Feasibility of Champlain Canal
Aquatic Nuisance Species Barrier Options

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Executive Summary

The present-day Champlain Canal is 60 miles long and runs between the Erie Canal at Waterford in the south and the southernmost point of Lake Champlain at Whitehall to the north. With its inception in 1823 the canal connected previously unconnected drainages – including the Hudson-Mohawk and the Champlain. Organisms thought to have invade

NYS Canal System. The costs associated with such new infrastructure need to be detailed before any serious deliberation on the problem of canal/ANS could begin.

By their very nature, canals serve as unnatural watershed connections. Global trade and 21st century travel and tourism will combine to deliver many new invasive species across several watersheds to Lake Champlain in future decades. If no action is taken, the future will see new invasive fish, plant, and invertebrate colonizations in Lake Champlain.

Introduction

Interest in the issue of the Champlain Canal as a vector of aquatic nuisance species (ANS) dates to at least 1989 (Smith-Root, Inc. 1993). In 1998, the U.S. Fish and Wildlife Service (USFWS) sponsored a workshop summarizing the role that the NYS Canal System plays in the role of ANS invasion. Despite these efforts, no engineering efforts or operational changes in the canal have been implemented to minimize the threat of ANS invasions via the canal to Lake Champlain. It has been argued that ….

(http://www.aisstrategyteam.org/)

Interest in addressing this "tractable scenario" led to a proposal and subsequent funding of a project to outline the nature of the problem by describing the types of organisms that have or are able to traverse the canal into Lake Champlain. We also sought to assemble a team of experts to propose solutions to the barrier problem, and then conduct an analysis of the leading two or three ideas, taking into consideration a wide range of human and ecological factors. The following represents findings and recommendations emerging from this work. This information should be of value to decision makers involved with management Lake Champlain and Champlain Canal aquatic resources.

Background

Aquatic nuisance species are increasingly cited as causes for loss of biodiversity, and change of ecosystem structure and function. Costs associated with invasive species control and prevention have been reported in the millions or billions at the national level (Office of Technology Assessment, 1993; Pimentel et al., 2000)

At the local level, Lake Champlain's aquatic ecosystem continues to be shaped by the arrival and establishment of aquatic nuisance species. Like other lakes and ponds in the U.S., aquatic nuisance species arrive through a variety of pathways, causing economic and environmental problems in unexpected ways (e.g. selective zebra mussel filtering altering phytoplankton species dominance). Invasive invertebrates, fish, and plant species enter through canals, escape from aquaculture/aquarium systems, transport by recreational boat trailers, baitfish transport, and gardening (particular residential water gardens).

This study was undertaken to 1) better understand how aquatic nuisance species have impacted the lake, 2) what vectors or pathways enable ANS colonizations of the lake, and 3) what solutions might be offered to protect Lake Champlain aquatic resource in years to come.

Champlain Canal Characteristics

The major branch of the New York State Canal System known as the Erie Canal provides connection between Lake Erie and the tidal Hudson River. Other components of the NYS canal system include: 1) the Oswego, connecting the Erie Canal to Lake Ontario; 2) the Cayuga-Seneca which connects the Erie to the two largest Finger Lakes; and 3) the Champlain, c connecting the Erie to southern Lake Champlain. Outside of New York, this system connects to the Chambly Canal in Quebec providing recreational vessel access between northern Lake Champlain and the St. Lawrence River at Sorel-Tracy (Figure 1).

Figure 1 . Erie, Champlain and Chambly Canals

The focus of this report is aimed at the Champlain Canal, first opened in 1823. The original canal ran from Whitehall to Troy, NY; it was 40 ft wide, 4 ft deep, and had 24 locks.

Canal boats were specifically designed to have a shallow draft and masts that could be readily stepped and un-stepped from the deck. Modifications between 1860 and 1962 deepened and widened the canal, and reduced the number of locks. The present-day Champlain Canal is 60 miles long and runs between the Erie Canal at Waterford in the south and the southernmost point of Lake Champlain at Whitehall to the north. There are 11 locks on the canal, which has a minimum depth of 12 feet, a twelfth lock is situated at Troy and joins the Hudson River to both the Champlain and Erie canals. The canal passes a height of land near Fort Edwards, so that the canal flow downwards from lock 8 to the Hudson river (a drop of 134'), and downward from lock 9 toward Lake Champlain, a drop of 54' northbound (Figure 2). Between locks 8 and 9, the canal is filled by a 12-mile feeder canal linking Glens Falls with the canal, opened in 1837. The canal closes each winter in late November and is drained; the canal reopens in early May. Transits through the canal take from one to one-and-a-half days due to the 10 mph speed limit.

Key: Upper Numbers – elevation changes in feet
Lower Numbers – lock numbers

Figure 2. Champlain Canal Profile redrawn from McKibben et al.

As with the rest of the NYS Canal System, the Champlain Canal has transitioned largely to a recreational and historic resource (http://www.canals.state.ny.us/cculture/history/index.html). Alternative freight transportation systems (interstate highways, railroads, etc.) and increased tourism opportunities are largely responsible for this shift. The closure of the Plattsburgh Air Force Base in 1995 also reinforced this trend (specifically in the Champlain Canal segment) as the need for barges hauling jet fuel disappeared.

The Canal System opens the first Monday in May and closes in mid-to-late November. Locks operate daily for recreational vessels and on a 24 hour schedule by request for commercial (New York State Canal System Traffic report 1997). The income from the charged fee on vessels passing through Champlain Canal in 1996 and 1997 was $17,390 and $22,625 respectively. Cumulative Vessel Lockings in the Champlain Canal in 2004 were broken down as follows: Recreational 22,315; Cargo 495; Tour 715; Hire 129; State 1,322; Total 24,976 (New

York State Canal System Annual Traffic Report, 2004, NYS Canal Corporation, Office of Maintenance and Operations)

Commercial shipping (as defined by commercial tonnage) on the Champlain Canal has declined to negligible levels in recent years (Figure 3). However, some 770 tons of cargo moved through the canal in 2004, suggesting that commercial interests are still aware of the system's capabilities to move heavy awkward cargo between the Hudson River/Erie Canal and Lake Champlain. Cumulative vessel lockings for commercial traffic still numbers in the thousands, however, suggesting significant amounts of intra-canal traffic between Waterford and Whitehall (Figure 4). Vessel lockings data also underscore the transition from a cargo transportation system to that of a recreational or tourism-based system. During the period 1996 to 2004, recreational lockings exceeded commercial lockings by 8 – 10 fold (Figure 3).

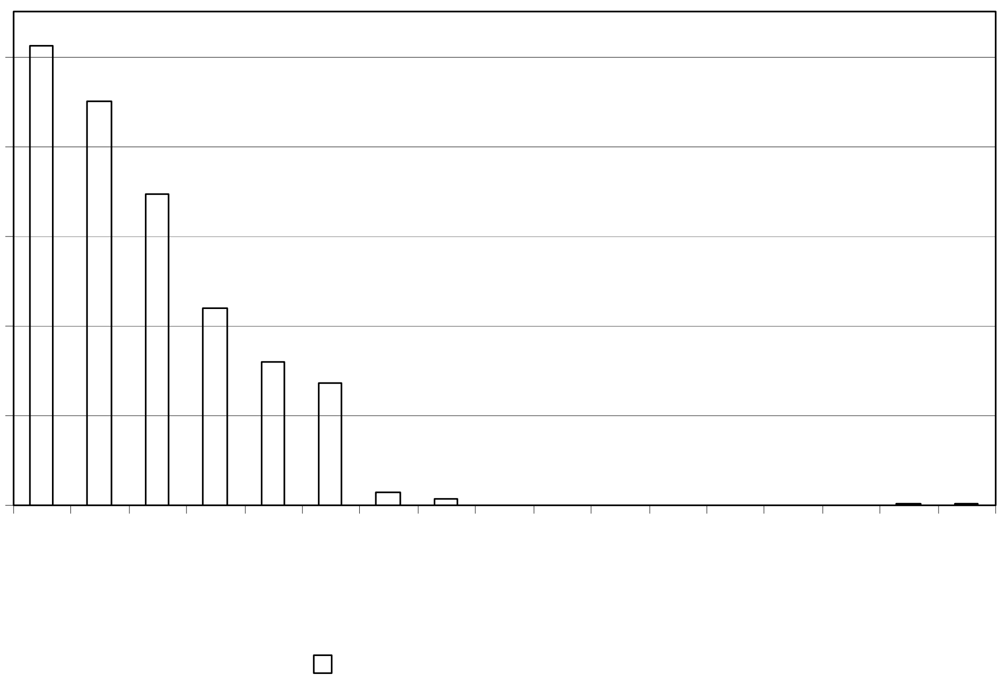
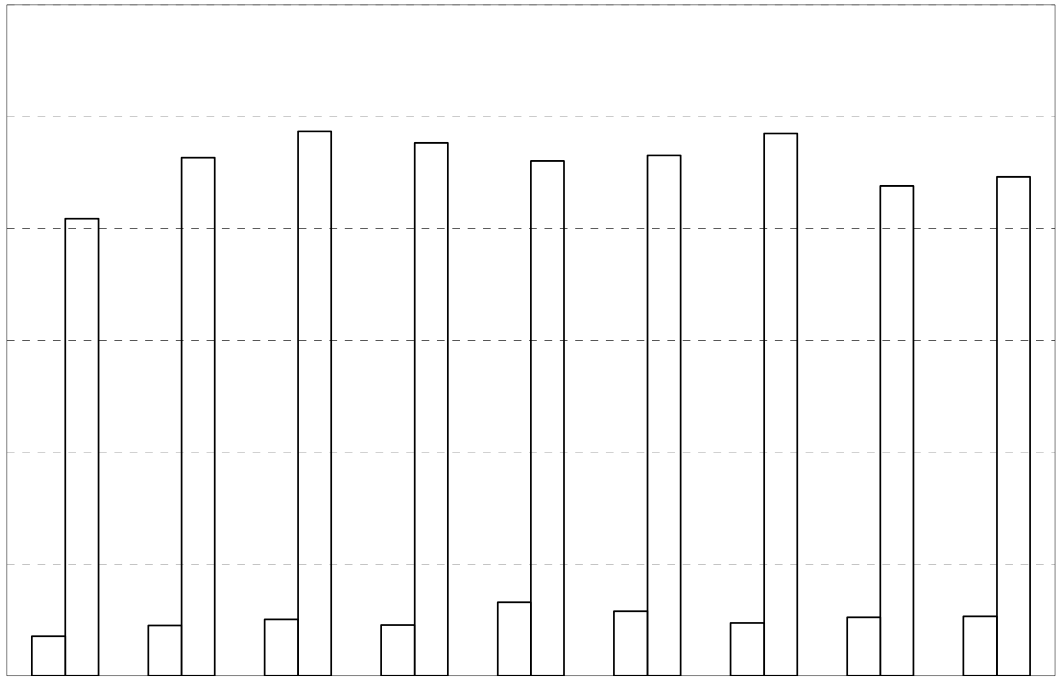


Figure 3. Tonnage of commercial vessels transiting the Champlain Canal from 1988 to 2004.



threats to Lake Champlain aquatic resources, (3) they are the only ones from the list of 47 for which at least some economic data (primarily control expenditures) are known to exist. The known control expenditure data associated with several of these species in Lake Champlain is summarized in Table 1. As can be seen, public and private sector control efforts for 3 species is expected to exceed $16 million for the period 1982-2008.

Table 1. Known Lake Champlain Invasive Species Costs

	Control Period	Expenditures	Annual Costs
Sea Lamprey[a]	1990-1997	$6,903,700	$862,963
Sea Lamprey[b]	L.T. Program 2005-2008	$1,684,473	$421,118
Water Chestnut[c]	1982 - 2004	$5,802,082	$480,000
Zebra Mussel[d]	2000 - 2002	$91,501	$30,500
Zebra Mussel[e]	1992 to current	$1,635,000	$35,000
Total		$16,116,756	

a) Gillbert, 1999; includes treatment and assessment costs. b) Projected TFM and other lamprey mgmt. costs 2005-2008 inclusive, LC Fish. Tech. Committee.

Pimentel et al. (2000) reported that zebra mussel fouling caused $100 million per year in damages to electrical generating plants in the U.S. We surveyed marinas, recreational facilities, institutions, municipal drinking water systems, and commercial firms and found direct expenditures associated with Lake Champlain zebra mussel maintenance costs equal to $91,501 for the period 2000 to 2002. Costs associated with the prevention of zebra mussel colonization of the Ed Weed Fish Hatchery infrastructure in Grand Isle, VT have been estimated at about $35,000 per annum or a total of 1.6 million since the discovery of zebra mussels in Lake Champlain in 1992 (K. Kelsey,
VTDFW, pers. comm.).

Sea Lamprey

Though the status of sea lamprey as a non-native has recently come into dispute, it remains classified as a nuisance species with an enormous impact on lake trout, landlocked salmon, and other native fish. If it is non-native to Lake Champlain, it probably entered the lake via one or both of the canals. Its parasitic life style at the sub-adult stage results in extremely high wounding rates for its targeted species — primarily salmon and trout. The economic damage attributable to this species has not been calculated to date, though some costs have been tallied. At current sea lamprey population levels, fisheries managers have conceded that restoration of native Atlantic landlocked salmon and lake trout fisheries are impossible (though the recreational fishery for both species can be sustained by stocking). Expenditures by New York and Vermont anglers who targeted Lake Champlain trout and Atlantic landlocked salmon was valued at $37,398,827 and $24,501,250, respectively, in 1997 (Gilbert, 2000). These expenditure data and the threat posed to trout and salmon restoration were key justifications for adoption of the (Fisheries Technical Committee, 2001). The estimated annual cost of current sea lamprey management is $612,000 per year (USFWS/Fisheries Technical Committee, 2001).

Alewife

This marine invader arrived in Lake St. Catherine in 1997, and has now disrupted the food web in that lake. Lake St. Catherine is in the Lake Champlain drainage and this non-native invasive species could reach Lake Champlain via the following downstream route: Mill Brook to the Mettawee River to the Champlain Canal in the vicinity of Locks 11 and 12.

……

(VTDEC Alewife pamphlet, undated)

The USFWS Lake Champlain Resource Office recently commissioned an investigation of the feasibility of Lake St. Catherine alewife eradication. It has been estimated that the cost of this eradication (via complete destruction of the entire Lake St. Catherine fish community) would be approximately $665,162 (Spateholts, 2004). The eradication effort is being considered by the Lake Champlain Fish and Wildlife Management Cooperative. While expensive, it may represent the best option for preventing a likely coloni caught a single specimen while angling in

Proposed Task/Objective 1b:

To accomplish this task we conducted a literature review and initiated contacts with other aquatic invasive species specialist in the Great Lakes and Hudson River drainages. Additional information was collected from various Internet web sites, including the (http://www.aquaticinvaders.org/nan_ld.cfm), along with other Sea Grant and federal agency (i.e. U.S.G.S.) sites. From these sources, we established the following list. All of these organisms are seen as potential invaders of Lake Champlain via the Champlain Canal.

Threats from Lake Ontario

- fish-hook waterflea ( )
- spiny waterflea ( )
-
- round goby
-
-
-

from the Hudson River and Estuary

- European stream valvata
- liver elimia
- Wabash pigtoe
- paper pondshell
- Atlantic rangia
-
-
-
-

from the Erie Canal portion of the NYS Canal System

- quagga mussel
- Piedmont elimia snail

Proposed Task/Objective 2:

Lake Champlain and Champlain Canal Stakeholder Input

Two major stakeholder participation efforts were undertaken to gather stakeholder input relative to the problem of ANS vectors for Lake Champlain.

Workshop

On May 9, 2002 Lake Champlain Sea Grant convened a workshop to: 1) inform stakeholders of the current state of knowledge of aquatic nuisance species in Lake Champlain; 2) initiate a dialog with stakeholders; 3) gather opinions, knowledge, and ideas from stakeholders that might help formulate possible solution to the problem of invasive species migration through the canal. Participants included marina operators, natural resource agency staff, tourism representatives, boaters, shoreline property owners, and others. Approximately 40 attendees learned about canal history, design, invasives problems, and possible solutions. Speakers also presented information about the Chicago Sanitary Canal and its role as an invasive species vector between the Mississippi and Great Lakes watersheds. Much of the day was aimed at gathering stakeholder's views about the canal attributes and liabilities relative to tourism, commerce, public policy, and invasive species. The collective list of concerns given by workshop participants is given in Appendix C.

Champlain Canal Barrier Options Delphi Survey Report

Following the workshop, we surveyed knowledgeable opinion leaders on issues similar to those explored at the workshop. A full report on the survey is given in Appendix D. The following is a portion of the summary authored by Bryan R. Higgins, Department of Geography and Planning, Center for Earth and Environmental Science SUNY Plattsburgh.

Stakeholder Summary

These efforts confirmed a diversity of opinions among the many stake holders and opinion leaders. While many expressed concerns over the invasive species issues, some people didn't feel that the canal posed a significant risk as an invasive pathway. Others felt that any modifications done to the Champlain Canal must simultaneously address another canal pathway at the outlet to Lake Champlain in Quebec — namely the Chambly Canal that bypasses two non-navigable sections of the Richelieu River. Still others didn't feel the canal was the most important pathway relative to boat trailers, bait trade, aquaria/pet trade, and other vectors.

Project Findings

Subsequent (and ongoing) extensive literature reviews by two of us (Marsden and Hauser) indicate that exotic species introduction via one or both of the canals represent at least 40% of the introductions for which the vector is known or can be reasonably guessed at (Figure 5). While a project to reduce future invasions via the Champlain Canal would certainly not eliminate the risk of invasions, other pathways of invasion are or have been addressed separately. Despite the historic introduction of rainbow trout ( ) and brown trout ( ) to the lake, management agencies no longer perceive stocking of exotic species as a desirable management strategy; future introductions through deliberate stocking are unlikely. Legislation to control the introduction of non-native bait fish species in Vermont was passed in 2002, effectively reducing the risk of new introductions via this route (Note: this issue remains largely intractable in New York). In response to the problems caused by zebra mussels, water milfoil, and other exotics in the Lake Champlain basin and throughout the Great Lakes region, public education campaigns and signage at boat launches have addressed the risk of invasions via boat trailers and aquarium dumping.

Once appropriate technology is in place in the Champlain Canal to restrict future introductions of exotic species, similar methods can be applied to the Chambly Canal. However, this project was initiated in the U.S., and the researchers have no jurisdiction to work in Canada. Moreover, the Chambly Canal, unlike the Champlain Canal, does not link Lake Champlain to any new ecosystems; it is only a more navigable stretch of an existing aquatic conduit, the Richelieu River. Thus, the risk of novel introductions occurring via this pathway is lower than from the Champlain Canal.

Figure 5. Number of exotic species that have

We also note that any method that reduces the passage of exotic species through the Champlain Canal also benefits the Hudson, St. Lawrence, and Great Lakes ecosystems, as Lake Champlain has historically served as a conduit for species between these ecosystems (Daniels 2001).

Figure 6. Relative magnitude of aquatic invasive species threats in nearby watersheds

Alternative One: Do Nothing

(i.e. No change in canal engineering or operations)

This alternative implies an acceptance of the

Lake Champlain currently has on record 47 exotic species. Though not insignificant, this number is low relative to the number non-native species that have invaded nearby watersheds heritage resource from the region. Boat options for accessing the Great Lakes and Hudson River from Lake Champlain, and vice versa, would be severely curtailed. Impacts on commercial canal and lake traffic in the region would be significant, despite changing uses of the canal in recent years. If the canal was neither filled nor otherwise managed, closure might create artificial wetlands and ponds with both societal and ecological benefits and costs. A more apt description of this option might be "dewatering" of the Champlain Canal system. Since water depth for navigation is maintained via a system of locks and "make up water" (i.e. feeder canals), it may be fairly easy to dewater the system. However, flow into the canal bed via feeder canals (primarily Glens Fall feeder canal) would need to be addressed.

Benefits:

The closed canal could be converted to a variety of uses. Water could potentially be stored in newly ponded sections of the canal. Canals might be used for sport activities, or completely filled and the land recovered for alternate uses. Though not estimated, there could presumably be some small economic benefits associated with minor recreational uses (bike paths, fishing sites, etc.) Ecological benefits associated with dewatering could be major, given the role of the canal as a major ANS conduit.

Cost:

The Champlain Canal supports very few commercial vessels and evidence suggests that at least some of this traffic is not time-sensitive. Lock transits in the late 1990s varied from 195 to 390 transits per lock. Total tonnage of commercial goods traversing the canal has steadily decreased in the last decade, to less than 10% of transits in 1997. Recreational transits at each lock during the same period ranged from approximately 1,700 to 2,420 vessels. Cumulative Vessel Lockings in the Champlain Canal in 2004 were broken down as follows: Recreational 22,315; Cargo 495; Tour 715; Hire 129; State 1,322; Total 24,976 (Canal System Annual Traffic Report, 2004).

Use of the canal requires permits for lock use and opening of bridges. Passes vary from a 2-day pass for small boats at $5, to a seasonal permit for large vessels, which can be as much as $100. Total income from the permits and passes in 1997 was $22,625. Newer income data for the Champlain Canal are unavailable, though the New York state canal system as a whole is thought to contribute $384 million dollars annually in economic benefits (Canal System Annual Traffic Report, 2004). If the canal is closed, the revenues are directly influenced. Allowing for the small scale of commercial uses by the canal, we expect that the opportunity cost in closing the canal would be limited. However, in terms of individual stakeholders (i.e. Lake Champlain Transportation Company) the strategy would push them into the margin of business risk (W. Dumbleton, LC Trans. Co., pers. comm.).

Alternative Three: Physical/Mechanical Modifications to the Canal

Physical barrier

It may be possible to fill or dewater a very short stretch of the canal to serve as an ANS barrier. Existing locks could be made to open only for commercial transits, and only by permit for emergency/priority use. Recreational vessel passage would be enabled by short-distance transport vehicles/systems. Obviously, significant engineering or operational solutions would be needed to allow for both recreational and commercial vessel passage under this scenario.

At least three applicable methods have been developed to transport pleasure boats short distances overland. These methods could readily be adapted to boats needing to circumvent a physical canal barrier. The simplest approach is the forklift system used at many dry-stack boat storage yards and marinas. A second technology is the sling-type lift in which a boat is lifted, transported a short distance overland via a lift vehicle, and subsequently lowered back into the water. This boat hoist system is used to annually remove boats from the water for winter storage. Sling-type lifts have been designed for 600 ton capacity, though units above 150 tons capacity are relatively uncommon. A third system is the marine railway such as the Big Chute railway used on the Trent-Severn Waterway (see: http://collections.ic.gc.ca/waterway/ov_eng_i/bigchute.htm). This technology was first incorporated during construction of the canal in 1917. A “new” railway was opened in 1978 with a capacity of 90 tons and 100' long and 24' wide, able to accommodate up to 6' draft.

Passage of commercial/state barges, tugs, tour boats etc. around a physical barrier is much more problematic. Travel lift technology would not enable passage of large vessels (i.e. barges, ferries). Vessels in this class would have to be accommodated by marine railway systems, or perhaps via highly regulated rare instance uses of specialized new locks (e.g. graving docks), built adjacent to/around the separation barrier. Marine railways continue to exist in old shipyards (Shelburne, VT; Greenport, NY) and may have broader application as boat transportation devices around invasive species barriers. Graving docks (also known as dry docks) which are normally used for major hull maintenance could also be used to block ANS. This technology dates to at least 1746, when a new graving dock was built in Liverpool, England for ship maintenance and removal of barnacles (http://www.diduknow.info/docks/access/gl_graving.asp and http://www.diduknow.info/docks/access/dock_history7.html)

In the case of the Champlain Canal, commer

A physical barrier in the Champlain Canal would ideally be located at the high point of the system, between locks 8 and 9. In this manner both northerly and southerly bound ANS would be blocked before “crossing the divide.” Currently, ANS passing this region are transported down slope, effectively reaching a new watershed. Since makeup water is introduced at this point via the Glens Falls Feeder Canal, some provision would need to be made for supply of ANS-free water to either side of a physical barrier.

This method would be effective at blocking movements of all taxa. Assuming some degree of boat hull inspection and cleaning takes place during transit over the barrier, and that live wells, bait buckets, etc. are emptied; the effectiveness approaches 100%.

Hydrologic separation is documented in the s of an thehTp9rwt Tw3(Ch sigo Spectary Ship5.9(r costs (site preparation, dredging, etc.) are yet to be estimated. The cost of building a graving/dry dock is also yet to enumerated, and likely presents a significant investment in new canal infrastructure. Transporting boats across a barrier will carry a per-boat cost. This cost can be paid by the boater, as a tax for use of the canal system, by the state(s) that are protected by the presence of the barrier, by the businesses that benefit from the barrier to slow boat traffic and provide commerce opportunities, or a combination of the three. Vessels transiting the Trent-Severn Lockage in Ontario, Canada are charged per foot length of vessel. Some examples are: single lock and return – $0.85; single day – $1.50; transit one-way – $4.25; six-day – $4.60 and seasonal – $8.10.

The primary limitation of this strategy is the inability to lift very large vessels. The travel lift may pose a limitation on the size of ships that combinations of the above. These technologies (alone and in combination) have been used successfully to deter some fish from power plant intakes, irrigation canals, and other engineered conduits and waterways. The concept of an electrical barrier for the Champlain Canal was first investigated by Smith-Root, Inc. at the request of NYSDEC in 1989 (Smith-Root, Inc., 1993). The primary concern at that time was the potential invasion of alewife into Lake Champlain from the Hudson River. The plan was not pursued due to concerns about safety and liability by the NYS Canal Corporation. In April 2002, an electrical barrier (Barrier I) was put into operation on the Chicago Canal to prevent fish movement between the Mississippi River drainage and the Great Lakes drainage. A more permanent barrier (Barrier II) has been funded and is scheduled for completion in 2005 (http://www.seagrant.wisc.edu/ais/Default.aspx?tabid=393). An electrical barrier is only effective against vertebrate aquatic species (fishes) and, to some extent, macroinvertebrates (crayfish and large insect larvae); the field would not affect plants or bacteria, and would have a negligible effect, if any, on plankton or mollusks.

Boating traffic would be unimpeded, and the effect of the installation on the canal scenery could be relatively minor. Historical works by interfering with oxygen take-up across gill membranes (Bettoli and Maceina 1996). The primary concerns with any of these methods are human health hazards, cost, implementation, liability, and imp trihalomethanes in drinking water and contradicts the efforts of some environmental activities to reduce chlorine in the ecosystem.

It remains open to question whether any of these methods could be used to establish and maintain an ANS barrier throughout the canal operating season.

Chemical control is still deemed as a very effective method in preventing invasive species. Keppner and Theriot (1997) compared chemical and physical methods of preventing ANS in the Illinois Waterway system in terms of effectiveness, cost and regulatory restriction. They conclude that the applications of rotenone, antimycin and chlorine are more desirable than electrical barriers while the costs of chemical alternatives are higher. They ranked each factor with a 1-3 point scale with three being the most desirable. In the effectiveness ranking, the electrical barrier scored 2 while the chemical applications scored 3. But when considering cost, the electrical method was give 3 points while rotenone and chlorine scored 2 and antimycin only scored 1.

There are at least three costs that we need to include in the cost-benefit analysis when considering the chemical control option. First are the resource requirements of the chemical control method such as the chemical product, labor, and equipment for application. Due to the relatively small market for many invasive species control products, market forces serve to elevate product costs. As an example,
is expected to incur about $1 million in chemical lampricide purchases during the period 2005-2009 (W. Schoch, Lake Champlain Fisheries Tech. Committee, pers. comm).

The second cost is related to permit requirements and maintaining or supervising the application. Experience with permitting and public policy issues suggest that these costs would be difficult to forecast. In any case, this process requires careful review of scientific and legal records, and involves a substantial investment in time, state personnel, and fees.

The third cost is environmental costs transferred into economical costs. Non-target and unanticipated ecological impacts may result in additional costs (i.e., remediation). As soon as the application of the chemical produces a negative effect, the environmental impact will immediately turn into real costs by computing economic loss.

Technical application costs associated with chemical/water quality reductions are difficult to estimate for an as-yet-to-be-specified barrier. However, dosing equipment, boilers, heat exchangers, ozone production systems and/or chemicals can be expected to cost from tens to hundreds of thousands of dollars.

Alternative Six: Biological Barriers

Biological control of invasive species has historically involved use of a predator to limit the numbers of an already established exotic. Mosquitofish (spp.), have been stocked throughout the U.S. to control disease-bearing mosquitoes, and Pacific salmon (and) were stocked in the Great Lakes to control invasive alewife ( ) (Fuller et al.1999). Increasing the densities of natural and exotic predators was also considered as a potential method to limit the expansion of ruffe ( ) in Lake Superior. In Vermont, stocking of predators was considered as an option to control alewife in Lake St.Catherine (Vermont Department of Fish and Wildlife, 2003).

In the context of herbivory, grass carp ( ) have been stocked to reduce beds of unwanted aquatic vegetation. Aquatic weevils ( ) and moths (

In analyzing the benefits/costs of biological cont

Further analysis is clearly warranted. Sound decisions as to the fate of any Champlain Canal ANS barrier will require at least two types of information. First, well designed socio-economic surveys are needed to better understand current canal usage and importance. Surveys of this type should also enable decision makers to formulate "what-if" scenarios relative to boat traffic impacts caused by ANS barriers and/or canal operational changes. Such studies are routinely conducted to help answer resource economics questions similar to this. Many universities have this capability, but these data will go lacking absent any directed research toward user attitudes and canal transit expenditures. Similar information from other regions (even if it exists) is simply not transferable to the problem at hand.

Secondly, engineering studies are needed to predict the physical viability and costs associated with Alternatives 3 and 4. The construction of graving docks, boat hoists, behavior barriers, feeder canal diversions, etc. would require significant new investment in the NYS Canal System. The costs associated with such new infrastructure need to be detailed before any serious deliberation on the problem of canal/ANS could begin.

As a final conclusion, it should be stressed that Alternative 1 (no change/no action) represents an important decision for Lake Champlain aquatic resource stakeholders. Aquatic nuisance species will continue their "march" toward Lake Champlain aboard boat trailers, in bait buckets, aquarium trade, aquatic plant trade, but most likely through the Champlain Canal. This and other canals were of vital commercial importance in the 19th century and continue to have enormous tourism benefit today. By their very nature, however, canals serve as unnatural watershed connections. Global trade and 21st century travel and tourism will combine to deliver many new invasive species across several watersheds to Lake Champlain in future decades. If no action is taken, the future will see new fish, plant, and invertebrate ANS colonizations in Lake Champlain.

Addendum

On May 16, 2005 two of us (Malchoff and Marsden) met with eight New York State Canal Corporation staff at New York State Thruway Authority/Canal Corporation Headquarters in Albany, New York to review the above project findings. The meeting with the key stakeholder group provided an opportunity to offer ideas and receive constructive criticism. The following e-mail excerpt was received by Malchoff following the meeting. It concisely summarizes the view points expressed by the Canal Corporation staff on May 16.

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Appendix A. (from LCBP ANS Management Plan)

Non-native Lake Champlain Basin Species of Potential Concern

<u>Within the Lake Champlain Basin</u>

Other nonnative plant and animal species that have the potential to become problematic are found throughout the Lake Champlain Basin. Many of these species have not been well documented and the full

*quagga mussel ( )
Asian clam ( )
Chinese mystery snail ( )
Piedmont elimia snail ( )
liver elimia ( )
sharp hornsnail ( )
Wabash pigtoe ( )
paper pondshell ( )
Atlantic rangia ( )
ridged lioplax ( )
green floater ( )
New Zealand mudsnail ( )

Crustaceans

*spiny waterflea ( )

waterflea

*fishhook waterflea

amphipod ( )
calanoid copepod ( )
calanoid copepod ( )

Appendix C.

Summary of “mind map” from May 9, 2002 Champlain Canal Stakeholder Conference.

List represents the total catalog of issues related to management of aquatic nuisance species invasions through the Champlain Canal, as captured by workshop participants and professional facilitator. Asterisks denote the labeling of given issue as “important”. Triangles denote the labeling of a given issues as “urgent”. Count of symbols indicates level of group agreement on a particular issue (i.e. more symbols = more agreement).

1. Increase pressure on sport fisheries - prevent NIS ***
2. How to value non-market resources **
3. Voluntary action Programs; increase communication re: voluntary needs
4. Imposing Costs ΔΔΔ
5. Increase classroom learning about NIS
6. Education
7. Provide Curriculum
8. Put on Regents Exam
9. Biological migration – Barrier Δ
10. Modify canal use ***ΔΔ

22. Impacts to cultural heritage resources – prevent additional introductions *****
23. Increasing importance of "political will"
24. Increased competition for limited resources – collaborative products – increase resources
25. Uncertain future *
26. It's not over – continuing problem – ballast water **
27. Nineteenth century technology – 22nd century issues
28. Sonication, electric barrier ΔΔΔΔΔΔ**
29. Ecological Imbalance – change *
30. Regional vs. Local tension
31. Burdensome permitting process *
32. Change in basin population – smart growth policies
33. Increased uncertainty in ecosystem management
34. Changing social/economic character of population
35. Local water front revitalization
36. Conflict between status quo : change *****Δ
37. Costs to taxpayers – business community ****
38. Data Needs ΔΔΔΔΔΔ*
39. Fund monitoring and research **
40. Improving water quality
41. impacts on shoreline/ private property use/values ***
42. Changing recreational opportunities ΔΔ
43. Recreational boating ΔΔΔ
44. Communication and cooperation across the border ΔΔ
45. User surveys **
46. Education / behavior changes ΔΔ
47. Increase funding to address issues **
48. Gene attached species introduction *
49. Increasing need for regional / national / international perspective ****
50. public awareness **
51. increased funding for outreach/ media *

52. heightened public concern **
53. water shed development *
54. Develop watershed management plans and assessments

Appendix D.

Champlain Canal Barrier Options
Delphi Survey Report (abbreviated version)

February 14, 2003

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This report is one component of a
National Oceanic and Atmospheric Administration grant entitled:

Multidisiplinary Analyses of the Feasibility of Champlain Canal Barrier Options: A Proposal to National Sea Grant

This report summarizes the results of a Delphi Survey about potential Champlain Canal barrier options which was part of a National Sea Grant project. This study included two distinct survey instruments that are presented in the appendix of this report. This survey was based upon a example, if "non-indigenous species" are defined as the threat, why are "non-indigenous fish" currently stocked in Lake Champlain? Thus, attention should be given to systematically define the key notions and public policy framework for assessing a canal barrier. Third, given the diversity of frameworks for understanding nature and perceived importance of a wide range of values, policy analysis of potential canal barriers should establish a systematic framework that includes and assess direct, indirect, option and existence values. Fourth, given the multiple paths by which plants and animals may enter Lake Champlain, public policy studies should simultaneously assess the potential of all key alternatives such as release of live bait, home aquarium fish, and boats entering the basin by trailer. Finally, even though fish species are clearly important, assessment of canal barrier options should systematically evaluate the potential for all species.

Results of the Second Round of the Delphi Survey

Average of
<u>Responses</u>

1.2 The impact on sport fishing in Lake Champlain. New fish species may directly displace a current species or new plants and microorganisms may alter the niche of current sport fish populations.
   1. Very important - 16
   2. Somewhat important - 3
   3. Not important - 0
   4. Undecided - 0

1.3 The impact of aquatic nuisance species entry to Lake Champlain through the Chambly Canal or Richelieu River in Quebec.
   1. Very important - 14
   2. Somewhat important - 5
   3. Not important - 0
   4. Undecided - 0

1.3 The impact on tourism businesses.
   1. Very important - 14
   2. Somewhat important - 5
   3. Not important - 0
   4. Undecided - 0

1.4 The impact of live bait for fishing and/or release of home aquarium fish as alternative entry routes for nuisance species

2. Somewhat important - 6
3. Not important - 1
4. Undecided - 0

1.5 The impact on Lake Champlain water systems for drinking, fish hatchery production, etc.. This includes the costs of research, preventative measures and modifications of current systems.

1. Very important - 10
2. Somewhat important - 9
3. Not important - 0
4. Undecided - 0

1.9 The uneven impact on residents in New York, Vermont and Quebec, Canada.

1. Very important - 4
2. Somewhat important - 11
3. Not important - 3
4. Undecided - 1

1.9 The impact on non-consumptive value such as nutrient recycling and scientific research.

1. Very important - 4
2. Somewhat important - 12
3. Not important - 3
4. Undecided - 0

1.9 The impact on waterfront development for municipalities along the Champlain Canal. Modifications in the operation of the canal may impact future development potential.

1. Very important - 6
2. Somewhat important - 8
3. Not important - 5
4. Undecided - 0

2.0 The impact on boaters who utilize the Champlain Canal and Lake Champlain. Depending on the option, this may include increased risk with an electrical barrier or more time for passage with a boat lift.

1. Very important - 4
2. Somewhat important - 11
3. Not important - 4
4. Undecided - 0

2.0 The impact of new economic opportunities that respond to the entry of aquatic nuisance species (e.g. zebra mussel protection systems).

1. Very important - 7
2. Somewhat important - 4
3. Not important - 8
4. Undecided - 0

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