PROPOSED

Species at Risk Act

Recovery Strategy Series

Recovery Strategy for the Round Hickorynut (*Obovaria subrotunda*) and the Kidneyshell (*Ptychobranchus fasciolaris*) in Canada

Round Hickorynut and Kidneyshell

January 2006

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

About the Species at Risk Act Recovery Strategy 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 provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (http://www.sararegistry.gc.ca/the_act/default_e.cfm) spell out both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

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

To learn more

To learn more about the Species at Risk Act and recovery initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/) and the web site of the Recovery Secretariat (http://www.speciesatrisk.gc.ca/recovery/default_e.cfm).

Recovery Strategy for the Round Hickorynut (*Obovaria subrotunda*, Rafinesque 1820) and Kidneyshell (*Ptychobranchus fasciolaris*, Rafinesque 1820) in Canada [Proposed]

January 2006

Recommended citation:

Morris, T. J. 2006. Recovery Strategy for the Round Hickorynut (*Obovaria subrotunda*, Rafinesque 1820) and the Kidneyshell (*Ptychobranchus fasciolaris*, Rafinesque 1820) in Canada [Proposed]. *In* Species at Risk Act Recovery Strategy Series. Ottawa: Fisheries and Oceans Canada. 47 pp.

Additional copies:

You can download additional copies from the SARA Public Registry (http://www.sararegistry.gc.ca/)

Cover illustrations: courtesy Environment Canada

Également disponible en français sous le titre
« **Stratégie de rétablissement de l'obovarie ronde (*Obovaria subrotunda, Rafinesque 1820*) et du ptychobranche réniforme (*Ptychobranchus fasciolaris, Rafinesque 1820*) au Canada** »

ISBN To come
Cat. no. To come

DECLARATION

This proposed recovery strategy for the Round Hickorynut and the Kidneyshell has been prepared in cooperation with the jurisdictions described in the Preface. Fisheries and Oceans Canada has reviewed and accepts this document as its recovery strategy for the Round Hickorynut and the Kidneyshell as required by the *Species at Risk Act*.

Success in the recovery of these species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. In the spirit of the National Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all Canadians to join Fisheries and Oceans Canada in supporting and implementing this strategy for the benefit of the Round Hickorynut and the Kidneyshell and Canadian society as a whole. Fisheries and Oceans Canada will support implementation of this strategy to the extent possible, given available resources and its overall responsibility for species at risk conservation. The Minister will report on progress within five years.

This strategy will be complemented by one or more action plans that will provide details on specific recovery measures to be taken to support conservation of the species. The Minister will take steps to ensure that, to the extent possible, Canadians interested in or affected by these measures will be consulted.

RESPONSIBLE JURISDICTIONS

The responsible jurisdiction for the Round Hickorynut and the Kidneyshell is Fisheries and Oceans Canada. The Round Hickorynut and the Kidneyshell occur in Ontario, and the government of Ontario cooperated in the production of this recovery strategy:

AUTHORS

This document was prepared by Todd J. Morris on behalf of the Ontario Freshwater Mussel Recovery Team and Fisheries and Oceans Canada.

ACKNOWLEDGMENTS

The Ontario Freshwater Mussel Recovery Team would like to thank the following organizations for their support in the development of the recovery strategy for the Round Hickorynut and Kidneyshell: Fisheries and Oceans Canada, Environment Canada, Ontario Ministry of Natural Resources, University of Guelph, University of Toronto/Royal Ontario Museum, McMaster University, Ausable-Bayfield Conservation Authority, Grand River Conservation Authority, Maitland Valley Conservation Authority, St. Clair Region Conservation Authority, Upper Thames River Conservation Authority, Lower Thames Valley Conservation Authority and the Walpole Island Heritage Centre.

PREFACE

The Round Hickorynut and the Kidneyshell are freshwater mussels and are under the jurisdiction of the federal government. The *Species at Risk Act* (SARA, Section 37) requires the competent minister to prepare recovery strategies for listed extirpated, endangered or threatened species. The Hickorynut and the Kidneyshell were listed as Endangered under SARA in May 2003. Fisheries and Oceans Canada – Central and Arctic region led the development of this recovery strategy. The proposed strategy meets SARA requirements in terms of content and process (Sections 39-41). It was developed in cooperation or consultation with:

- Jurisdictions – Environment Canada, Ontario Ministry of Natural Resources.
- Aboriginal groups – Southern First Nations Secretariate, London Chiefs Council, Walpole Island First Nation, Six Nations of the Grand, Chippewa of Stoney and Kettle Point, Chippewa of Sarnia, Caldwell First Nation, Moravia of Thames First Nation, Chippewa of the Thames, Oneida, Munsey-Delaware First Nation, Mississauga of New Credit First Nation.
- Environmental non-government groups – Ausable-Bayfield Conservation Authority, Grand River Conservation Authority, Maitland Valley Conservation Authority, St. Clair Region Conservation Authority, Upper Thames River Conservation Authority, Lower Thames Valley Conservation Authority, University of Guelph, University of Toronto/Royal Ontario Museum, McMaster University, Iowa State University.

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 strategies may also inadvertently lead to environmental effects beyond the intended benefits. The recovery planning process based on national guidelines 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 in the strategy itself, but are also summarized below.

This recovery strategy will clearly benefit the environment by promoting the recovery of the Round Hickorynut and the Kidneyshell. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. Refer to the following sections of the document in particular: Description of the species' needs – biological needs, ecological role and limiting factors; Effects on other species; and Recommended approach for recovery, as applicable.

EXECUTIVE SUMMARY

Freshwater mussels (Unionidae) are amongst the world's most imperiled taxa with declines reported at global, continental and national scales. Nearly 75% of North America's approximately 300 freshwater mussel species are facing varying degrees of extinction risk. Southern Ontario is home to the largest and most diverse mussel communities in Canada as three quarters of the nation's mussel species can be found in the lower Great Lakes drainage. Three of the largest mussel rivers in this region, the Thames, Grand and Sydenham rivers, have all shown significant declines during the latter half of the last century with species declines totaling 29%, 26% and 12% respectively. Eight species, all with distributions restricted to this region of southwestern Ontario and with current or historic distributions which include these three drainages, have been listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Two of these species, the Round Hickorynut (*Obovaria subrotunda*) and the Kidneyshell (*Ptychobranchus fasciolaris*) share common current and historic distributions and are facing similar threats to their continued existence. These two species are considered here in a multispecies recovery strategy developed by the Ontario Freshwater Mussel Recovery Team to facilitate the protection and recovery of both species in Canada.

The Round Hickorynut is a small mussel reaching a maximum size of 60 - 65 mm in Canada. The mussel is readily recognized by its round shape and prominent centrally located, inward curving beaks that are elevated well above the hinge line. The Canadian distribution of this species has always been restricted to southwestern Ontario where it was once found in the Welland, Grand, Sydenham, Thames, St. Clair and Detroit Rivers as well as the waters of Lake St. Clair and western Lake Erie. Declining water quality and the introduction of dreissenid mussels have resulted in a sharp decline in the Canadian distribution of the Round Hickorynut and it is now only found in the waters of the Lake St. Clair delta and a small portion of the East Sydenham River.

The Kidneyshell is a medium to large freshwater mussel that is readily distinguished by its elongate, elliptical shell and yellowish-brown periostracum with wide, interrupted green rays that look like squarish spots. The Kidneyshell has also always had a Canadian distribution limited to southwestern Ontario where it was once found in lakes St. Clair and Erie, as well as the Detroit, Sydenham, Thames, Ausable, Grand, Welland and Niagara rivers. Recent surveys have shown that this distribution has been severely reduced and the Kidneyshell is now limited to the Sydenham and Ausable rivers with a few specimens in the Lake St. Clair delta (COSEWIC 2003b).

Threats to the Round Hickorynut and Kidneyshell are many and varied although they can be separated into two major groups: those affecting lake populations (i.e. Great Lakes and connecting channels) and those affecting in-land riverine populations. The main reason for the declines in lake populations, and the major current threat to the Lake St. Clair populations of the Round Hickorynut and the Kidneyshell, is the presence of exotic dreissenid mussels. Dreissenid mussels (zebra and quagga mussels) attach to the shells of native mussels and act to inhibit feeding, respiration, excretion and locomotion. The near complete loss of freshwater mussels from the Great Lakes and their connecting channels can be attributed to the detrimental effects of these invasive mussels. As the largest remaining population of the Round Hickorynut is the St. Clair

delta population, dreissenid mussels should be seen as the most significant threat to the continued existence of the Round Hickorynut in Canada.

Riverine populations of both mussel species are subject to different threats than the lake populations with the primary threats being declining water quality and a general disappearance of suitable habitat. The two watersheds where these species can still be found are predominantly agricultural with high nutrient and sediment inputs to the watercourse from the adjacent lands. Waters with high sediment loads, particularly when composed of fine sediments like those associated with agricultural run-off, have been shown to cause clogging of the gill structures which can interfere with feeding, respiration and reproduction.

The obligate parasitic nature of the reproductive cycle of these mussels necessitates a consideration of threats to the host fish species as well as the direct threats to the mussel.

This Recovery Strategy was assembled by the Ontario Freshwater Mussel Recovery Team consisting of members from Fisheries and Oceans Canada, Environment Canada, Ontario Ministry of Natural Resources, University of Guelph, University of Toronto, McMaster University, Ausable-Bayfield Conservation Authority, Grand River Conservation Authority, Maitland Valley Conservation Authority, St. Clair Region Conservation Authority, Upper Thames River Conservation Authority, Lower Thames Valley Conservation Authority and the Walpole Island Heritage Centre.

The long-term goals of this recovery strategy are:

i. to prevent the extirpation of the Round Hickorynut and Kidneyshell in Canada;
ii. to return healthy self-sustaining populations of Round Hickorynut to the Sydenham River and Lake St. Clair delta and;
iii. to maintain healthy self-sustaining Kidneyshell populations in the Ausable and Sydenham rivers while returning the Lake St. Clair delta population to a self-sustaining level.
iv. to re-establish populations in historically occupied habitats.

These populations can only be considered recovered when they have returned to historically estimated ranges and/or population densities and are showing signs of reproduction and recruitment.

The following specific short term objectives have been identified to assist with meeting the long term goal:

i. Determine extent, abundance and population demographics of existing populations.
ii. Determine fish hosts and their distributions and abundances.
iii. Define key habitat requirements to identify critical habitat.
iv. Establish a long-term monitoring program for Round Hickorynut and Kidneyshell populations, their hosts and the habitat of both.
v. Identify threats, evaluate their relative importance and implement remedial actions to minimize their impacts.
vi. Examine the feasibility of relocations, reintroductions and the establishment of managed refuge sites.

vii. Increase awareness about the distribution, threats and recovery of these species.

The Recovery Team has identified a variety of approaches that are necessary to meet the recovery objectives. These approaches have been broadly organized into four categories: Research and Monitoring, Management, Stewardship and Awareness.

This Recovery Strategy represents one component of a multi-faceted approach to preserve these endangered mussels. Because of the sedentary nature of mussels and their filter-feeding behaviour, they have a value beyond basic biodiversity in their role as indicators of ecosystem health. Threats that have been indicated as affecting riverine populations may, in most cases, be considered as threats to the aquatic ecosystem in general. Correspondingly, activities directed at mitigating threats to mussels will benefit the aquatic ecosystem as a whole and general ecosystem recovery actions like those proposed in the Sydenham and Ausable river ecosystem recovery strategies (Dextrase et al. 2003; ARRT 2004) will assist with the recovery of the Round Hickorynut and Kidneyshell.

In addition to the ecosystem recovery planning efforts a number of ongoing research programs will assist with achieving the objectives outlined in this strategy. A team at the University of Guelph has established a research facility to investigate mussel-host relationships and juvenile rearing and has already succeeded in identifying hosts for the Kidneyshell in Canada. A laboratory at the University of Toronto/ Royal Ontario Museum has recently begun to examine the conservation genetics of mussel species at risk. Researchers from the National Water Research Institute of Environment Canada are conducting ongoing surveys for mussel species at risk in southwestern Ontario as well as examining the feasibility of establishing managed refuge sites in the St. Clair delta region. A permanent, long-term monitoring network to track changes in mussels and their habitat has been established in the Sydenham and Thames rivers and will be expanded to the Ausable River. Ongoing stewardship activities have been established through local conservation authorities throughout the ranges of both the Round Hickorynut and Kidneyshell.

The Round Hickorynut prefers sand and gravel substrates with steady, moderate flows at depths of up to 2 m. Currently occupied habitat for the Round Hickorynut consists of a 12 km^2 region of the Canadian waters of the St. Clair delta and a 60 km reach of the east Sydenham River from just upstream of Alvinston downstream to Dawn Mills. Historically occupied habitat would include the Thames River from London to Chatham and the Grand River near Dunville. If the impacts of dreissenid mussels can be mitigated then historically occupied areas in the Detroit, St. Clair and Welland rivers as well as the open waters of western Lake Erie and Lake St. Clair may also function as suitable habitat for recovery. The Kidneyshell prefers shallow areas with clear, swift-flowing water and substrates of firmly packed coarse gravel and sand. Currently occupied habitat for this species includes areas that fit this description in the coastal margin of the Lake St. Clair delta, 60 km of the East Sydenham River from Alvinston to Dawn Mills, and approximately 50 km of the Ausable River from Huron Park to Arkona Gorge. Historically occupied habitat for the Kidneyshell includes 50 km of the Lower Grand River from Caledonia to Port Maitland, a small portion of the Welland River, and locations within the Thames River between London and Chatham. Areas in Lake Erie, Lake St. Clair and the Niagara River may also function as future habitat if the influence of dreissenid mussels can be reduced.

The Recovery Team believes that the approaches outlined in this strategy to achieve recovery of the Round Hickorynut and Kidneyshell are best accomplished through cooperation with the existing ecosystem recovery teams. In watersheds with existing ecosystem teams, implementation of recovery actions should be coordinated to confirm that activities are beneficial to all species at risk and to eliminate the possible duplication of efforts. Where ecosystem teams are absent, Recovery Implementation Groups may be struck to facilitate the carrying out of recovery actions. Evaluation of the success of recovery actions will be achieved primarily through the routine monitoring programs established to track changes in population demographics and habitat, however, RIGs will also incorporate specific milestones into Recovery Action Plans. The entire Recovery Strategy will be reassessed after 5 years to evaluate the progress towards achieving the goals and objectives and to incorporate new information.

Table of Contents

INTRODUCTION

Freshwater mussels are among the world's most imperiled taxa with declines reported on a global scale (Bogan 1993; Lydeard *et al.* 2004). The rich unionid fauna of North America has been hit particularly hard with over 70% of the approximately 300 species showing evidence of declines with many now considered rare, endangered, threatened or imperiled (Allan and Flecker 1993; Williams *et al.* 1993). Canada is home to 55 unionid species, 41 of which can be found in the province of Ontario with 18 species having Canadian distributions restricted to this province. The rivers of southwestern Ontario, primarily those draining into Lake St. Clair and Lake Erie, are home to the richest unionid assemblages in Canada. The Sydenham River has historically been considered to be the richest unionid river in all of Canada (Clarke 1992) with a total species count of 34 (Metcalfe-Smith *et al.* 2003), however, recent evidence suggests that the Grand (Metcalfe-Smith *et al*. 2000) and Thames rivers (pers. comm. J. Metcalfe-Smith, National Water Research Institute, Burlington, Ontario), also with historic species counts of 34, were equally diverse.

Despite the historic richness of these rivers, recent events have led to significant declines in the unionid communities of southwestern Ontario. Intensive agricultural activity, expanding urbanization and the introduction of invasive dreissenid mussels (zebra (*Dreissena polymorpha*) and quagga (*Dreissena bugensis*) mussels) have all been implicated in large scale declines observed in freshwater mussel populations over the last two to three decades (Nalepa 1994; Metcalfe-Smith et al. 2000; Metcalfe-Smith et al. 2003). During this time 4 species have been lost from the Sydenham River, 10 species have disappeared from the Thames River and the community of the Grand River has been reduced by 9 species. These declines, coupled with the near complete collapse of the Great Lakes populations (Nalepa *et al*. 1996), have led to the listing of 8 Ontario mussel species as endangered by the Committee on the Status of Endangered Wildlife In Canada (COSEWIC).

The Ontario Freshwater Mussel Recovery Team (OFMRT) was formed in the spring of 2003 to address concerns about the status of Ontario's freshwater mussel populations and to begin to address the recovery planning obligations under Canada's new Species at Risk Act (SARA). The National Recovery Strategy for the Round Hickorynut and the Kidneyshell was developed by the OFMRT using the best available information in an effort to reduce the threats, prevent their extirpation and, if possible, to restore these species to healthy, self-sustaining levels. In recognition of the degree of overlap between these species in both their historical and current distributions, as well as the commonality of threats, the OFMRT has adopted a multi-species approach to the recovery of these species.

I. BACKGROUND

1. SPECIES INFORMATION – ROUND HICKORYNUT

COSEWIC Assessment Summary – May 2003

Common Name: Round Hickorynut
Scientific Name: *Obovaria subrotunda*
COSEWIC Status: Endangered
COSEWIC Reason for designation: This species has been lost from 90% of its former range in Canada. Populations in the Grand and Thames rivers are extirpated and populations in the Sydenham River are declining, all due to the combined effects of pollution and agricultural impacts. Most of the Great Lakes populations have been lost due to impacts of the zebra mussel, and the remaining population in the St. Clair delta near Walpole Island may be at risk. If the Eastern Sand Darter were the host of this species, then the decline of this threatened fish would affect the mussel's survival.
Occurrence: Ontario
COSEWIC Status history: Designated Endangered in 2003.

The Round Hickorynut is one of only 6 species in the genus *Obovaria*. Only two of these species, *O. subrotunda*, and *O. olivaria*, have distributions which extend into Canada where both species are restricted to the Lower Great Lakes/St. Lawrence River drainage. The Round Hickorynut is considered globally secure (G4) and nationally secure (N4) within the United States although the American Fisheries Society has listed it as a species of special concern. The species is beginning to show declines across its entire American distribution. It is considered endangered within Michigan and is believed to be extirpated from Illinois (G. Kruse, Illinois Department of Natural Resources, pers. comm. February, 2004)) and New York (D. Strayer, Institute of Ecosystem Studies, pers. comm., February 2004). In Canada, the Round Hickorynut is considered critically imperiled (N1) and was designated as endangered by the Committee on the Status of Endangered Wildlife in Canada in 2003. The Canadian distribution of this species has always been restricted to southwestern Ontario where it was once found in the Welland, Grand, Sydenham,

Figure 1: Two Round Hickorynut specimens from the Lake St. Clair delta. Note the characteristic lightening of the posterior slope. Photo credit: D. McGoldrick, Environment Canada.

Thames, St. Clair and Detroit Rivers as well as the waters of Lake St. Clair and western Lake Erie. Declining water quality and the introduction of dreissenid mussels have resulted in a sharp decline in the Canadian distribution of the Round Hickorynut and it is now only found in the waters of the Lake St. Clair delta and a small portion of the East Sydenham River.

The Round Hickorynut is a small mussel reaching a maximum size of 60 - 65 mm in Canada. The mussel is readily recognized by its round shape and prominent centrally located, inward curving beaks that are elevated well above the hinge line. Beak sculpture is slight, consisting of 4 to 5 weak double bars which are sinuous centrally and angled posteriorly (Parmalee and Bogan 1998). The shell is generally dark in colour ranging from olive-brown to dark brown and is relatively smooth except for prominent growth rests. The posterior slope is often distinctly lighter than the rest of the shell (COSEWIC 2003a) (Figure 1). The hinge teeth of this species are heavy and strong. The left valve has two thick, roughened, triangular pseudocardinal teeth and two slightly curved, short, strong lateral teeth. The right valve has one large, massive serrated triangular pseudocardinal tooth, usually with a small, low compressed tubercular tooth on either side. There is one short, curved, thick, roughened lateral tooth and often an incomplete secondary lateral tooth in the right valve (Parmalee and Bogan 1988).

Distribution

Global Range: The global distribution of the Round Hickorynut is restricted to eastern North America (Figure 2). In the United States the Round Hickorynut is considered nationally secure but is showing declines across its range. This species is historically known from the Ohio, Tennessee, Cumberland and Mississippi River systems as well as the St. Lawrence, Lake Erie and Lake St. Clair drainages. It is currently found in Alabama, Indiana, Kentucky, Michigan, Mississippi, Ohio, Pennsylvania, Tenessee and West Virginia and is believed to have been extirpated from New York and Illinois. In Canada the Round Hickorynut is considered critically imperiled, classified as endangered by COSEWIC and found only in southwestern Ontario.

Canadian Range: In Canada, the Round Hickorynut is historically known from the waters of western Lake Erie, Lake St. Clair and the Welland, Grand, Thames, Sydenham and Detroit Rivers (COSEWIC 2003a). Since 1996, live specimens have only been reported from the Sydenham River and Lake St. Clair (Figure 3).

Percent of Global Range in Canada: Approximately 1% of the global range of this species occurs in Canada.

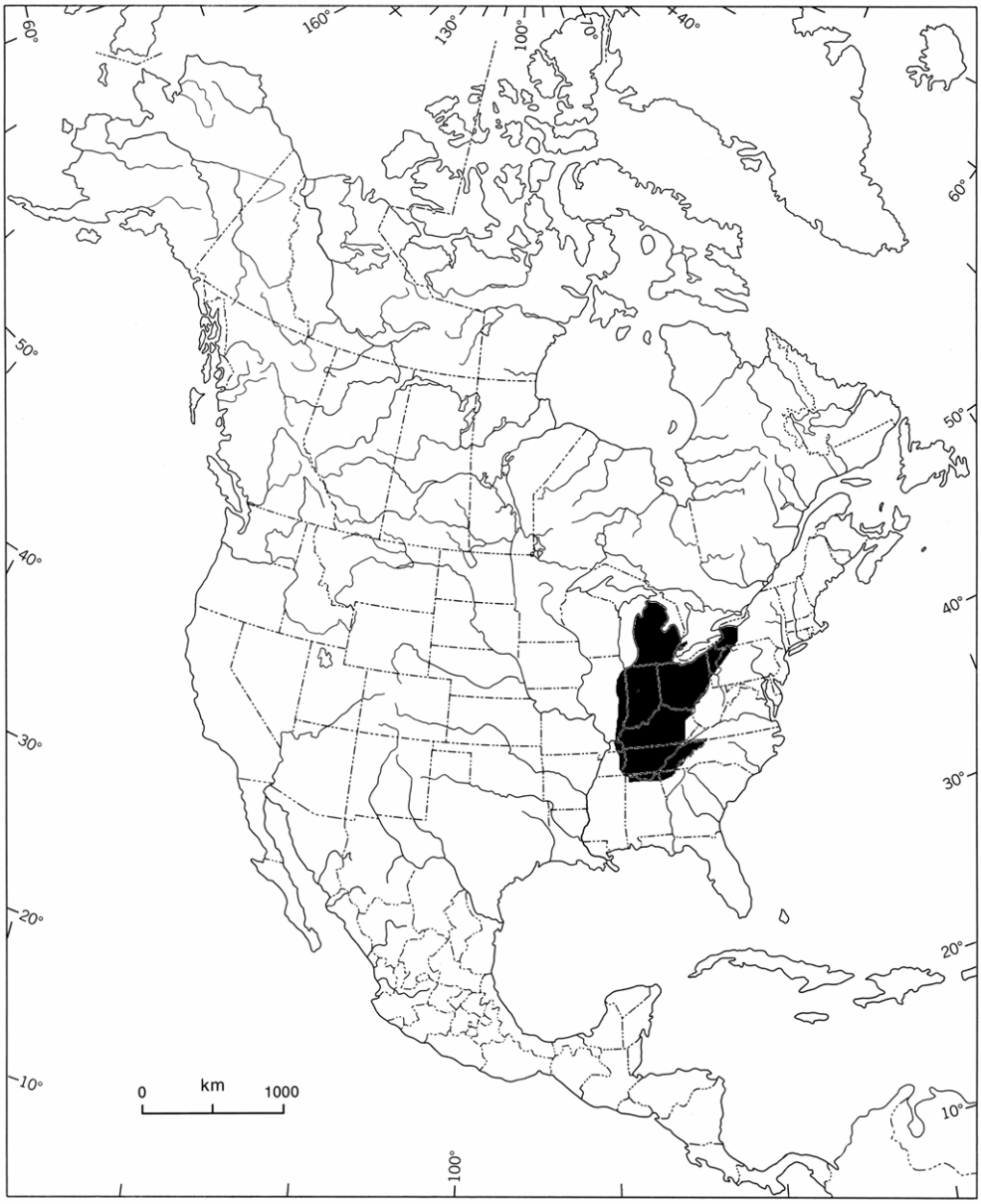

Figure 2: Global distribution of the Round Hickorynut (modified from Parmalee and Bogan 1998)

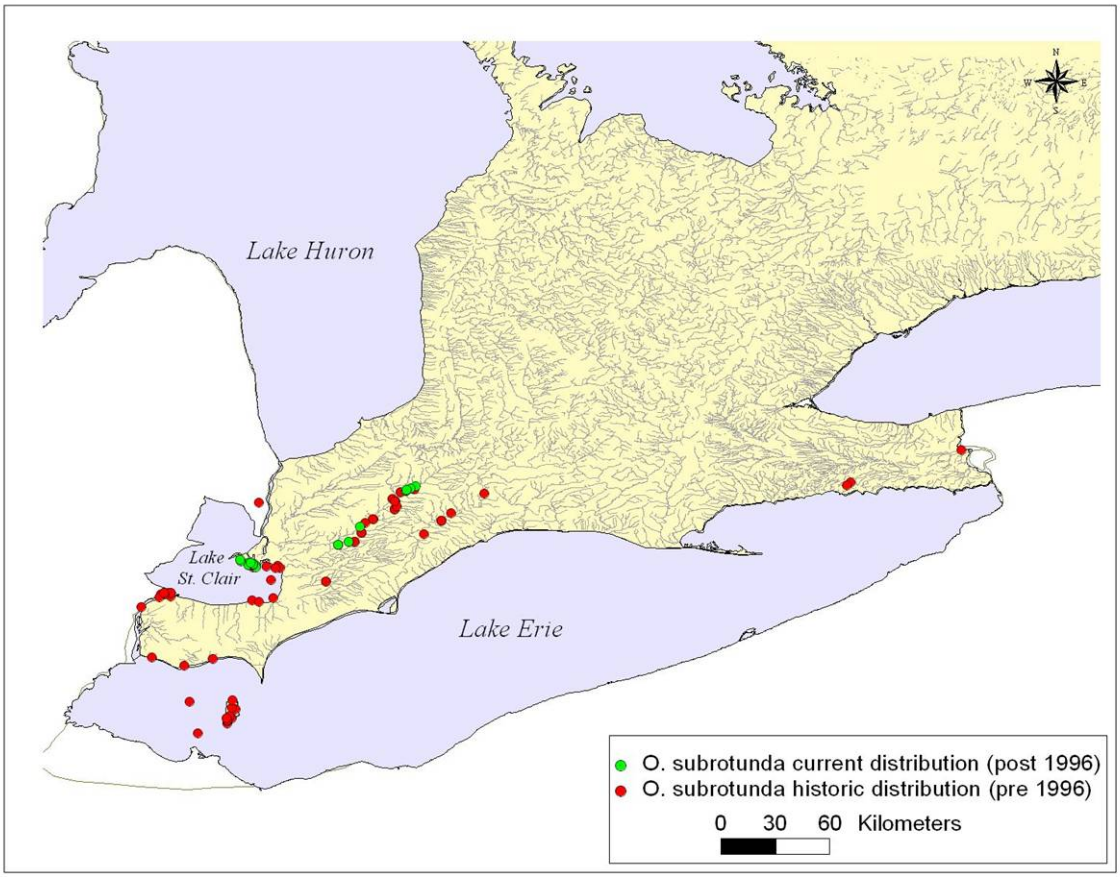

Figure 3: Distribution of the Round Hickorynut in Canada. Current distribution reflects surveys since 1996.

Distribution Trend: Since the invasion of the Great Lakes by dreissenid mussels the Canadian geographical distribution for this species has been reduced by 90%.

Population Abundance

Global Range: In the United States the Round Hickorynut is seldom a significant component of the mussel community, typically representing between 0.1 and 1.4% of the species present (COSEWIC 2003a).

Canadian Range: The largest Canadian population of the Round Hickorynut occurs in the delta region of Lake St. Clair where it comprises 0.011% of the overall mussel community and occurs at a density of 0.0006/m^2. In the Sydenham River the Round Hickorynut represents approximately 0.0024% of the mussel community.

Percent of Global Abundance in Canada: Less than 1% of the global abundance of this species occurs in Canada.

Population Trend: It is estimated that the population of Round Hickorynut in Canada has declined by 90% since the invasion of the Great Lakes by dreissenid

mussels. This estimate is based on the number of historical records that occur in waters that now contain dreissenid mussels.

Biological Limiting Factors

Reproductive Attributes: The reproductive biology of the Round Hickorynut follows the general reproductive biology of most unionid mussels. During spawning, male mussels release sperm into the water column and females filter it out of the water with their gills. Fertilization is then able to occur in specialized regions of the gills known as marsupia. Immature juveniles, known as glochidia, develop in the gill marsupia and are released by the female into the water column to undergo a period of parasitism on a suitable host fish species. Further development to the juvenile stage can not continue without a period of encystment on the host. The hookless glochidia become encysted on the gills of the host and are encapsulated in a fluid filled sac where they are nourished by the host until they metamorphose and break free, settling to the substrate to begin life as free-living juveniles. The host fish species for the Round Hickorynut has not been confirmed for Canadian populations although 5 host species have been identified in the United States. These 5 species include: varigate darter (*Etheostoma variatum*); frecklebelly darter (*Percina stictogaster*); speckled darter (*E. stigmaeum*); greenside darter (*E. blennioides*); and emerald darter (*E. baileyi*) (M. McGregor, Kentucky Department of Fish and Wildlife Resources, pers. comm., January 2004). Only the greenside darter is found in Canada where its range appears to be expanding. Interestingly, the known current and historic range of the greenside darter does not completely overlap with the historic range of the Round Hickorynut (i.e., greenside darters are not known from the Grand River prior to 1990 and no records exist for this species from the Welland River or Lake Erie (A. Dextrase, Ontario Ministry of Natural Resources, Peterborough, pers. comm.)) suggesting the existence of an additional host. Round Hickorynuts are known to be gravid between September and June and may be using host fish during this time.

Dispersal: Like most native freshwater mussels, Round Hickorynut adults are essentially sessile with movement limited to only a few meters on the river/lake bottom. Although adult movement can be directed upstream or downstream, studies have found a net downstream movement through time (Balfour and Smock 1995; Villella *et al.* 2004). The primary means for large scale dispersal, upstream movement, and the invasion of new habitat or evasion of deteriorating habitat, is limited to the encysted glochidial stage on the host fish.

2. SPECIES INFORMATION – KIDNEYSHELL

COSEWIC Assessment Summary – May 2003

Common Name: Kidneyshell
Scientific Name: *Ptychobranchus fasciolaris*
COSEWIC Status: Endangered
COSEWIC Reason for designation: This species has been lost from about 70% of its historical range in Canada due to impacts of the zebra mussel and land use practices. It is now restricted to the East Sydenham and Ausable rivers. Although both populations appear to be reproducing, there is evidence that abundance has declined in the East Sydenham River. Agricultural impacts, including siltation, have eliminated populations in the Grand and Thames rivers, and threaten the continued existence of this species in Canada.
Occurrence: Ontario
COSEWIC Status history: Designated Endangered in 2003.

The Kidneyshell (Figure 4) is one of 5 members of the genus *Ptychobranchus* that occur in North America, however, it is the only member of the genus with a distribution that extends into Canada. The species is considered globally secure (G4) and is listed by the American Fisheries Society as being stable within the United States although, in Canada, the Kidneyshell was designated as endangered by COSEWIC in 2003. The Kidneyshell has always had a Canadian distribution limited to southwestern Ontario where it was once found in lakes St. Clair and Erie, as well as the Detroit, Sydenham, Thames, Ausable, Grand, Welland and Niagara rivers. Recent surveys have shown that this distribution has been reduced and the Kidneyshell is now limited to the Sydenham and Ausable rivers with a few scattered specimens in the Lake St. Clair delta.

Figure 4: Two kidneyshell specimens from the Sydenham River. Note the characteristic squarish spots. Photo credit: T. Morris, Fisheries and Oceans Canada.

The Kidneyshell is a medium to large freshwater mussel that is readily distinguished by its elongate, elliptical shell and yellowish-brown periostracum with wide, interrupted green rays that look like squarish spots (Figure 4). The type locality is the Muskingham River, Ohio. The following description of the species, reported in COSEWIC (2003b), was adapted from Clarke (1981), Strayer and Jirka (1997) and Parmalee and Bogan (1998). The shell is solid, heavy and compressed, and may have a humped shape in old individuals. The anterior end is rounded and the posterior end is bluntly pointed. Beak sculpture is poorly developed, consisting of several fine, indistinct wavy ridges. The surface of the shell (periostracum) ranges in colour from yellowish to yellowish-green,

yellowish-brown, or medium brown, with generally distributed broad, interrupted green rays; the shells of old specimens may be a dark chestnut brown and rayless. The periostracum is unsculptured except for coarse growth rests and a roughened posterior slope. The nacre is generally white or bluish white, but may be pinkish in young specimens. The hinge teeth are heavy. The left valve has two low, thick, serrated triangular pseudocardinal teeth and two lateral teeth that are short, nearly straight, and usually widely separated. The right valve has one somewhat compressed and pyramidal elevated tooth and one wide, elongated and serrated lateral tooth. The lateral teeth are almost pendulous distally, which is a good distinguishing feature. The interdentum is wide and the beak cavity is shallow. Females have a conspicuous groove on the inside of the shell that runs diagonally from the beak cavity towards the posterioventral end; this groove corresponds to the marsupium (COSEWIC 2003b).

Distribution:

Global Range: In the United States, the Kidneyshell is currently found in Ohio, Tennessee, Kentucky, Michigan, New York, Pennsylvania, West Virginia, Virginia, Alabama, Mississippi and Illinois.

Canadian Range: In Canada, the Kidneyshell is found only in southwestern Ontario. Since 1997, live specimens have only been reported from the Ausable River, Sydenham River, and Lake St. Clair.

Percent of Global Range in Canada: Less than 5% of the global range of this species occurs in Canada.

Distribution Trend: Since the invasion of the Great Lakes by dreissenid mussels the Canadian geographical distribution for this species has been reduced by 70%.

Population Abundance:

Global Range: In the United States the Kidneyshell is seldom a significant component of the mussel community but may be locally abundant. It usually represents on average 2.5% (0.2-8.0%) of the mussel community in rivers but at individual sites where it is found the Kidneyshell may account for more than 10% of the community.

Canadian Range: The largest Canadian population of the Kidneyshell occurs in the Ausable River where it comprises 1.5% of the overall mussel community. In the Sydenham River it occurs in an average estimated density of $0.12/m^2$ at sites where it was found alive. In the Lake St. Clair delta Kidneyshells comprised only 0.3% of the overall mussel community (COSEWIC 2003b).

Percent of Global Abundance in Canada: Less than 5% of the global abundance of this species occurs in Canada.

Population Trend: It is estimated that the population of Kidneyshell in Canada has declined by 70% since the invasion of the Great Lakes by dreissenid mussels. This estimate is based on the number of historical records that occur in waters that now contain dreissenid mussels.

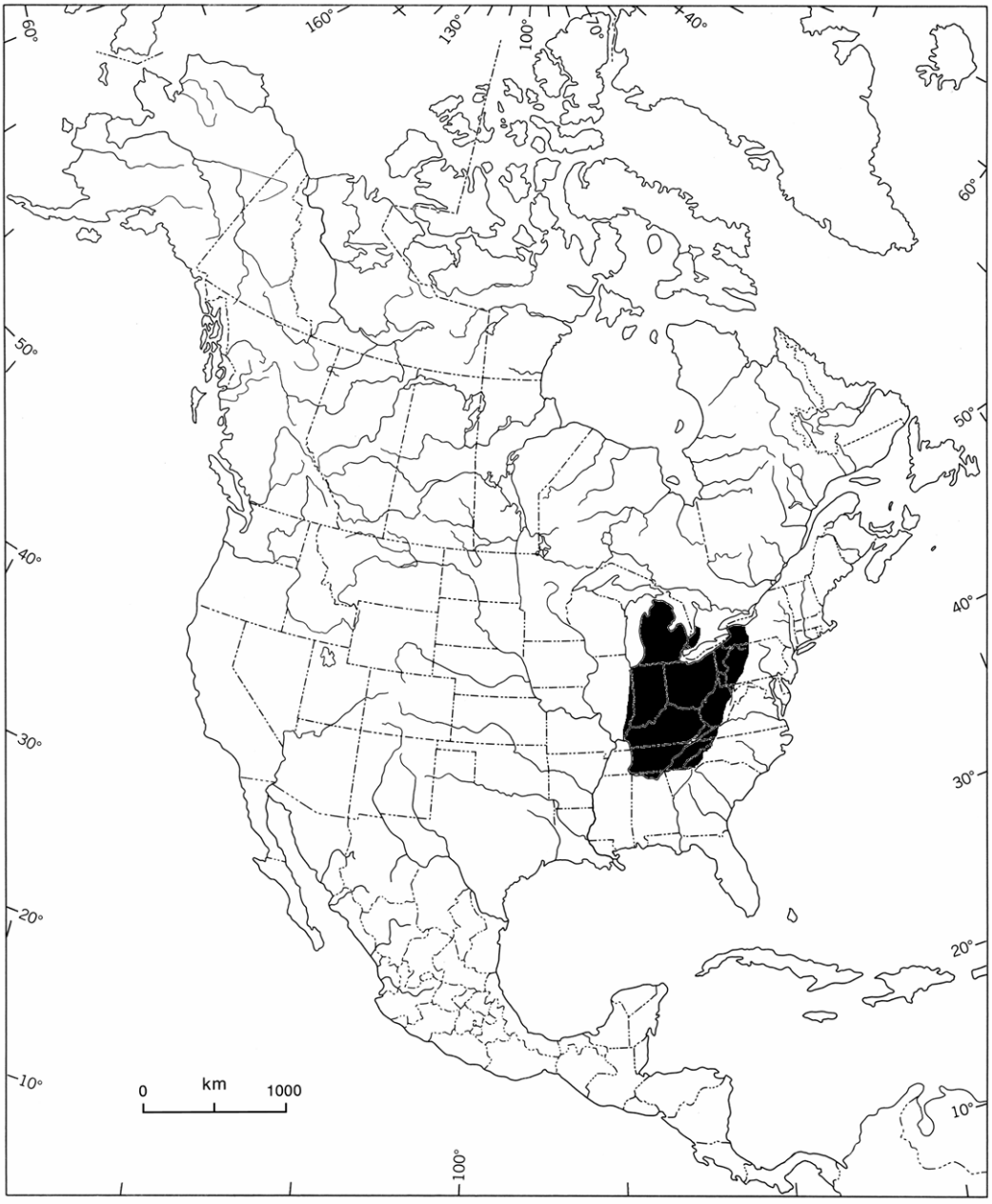

Figure 5: Global distribution of the Kidneyshell (modified from Parmalee and Bogan 1998)

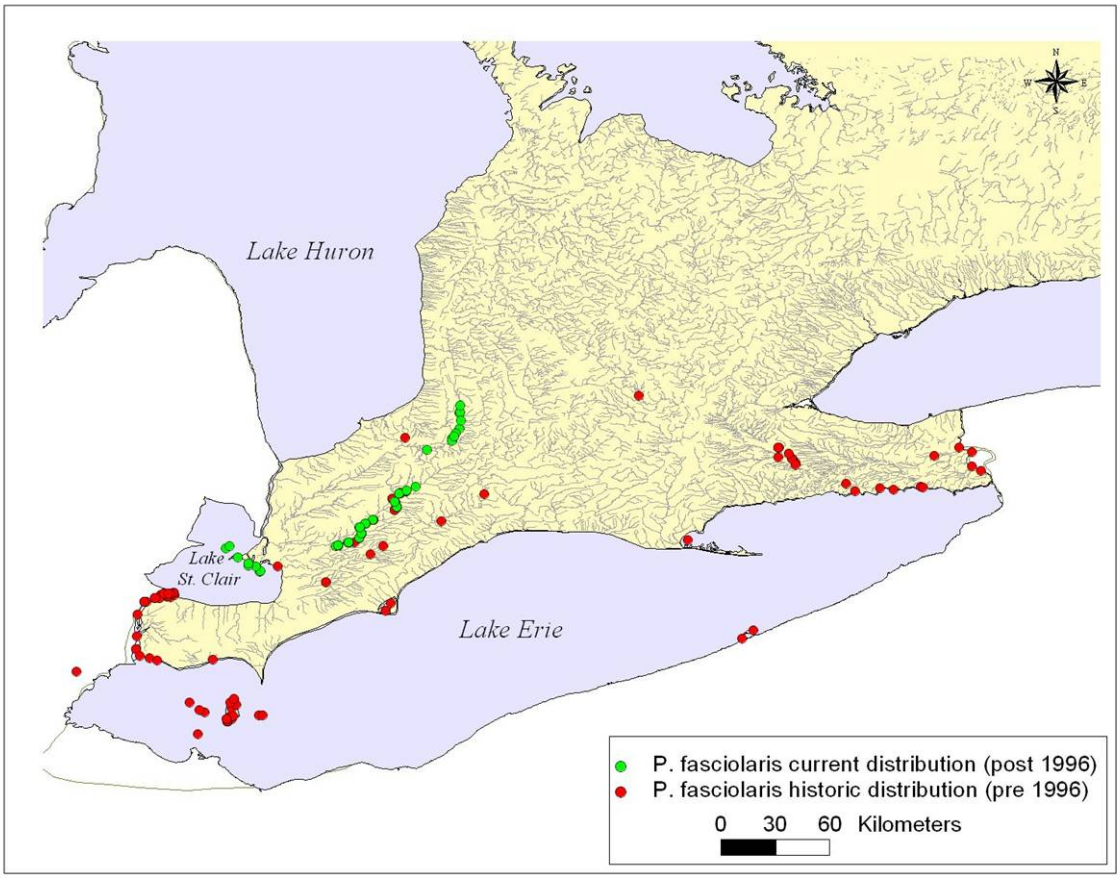

Figure 6: Distribution of the Kidneyshell in Canada. Current distribution reflects surveys since 1997.

Biological Limiting Factors

Reproductive Attributes: The reproductive biology of the Kidneyshell follows the general reproductive biology of most unionid mussels. During spawning, male mussels release sperm into the water column and females filter it out of the water with their gills. Fertilization is then able to occur in specialized regions of the gills known as marsupia. Immature juveniles, known as glochidia, develop in the gill marsupia and are released by the female into the water column to undergo a period of parasitism on a suitable host fish species. Further development to the juvenile stage can not continue without a period of encystment on the host. Members of the genus *Ptychobranchus* have evolved a specialized method of delivering glochidia designed to increase the likelihood of encountering a suitable host. The glochidia are released in mucous encased packages termed conglutinates which have been shown to resemble fish fry complete with eye spots, or benthic invertebrates such as chironomids. These two forms represent prey items of the host species and stimulate the feeding instincts of the host resulting in an active uptake into the mouth where the conglutinates rupture, releasing glochidia in close proximity to the gills of the host. The hookless glochidia become encysted on the gills of the host and are encapsulated in a fluid filled sac where they are nourished by the host until they metamorphose and

break free, settling to the substrate to begin life as free-living juveniles. Three glochidial host fishes have been identified for the Kidneyshell in Canada: blackside darter (*Percina maculata*); fantail darter (*Etheostoma flabellare*); johnny darter (*E. nigrum*) (McNichols and Mackie 2004). In Canada, Kidneyshells are known to be gravid between September and November and encystment has been shown to last up to 60 days resulting in the potential for encysted glochidia on the host fishes anytime between September and January (McNichols and Mackie 2004).

Dispersal: Like most native freshwater mussels, Kidneyshell adults are essentially sessile with movement limited to only a few meters on the river/lake bottom. Although adult movement can be directed upstream or downstream, studies have found a net downstream movement through time (Balfour and Smock 1995; Villella *et al.* 2004). The primary means for large scale dispersal, upstream movement, and the invasion of new habitat or evasion of deteriorating habitat, is limited to the encysted glochidial stage on the host fish.

3. THREATS

The Round Hickorynut and the Kidneyshell, like most mussel species, are sensitive to a wide variety of stressors including exotic species, poor water quality resulting from point (industrial and residential discharge) and non-point (herbicide, pesticide and surface run-off) sources, loss of host fish species, impoundments, siltation/sedimentation, predation and urbanization. The following discussion of threats focuses on those threats which are specific to the two remaining populations of the Round Hickorynut (St. Clair delta, Sydenham River) and three remaining populations of the Kidneyshell (St. Clair delta, Sydenham River, Ausable River) although it is likely that all of the stressors listed previously have contributed to the decline of these species in Canada.

Threats to Extant Populations

St. Clair Delta Populations: The introduction and spread of the exotic zebra and quagga mussels throughout the Great Lakes basin has resulted in steep declines of native mussel species (Schloesser *et al.* 1996). These invasive mussels are known to attach to the shells of unionids and can cause death by interfering with feeding, respiration, excretion and locomotion (Haag *et al.* 1993; Baker and Hornbach 1997). COSEWIC (2003b) reported that 64% of the Canadian sites where the Round Hickorynut was historically found are now infested with zebra mussels rendering much of the habitat unsuitable for unionids. The St. Clair delta population occurs in waters inhabited by zebra mussels and Round Hickorynuts were found in areas with relatively high zebra mussel infestation rates (D. McGoldrick, National Water Research Institute, Environment Canada, pers. comm., October 2003). It is not known why the mussels of the St. Clair delta have survived when other areas in Lake St. Clair have been devastated by the zebra mussel invasion (Nalepa *et al.* 1996) nor is it known if this population will persist (Zanatta *et al.* 2002). The St. Clair delta Round Hickorynut and Kidneyshell populations are very small with only 9 Round Hickorynuts and 1 Kidneyshell detected during sampling of nearly 15,000 m^2 in 2003 (Metcalfe-Smith *et al.* 2004)). These populations are dominated by relatively large, older individuals indicating poor reproductive success with the possibility of frequent year-class failure (COSEWIC 2003b).

Sydenham and Ausable River Populations

Water Quality: The Sydenham River flows through an area of prime agricultural land in southwestern Ontario and over 85% of the land in the watershed is in agricultural use with 60% of land in tile drainage (Staton *et al.* 2003). Large areas of the river have little to no riparian vegetation as only 12% of the original forest cover remains. Strayer and Fetterman (1999) identified high sediment and nutrient loads and toxic chemicals from non-point sources, especially agricultural activities, as the primary threat to riverine mussels. Agricultural lands, particularly those with little riparian vegetation and large amounts of tile drain, allow large inputs of sediments to the watercourse. In the case of tile drained land, the sediment input is often of a very fine grain which can clog the gill structures of mussels resulting in decreased feeding and respiration rates and reductions in growth efficiency. The Sydenham River has historically shown high nutrient levels with total phosphorus levels consistently exceeding provincial water quality levels over the last 30 years while chloride levels have shown recent inclines due to an increased use of road salt (Staton *et al.* 2003).

Agriculture is also the dominant land-use within the Ausable River basin with over 80% of the land in agricultural use and 71% of the land area in tile drainage (Nelson *et al.* 2003). Suspended sediment levels are high throughout the river with levels in the lower main channel consistently exceeding those required to maintain good fisheries (Nelson *et al.* 2003). Nutrient levels (N, P, un-ionized ammonia) regularly exceed provincial Water Quality Objectives for the protection of wildlife and Canadian Council of Ministers of Environment guidelines. Recent evidence has shown that juvenile mussels are among the most sensitive aquatic organisms to ammonia toxicity (Mummert *et al.* 2003; Newton 2003; Newton *et al*. 2003).

Dissolved oxygen (DO) levels in the East Sydenham River typically average about 10 mg/L however levels at all four Provincial Water Quality Monitoring Stations in this basin have dropped as low as 5 mg/L during the last 35 years (Jacques Whitford Environment Ltd. 2001). Over the same time period, DO levels in the Ausable River have on occasion fallen to comparable levels (2-3 mg/L) (Nelson *et al.* 2003). Johnson *et al*. (2001) have found mussel survival rates are closely related to DO levels while Tetzloff (2001) reported massive mussel die-offs in Big Darby Creek, Ohio, following a low oxygen event resulting from a chemical spill. Kidneyshells were one of the most sensitive species to these conditions with greater than 95% mortality, much of it coming rapidly after the onset of low oxygen conditions. Three years after the low O_2 event many of the affected species have still not recovered to pre-event levels (pers. comm., J. Tetzloff, Darby Creek Association Inc., March 2004).

Water Quantity: Hydrologic regimes can affect mussels in a number of ways. High flow conditions can cause dislodgement and passive transport of mussels from areas of suitable habitat into areas of lesser or marginal habitat. Neither the Round Hickorynut nor the Kidneyshell show the typical shell adaptations associated with resistance to scour and shear stress associated with hydrologically flashy rivers (pustules, ridges, fluting) (Watters 1994). In contrast to the dislodgement associated with high flows, low flows can result in depressed

dissolved oxygen levels, desiccation, and elevated temperatures. In a study of drought conditions in relation to mussel survival, Johnson *et al*. (2001) identified the need for instream flow protection as a critical issue for mussel conservation and protection in the southwestern U.S. Low flow events in the Ausable River often result in the stranding of mussels.

Host Fish: The Round Hickorynut is an obligate parasite unable to complete its early life stages without a suitable host. The host species for the Round Hickorynut has not yet been confirmed in Canada although evidence indicates the greenside darter (see Reproductive Attributes section) likely functions as a Canadian host. Clark (1977) also noticed an association between the Round Hickorynut and the eastern sand darter (*Ammocrypta pellucida*) suggesting a possible host relationship although this species has not been formally tested (M. McGregor, Kentucky Department of Fish and Wildlife Resources, pers. comm., January 2004). The greenside darter is considered a species of special concern in Canada where it is found in both the Sydenham River and Lake St. Clair although it is believed to be relatively abundant and stable in the Sydenham River (Dextrase *et al.* 2003).The eastern sand darter is listed as a threatened species in Canada but can be found in the East Sydenham River in areas where the Round Hickorynut persists. Siltation resulting from agricultural activities has been cited as one of the main reasons for the decline of the eastern sand darter (Holm and Mandrak 1996).

Three species have been identified as hosts for the Kidneyshell: blackside darter; fantail darter; johnny darter (McNichols and Mackie 2004). Recent surveys have shown that johnny darters and blackside darters are abundant throughout the Ausable (Nelson *et al.* 2003) and Sydenham rivers (N. Mandrak, Department of Fisheries and Oceans, Burlington, pers. comm., March 2004) while fantail darters are neither abundant nor widespread in either system. If johnny darters or blackside darters are acting as a host for wild populations in the Ausable or Sydenham rivers then host limitation should not be a primary cause of the observed declines. Only a heavy reliance on the fantail darter as the host would appear to place these species in danger of being host-limited.

Any threats that affect the host species' abundance, movements, or behaviour during the period of glochidial release must be considered as threats to these mussels as well. For example, the invasive round goby has been implicated in the following declines of native benthic fish species in the lower Great Lakes: 1) logperch (*Percina caprodes*) and mottled sculpin (*Cottus bairdi*) populations in the St. Clair River (French and Jude 2001); 2) johnny darter (*Etheostoma nigrum*), logperch, and trout-perch (*Percopsis omiscomaycus*) in Lake St. Clair (Thomas and Haas 2004); and, 3) channel darter (*P. copelandi*), fantail darter (*E. flabellare*), greenside darter (*E. blenniodes*), johnny darter, and logperch in the Bass Islands, western Lake Erie (Baker 2005). Index trawling data from 1987 to 2004 (unpublished data, Lake Erie Fisheries Assessment Unit MNR) indicate that similar declines have occurred in the Inner Bay of Long Point Bay and the western basin of Lake Erie. Potential causes include goby predation on eggs and juveniles, competition for food and habitat, and interference competition for nests (French and Jude 2001, Janssen and Jude 2001). The round goby poses a real threat to host fish populations and could seriously

Table 1: Assessment of threats to extant populations of the Round Hickorynut and Kidneyshell. St. Clair delta and Sydenham River threats apply to Round Hickorynut and Kidneyshell populations. Ausable River threats apply only to the Kidneyshell population in the Ausable River.

Threat	**Relative Impact** predominant/ contributing			**Spatial/Temporal** widespread/local chronic/ephemeral			**Certainty** probable/speculative/unknown		
	St. Clair delta	Sydenham R.	Ausable R.	St. Clair delta	Sydenham R.	Ausable R.	St. Clair delta	Sydenham R.	Ausable R.
Dreissenid mussels	predominant	-	-	widespread chronic	-	-	probable	-	-
Siltation	-	predominant	predominant	-	widespread chronic	widespread chronic	-	probable	probable
Water quality – nutrients & contaminants	contributing	contributing	contributing	widespread chronic	widespread chronic	widespread chronic	speculative	probable	probable
Water quantity	-	contributing	contributing	-	widespread ephemeral	widespread ephemeral	-	speculative	speculative
Decline of host fish	contributing	contributing	-	widespread chronic	widespread chronic	-	speculative	speculative	-
Urbanization	-	contributing	contributing	-	local chronic	local chronic	-	speculative	speculative
Impoundments	-	contributing	-	-	local chronic	-	-	unknown	-
Predation	-	contributing	contributing	-	local ephemeral	local ephemeral	-	unknown	unknown

impact the future survival and recovery of Round Hickorynut and Kidneyshell populations.

Threats in Historically Occupied Habitats

Welland River: A single record exists for the Round Hickorynut in the Welland River consisting of a single shell collected in 1931 by an unidentified collector (COSEWIC 2003a). Its current status in this river is unknown. The small 880 km^2 watershed of this river is dominated by rural land-uses and the river is subject to many of the same disturbances seen in the larger rural watersheds of southwestern Ontario which have contributed to the decline of freshwater mussels in these systems (A. Mack, Niagara Peninsula Conservation Authority, pers. comm. February 2004). Intensive agricultural activity coupled with extensive tile drainage and reduced riparian vegetation has resulted in high sediment inputs to the river, increased turbidity, elevated nutrient and bacterial levels and an overall reduction in the quantity and quality of aquatic habitat (http://www.conservation-niagara.on.ca/wellriver.htm).

Grand and Thames Rivers: The existence of the Round Hickorynut in the Grand River is indicated by three shells collected between 1966 and 1972 (COSEWIC 2003a). The Kidneyshell was probably more abundant in the Grand River than the Round Hickorynut as it was historically reported from 7 sites along a 50 km stretch between Caledonia and Port Maitland (COSEWIC 2003b). Recent surveys indicated no sign of live individuals of either species at 95 sites throughout the main channel and tributaries suggesting that the species may have been extirpated from the Grand River for an extended period of time. Like the Grand River population, the Thames River Round Hickorynut population is believed to have been lost as early as the turn of the 20th century (COSEWIC 2003a) with no live specimens collected since 1894. Several fresh shells of the Kidneyshell have been collected from the Thames River between London and Chatham as recently as 1997, however live specimens have never been collected (COSEWIC 2003b).

It is difficult to attribute a cause to the historic loss of populations such as those in the Grand and Thames Rivers although untreated wastewater inputs from major urban centres in these watersheds likely contributed to the declines.

Lake St. Clair, Detroit River, Lake Erie and Niagara River: The loss of the Round Hickorynut and Kidneyshell from historical habitat in these water bodies can be largely attributed to the detrimental effects of zebra mussels. Although, there is some indication that the Lake Erie population of the Round Hickorynut was in decline in the first half of the last century and may have been extirpated as early as 1950 (COSEWIC 2003a). Dreissenid mussels, however, pose the greatest limitation on recovery in these areas.

4. HABITAT – ROUND HICKORYNUT

Description

The Round Hickorynut is typically found in medium-sized to large rivers (van der Schalie 1938; Strayer 1983; Parmalee and Bogan 1998), but is also known from

Lake Erie and Lake St. Clair (Clarke 1981; Strayer and Jirka 1997). The preferred habitat of the Round Hickorynut is generally described as sand and gravel substrates with steady, moderate flows at depths of up to 2 m (Ortmann 1919; Gordon and Layzer 1989; Parmalee and Bogan 1998). In southeastern Michigan, however, it has mainly been found in turbid, low-gradient, hydrologically unstable rivers with clay/sand or clay/gravel substrates (van der Schalie 1938; Strayer 1983). In Lake St. Clair, *O. subrotunda* currently occupies shallow (<1 m) nearshore areas with firm, sandy substrates (Zanatta *et al.* 2002).

Currently Occupied Habitat:

Geospatial Description: Habitat in need of conservation for the Kidneyshell has been geospatially located using the methods developed by McGoldrick *et al* (2005) (Figures 7 & 8) who recommend using the Ontario Ministry of Natural Resource's Aquatic Landscape Inventory Software (ALIS version 1) (Stanfield and Kuyvenhoven 2005) as the base unit for definition of important habitat within riverine systems. The ALIS system employs a valley classification approach to define river segments with similar habitat and continuity on the basis of hydrography, surficial geology, slope, position, upstream drainage area, climate, landcover and the presence of instream barriers. For Great Lakes populations where ALIS segments can not be employed, McGoldrick *et al* (2005) recommend using a 5km buffer around known species occurrences. The 5km buffer was selected in light of the spatial extent of historic sampling within Lake St. Clair. Within all identified river segments the width of the habitat zone is defined as the area from the mid-channel point to bankfull width on both the left and right banks.

Functional Description:

Within the area defined under Currently Occupied Habitat only areas meeting the characteristics described below are deemed to represent habitat in need of conservation:

- permanently wetted and
- of a stream order greater than 2 (riverine population only) and
- having sand/gravel substrates and
- steady to moderate flows (riverine populations only) or
- nearshore areas with firm sand substrate (Great Lakes populations).

Activities Likely to Impact Currently Occupied Habitat

The Currently Occupied Habitat of the Kidneyshell could be negatively affected by a variety of activities. Direct destruction could result from in-stream activities such as dredging, bridge and pipeline crossings or the construction of dams. Habitat could also be negatively affected by any land-based activities that affect water quality or quantity. Such activities would include, but are not limited to, the input of nutrients, sediment and

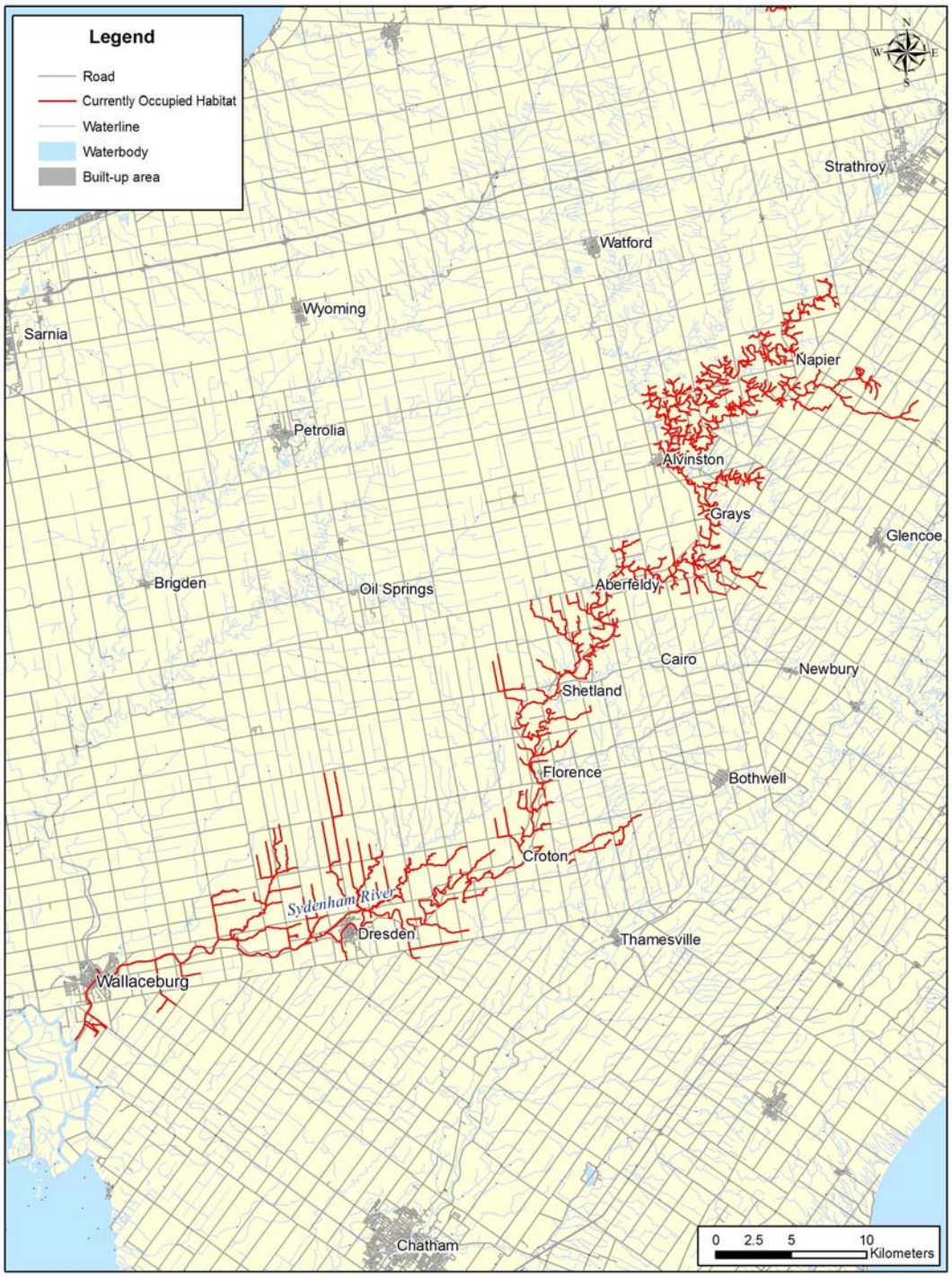

Figure 7: Currently Occupied habitat zone for the Round Hickorynut in the Sydenham River. Areas within this zone matching the functional description should be considered habitat in need of conservation.

Figure 8: Currently Occupied habitat zone for the Round Hickorynut in the Lake St. Clair delta. Areas within this zone matching the functional description should be considered habitat in need of conservation.

toxic substances through improperly treated storm water, cultivation of riparian lands, unfettered access of livestock to the river, channelization and drainage works, water taking, aggregate extraction, and the release of improperly treated sewage.

When dealing with freshwater mussels it is necessary to consider not only the physical and chemical components of habitat but also the biological. Any activity which disrupts the connectivity between Kidneyshell populations and their host species (see section on Reproduction) may result in the destruction of habitat. Activities which may disrupt the mussel-host relationship include, but are not limited to, damming, dewatering and sport or commercial harvest. Note that activities occurring outside the Currently Occupied Habitat zone may affect the host population within the zone (e.g., downstream damming activites may prevent the movement of fish into the zone during the period of mussel reproduction (September 1 – January 1)). Any activity that impacts a host population within an area of Currently Occupied Habitat should be evaluated to ensure that the reproductive cycle is not disrupted.

Historically Occupied Habitat: Historically occupied habitat is defined as all areas where the Round Hickorynut is known to have once occurred but is no longer found. Evidence for occurrence may be through records of historically collected live individuals or shells or through recent collects of weathered shells. Historically occupied habitat includes a 40km stretch of the Sydenham River from below Alvinston downstream to Florence, the Thames River from London to Chatham and the Grand River near Dunville. Historically occupied areas in the Detroit River, Lake Erie and Lake St. Clair may function as recovery habitat if the impacts of dreissenid mussels can be mitigated.

Critical Habitat: The identification of critical habitat requires a thorough knowledge of the species needs during all life stages as well as an understanding of thedistribution, quantity, and quality of habitat across the range of the species. At present, this information is not available for the Kidneyshell although Table 2 outlines activities that would assist with obtaining the required information. The activities listed in Table 4 are not exhaustive but outline the range and scope of actions identified by the Recovery Team as necessary to identify critical habitat for the round kidneyshell. It is likely that the process of investigating the actions in Table 2 will lead to the discovery of further knowledge gaps that will have to be addressed. Until critical habitat can be defined the recovery team has identified the areas listed in the Currently Occupied Habitat section as areas in need of conservation.

Table 2: Schedule of activities to identify critical habitat

Activity	Approximate Time Frame[1]
Conduct mussel population surveys	2006-2008
Assess habitat conditions in occupied areas (e.g., flow,	2006-2008

Activity	Approximate Time Frame[1]
substrate, water clarity and quality)	
Determine any life stage differences in habitat use	2007-2009
Survey and map areas of suitable but unused habitat within historical range	2008-2010
Assess genetic structure of populations	2006-2008
Determine host fish species	2006
Conduct host fish population surveys	2006-2008
Assess habitat use by host species	2006-2008
Determine areas of overlap between mussel and host habitat	2009-2010

[1] timeframes are subject to change as new priorities arise or as a result of changing demands on resources or personnel

5. HABITAT – KIDNEYSHELL

Habitat Identification: The Kidneyshell prefers shallow areas with clear, swift-flowing water and substrates of firmly-packed coarse gravel and sand. In the Great Lakes it has been found on gravel shoals in Lake Erie and Lake St. Clair.

Currently Occupied Habitat:

Geospatial Description: Habitat in need of conservation for the Kidneyshell has been geospatially located using the methods developed by McGoldrick *et al* (2005) (Figures 9 & 10) who recommend using the Ontario Ministry of Natural Resource's Aquatic Landscape Inventory Software (ALIS version 1) (Stanfield and Kuyvenhoven 2005) as the base unit for definition of important habitat within riverine systems. The ALIS system employs a valley classification approach to define river segments with similar habitat and continuity on the basis of hydrography, surficial geology, slope, position, upstream drainage area, climate, landcover and the presence of instream barriers. For Great Lakes populations where ALIS segments can not be employed, McGoldrick *et al* (2005) recommend using a 5km buffer around known species occurrences. The 5km buffer was selected in light of the spatial extent of historic sampling within Lake St. Clair. Within all identified river segments the width of the habitat zone is defined as the area from the mid-channel point to bankfull width on both the left and right banks.

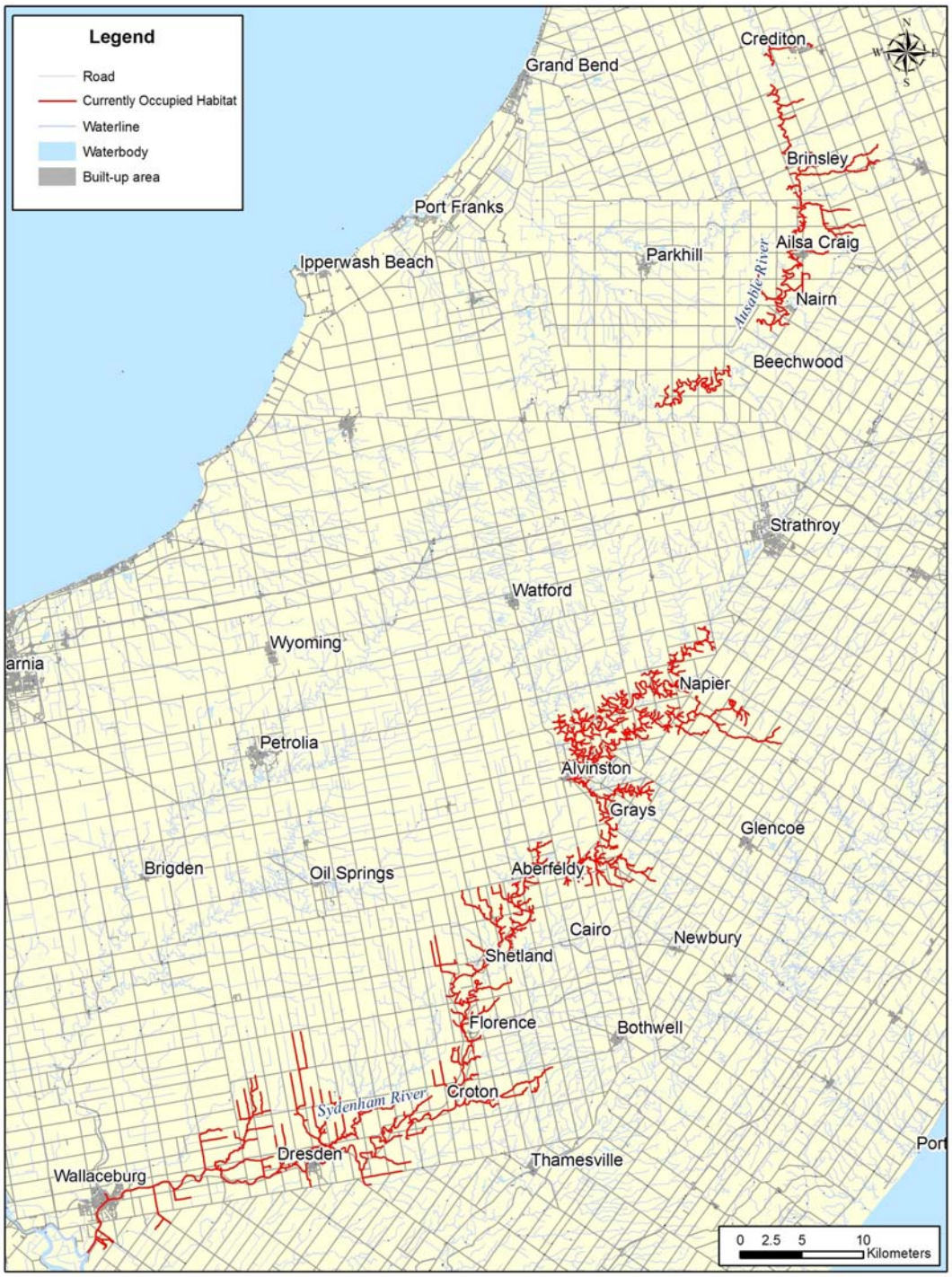

Figure 9: Currently occupied habitat zone of the Kidneyshell in the Sydenham and Ausable rivers. Areas within this zone matching the functional description should be considered habitat in need of conservation.

Figure 10: Currently occupied habitat zone of the Kidneyshell in the Lake St Clair delta. Areas within this zone matching the functional description should be considered habitat in need of conservation.

Functional Description:
Within the area defined under Currently Occupied Habitat areas meeting the characteristics described below are deemed to represent habitat in need of conservation:

- permanently wetted and
- of a stream order greater than 2 (riverine population only) and
- having firmly-packed coarse gravel and sand substrates and
- swift-flowing waters (riverine populations only) or
- gravel shoals (Great Lakes populations).

Activities Likely to Impact Currently Occupied Habitat

The Currently Occupied Habitat of the Kidneyshell could be negatively affected by a variety of activities. Direct destruction could result from in-stream activities such as dredging, bridge and pipeline crossings or the construction of dams. Habitat could also be negatively affected by any land-based activities that affect water quality or quantity. Such activities would include, but are not limited to, the input of nutrients, sediment and toxic substances through improperly treated storm water, cultivation of riparian lands, unfettered access of livestock to the river, channelization and drainage works, water taking, aggregate extraction, and the release of improperly treated sewage.

When dealing with freshwater mussels it is necessary to consider not only the physical and chemical components of habitat but also the biological. Any activity which disrupts the connectivity between Kidneyshell populations and their host species (see section on Reproduction) may result in the destruction of habitat. Activities which may disrupt the mussel-host relationship include, but are not limited to, damming, dewatering and sport or commercial harvest. Note that activities occurring outside the Currently Occupied Habitat zone may affect the host population within the zone (e.g., downstream damming activities may prevent the movement of fish into the zone during the period of mussel reproduction (September 1 – January 1)). Any activity that impacts a host population within an area of Currently Occupied Habitat should be evaluated to ensure that the reproductive cycle is not disrupted.

Historically Occupied Habitat: Historically occupied habitat is defined as all areas where the Kidneyshell is known to have once occurred but is no longer found. Evidence for occurrence may be through records of historically collected live individuals or shells or through recent collects of weathered shells. Historically Occupied Habitat for the Kidneyshell includes a 50 km of the Lower Grand River from Caledonia to Port Maitland, a small portion of the Welland River, and a stretch of the Thames River between London and Chatham. Historically occupied areas in the Detroit River, Lake Erie and Niagara River will only function as potential recovery habitat if the impacts of dreissenid mussels can be eliminated.

Critical Habitat: The identification of critical habitat requires a thorough knowledge of the species needs during all life stages as well as an understanding of the distribution, quantity, and quality of habitat across the range of the species. At present, this information is not available for the Kidneyshell although Table 3 outlines activities that would assist with obtaining the required information. The activities listed in Table 4 are not exhaustive but outline the range and scope of actions identified by the Recovery Team as necessary to identify critical habitat for the round kidneyshell. It is likely that the process of investigating the actions in Table 3 will lead to the discovery of further knowledge gaps that will have to be addressed. Until critical habitat can be defined the recovery team has identified the areas listed in the Currently Occupied Habitat section as areas in need of conservation.

Table 3: Schedule of activities to identify critical habitat

Activity	Approximate Time Frame[1]
Conduct mussel population surveys	2006-2008
Assess habitat conditions in occupied areas (e.g., flow, substrate, water clarity and quality)	2006-2008
Determine any life stage differences in habitat use	2007-2009
Survey and map areas of suitable but unused habitat within historical range	2008-2010
Assess genetic structure of populations	2006-2008
Determine host fish species	2006
Conduct host fish population surveys	2006-2008
Assess habitat use by host species	2006-2008
Determine areas of overlap between mussel and host habitat	2009-2010

[1] timeframes are subject to change as new priorities arise or as a result of changing demands on resources or personnel

6. HABITAT TREND

Habitats for the Round Hickorynut, Kidneyshell and other unionids in Lake Erie and Lake St. Clair have been largely destroyed by dreissenid mussels. Native mussel communities were virtually extirpated from the offshore waters of western Lake Erie by 1990 (Schloesser and Nalepa 1994) and the offshore waters of Lake St. Clair by 1994 (Nalepa *et al.* 1996). The mussel communities of Lake Erie were already in decline, probably due to a general decline in water quality over the past 40 years (Nalepa *et al.* 1991), but Lake St. Clair still supported an abundant and diverse mussel assemblage as recently as 1986 (Nalepa and Gauvin 1988). Unionids continue to survive in some nearshore areas with very shallow water, a high degree of connectivity to the lake (which ensures access to host fishes), and harsh conditions for dreissenid mussels (high water temperatures and considerable wave action in summer; ice scour in winter). However,

such “refugia” are rare, and most of the unionid habitat in the Great Lakes has been permanently lost (COSEWIC 2003a).

The Round Hickorynut and Kidneyshell have apparently been lost from the Thames and Grand rivers, and the Round Hickorynut has declined significantly in the Sydenham River. Agriculture is believed to be the main cause of the destruction of mussel habitat across North America (Strayer and Fetterman 1999) and southwestern Ontario is no exception. Since agriculture accounts for 75-85% of land use in the Grand, Thames and Sydenham River basins, it is likely that agricultural impacts (e.g., runoff of sediment, nutrients and pesticides, increased water temperatures due to loss of riparian vegetation, destruction of habitat by tractor crossings and cattle) are primarily responsible for the loss of mussel habitat in these rivers (COSEWIC 2003a).

7. HABITAT PROTECTION

The federal *Species at Risk Act* (SARA) was proclaimed in June of 2003. Under SARA there are general prohibitions against killing, harming, taking, possessing, capturing, and collecting the Round Hickorynut or Kidneyshell and against damaging or destroying their residences, as well as prohibitions on the destruction of Critical Habitat. The Federal *Fisheries Act* represents another significant piece of legislation protecting freshwater mussels and their habitat in Canada since fish are broadly defined under the Act to include shellfish. The collection of live mussels is considered fishing and would fall under the Ontario Fishery Regulations that are made under the *Fisheries Act*. The protection of other fish and fish habitat under the *Fisheries Act* may indirectly protect the habitat of the Round Hickorynut or Kidneyshell and other species of freshwater mussels. The Provincial Policy Statement under Section 3 of the Planning Act provides for protection from development and site alteration in the significant habitats of threatened and endangered species. Other mechanisms for protecting mussels and their habitat in Ontario include the Ontario Lakes and Rivers Improvement Act, which prohibits the impoundment or diversion of a watercourse if it would lead to siltation; and the voluntary Land Stewardship II program of the Ontario Ministry of Agriculture, Food, and Rural Affairs, which is designed to reduce erosion on agricultural lands. Stream-side development in Ontario is managed through flood plain regulations enforced by local Conservation Authorities. The majority of land in the Sydenham and Ausable rivers where these mussels are found is privately owned while the land in the St. Clair delta is controlled by the Walpole Island First Nation.

8. ECOLOGICAL ROLE

Freshwater mussels play an integral role in the functioning of aquatic ecosystems. Vaughn and Hakenkamp (2001) have summarized much of the literature relating to the role of unionids and identified numerous water column (size-selective filter-feeding; species-specific phytoplankton selection; nutrient cycling; control of phospohorus abundance) and sediment processes (deposit feeding decreasing sediment organic matter; biodeposition of feces and pseudofeces; epizoic invertebrates and epiphytic algae colonize shells; benthic invertebrate densities positively correlated with mussel density) mediated by the presence of mussel beds. Welker and Walz (1998) have demonstrated that freshwater mussels are capable of limiting plankton in European rivers while Neves and Odom (1989) reported that mussels also play a role in the transfer of energy to the terrestrial environment through predation by muskrats and raccoons.

9. IMPORTANCE TO PEOPLE

Although these species have no apparent economic significance, freshwater mussels are sensitive to environmental pollution and a diverse mussel community indicates a healthy ecosystem. Besides decreased biodiversity in Canada, the loss of the Round Hickorynut or Kidneyshell may indicate further environmental degradation of southwestern Ontario watercourses which would adversely affect those people who depend on surface water for drinking, recreation or watering livestock.

10. KNOWLEDGE GAPS

- *What is the Canadian host for the Round Hickorynut?*
  Although the host for the Round Hickorynut has been identified in the United States as the greenside darter, host specificity has been reported at the watershed scale for some species and this identification should be verified for Canadian populations if possible.
- *What are the habitat requirements of the Round Hickorynut and Kidneyshell?*
  Habitat use must be quantified for all life-stages with particular attention to the glochidial, encysted and juvenile stages when mortality is high.
- *Are the Round Hickorynut and Kidneyshell host-limited?*
  Host fish distributions for both mussel species need to be mapped in high detail. Host fish may be functionally unavailable to mussels if their distributions do not overlap at times when female mussels are releasing mature glochidia.
- *Are there life-stage specific threats?*
  The relative importance of each identified threat to each distinct life-stage (glochidium, larva, adult) must be identified.
- *Can the St. Clair refuge sites be maintained?*
  It must be determined if these sites represent permanent refugia or whether the mussels at these sites will eventually succumb to the harmful effects of dreissenid mussels. If these sites can not be naturally maintained then the feasibility of actively managing these sites to reduce the effects of dreissenid mussels must be investigated.
- *Can these species be relocated from other jurisdictions or artificially propagated for reintroduction?*
  Conservation genetics need to be assessed as they relate to relocations/reintroductions and the technical feasibility of artificial propagation should be examined.

11. BIOLOGICAL AND TECHNICAL FEASIBILITY OF RECOVERY

Recovery of the Round Hickorynut and Kidneyshell is believed to be both biologically and technically feasible as reproducing populations still exist as potential sources to support recovery, suitable habitat can be made available through recovery actions, threats can be mitigated and proposed recovery techniques are anticipated to be effective. Although recovery at the species level is believed to be feasible the effort required to achieve recovery will not be uniform across all populations.

- Mussels are slow growing and sedentary animals dependant upon their host fishes for the survival and dispersal of their young. The slow rate of population growth of freshwater mussels makes the natural recovery of decimated populations extremely difficult.

- The habitat in the Sydenham and Ausable rivers could be improved significantly with proper stewardship of both agricultural and urban lands in the watershed.
- Reductions in soil erosion and turbidity in all the watersheds can be achieved but would be challenging due to the number and intensity of the impacts.
- Complete removal of the impacts of dreissenid mussels to the Lake St. Clair populations is not possible at this time however it may be possible to establish managed refuge sites to reduce the impacts of dreissenid mussels on Round Hickorynuts and Kidneyshells.

A high level of effort will be required to recover the Sydenham and Lake St. Clair populations of the Round Hickorynut. There is little evidence of natural reproduction within these populations and recovery may require captive breeding and/or relocations from U.S. populations.

A low to moderate level of effort will be required to recover the Sydenham and Ausable river Kidneyshell populations. These populations are believed to be threatened by general habitat loss resulting from characteristic land-use practices within the basin. A general suite of ecosystem recovery actions such as those proposed by Dextrase *et al.* (2003) will assist with the recovery of this population.

Recovery of the Lake St. Clair populations of both species will require a higher degree of effort. Active management of selected refuge sites including the regular cleaning of dreissenid mussel infested individuals will be required to maintain and recover this population. Long term population augmentation and/or translocations may also be required to return the Round Hickorynut and Kidneyshell to healthy self-sustaining levels in Canada.

II. RECOVERY

1. RECOVERY GOAL

The long-term goals of this recovery strategy are:

i. to prevent the extirpation of the Round Hickorynut and Kidneyshell in Canada;
ii. to return healthy self-sustaining populations of Round Hickorynut to the Sydenham River and Lake St. Clair delta and;
iii. to maintain healthy self-sustaining Kidneyshell populations in the Ausable and Sydenham rivers while returning the Lake St. Clair delta population to a self-sustaining level.
iv. to re-establish populations in historically occupied habitats.

These populations can only be considered recovered when they have returned to historically estimated ranges (see Figure 3 and 6) and/or population densities and are showing signs of reproduction and recruitment.

2. RECOVERY OBJECTIVES (5 YEAR)

i. Determine extent, abundance and population demographics of existing populations.
ii. Determine fish hosts and their distributions and abundances.
iii. Define key habitat requirements to identify critical habitat.
iv. Establish a long-term monitoring program for Round Hickorynut and Kidneyshell populations, their hosts and the habitat of both.
v. Identify threats, evaluate their relative importance and implement remedial actions to minimize their impacts.
vi. Examine the feasibility of relocations, reintroductions and the establishment of managed refuge sites.
vii. Increase awareness about the distribution, threats and recovery of these species.

3. APPROACHES TO MEETING RECOVERY OBJECTIVES

The approaches to recovery have been organized into four distinct groups – research and monitoring, management, stewardship and awareness. Successful recovery across the ranges of the Round Hickorynut and Kidneyshell will require consideration of approaches from all categories. A narrative has been included after each table where appropriate.

Recovery of these two species can not be achieved through the actions of any one party. Implementation of the recovery approaches outlined below will require a concerted effort of many groups including, but not limited to, federal, provincial and municipal governments, conservation authorities, academic institutions, First Nations communities, non-governmental organizations and local citizens.

a) Research and Monitoring Approaches

Priority	Number	Objective Addressed	Broad Approach/ Strategy	Specific Steps	Anticipated Effect	Threat Addressed
URGENT	1-1	ii, v	Research – host fish.	Confirm the host fish species for the Round Hickorynut.	Will help determine if host abundance is limiting the Round Hickorynut. Will assist with defining the larval residence site and in identifying critical habitat.	Host fish declines.
URGENT	1-2	ii, v	Surveys – host fish.	Determine the distribution and abundance of the host species.	Will help determine if host abundance is limiting the Round Hickorynut or Kidneyshell.	Host fish declines.
URGENT	1-3	iii	Research – Critical Habitat.	Determine the habitat requirements for all life stages.	Will assist with further refining critical habitat for the Round Hickorynut and Kidneyshell.	
URGENT	1-4	iii, vi	Surveys – Critical Habitat.	Prepare a distribution map of areas of suitable habitat.	Will assist with defining critical habitat and potential areas of reintroduction.	

Priority	Number	Objective Addressed	Broad Approach/ Strategy	Specific Steps	Anticipated Effect	Threat Addressed
URGENT	1-5	vi	Research – managed refuge sites.	Investigate the feasibility of establishing actively managed refuge sites in the St. Clair delta.	Will determine if Round Hickorynuts in the St. Clair delta can be insulated from the effects of dreissenid mussels.	Dreissenid mussels.
NECESSARY	1-6	i, iv	Monitoring – mussel and fish host populations.	Establish a network of permanent monitoring stations throughout the distribution of the Round Hickorynut.	Will permit tracking of populations, analysis of trend patterns, and permit the evaluation of recovery actions.	Host fish declines.
NECESSARY	1-7	iv, v	Monitoring – habitat.	Establish permanent monitoring sites for tracking changes in habitat.	Provides trend data for key habitat and will help evaluate the relative threat of habitat loss.	All threats.
NECESSARY	1-8	v	Research – threats.	Identify and evaluate threats to all life stages.	Will assist with determining reasons for declines and developing remedial actions.	All threats.

Priority	Number	Objective Addressed	Broad Approach/ Strategy	Specific Steps	Anticipated Effect	Threat Addressed
NECESSARY	1-9	vi	Research – conservation genetics.	Compare the within and among population genetic variability of Canadian populations and determine if populations show genetic structure by comparing variability between populations in Canadian and U.S. waterways.	Will assist with determining if population translocation or augmentation is appropriate.	

1-1 & 1-2: The necessity for a period of encystment represents a potential bottleneck in the lifecycle of the mussel. Research and recovery actions focusing on the pre or post encystment period may prove unproductive if the presence of a host fish is the limiting step. In order to determine if these species are host limited it is necessary to first identify the host species and then to confirm that the distributions of the mussel and its host overlap in time and space in a manner that will permit successful encystment. The identification of high host specificity in some mussel species requires that hosts be identified for local populations whenever possible. McNichols and Mackie (2004) have identified three host species for Canadian populations of the Kidneyshell but no Canadian host for the Round Hickorynut has yet been identified. Efforts should be directed towards confirming that species identified as hosts for American populations also function as hosts in Canada.

Once the Canadian hosts have been confirmed for both of these species it is necessary to verify that host species distributions overlap with the Round Hickorynut and Kidneyshell distributions. Since adult mussels are essentially sessile this can be accomplished by confirming that members of the hosts species occur in reaches with mature female mussels at times when the female mussels possess mature glochidia.

1-3 & 1-4: Determination of critical habitat is an essential component in the recovery of these species. Although adult mussels are relatively passively distributed, distinct habitat types can be associated with adult distributions suggesting that survival is linked to local habitat conditions. Habitat conditions may be equally important during the juvenile stage and attention must also be paid to the habitat preferences of the hosts. Identification of critical habitat will be a multi-stage incremental process.

1-5: The best remaining population of Round Hickorynuts along with a small population of Kidneyshells can be found in the delta area of Lake St. Clair despite the presence of dreissenid mussels. Metcalfe-Smith *et al.* (2004) reported zebra mussel infestation rates ranging from 0 to 36 zebra mussels/unionid in this area during 2003. While this rate of infestation is below the lethal limits reported elsewhere (Ricciardi *et al.* 1995) it may be resulting in long term chronic effects that are causing prolonged declines. Comparisons of collections made in 2001 with those in 2003 showed that abundance of all unionids had declined by about 14% while declines were much higher for some species (i.e., 80% decline of Round Hickorynut) (Metcalfe-Smith *et al.* 2004). Although the overall trend was toward declining unionid densities some sites showed stable overall abundances. These sites were associated with low zebra mussel infestation rates and high unionid diversity and may represent potential refuge sites. Since these sites are still affected by zebra mussels it is likely that unionids will need to be actively managed with regular zebra mussel removal and the active relocation of Round Hickorynuts, Kidneyshells and other mussel SAR to these locations from the more heavily infested sites. The feasibility of actively managing refuge sites in the St. Clair delta must be determined quickly as this will likely represent the only chance of saving the Round Hickorynut.

1-6 & 1-7: A network of detailed, permanent monitoring stations should be established throughout the present and historic ranges of the Round Hickorynut and Kidneyshell. Monitoring sites should be established in a manner so as to permit:

- Quantitative tracking of changes in mussel abundance or demographics (size distribution, age structure etc.) or that of their hosts.
- Detailed analyses of habitat use and the ability to track changes in use or availability.
- The ability to detect the presence of exotic species (i.e. dreissenid mussels). Reservoirs represent the likely seed locations for dreissenid mussels in the Sydenham and Ausable rivers. Monitoring sites should be established within or close to these reservoirs to permit the early detection of dreissenid mussels in the event that they invade these systems. Monitoring of exotics in the Lake St. Clair delta will likely be conducted in close association with the managed refuge sites.

b) Management Approaches

Priority	Number	Objective Addressed	Broad Approach/ Strategy	Specific Steps	Anticipated Effect	Threat Addressed
URGENT	2-1	i-vi	Capacity Building	Promote and enhance expertise in freshwater mussel identification/biology and provide for the transfer of knowledge.	Will ensure correct identification of mussel species at risk.	

Priority	Number	Objective Addressed	Broad Approach/ Strategy	Specific Steps	Anticipated Effect	Threat Addressed
URGENT	2-2	v, vi	Cooperation – ecosystem recovery strategies	Work with existing ecosystem recovery teams to implement recovery actions.	Encourage a seamless implementation of all recovery actions.	
NECESSARY	2-3	v	Municipal Planning	Encourage municipal planning authorities to consider Recovery Goals in official plans.	Will provide further protection for the Round Hickorynut and Kidneyshell and promote future development that does not degrade important habitat.	Urbanization, water quality, water quantity, impoundments.
NECESSARY	2-4	v	Drainage	Work with drainage supervisors, engineers and contractors to limit the effects of drainage activities on mussel habitat.	Will reduce the harmful effects of drainage activities.	Water quality, siltation, water quantity.
NECESSARY	2-5	ii, iii, v	Fish Management Plans	Encourage the development of management plans for non SAR fish species within watersheds inhabited by the Round Hickorynut and Kidneyshell	Will provide protection for potential host species.	Host fish declines.
NECESSARY	2-6	v	Baitfish	Work with the baitfish industry to reduce the impacts of commercial baitfishing on host species.	Will provide protection for potential host species.	Host fish declines.

Priority	Number	Objective Addressed	Broad Approach/ Strategy	Specific Steps	Anticipated Effect	Threat Addressed
NECESSARY	2-7	v	Wastewater treatment plants and stormwater management facilities	Verify that wastewater treatment plants are functioning up to specifications and encourage upgrading where appropriate. Review stormwater management facilities for quantity and quality control in new developments, and retro-fit existing development where possible	Will improve water quality by reducing nutrient and suspended solid inputs from urban centres.	Water quality, water quantity, impoundments.

2-1: The current capacity within southwestern Ontario to perform the necessary survey and monitoring work is insufficient. Knowledge of freshwater mussel identification, distribution, life history and genetics is limited to a small number of individuals from a limited number of government and academic institutions. Furthermore, the retirement of several key researchers is expected prior to the 5-year re-evaluation period for this strategy. A concerted effort must be made to increase this capacity by:

- Training personnel in the identification of all mussel species with emphasis on the rare species.
- Producing a field guide to the mussels of Ontario.
- Encourage graduate and post-graduate research aimed at fulfilling the needs identified under Research and Monitoring.

2-2: Many of the threats to the Round Hickorynut and Kidneyshell can be classified as widespread and chronic (Table 1) and represent general ecosystem threats affecting numerous other aquatic species. Efforts to remediate these threats will benefit many species in addition to these two mussel species and should be attempted in close connection with the aquatic ecosystem recovery teams for the Ausable and Sydenham rivers (see section II.5, Activities already completed or underway) to eliminate duplication of efforts and ensure that undertaken activities are not detrimental to other species.

2-5: The host fishes for these two mussel species must be afforded some degree of protection if the Round Hickorynut and Kidneyshell are to recover. The greenside darter, which functions as the probable host for the Round Hickorynut, is listed as a species of special concern by COSEWIC. This species is given consideration in the aquatic

ecosystem recovery strategies for both the Sydenham River (Dextrase *et al*. 2003) and Ausable River (ARRT 2003) and will therefore be actively monitored and managed within these systems. The three host species for the Kidneyshell (blackside darter, johnny darter and fantail darter) are not listed by COSEWIC and therefore not explicitly considered in any recovery plans. It may be necessary to develop formal management plans for these species to make certain that their populations remain healthy and do not hinder the recovery of the Kidneyshell.

2-6: While the host species of the Round Hickorynut and Kidneyshell are not typically targeted as baitfish they are potentially collected as bycatch during legal bait harvesting activities. Effort should be made to minimize potential bycatch of these species and to verify that gear selection and operation do not contribute to habitat degradation which may adversely affect host populations. In watersheds supporting Round Hickorynut and Kidneyshell, live bait storage ponds should be isolated from the watercourse in order to prevent accidental escapement of round gobies. Mechanisms to confirm that bait bucket releases do not further spread the round goby and detrimentally impact host populations should be employed.

c) Stewardship Approaches

Priority	Number	Objective Addressed	Broad Approach/ Strategy	Specific Steps	Anticipated Effect	Threat Addressed
URGENT	3-1	v	Riparian buffers	Establish riparian buffer zones in areas of high erosion potential by encouraging naturalization or planting of native species.	Will improve water quality by reducing bank erosion, sedimentation and overland run-off.	Water quality, siltation, water quantity.
URGENT	3-2	v	Tile drainage	Work with landowners to mitigate the effects of tile drainage.	Will reduce nutrient and sediment inputs.	Water quality, siltation, water quantity.
URGENT	3-3	v	Herd management	Encourage the active exclusion of animals from the watercourse.	Will reduce bank erosion, sediment and nutrient inputs.	Water quality, siltation.

Priority	Number	Objective Addressed	Broad Approach/ Strategy	Specific Steps	Anticipated Effect	Threat Addressed
URGENT	3-4	v	Livestock waste management	Assist with establishing adequate manure collection and storage systems to avoid accidental spills, and winter-spreading of manure.	Will improve water quality by reducing nutrients.	Water quality.
URGENT	3-5	v	Farm planning	Encourage the development and implementation of Environmental Farm Plans and Nutrient Management Plans.	Will assist with minimizing inputs of nutrients and sediments.	Water quality.
URGENT	3-6	v	Sewage treatment	Work with landowners to improve faulty septic systems.	Will improve water quality by reducing nutrient inputs.	Water quality.
BENEFICIAL	3-7	v	Soil testing	Encourage soil testing to determine fertilizer application rates.	Will reduce nutrient inputs to the river.	Water quality.

The stewardship activities outlined here can be described as “best management practices” and represent a non-exhaustive selection of activities that can be encouraged within these predominantly agricultural watersheds to help reduce the impacts of terrestrial practices on aquatic ecosystems. Encouragement can be achieved through increasing awareness of these activities as well as through the provision of financial assistance to local landowners.

d) Awareness Approaches

Priority	Number	Objective Addressed	Broad Approach/ Strategy	Specific Steps	Anticipated Effect	Threat Addressed
URGENT	4-1	vii	Awareness – stewardship actions	Increase public knowledge of stewardship options and financial assistance available to participate in activities.	Increased public participation in recovery actions and a reduction in threats to the Round Hickorynut and Kidneyshell.	Water quality, siltation, water quantity.
URGENT	4-2	vii	Exotic species	Increase public awareness of the potential impacts of transporting/releasing exotic species.	Will reduce the risk of dreissenid mussels or gobies becoming established.	Exotic species
BENEFICIAL	4-3	vii	Outreach	Encourage public support and participation by developing awareness materials and programs.	Will increase public awareness of the importance of species at risk.	All threats.

Public participation in the recovery process for these species is essential as the primary threats to populations in the Ausable and Sydenham rivers result from diffuse non-point source inputs relating to the general agricultural activities within these watersheds. Recovery can not occur without the full participation of local citizens and landowners. The need for an effective public awareness program is crucial to the recovery of these two species.

4. POTENTIAL IMPACTS OF RECOVERY STRATEGY ON OTHER SPECIES/ECOLOGICAL PROCESSES: The Round Hickorynut and Kidneyshell are sensitive species, particularly to issues of water quantity and quality. For this reason, we expect that efforts made to improve conditions for these mussels will benefit most other aquatic species. A few opportunistic species that can readily adapt to degraded conditions (e.g., giant floater (*Pyganodon grandis*) or fathead minnow (*Pimephales promelas*)) may see a decline in numbers/range as a result of rehabilitative efforts. These changes should not be viewed

in a negative light but rather as a restoration of the aquatic community to pre-disturbance conditions.

5. ACTIONS ALREADY COMPLETED OR UNDERWAY

Sydenham River Aquatic Ecosystem Recovery Strategy: The Sydenham River Recovery Team became the first group in Canada to adopt an ecosystem approach to recovering aquatic species when they completed the Sydenham River Aquatic Ecosystem Recovery Strategy (SRAERS) in 2003 (Dextrase *et al.* 2003). The recovery strategy focuses on the 14 aquatic species (5 mussels, 8 fishes, 1 turtle) within the basin that are listed as endangered, threatened or of special concern by the COSEWIC. Both the Round Hickorynut and the Kidneyshell were listed after the SRAERS was completed and so these species are not directly considered within the strategy. Despite their exclusion from the strategy many of the actions proposed by Dextrase *et al.* (2003) to benefit the 5 included mussel species will be beneficial for recovery of these two species.

Thames River Recovery Ecosystem Strategy: The Thames River Recovery Team (TRRT) has set out to develop an ecosystem based recovery strategy for the Thames River watershed. The stated goal is to develop "a recovery plan that improves the status of all aquatic species at risk in the Thames River through an ecosystem approach that sustains and enhances all native aquatic communities" (Thames River Recovery Team 2003). This recovery strategy addresses 25 COSEWIC listed species including 7 mussels, 12 fishes and 6 reptiles. Both the Round Hickorynut and the Kidneyshell are being considered in the development of this strategy as both species historically occurred within this watershed. Although neither species is still known to occur in the Thames River, recovery actions proposed by the TRRT will increase the likelihood that Recovery Habitat for these species in the Thames River will prove suitable for possible future repatriations.

Ausable River Ecosystem Recovery Strategy: The Ausable River Recovery Team is developing an ecosystem Recovery Strategy for the 14 COSEWIC listed aquatic species in the Ausable River basin. This plan covers 4 endangered mussel species including the Kidneyshell. The overall goal of the strategy is to "sustain a healthy native aquatic community in the Ausable River through an ecosystem approach that focuses on species at risk "(Ausable River Recovery Team 2004). The Ausable River Recovery Team (2004) has also established a species-specific recovery goal for all mussels of "maintain(ing) existing populations of species at risk and restor(ing) self-sustaining populations of each species to areas of the river where they formerly occurred.

Grand River Fish Species at Risk Recovery Strategy: The Grand River Recovery Team has developed a draft recovery strategy for fish species at risk in the Grand River. The goal of this strategy is "to conserve and enhance the native fish community using sound science, community involvement and habitat improvement measures" (Portt *et al.* 2003). Although the strategy does not directly address any mussels species, their "habitat preferences and requirements will be taken into account when assessing management actions targeting fish species at

risk. In most cases, it is anticipated that recovery actions benefiting fishes at risk will also benefit these other rare species" (Portt *et al.* 2003).

Walpole Island Ecosystem Recovery Strategy: The Walpole Island Ecosystem Recovery Strategy Team was established in 2001 to develop an ecosystem based recovery strategy for the area containing the St. Clair delta with the goal of outlining steps to maintain or rehabilitate the ecosystem and species at risk (Walpole Island Heritage Centre 2002). Although the strategy is initially focusing on terrestrial ecosystems there are future plans to include aquatic components of the ecosystem.

Fish Host Identification: A research group led by Dr. J. Ackerman and Dr. G. L. Mackie has been established at the University of Guelph to investigate aspects of the reproductive cycle of freshwater mussels (host fish determination, glochidial development, juvenile growth and survival). The group conducts its research at the Hagen Aqua Lab on the grounds of the university in Guelph, Ontario, Canada. This facility has been used to investigate potential hosts for four species of endangered mussels including the Kidneyshell (McNichols and Mackie 2003). In 2003 they identified three host species for the Kidneyshell (blackside darter, Johnny darter, fantail darter) but have yet to attempt to identify or confirm the host for the Round Hickorynut (McNichols and Mackie 2004).

Stewardship Activities: Stewardship programs have been available in the St. Clair Region Conservation Authority in 2000 for projects involving tree planting; stream stabilization; wetland creation; buffer strips; grassed waterways; sediment traps; repair or replacement of faulty septic systems; manure storage facilities; clean water diversions; runoff collection systems; fencing livestock from watercourses; plugging and repairing wells and nutrient management plans. Implementation of these projects improves and protects rural water quality, and the habitat for aquatic species at risk.

Currently, the Ausable-Bayfield Conservation Authority is able to provide funding for stewardship activities such as: tree planting, windbreaks, buffer strips, Nutrient Management Plans, well-decommissioning, wellhead protection, livestock washwater, manure spreading equipment modifications, conservation tillage modifications, clean water diversion, livestock restriction, fertilizer, fuel and chemical storage and handling, erosion control, conservation tillage equipment modifications and septic system upgrades. Implementation of these projects improves water quality and habitat for aquatic species at risk.

Mussel Monitoring Network: Fifteen permanent monitoring stations for mussels have been established on the Sydenham River and a further 6 on the Thames River. Additional stations will be located on the Ausable River during 2006. These sites will be part of an ongoing monitoring system as part of the Sydenham, Ausable and Thames ecosystem recovery strategies and will provide quantitative trend through time data to evaluate recovery actions as well as the overall status of mussel communities.

Nutrient Management Act: Implementation of this provincial legislation, which came into force September 30 2003, will regulate the storage and use of nutrients including manure, farmyard run-off and farm washwater. This should reduce nutrient inputs to the watercourses, which will benefit the aquatic habitats of the mussels.

Source Protection Planning: A White Paper on Watershed-based Source Protection Planning was released in February 2004. Source Protection Planning will identify potential sources of contamination to the surface water and groundwater, determine how much water is readily available, evaluate where that water is vulnerable to contamination and implement programs to minimize risk of contamination to water quality as well as minimizing threats to water quantity.

6. RECOVERY ACTION PLANS

One or more action plans relating to this recovery strategy will be produced within 5 years of the strategy being completed. Wherever possible recovery action plans should be linked to existing watershed recovery teams. Recovery resources in southwestern Ontario (both fiscal and personnel) are limited. Partnership with these other recovery teams will ensure that efforts are not duplicated and will help to prevent the implementation of recovery efforts for differing species that may conflict.

7. EVALUATION

The routine monitoring programs will provide the primary means of evaluating the success of the listed recovery approaches. The monitoring programs will provide trend through time data allowing the tracking of Round Hickorynut and Kidneyshell populations and habitat and will form the basis of an adaptive management program. Recovery Implementation Groups will develop specific targets in the Recovery Action Plans to provide a further basis for evaluating success. The entire Recovery Strategy will be reviewed in 5 years at which time all goals, objectives and approaches will be re-evaluated.

REFERENCES

Allan, J. D., and A. S. Flecker. 1993. Biodiversity conservation in running waters. BioScience 43: 32-43.

Ausable River Recovery Team. 2004. Recovery Strategy for species at risk in the Ausable River. An ecosystem approach 2004-2009. Draft 2 – March 17, 2004. xii + 125 pp.

Baker, K. 2005. Nine year study of the invasion of western Lake Erie by the round goby (Neogobius melanostomus): changes in goby and darter abundance. Ohio Journal of Science 105: A-31.

Baker, S. M. and D. J. Hornbach. 1997. Acute physiological effects of zebra mussel (*Dreissena polymorpha*) infestation on two unionid mussels, *Actinonaias ligamentina* and *Amblema plicata*. Canadian Journal of Fisheries and Aquatic Sciences 54: 512-519.

Bogan, A. E. 1993. Freshwater bivalve extinctions (Mollusca: Unionidae): a search for causes. American Zoologist 33: 599-609.

Clarke, A. H. 1977. The endangered mollusks of Canada. In: T. Mosquin and C. Suchal (eds.) Canada'a threatened species and habitats. Canadian Nature Federation Special Publication Number 6. p 148-150.

Clarke, A. H. 1981. The freshwater molluscs of Canada. National Museums of Canada, Ottawa, Canada. 446 pages.

Clarke, A.H. 1992. Ontario's Sydenham River, an important refugium for freshwater mussels against competition from the zebra mussel Dreissena polymorpha. Malacology Data Net 3: 43-55.

COSEWIC 2003a. COSEWIC assessment and update status on the Round Hickorynut *Obovaria subrotunda* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 31 pp.

COSEWIC 2003b. COSEWIC assessment and update status on the Kidneyshell *Ptychobranchus fasciolaris* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 32 pp.

Dextrase, A. J., S. K. Staton, J. L. Metcalfe-Smith. 2003. National Recovery Strategy for species at risk in the Sydenham River: An ecosystem approach. National Recovery Plan No. 25. Recovery of Nationally Endangered Wildlife (RENEW). Ottawa, Ontario. 73 pp.

French, J.R.P., and D.J. Jude. 2001. Diets and diet overlap of nonindigenous gobies and small native fishes co-habitating the St. Clair River, Michigan. Journal of Great Lakes Research 27:300-311.

Gordon, M. E., and J. B. Layzer. 1989. Mussels (Bivalvia: Unionoidea) of the Cumberland River: review of life histories and ecological relationships. Biological Report 89(15). U.S. Department of the Interior, Fish and Wildlife Service, Washington D.C. vii + 99pp.

Haag, W. R., D. J. Berg, D. W. Garton, and J. L. Farris. 1993. Reduced survival and fitness in native bivalves in response to fouling by the introduced zebra mussel (*Dreissena polymorpha*) in western Lake Erie. Canadian Journal of Fisheries and Aquatic Sciences 50: 13-19.

Holm, E., and N. E. Mandrak. 1996. The status of the eastern sand darter, *Ammocrypta pellucida* in Canada. Canadian-Field Naturalist 110(3): 462-469.

Jacques Whitford Environment Ltd. 2001. Sydenham River Recovery Project: Synthesis and analysis of background data. Report to the Sydenham River Recovery Team. December 2001. 50p. + Appendix.

Janssen, J., and D.J., Jude. 2001. Recruitment failure of mottled sculpin *Cottus bairdi* in Calumet Harbour, southern Lake Michigan, induced by the newly introduced round goby *Neogobius melanostomus*. Journal of Great Lakes Research 27:319-328.

Johnson, P. M., A. E. Liner, S. W. Golladay, and W. K. Michener. 2001. Effects of drought on freshwater mussels and instream habitat in Coastal Plains tributaries of the Flint River, southwest Georgia (July-October, 2000). Final Report to the Nature Conservancy Apalachicola River and Bay Project, August 25, 2001. 30 pp. Available at: http://www.jonesctr.org/education/education.resources.html.

Lydeard, C., R. H. Cowie, W. F. Ponder, A. E. Bogan, P. Bouchet, S. A. Clark, K. S. Cummings, Te. J. Frest, O. Gargominy, D. G. Herbert, R. Hershler, K. E. Perez, B. Roth, M. Seddon, E. E. Strong, and F. G. Thompson. 2004. The global decline of nonmarine mollusks. BioScience 54: 321-330.

McGoldrick, D.J., T.J. Morris, J.L. Metcalfe-Smith, V.S. Jackson. 2005. Developing critical habitat descriptions for Threatened and Endangered freshwater mussels – A case study using the Wavyrayed Lampmussel (*Lampsilis fasciola*). DFO Can. Sci. Advis. Sec. Res. Doc. 2005/061.

McNichols, K., and G. Mackie. 2003. Fish host determination of endangered freshwater mussels in the Sydenham River Ontario, Canada. ESRF 2002-03 Final Report. 20 pp.

McNichols, K. and G. L. Mackie 2004. Fish host determination of endangered freshwater mussels in the Sydenham River Ontario. ESRF 2003/2004 Final Report. Canada**.** 26 pp.

Metcalfe-Smith, J. L., G. L. Mackie, J. Di Maio, and S. Staton. 2000. Changes over time in the diversity and distribution of freshwater mussels (Unionidae) in the Grand River, southwestern Ontario. Journal of Great Lakes Research 26(4): 445-459.

Metcalfe-Smith, J. L., J. Di Maio, S. K. Staton, and S. R. De Solla. 2003. Status of the freshwater mussel communities of the Sydenham River, Ontario, Canada. American Midland Naturalist 150:37-50.

Metcalfe-Smith, J.L., D.J. McGoldrick, M. Williams, D.W. Schloesser, J. Biberhofer, G.L. Mackie, M.T. Arts, D.T. Zanatta, K. Johnson, P. Marangelo and T.D. Spencer. 2004. Status of a refuge for native freshwater mussels (Unionidae) from the impacts of the exotic zebra mussel (*Dreissena polymorpha*) in the delta area of Lake St. Clair. Environment Canada, National Water Research Institute, Burlington, Ontario. Technical Note No. AEI-TN-04-001.

Mummert, A. K., R. J. Neves, T. J. Newcomb and D. S. Cherry. 2003. Sensitivity of juvenile freshwater mussels (Lampsilis fasciola, Villosa iris) to total and un-ionized ammonia. Environmnetal Toxicology and Chemistry. 22: 2545-2553.

Nalepa, T. F. 1994. Decline of native unionid bivalves in Lake St. Clair after infestation by the zebra mussel, *Dreissena polymorpha*. Canadian Journal of Zoology 61: 832-838.

Nalepa, T. F., and J. M. Gauvin. 1988. Distribution, abundance, and biomass of freshwater mussels (Bivalvia: Unionidae) in lake St. Clair. Journal of Great Lakes Research 14(4): 411-419.

Nalepa, T. F., D. J. Hartson, G. W. Gostenik, D. L. Fanslow, and G. A Lang. 1996. Changes in the freshwater mussel community of Lake St. Clair: from Unionidae to *Dreissena polymorpha* in eight years. Journal of Great Lakes Research 22: 354-369.

Nelson, M., M. Veliz, S. Staton, and E. Dolmage. 2003. Towards a recovery strategy for species at risk in the Ausable River: Synthesis of background information. Final Report prepared for the Ausable River Recovery Team. September 2003. 92 pp.

Neves, R.J. and M.C. Odom. 1989. Muskrat predation on endangered freshwater mussels in Virginia. Journal of Wildlife Management 53(4):934-941.

Newton, T. J. 2003. The effects of ammonia on freshwater unionid mussels. Environmental Toxicology and Chemistry 22: 2543-2544.

Newton, T. J., and J. W. A., J. A. O'Donnell, M. R. Bartsch, and W. B. Richardson. 2003. Effects of ammonia on juvenile unionid mussels (*Lampsilis cardium*) in laboratory toxicity tests. Environmental Toxicology and Chemistry 22: 2554-2560.

Ortmann, A. E. 1919. A monograph of the naiads of Pennsylvania, Part III. Systematic account of the genera and species. Memoirs of the Carnegie Museum 8(1), Carnegie Institute, Pittsburgh, Pennsylvania. 384 pp.

Parmalee, P.l W., and A. E. Bogan. 1998. The freshwater mussels of Tennessee. The University of Tennessee Press, Knoxville. 328 pp.

Portt, C., G. Coker, and K. Barrett. 2003. Recovery strategy for fish species at risk in the Grand River, Ontario. Draft report prepared for the Grand River Recovery Team, March 31, 2003.

Ricciardi, A., F. G. Whoriskey and J. B. Rasmussen. 1995. Predicting the intensity and impact of Dreissena infestation on native unionid bivalves from Dreissena field density. Canadian Journal of Fisheries and aquatic Sciences 52: 1449-1461.

Schloesser, D. W., and T. F. Nalepa. 1994. Dramatic decline of unionid bivalves in offshore waters of western Lake Erie after infestation by the zebra mussel, *Dreissena polymorpha*. Canadian Journal of Fisheries and Aquatic Sciences 51: 2234-2242.

Schloesser, D. W., T. F. Nalepa, and G. L. Mackie. 1996. Zebra mussel infestation of unionid bivalves (Unionidae) in North America. American Zoologist 36: 300-310.

Stanfield, L. and R. Kuyvenhoven. 2005. Protocol for applications used in the Aquatic Landscape Inventory Software application for delineating, characterizing and classifying valley segments within the Great Lakes basin. Ontario Ministry of Natural Resources Report, July 27, 2005.

Staton, S. K., A. Dextrase, J. L. Metcalfe-Smith, J. Di Maio, M. Nelson, Paris Geomorphic Ltd., B. Kilgour, and E. Holm. 2003. Status and trends of Ontario's Sydenham River ecosystem in relation to aquatic species at risk. Ecological Monitoring and Assessment 88: 283-310.

Strayer, D. L. 1983. The effects of surface geology and stream size on freshwater mussel (Bivalvia: Unionidae) distribution in southwestern Michigan, USA. Freshwater Biology 13: 253-264.

Strayer, D. L., and A. R. Fetterman. 1999. Changes in the distribution of freshwater mussels (Unionidae) in the Upper Susquehanna River Basin, 1955-1965 to 1996-1997. American Midland Naturalist 142: 328-339.

Strayer, D. L., and K. J. Jirka. 1997. The pearly mussels of New York State. Memoirs of the New York State Museum 26: 113 pages + 27 plates.

Thomas, M.V., and R.C. Haas. 2004. Status of Lake St. Clair fish community and sport fish,1996-2004. Michigan Department of Natural Resources, Fisheries Division. Fisheries Research Report 2067. 26p.

Tetzloff, J. 2001. Survival rates of unionid species following a low oxygen event in Big Darby Creek, Ohio. Ellipsaria 3: 18-19.

Thames River Recovery Team. 2003. Thames River Recovery Plan – Terms of Reference. Upper Thames Region Conservation Authority web site - http://www.thamesriver.org/Species_at_Risk/terms_of_reference.htm. Accessed May 21, 2003.

Van der Schalie. 1938. The naiad fauna of the Huron River, in southeastern Michigan. Miscellaneous Publication No. 40, Museum of Zoology, University of Michigan. University of Michigan Press, Ann Arbor, Michigan. 83 pp + Plates I-XII.

Vaughn, C.C. and C.C. Hakenkamp. 2001. The functional role of burrowing bivalves in freshwater ecosystems. Freshwater Biology 46: 1431-1446.

Villella, R. F., D. R. Smith and D. P. Lemarie. 2004. Estimating survival and recruitment in a freshwater mussel population using mark-recapture techniques. American Midland Naturalist 151: 114-133.

Walpole Island Heritage Centre. 2002. Walpole Island First Nation Heritage Centre Newsletter. Special Edition. Summer/Fall 2002. Published by the Walpole Island Heritage Centre, R.R. 3 (Walpole Island), Wallaceburg, Ontario, Canada, N8A 4K9. 16pp.

Watters, G. T. 1994. Form and function of unionoidean shell sculpture and shape (Bivalvia). American Malacological Bulletin 11: 1-20.

Welker, M. and N. Walz. 1998. Can mussels control the plankton in rivers? A Plantological approach applying Lagrangian sampling strategy. Limnology and Oceanogarphy 43: 753-762.

Williams, J. D., M. L. Cummins Jr., K. S. Harris, and R. J. Neves. 1993. Conservation status of the freshwater mussels of the United States and Canada. Fisheries 18: 6-22.

Woolnough, D.A. 2002. Life-history of Endangered freshwater mussels of the Sydenham River, southwestern Ontario. MSc. Thesis, University of Guelph, Guelph, Ontario, Canada. 128 pp.

Zanatta, D. T., G. L. Mackie, J. L. Metcalfe-Smith, and D. A. Woolnough. 2002. A refuge for native freshwater mussels (Bivalvia: Unionidae) from impacts of the exotic zebra mussel (*Dreissena polymorpha*) in Lake St. Clair. Journal of Great Lakes Research 28(3): 479-489.

APPENDIX 1

APPENDIX 1

RECORD OF COOPERATION AND CONSULTATION

Fisheries and Oceans Canada engaged several first nation communities in Southern Ontario in the development of recovery strategies for Ontario mussel species. There were several meetings with members of the London Chiefs Council, one to discuss sampling the Thames River adjacent to the Chippewa, Oneida and Delaware communities and one to discuss the Thames River Recovery Strategy. There was ongoing dialogue between DFO and the policy advisor to the Southern First Nations Secretariat which is the administrative agency of the London Chiefs Council. DFO had meetings with the director of the Walpole Island Natural Heritage Centre and the Fish and Game Enforcement Officer from Walpole Island First Nation. During these meetings, general information on the Species at Risk Act was presented and the Walpole Island Recovery Strategy was discussed. A representative from Walpole Island First Nation was invited to participate on the Ontario Freshwater Mussel Recovery Team which prepared the Round Hickorynut and Kidneyshell Recovery Strategy; the representative was invited to attend all meetings and included in all correspondence sent to the recovery team members regarding this and other mussel recovery strategies. DFO also discussed SARA issues with a representative of the Six Nations of the Grand who works from the Six Nations EcoCentre and who also represents First Nation interests on the Grand River Fishes at Risk Management Plan, the Thames River Fish Management Plan and the St. Clair River Management Strategy.

An information package, which includes a copy of the Round Hickorynut and Kidneyshell recovery strategy and a summary description of the strategy, was prepared to solicit comments from potentially affected First Nations. This package was sent to the Chief and Council of Chippewa of Stoney and Kettle Point, Chippewa of Sarnia, Caldwell First Nation, Moravia of Thames First Nation, Chippewa of the Thames, Oneida, Munsey-Deleware First Nation, Mississauga of New Credit First Nation and Six Nations of the Grand. Members of these communities may have traveled or harvested fish from the waters of the Ausable River, Sydenham River, Thames River and Grand River where these mussels were historically found. Follow-up telephone calls were made to each community office to ensure that packages were received and to ask if they would like to schedule a meeting to learn more about the recovery strategy or the SARA.

The Ontario Freshwater Mussel Recovery Team had representation from all of the Conservation Authorities responsible for managing the rivers where mussels at risk are presently or were historically found. In addition to this, DFO prepared a list of non governmental organizations and municipalities which may be impacted by the Round Hickorynut and Kidneyshell Recovery Strategy. Information packages were prepared to inform these groups that the recovery strategy was posted on the SARA Public Registry and inviting each group to comment on the strategy. As well, an announcement was prepared and placed in newspapers with circulation in the area where these mussels are found to inform landowners and the general public about the strategy and to request their comments. These packages were sent and the announcements published to coincide with posting of the Recovery Strategy on the SARA Registry.

The province of Ontario was represented on the Recovery Team by the Ministry of Natural Resources (OMNR) and actively participated in the development of this Recovery Strategy. Further to their participation in the development of the Recovery Strategy, the OMNR conducted a thorough review of the penultimate draft (December 2004) providing valuable additional insight. A letter to request further Provincial comment on the Recovery Strategy was sent to the OMNR to coincide with posting of the Recovery Strategy on the SARA Public Registry.

The National Water Research Institute of Environment Canada was actively engaged in the development of this recovery strategy providing two members to the Ontario Freshwater Mussel Recovery Team. Environment Canada was invited to review and provide comment on the December 2004 draft of the Round Hickorynut and Kidneyshell recovery strategy.

The Recovery Team contacted representatives from Resource Management agencies at the state and federal levels in the U.S.A., where Round Hickorynut and Kidneyshell are extant, to invite their participation if interested; none participated. These two mussels are only found in Canada and the U.S.A. Information packages were sent to each U.S. agency to coincide with posting of the Recovery Strategy on the SARA Public Registry.