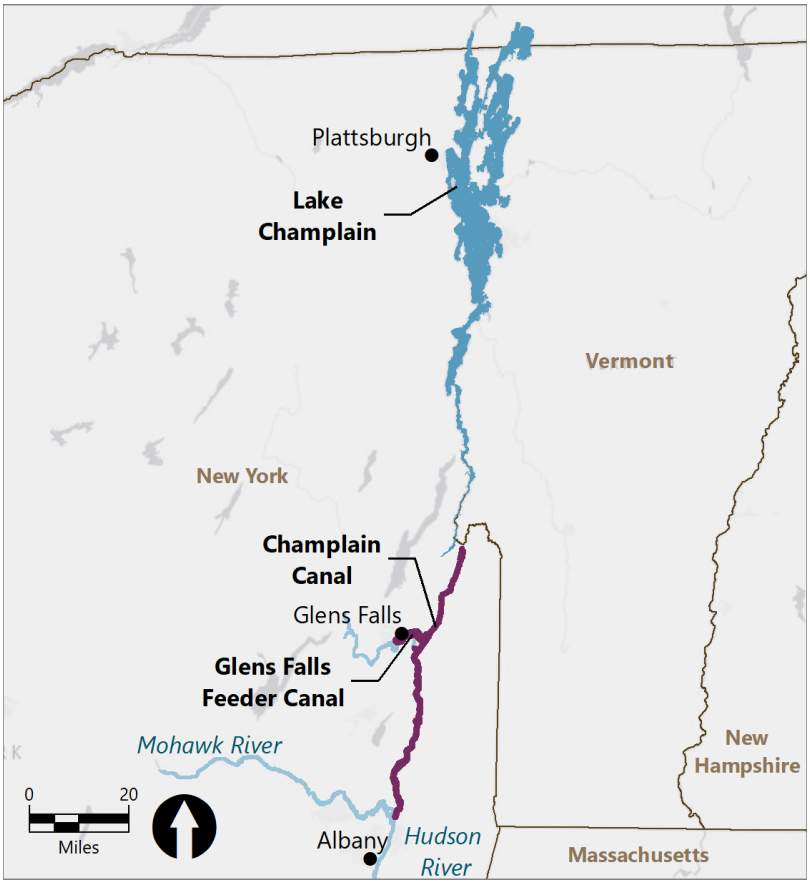
MITIGATING THE SPREAD OF THE INVASIVE ROUND GOBY: INTERIM RAPID RESPONSE PLAN FOR THE CHAMPLAIN CANAL SYSTEM IN NEW YORK STATE



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STATEMENT

This document presents the 2023 updated Rapid Response Plan for round goby. NYPA and DEC expect that this interim plan will be updated periodically as more information on the distribution of round goby becomes available and as additional control methods are identified and developed. This plan does not commit NYPA or DEC to authorizing any individual control measure described in this plan, and NYPA and DEC expect those measures to be further evaluated based on continuing studies and other information gathering. Prior to undertaking any of the recommended actions described in this plan, NYPA and DEC will comply with applicable laws, regulations and permitting requirements. To the extent that some of these recommendations are already within the scope of routine management and operations of the Canal System, that decision-making will continue to be exercised by the NYPA and its subsidiary, the New York State Canal Corporation.

This plan addresses the criticality of the round goby's movement through the Canal System into waterbodies, or portions thereof, that it has not otherwise reached based on validated data. The recommended actions in this plan are aimed to guide decision-making for possible emergency actions that would be immediately necessary on a limited and temporary basis for the protection of natural resources from an invasive species, and as such would be performed to cause the least change or disturbance, practicable under the circumstances, to the environment. When these actions are taken on a discretionary or long-term basis, such actions would be potentially subject to future environmental review in accordance with New York State's Environmental Quality Review Act and its regulations.

This plan is in contemplation of the continued collection of information and conducting concurrent environmental, engineering, economic, feasibility and other studies, that will support identification and development of proposals for action to provide long-term control measures.

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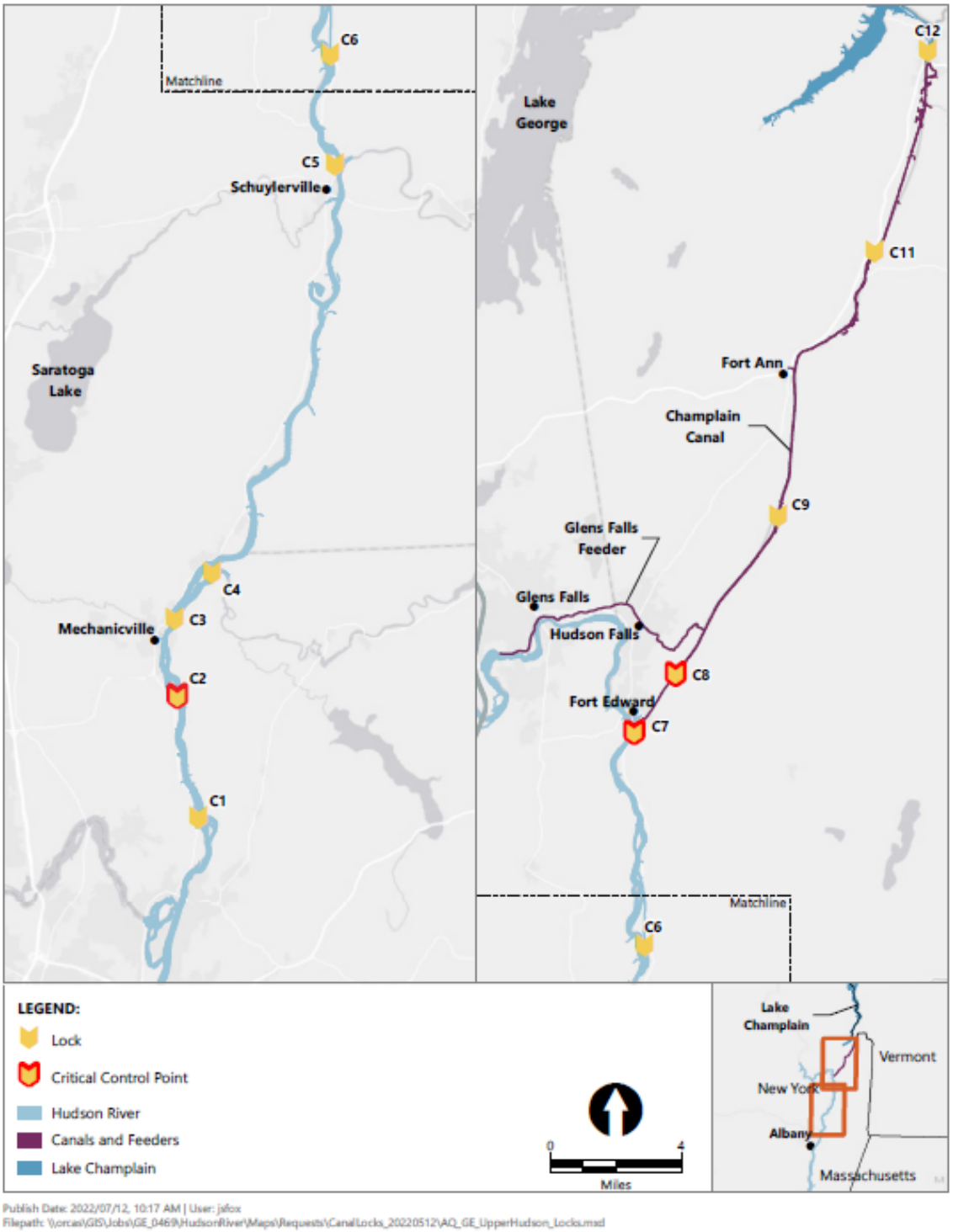
The Champlain Canal



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AIS	Aquatic Invasive Species
APA	Adirondack Park Agency
eDNA	environmental DNA
LLBDM	Little Lake Butte des Morts
LCBP	Lake Champlain Basin Program
MARAD	U.S. Department of Transportation, Maritime Administration
NMSS	National Oceanic Atmospheric Administration, National Marine Fisheries Services
NWP	Nationwide permit
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYPA/Canals	New York Power Authority and New York State Canal Corporation
NYSOGS	New York State Office of General Services
RRP	Rapid Response Plan
SEQR	State Environmental Quality Review Act
SHPO	State Historic Preservation Office
TARP	Trigger Action Response Plan
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WISP	Watercraft Inspection Steward Program

1.0 RAPID RESPONSE IMPLEMENTATION PLAN SUMMARY

This Round Goby Rapid Response Plan (Plan), developed by The New York Power Authority, New York State Canal Corporation (NYPA/Canals) and New York State Department of Environmental Conservation (NYSDEC), is designed to operate in conjunction with Aquatic Invasive Species (AIS) plans implemented by other federal/state agencies, adjoining states, countries, international commissions (e.g., International Joint Commission), resource managers, nongovernmental organizations, industry, and stakeholders. The Plan describes interim measures that would be implemented to mitigate the spread of round goby in the Champlain Canal until a long-term solution is identified. This Plan will be updated in the future as necessary as additional information on the distribution of round goby within the region becomes available and as additional control methods are developed.

Currently, round goby (*Neogobius melanostomus*) has not been observed in Lake Champlain or in the Hudson River above Lock C1, which is located immediately north of Waterford, New York. The goal of the Plan is to prevent the dispersal and establishment of round goby into the New York State Champlain Canal system, which is linked to Lake Champlain, and thus avoid the potential ecological and economic impacts that may result from such introductions. It is important to note that the ability to prevent movement of goby is limited to NYPA/Canals operational authority and would not affect potential actions taken by boater or fishers such as illegally transporting goby in bait buckets. Thus, rapid response actions identified are focused on operation of the Champlain Canal lockage system.

The Plan identifies a strategy that involves a combination of prevention, early detection, and rapid response actions which will be implemented in an adaptive manner. Prevention focuses on public education and outreach to achieve human behavior change to reduce opportunities for introduction of round goby. Early detection involves surveys and monitoring to detect the presence and dispersal of round goby in the Champlain Canal system. Rapid response efforts include measures that can be implemented quickly to contain round goby in a portion of the Champlain Canal system when detected and prevent further spread of the species in the system. This strategy is based on the experience of subject matter experts involved in AIS at local, state, and regional levels.

The Plan focuses on the Champlain Canal as a specific pathway for round goby dispersal. Given this focus, the Plan considers round goby mobility in relation to the following:

1. The species ability to traverse locks.
2. Operational changes that could prevent round goby dispersal.
3. Measures to avoid assisted dispersal via watercraft and through bait buckets.

In alignment with existing AIS rapid response plans issued by other organizations, initiatives will minimize restrictions on water use, public access, parks, and other facilities whenever possible.

A Trigger Action Response Plan (TARP) is provided in Table 1 below. The response actions specified in the TARP were developed to prevent dispersal of round goby via the Champlain Canal system into Lake Champlain. Therefore, in the event that round goby are detected in Lake Champlain, which could result from other dispersal vectors such as transfer via bait buckets, the value of and need for these response actions will be re-evaluated. For example, due to the significant impacts associated with lock closure, lock closure included under the Level 4 response will be re-evaluated as a recommended trigger if round goby are detected in Lake Champlain. Evaluation will include considerations of abundance, location, and economic impacts.

Actions in the TARP have been selected based on best available information and current understanding of the round goby invasion front. Detailed descriptions of the various potential deterrents are provided in Appendix A. The TARP was developed taking into consideration the potential effectiveness and implementation risks of each potential response action, as detailed in Appendix B, and summarized in Section 9. This Plan provides recommended actions and is based on adaptive management strategies. Further refinements, updates, and changes are expected as additional monitoring and scientific information become available[1].

The response actions listed in Table 1 are considered temporary measures. Following implementation, the need for continued implementation would be evaluated considering:

- Additional evaluation regarding whether implementing additional or alternative deterrents that may take longer to implement would allow modification of the response
- Results from ongoing monitoring regarding round goby dispersion rates
- Whether round goby is detected within Lake Champlain
- Additional evaluation regarding the potential negative impacts of the response actions versus the potential negative impacts of round goby dispersal into Lake Champlain

[1] This Plan may be expanded in the future to include additional AIS or other canal segments, including the Erie, Oswego and Cayuga-Seneca canals.

Table 1. Trigger Action Response Plan

Condition			Trigger Action Rapid Response[2]	Communication & Long-Term Actions
Normal State	• Round goby has not been detected upstream of Lock C1	**Normal State Response**	• Implement scheduled lockages for recreational vessels at Locks C1 and C2, resulting in maximum of 5/day northbound and 5/day southbound for recreational vessels • As-needed lockages for commercial and maintenance vessels, typical average of 1 to 2 lockages/day in each direction based on historical data • Implement extended alternating double draining at Locks C1 and C2[3] • Implement revised Lock C1 seasonal Tainter gate operations	• Monitoring for round goby within Champlain Canal system to track advancement • Continued coordination with partner agencies • Community education and outreach • Additional boat launch stewards • Evaluation, planning and development of medium and long lead-time deterrents • Inform public & stakeholders of restrictions on operations
Level 1 Trigger	• Round goby detected between Locks C1 and C2	**Level 1 Response**	• Implement scheduled lockages for recreational vessels at Locks C2 and C3 resulting in maximum of 4/day northbound and 4/day southbound lockages for recreational vessels • As-needed lockages for commercial and maintenance vessels, typical average of 1 to 2 lockages/day in each direction based on historical data • Implement extended alternating double draining of Locks C2 and C3 • Based on determination of established population, discontinue extended alternating double draining and scheduled lockages at Lock C1	• Monitoring for round goby within Champlain Canal system to track advancement • Continued coordination with partner agencies • Community education and outreach • Additional boat launch stewards • Evaluation, planning and development of medium and long lead-time deterrents • Inform public & stakeholders of restrictions on operations

[2] See Appendix A for detailed explanation of different response actions

[3] The effectiveness of extended alternating double draining will be further evaluated; see Appendix C for a description of the extended alternating double draining procedure

Condition			Trigger Action Rapid Response[2]	Communication & Long-Term Actions
			• Implement revised Lock C1 seasonal Tainter gate operations.	• Conduct **weekly** status calls with partner agencies, as needed
Level 2 Trigger	• Round goby detected between Locks C2 and C4	**Level 2 Response**	• Implement moderate restrictions on vessel traffic consisting of: ○ Maximum of 3/day northbound and 3/day southbound for recreational vessels at the next two locks upstream of last known area of detection ○ As-needed lockages for commercial and maintenance vessels, typical average of 1 to 2 lockages/day in each direction based on historical data • Implement extended alternating double draining at next two locks upstream of last known area of detection • Accelerate evaluation and implementation of additional deterrents at lock(s) upstream of last known area of detection • Based on determination of established population, discontinue extended alternating double draining and scheduled lockages downstream of last known area of detection • Implement revised Lock C1 seasonal Tainter gate operations	• Monitoring for round goby within Champlain Canal system to track advancement • Continued coordination with partner agencies • Community education and outreach • Additional boat launch stewards • Evaluation, planning and development of medium and long lead-time deterrents • Conduct weekly status calls with partner agencies, as needed • Inform public & stakeholders of restrictions on operations

Conditions			Trigger Action Rapid Response	Communication & Long-Term Actions

Level 3 Trigger	• Round goby detected between Locks C4 and C5	**Level 3 Response**	• Implement dramatic restrictions on vessel lockages at Locks C5 and C6 consisting of:
			  ○ Maximum of 2/day northbound and 2/day southbound for recreational vessels at the next two locks upstream of last known detection
			  ○ As-needed lockages for commercial and maintenance vessels, typical average of 1 to 2 lockages/day in each direction based on historical data
			• Implement extended alternating double draining at Locks C5 and C6
			• Accelerate evaluation and implementation of additional deterrents at lock(s) upstream of last known area of detection
			• Based on determination of established population, discontinue extended alternating double draining and scheduled lockages downstream of last known area of detection
			• Implement revised Lock C1 seasonal Tainter gate operations
				• Monitoring for round goby within Champlain Canal system to track advancement
				• Continued coordination with partner agencies
				• Community education and outreach
				• Additional boat launch stewards
				• Evaluation, planning and development of medium and long lead-time deterrents
				• Conduct weekly status calls with partner agencies, as needed
				• Inform public & stakeholders of restrictions on operations

Condition			Trigger Action Rapid Response[4]	Communication & Long-Term Actions

Level 4 Trigger	• Round goby detected between Locks C5 and C8 or upstream in the Hudson River between the Glens Falls Feeder Canal and Great Sacandaga Lake	**Level 4 Response**	• Closure of Locks C8 and C9 for all recreational and commercial traffic as follows:
			  ○ If round goby is detected between Locks C5 and C8, close Lock C8 and C9
			  ○ If round goby is detected upstream in the Hudson River between the Glens Falls Feeder Canal and Great Sacandaga Lake, close Lock C8 and close or install alternative deterrent, such as an intake screen with pump bypass with round goby filter, at the entrance to the Glens Falls Feeder Canal
			  ○ Lock closure would not preclude users from operating above and below the closed lock, no provision made for lifting boats around locks, but may be considered long-term
			  ○ There may be limited specific exceptions, such as Canal Corp maintenance vessels conducting necessary operations and maintenance along canal
			• Manage water flow within the Champlain Canal system to prevent spillage over Lock C9 so that Lock C9 becomes a second redundant deterrent to round goby passage
			• Continue extended alternating double draining and scheduled lockages of the next two locks upstream of last known area of detection, but not north of C8
			• Based on determination of established population, discontinue extended alternating double draining and scheduled lockages downstream of last known area of detection
				• Monitoring for round goby within Champlain Canal system to track advancement
				• Continued coordination with partner agencies
				• Community education and outreach
				• Additional boat launch stewards
				• Evaluation, planning and development of medium and long lead-time deterrents
				• Conduct weekly status calls with partner agencies, as needed
				• Inform public & stakeholders of lock closures

[4] See Appendix A for detailed explanation of different response actions

Condition			Trigger Action Rapid Response[4]	Communication & Long-Term Actions
Level 4 Response		**Level 4 Response**	• Accelerate evaluation and implementation of additional deterrents at lock(s) upstream of last known area of detection	

2.0 ROUND GOBY BIOLOGY AND ORIGIN

The round goby is a small benthic fish native to the Black Sea in Central Eurasia. It has been introduced to many regions of the world, including North America. Adult round goby can grow up to seven inches in length, and are generalist benthic predators that consume invertebrates, small fish, fish larvae and fish eggs. They also prey on invasive dreissenid mussels (zebra and quagga mussels). Adults are prolific spawners, spawning every three to four weeks through the spring and summer months (Kornis et al. 2012).

Once established, round goby interact with other species directly though predation and indirectly through competition, altering faunal community dynamics, and altering water quality (George et al. 2021, Janssen and Jude 2001, Kornis et al. 2012, Lauer et al. 2004). Additionally, round goby can harbor and transfer disease to higher trophic levels (Getchell et al. 2019).

3.0 ROUND GOBY INTRODUCTION AND MOVEMENT IN NEW YORK STATE

In North America, the round goby was first introduced to the Laurentian Great Lakes through ballast water (Kornis et al. 2012). Additionally, introductions are likely to have occurred due to bait bucket transfer and/or by recreational boaters (Gutowsky and Fox 2011, Brownscombe et al. 2012, Johansson et al. 2018, Bussmann et al. 2022). The round goby was initially discovered in 1990 in the St. Clair River, which connects Lake Huron and Lake Erie. By 1995, round goby had spread to all five great lakes (George et al. 2021). In July 2021, the round goby was captured in the Hudson River south of the Troy Federal Lock and Dam. Continued downstream expansion through most or all of the tidal length of the Hudson River is likely. There is heightened concern over the potential spread of the invasive fish upstream through the Champlain Canal into Lake Champlain. Through December 2022, the furthest detected upstream dispersal of round goby is immediately below the dam at Lock 1[5], which is immediately upstream of the Mohawk River confluence in Waterford.

In addition to the round goby being present throughout the Great Lakes and Erie Canal/connected waterbodies, round goby is present along the Saint Lawrence River between Lake Ontario and Quebec. The Richelieu River and the Chambly Canal/lock system connect the Saint Lawrence River to the north end of Lake Champlain and the Quebec Ministry of Forestry, Wildlife and Parks conduct surveys annually to monitor for certain fish species, including the round goby.

3.1 Potential Impacts of Round Goby

The impacts of round goby to aquatic systems in New York State has varied over time and location with both negative and positive population level responses from different fish species, disruption of historic predator/prey relationships and ecosystem-scale impacts. Once introduced, round goby can rapidly establish robust populations that alter the fish and invertebrate communities. For example, in Oneida Lake in New York State round goby became the dominant benthic fish species while the native darter and sculpin populations declined within two years of its introduction. Conversely, round goby provides a food source for predatory game species in the lake, though they also prey on game species' eggs. round

[5] U.S. Geological Survey, 2023, Specimen observation data for *Neogobius melanostomus* (Pallas, 1814): U.S. Geological Survey Nonindigenous Aquatic Species Database data, https://nas.er.usgs.gov/queries/collectioninfo.aspx?SpeciesID=713.d

goby prefer invasive mussels as a food source, including zebra and quagga mussels, which could potentially reduce populations of these invaders. These varied observations of round goby impacts are consistent with patterns seen in other invaded waterbodies (Hirsch et al. 2016). Round goby also can be carriers of viral haemorrhagic septicaemia virus, which is transmissible to other fishes and has been identified from fish kills in New York. As with many invasive species, the long-term effects of their introduction are not yet fully understood.

Lake Champlain, the sixth largest freshwater lake in North America, attracts tens of thousands of tourists each year, and its fisheries catalyze spending throughout the Lake Champlain Basin and upstate New York region. The introduction of the round goby could disrupt angling, which could have a significant economic impact. Total spending by anglers on Lake Champlain exceeds $205 million annually (Decerega et al. 2016). Over 150 aquatic invasive species have already invaded New York waterways resulting in an estimated $500 million in economic losses annually (NYSDEC 2015).

3.2 Round Goby Dispersal

Round goby have three different mechanisms for dispersal (Table 2):

- Active dispersal via swimming
- Passive dispersal via downstream flow
- Assisted dispersal as stowaways or hitchhikers in a small pocket of water.

The following summarizes the current information available regarding vectors that would allow this species to move within or across waterbodies.

Following its initial introduction, round goby has spread via both active and assisted dispersal through commercial shipping within invaded ecosystems (Kornis et al. 2012). Individuals are typically sedentary (Björklund and Almqvist 2010) with limited home ranges [conservatively estimated at 5 m^2 by Ray and Corkum (2001) but may occasionally move long distances. River colonization appears to be driven by a combination of active dispersal over short distances by many individuals and long-distance active dispersal by migrant individuals (Bronnenhuber et al. 2011). Tierney et al. (2011) were able to demonstrate that round goby were surprisingly good swimmers, despite their benthic adaptations, utilizing a form of 'burst-and-hold' swimming (startle bursts of up to 163 cm/s recorded).

It is thought that the round goby was introduced to the Great Lakes via freighter ballast. Assisted dispersal of gobiids by ships, especially cargo vessels, seems to occur regularly (Ahnelt et al. 1998) due to the goby concealment behavior, in which round goby may occupy openings and depressions on ships hulls. Round goby have been noted to utilize boat surfaces and vertical walls for feeding, cover, and possibly nesting habitat, with one survey observing 28 gobies on one boat hull during a 45-minute period (Bussmann and Burkhardt-Holm 2020). Males can construct nests in ships hulls and be transported together with fertile eggs for long distances. This behavior, along with their dockside presence, predisposes gobies to be entrained into ballast tanks. A recent study in Switzerland found evidence of larval round goby in small watercraft motor cooling systems (Bussmann et al. 2022) indicating that any kind of in-water deterrent would not counteract stowaways.

Once established in the Great Lakes round goby expansion has continued through waterways, including the New York State Canal system and Saint Lawrence River, through active dispersal and assisted dispersal. This is indicated by the calculations of dispersal rates (presented in Section 4) that are consistent with natural dispersal; and rates that are higher than natural dispersal suggestive of assisted

dispersal via boat or angler. Two assisted dispersal mechanisms that could explain the rapid dispersal rate in New York waters are transfer via angler bait buckets and on recreational boats.

Bait bucket transfer occurs when an angler collects a goby from an infested waterbody and releases it elsewhere. An introduction of this sort alters an invasion's trajectory from a natural mechanism of dispersal within connected systems to an anthropogenic mechanism that can occur either within a connected waterbody or within an entirely different drainage. Bait bucket introductions have been attributed as the likely source of range expansion beyond the known invasion front of goby in the Trent River in Ontario (Brownscombe et al. 2012). Likewise, the round goby presence in Little Lake Butte des Morts (LLBDM), Fox River, Wisconsin in September 2015 was attributed to anthropogenic introduction because this incursion occurred during a period when there were five unrestored locks and three miles of dewatered channel downstream of LLBDM (Fox River Navigational System Authority letter to Wisconsin Department of Natural Resources, dated September 24, 2018).

Round goby are not legal to sell as bait in New York or surrounding states, so the transfer of the round goby through bait buckets would likely depend on anglers capturing their own bait and then bringing that bait elsewhere. New York regulations also prohibit the use of gobies as bait, which means anglers are not allowed to harvest them. In addition, New York has regulations in place that limit the personal use of bait to the same body of water the bait was collected in or within three designated transportation corridors of that waterbody. The best method of preventing bait bucket transfers would be through education and outreach to the angling community.

Recreational boating is a potential pathway for the unintentional introduction of round goby into waterbodies (Bussmann et al. 2022). Round goby larvae and adults will hide in and can survive transport in wetted crevices or compartments of recreational or commercial vessels, which could include openings in the hull, ballast tanks, live well, bilge, and even motors (e.g., backup motors, jet drive/directional thrusters, sail boats, etc.).

To prevent the spread of round goby through this pathway, all boaters launching watercraft in New York must adhere to the AIS Spread Prevention regulation, or 6 NYCRR Part 576, which requires that "reasonable precautions", such as cleaning, draining and treating, and drying are taken to prevent the spread of AIS prior to placing watercraft or floating docks into public waterbodies. Many New York counties, towns, and villages also have laws in place that prohibit the transport of aquatic invasive species on boats, trailers, and equipment. These statewide regulations apply to both private and public launches on public waterbodies within the state. Watercraft are defined as any motorized or non-motorized boats, vessels, or vehicles capable of being used for recreation or transportation on water.

The New York State Department of Environmental Conservation (NYSDEC) administers several education and outreach programs designed to mitigate human-assisted spread of AIS including its Watercraft Inspection Steward Program (WISP), which is active at greater than 250 boat launches across New York State.

Table 2. Evaluation of Dispersal Mechanisms and Relative Risk of Establishment

Vector	Life Stage	Establishment Risk	
		Severity	Probability
Active Dispersal- Swimming/Crawling	Adult	High – movement is slow, but gravid female has several thousand eggs; male needed to fertilize eggs. In addition, there are migratory individuals who are seeking new habitat.	High
Passive Dispersal- Downstream Drift	Larval/ Juvenile	High – if entry point is from Glens Falls Feeder Canal and dispersal from summit pool (area of the canal between locks) between Locks C8 and C9 is towards northward-flowing canal above Lock C9. Low – if round goby is present below Lock C7.	Moderate Low
Assisted Dispersal - On Boat/Barge Hull/ External crevices	Adult	Moderate – gravid female has several thousand eggs; male also needed to fertilize eggs; boat could move well beyond invasion front. Males have been documented nesting in boat hull crevices and a nest can have up to 10,000 eggs.	Moderate
Assisted Dispersal - In Boat Interior Spaces	Adult/ Juvenile/ Larval	Moderate – gravid female has several thousand eggs; male needed to fertilize eggs; boat could move well beyond invasion front.	Moderate
Assisted Dispersal- Bait Bucket Transport	Adult/ Juvenile/ Larval	Moderate – gravid female has several thousand eggs; male needed to fertilize eggs; transport could be well beyond invasion front.	Low

4.0 RISK OF UPSTREAM DISPERSAL THROUGH THE CHAMPLAIN CANAL

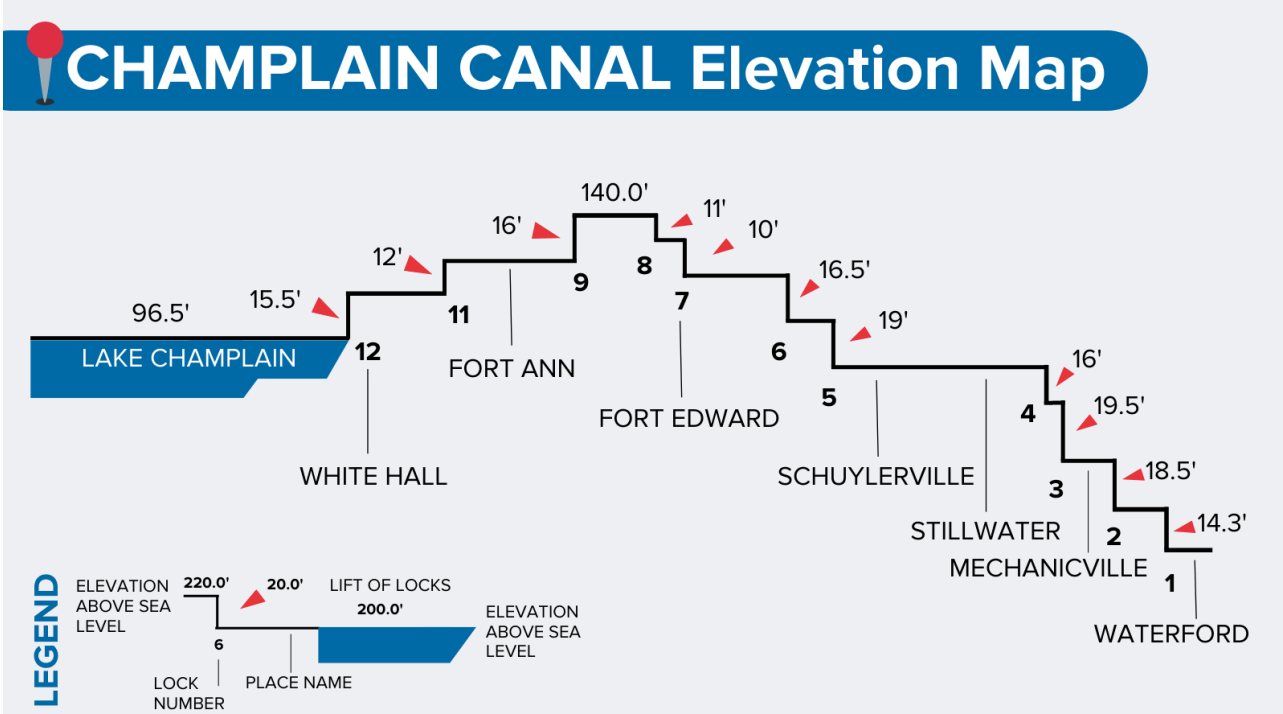
4.1 Overview

The primary purpose of this RRP is to prevent the round goby from moving into and through the Champlain Canal system into Lake Champlain. Round goby have been detected immediately downstream of Lock C1. For upstream dispersal to occur, round goby must overcome several limitations to expansion. In addition to upstream resistance from river currents, there are several natural barriers (falls) along the upper Hudson River between Waterford and Hudson Falls. Through six canal locks (Locks C1 through C6), the upper Hudson River is bypassed through the Champlain Canal. Therefore, the

Champlain Canal system can allow for the potential for round goby movement northward to the Lake Champlain Basin.

In total, between the confluence of the Mohawk and Hudson rivers and Lake Champlain, there are 11 locks. Locks C1 through C6 are all within the mainstem of the Hudson River. At Lock C7, the canal diverges from the Hudson River into what is referred to as the 'land cut' portion of the Champlain Canal (i.e., the portion north of Lock C7). Along the mainstem of the Hudson River there is a gain of approximately 115 feet of elevation over 35 miles with lock heights ranging between 14.25 feet and 19 feet. Within the land cut between the Hudson River and Lake Champlain, the first two locks (C7 and C8) raise another combined 21 feet over two miles before reaching the 'summit pool' or highest point of elevation of the canal between Locks C8 and C9. From Lock C9, the canal drops approximately 43.5 feet over approximately 16 miles before entering Lake Champlain. Dams are also present at several locations along the Champlain Canal, many of which are co-located with locks, as detailed in Appendix D.

The Plan considers these elevation changes and hydrologic conditions, in combination with data from other round goby migratory patterns, to establish an escalation strategy to address spread via the Champlain Canal to Lake Champlain.



4.2 Calculating Dispersal Rates

George et al. (2021) published the results of an investigation of round goby distribution in the section of the canal system between the eastern end of Oneida Lake and Federal Lock at Troy, New York from 2016 through 2019. based on data collected in this study, the authors concluded that there was minimal expansion eastward of round goby during the four-year study period. However, the authors did note that expansion rates could accelerate in sections where the canal and Mohawk River share the same channel. As referenced in the study, typical upstream expansion rates measured in other systems range

from 0.31 miles per year to 2.48 miles per year. Downstream expansion rates may be as high as 15.5 miles per year.

In 2021, sampling in the Mohawk River/Erie Canal between Oneida Lake and Troy revealed numerous detections of round goby as far east as Troy, New York. These detections marked an extraordinary expansion of round goby. Assuming expansion occurred through the Mohawk River/Erie Canal, the rate of expansion would greatly exceed both the accepted rate of expansion from the monitored invasion front and rates cited in literature. Maximum downstream dispersal rates are commonly cited at 15.5 miles per year; however large rapid changes in goby distribution, over 50 miles per year, have been noted in recent years and indicate the potential for assisted dispersal via watercraft or bait buckets. Although inconclusive, this discrepancy points to assisted dispersal mechanisms noted above, such as stowaways on or in boats, or transfer via bait buckets.

The Trent-Severn Waterway in Ontario, Canada is a riverine system that was invaded by the round goby through dispersal and spawning. In the Trent-Severn Waterway, gobies were first documented in the Trent River in 2003 and, by 2012, were present approximately 38 miles upstream (an average rate of about 4 miles per year). In this lock and river system, upstream dispersal occurred at approximately 8 miles per year. However, upstream range expansion in the Trent-Severn Waterway averaged only 1.9 miles per year in the first five years (Brownscombe et al. 2012).

While these rates of dispersal in other locations support estimation of passive dispersal rates for the Champlain Canal (Table 3), each waterway system is unique. The availability of high-quality habitat, which includes brackish water conditions, hard substrates, and an abundant food source such as zebra mussels, has been found to promote expansion rates while low quality habitat has the converse effect (Brownscombe et al. 2012). Coupled with flow rates, distance, and elevation change, evaluation of the habitat in the Champlain Canal system, including riverine and manmade segments, could further inform modeling of possible expansion rates.

Table 3. Summary of Distance Between Champlain Canal Locks and Estimated Passive Dispersal Time of round goby.

Canal Section	Distance (miles)	Longitudinal Channel Slope	Estimated Dispersal Rate (miles/year)		Estimated Dispersal Time (years)	
			Best Case[6]	Worst Case[7]	Best Case[2]	Worst Case[3]
C1 to C7	33.6	Upgradient	3	14	11.2	2.4
C1 **to C2**	3.8	Upgradient	3	14	1.3	0.3
C2 to C3	2.7	Upgradient	3	14	0.9	0.2
C3 to C4	1.9	Upgradient	3	14	0.7	0.1
C4 to C5	14.4	Upgradient	3	14	4.8	1.0
C5 to C6	3.7	Upgradient	3	14	1.2	0.3
C6 to C7	7.1	Upgradient	3	14	2.4	0.5
C7 to Feeder Canal Inlet	4.1	Upgradient	3	14	1.4	0.3
C7-C8	2.2	Upgradient	3	14	0.7	0.1
C8-C12	21.5	Downgradient	15	15	1.4	1.4
Great Sacandaga Lake to Feeder Canal Inlet	35.8	Downgradient	15	15	2.4	2.4

Note - Dispersal rates are estimated based on peer review research papers referenced in this document and historic data. Actual dispersal rates in a riverine environment may differ because of assisted dispersal mechanisms and will be updated as data become available over time.

[6] Based on slow dispersal.

[7] Based on rapid dispersal.

5.0 ROUND GOBY DISTRIBUTION MONITORING

The Lake Champlain Basin Program (LCBP) has contracted with the U.S. Geological Survey (USGS) to perform trawl and electroshocking surveys and environmental DNA (eDNA) surveys between 2022 and 2024. In 2022, additional survey work above and below the locks on the Champlain Canal and within other potential introduction points to the Champlain Canal was conducted by the USGS, U.S. Fish and Wildlife Service (USFWS), NYPA/Canals, and DEC. Plans for 2023 monitoring are currently being finalized. Efforts are underway to expand sampling locations to encompass other vectors of introduction of the round goby into Lake Champlain. The Canal Corporation and NYSDEC will sponsor additional sampling, as needed, ensuring a representative survey and minimizing data gaps. Sampling locations will be adapted as previous results and findings are considered, and will include but not be limited to:

- At the confluence of the Mohawk and Hudson Rivers
- Downstream of Lock C1
- Upstream of Lock C1
- Downstream of Lock C2
- Upstream of Lock C2
- Between Locks C4 and C5
- Near Fort Edward near Lock C7
- Within the Hudson River, upstream of the Glens Falls Feeder Canal

6.0 CRITICAL POINTS ALONG THE CHAMPLAIN CANAL

Within the Champlain Canal system there are three critical points that will indicate a significant shift in the distribution of round goby and increase the urgency to act and prevent the northward dispersal towards Lake Champlain. These are at Locks C2, C7, and C8. The TARP included in Section 1 includes potential response actions at these critical control points as well as other locks. There are seven dams on the Hudson River between Waterford and Fort Edward, which are likely to present a significant impediment to the northward dispersal of the round goby. Critical control points will be shifted to best prevent further upstream spread at the invasion front.

Lock C2 is the southernmost control point, representing an early-warning, or sentinel function. The dam at Lock C1 has a Tainter-style water control gate that is opened in the winter, which reduces the physical deterrent to upstream dispersal when the gates are raised. Because of this design at Lock C1, Lock C2 may provide a more significant deterrent to upstream dispersal than Lock C1. As Lock C2 is within the Hudson River, it has heavier flow rates than non-riverine sections of the canal, which may potentially slow the upstream dispersal of round goby. However, if round goby enter the pool above Lock C2, it indicates that round goby have the potential to traverse the pools and locks within the remaining upstream locks on the mainstem River.

The second critical point is at Lock C7 where the Champlain Canal leaves the Hudson River. If round goby breach this barrier, then they will be within a heavily regulated and controlled waterbody with reduced flow rates. Dispersal within this canal section may be similar to what was seen within the western region of the Erie Canal (defined by the New York State Canal Corporation as the section between the Niagara River and the east end of Oneida Lake, specifically the western end of the Sylvan Beach breakwater).

The third critical point is at Lock C8, which represents entrance to the highest elevation pool along the canal system; this ‘summit pool’ is contained by Locks C8 and C9. Once round goby pass through the Lock C8 barrier, then dispersal northward would be assisted by downstream flow through Lock C9 to Lake Champlain, which would likely occur more rapidly as observed in the eastern section of the Erie Canal.

7.0 REGULATORY COMPLIANCE

As discussed in Section 1, the potential response actions that may be implemented are considered temporary measures. Following implementation, the need for continued implementation would be evaluated based on multiple factors. How rapidly the different response actions could be implemented depends on numerous factors, and can generally categorized as short-term, mid-term and long-term, as discussed below.

In general, actions identified as short-term will be quick to implement with minimal to no regulatory requirements (i.e., permitting) and will include actions that are minor operational changes or infrastructure modifications (e.g., scheduled lockages).

Mid-term actions will likely require an increased level of regulatory compliance and documentation. These actions will generally take longer to plan, document, and implement, and may be subject to State Environmental Quality Review (SEQR) Act and State Historic Preservation Office (SHPO) review. In particular, the New York State Canal System has been designated a National Historic Landmark. These actions will consist of operational changes that differ significantly from past practice or result in moderate modification to qualities contributing to the historic character of a resource.

Long-term actions will also likely require significant permitting requirements or involve significant resource allocation. These actions will take the longest to plan, document, and implement, and will be subject to SEQR, SHPO, and federal/state permitting. For example, design and construction of a permanent deterrent (e.g., electric barrier) would require design, funding, regulatory approval, and adjustments to current navigation, operations and maintenance plans prior to implementation. In addition to SEQR and SHPO, depending on the response action, additional consultations, permits, approvals, and/or notifications may include:

- U.S. Army Corps of Engineers (USACE) - Nationwide Permit (NWP) Pre-construction Notification (PCN), Section 408 Civil Works Review, Transportation Regional General Permit (TGRP-1) Request for Authorization (RFA)
- U.S. Coast Guard - Local Notice to Mariners
- USFWS - Section 7
- National Oceanic Atmospheric Administration (NOAA), National Marine Fisheries Services (NMSS) – Section 7
- NYSDEC - Article 15 Protection of Waters substantive requirements, Incidental Take, Section 401 Water Quality Certification (WQC), Floating Objects, Article 24 Freshwater Wetlands
- NYS Department of State (NYSDOS) - Coastal Consistency Concurrence
- NYS Office of General Services (NYSOGS) - State-Owned Lands Underwater License/ Easement/ Permit
- NYS Office of Parks/Special Use Areas - Floating Objects,
- Municipal - Floodplain Development

8.0 GOBY MITIGATION AND RESPONSE ACTIONS

An initial list of potential mitigation measures and response actions that could reduce the overall risks of round goby dispersal in the Champlain Canal system was developed based on opportunities presented by the critical control points and other locks, round goby ecology and dispersal mechanisms, and additional factors. Response actions being considered within this plan include a number of proactive mitigation measures as well response actions that can be implemented at site -specific critical control points and other locks.

For the purpose of these response actions, "detection" encompasses any sampling method, including eDNA collection and traditional sampling means. Given the imprecise nature of eDNA data, any new detection should be validated for QA and follow-up samples should be collected to confirm an upstream presence of round goby.

8.1 General Mitigation Measures

Invasion Front Monitoring –NYPA/Canals and NYSDEC will coordinate with external agencies and partners to monitor the invasion front of the round goby in the canal. Monitoring locations will be modified (i.e., moved upstream) as the invasion front moves. Additional locations upstream of the invasion front are anticipated to be sampled to confirm round goby have not leapfrogged past the invasion front monitoring locations.

Monitoring techniques will focus on multiple lines of inquiry, including traditional sampling (e.g., electrofishing, bait traps), and eDNA surveys. As discussed in Section 5, LCBP has contracted with USGS and USFWS to implement round goby surveys between 2022 and 2024, and several other monitoring efforts are planned for 2023.

Education and Outreach – In response to detections of round goby within the Champlain Canal system, NYPA/Canals and NYSDEC have partnered with external agencies (e.g., LCBP) to develop consistent stakeholder outreach strategies and material including increased programs to educate the public about the dangers of transporting and introducing the round goby through bait buckets, etc. The Canal Corporation will assist with dissemination of material and information through social media, canal guides/signage, and via distribution at locks or other canal events. A key focus of education and outreach will be informing the public about spread of AIS via bait buckets and watercraft. An example of newly developed outreach material is the NYSDEC round goby web page found at https://www.dec.ny.gov/animals/125510.html [dec.ny.gov].

Early Action/Long-lead Planning – NYPA/Canals and NYSDEC have Initiated planning, organization and preparation needed for rapid deployment of critical control point actions. This includes planning for engineering, permitting, and procurement needed to stage, pre-deploy, and implement key actions, including staffing and operation and maintenance planning.

8.2 Potential Response Actions

Potential response actions include canal operations adjustments as well as barriers and deterrents, as summarized below and detailed in Appendix A.

Canal Operations Adjustments – Operational adjustments may range from simple to more complex actions requiring regulatory justification. The following operational adjustments have been identified as potential actions:

- Scheduled lockages
- Extended alternating double draining
- Restrictions on the number of daily lockages
- Enhanced dewatering of the land cut
- Revisions to the seasonal operations of Lock C1 Tainter gate
- Lock closure
- Closure of the Glens Falls Feeder Canal

As noted in the TARP included as Table 1, NYPA/Canals has already implemented several operational adjustments to prevent round goby dispersal. These adjustments include implementing changes to the lock draining procedures, scheduled opening/closing C1 Tainter gates, and winter operation of the locks, as described below.

Modification to Lock Draining Procedure: Currently, double draining is being performed at Locks C1 and C2, which are closest to the invasion front that is immediately downstream of Lock C1. During standard operations, water is discharged during lock draining through discharge openings on each side of the canal immediately downstream of the lower gate. The goal of the double-draining procedure initiated in 2022, as opposed to the traditional single-draining procedure, was to enhance 1) flushing of round goby out of the lock chamber and culverts before opening the upstream gates to boats, and 2) flushing of round goby from the area downstream of the discharges located immediately downstream of the lower gates prior to opening the upstream gates.

A computational fluid dynamic (CFD) model of Lock C2 was subsequently developed to analyze the potential effectiveness of the double-draining procedure to reduce the potential for round goby to move into and through Lock C2, and to evaluate potential methods to improve the effectiveness of lock draining in deterring round goby movement upstream into a lock. The full modeling report is included as Appendix E. Model results of the double-draining process, as implemented in 2022, show-velocities exceed round goby swim speeds in the downstream approach to the lock and in the discharge tunnels shortly after the valves are opened and draining begins.

Model runs of multiple alternative draining scenarios were also evaluated as discussed in Appendix E. Based on these evaluations, a revised protocol was developed for the double-draining procedure to open the valve on one side of the lock for 30 seconds before opening the valves on both sides of the lock to more effectively sweep the sides of entryway to the lock. During the second draining, the valve on the other side of the lock would be opened first. Both drainings should be completed before the lower gates are opened to allow a vessel to enter the lock. It was also concluded that it would be preferable to only open the valves ⅔ of the way to prolong the time the velocities exceed the round goby burst swimming speed of 4.1 ft/s. The extended alternating double-draining process should be more effective at preventing round goby from moving upstream into the lock than the traditional single draining because it enhances sweeping of round goby downstream away from the lower gate as the lock is drained and it extends the duration of high flow velocities; this approach will be implemented in 2023. Specific operational procedures are provided in Appendix C.

After the lock chamber is drained, water levels in the lock remain approximately 14 feet deep; this means that approximately 180,000 cubic feet of water remain in the lock chamber after it has been drained. Given the size of the lock chamber and the volume of remaining water, a round goby that entered the lock chamber could easily avoid being pulled out of the lock chamber by entrainment flows and into the sub-culverts in the lock wall used to drain water out of the lock. Model results indicate that velocities high enough to potentially entrain a round goby are only present in the immediate vicinity of the sub-culvert openings. Therefore, the draining process is unlikely to flush round goby out of the lock after they have entered due to the overall size of the locks relative to the size and velocities associated with the sub-culvert openings that drain the water.

Revised Seasonal Operation of Lock C1 Tainter Gates: Another operational adjustment NYPA/Canals has already implemented to prevent round goby dispersal is revising the Tainter gate removal and installation schedule adjacent to Lock C1. Unlike the fixed dams present adjacent to Locks C2 through C6, the water level at Lock C1 is controlled by Tainter gates which are closed during the normal canal operating season to maintain the navigation pool behind the gates, dam and adjacent Lock C1. This provides a seasonal barrier to upstream movement for round goby. The Tainter gates have historically been opened after the navigation season ends (typically in October) to drain the navigation pool and prevent ice damage to the gates, and then re-closed in May.

While information on round goby movement related to specific water temperatures is limited, several relevant journal articles note seasonal movement patterns, with goby moving into shallower, inshore/upstream areas during the summer and retreating downstream into deeper waters during the winter (Appendix F). These, along with a general understanding of fish behavior, energetics, and ecology, indicate that there would be a benefit to leaving the movable dams in place as long as practicably possible.

In fall of 2022, USGS and NYSDEC monitored water temperatures immediately below Lock C1 as part of their round goby monitoring program. Through November 7th, they had consistently captured goby immediately below the Tainter gates at the C1 dam. The water temperature on November 7th was 61 ^{0}F. No round goby were captured during their final two surveys, conducted on November 21st and November 28th, when the water temperature was 41 ^{0}F and 42 ^{0}F, respectively. At their positive control site on the Mohawk River at Peebles Island where goby are normally abundant, sampling efforts produced only 1 goby on 11/21 and no goby on 11/28. These findings provide supporting evidence that round goby may be moving out of the shallow/higher velocity areas when temperatures are lower.

Therefore, starting in fall 2022, the Tainter gate schedule was modified to keep the Tainter gates in place for a longer period, namely, to open the gates in December, and re-close them). earlier in the spring. In 2023, a water temperature trigger of 40^0 F[8] was used to begin closing the gates on March 24. Aerial drone videos were collected in January 2023 when the Tainter gates were open. The results indicate that even when the Tainter gates are open, the water velocity over the gate sill exceeds the round goby burst swimming speed of 4.1 ft/s, indicating that even when open, the Tainter gate structure serves as a deterrent to round goby movement under most flow conditions.

Winter Operations at Locks: An additional operational adjustment NYPA/Canals has already implemented to prevent round goby dispersal pertains to winter operations of the Locks. The drain valves and lower gate were maintained in closed positions at Locks C1 and C2 throughout the 2022/2023

[8] As measured at the USGS Cohoes Falls Gage.

non-navigation season to prevent round goby from moving upstream into the locks. However, there may be times when maintenance or flooding considerations will preclude this measure and require the valves and/or lower gates to be opened during the winter. While this could potentially allow round goby to move into a lock, they would be prevented from moving further upstream past the upstream gates and valves, which can be left closed during maintenance and flooding events. Under this situation, it would be beneficial to treat the lock with a piscicide prior to the spring reopening to eliminate round goby that may be present within the lock. Piscicide treatments are a relatively standard fisheries management practice used by resource agencies. In 2023, NYSDEC and NYPA/Canals, in conjunction with other partners, will use dye tracer studies and laboratory bench testing to develop a pilot test for piscicide application in a lock to eradicate any goby that have entered the lock structure.

Barriers and Deterrents – These potential response actions consist of measures designed to deter dispersal of round goby within the Champlain Canal System and include:

- Localized use of piscicide
- Temporary benthic (bottom) electric deterrent
- Air-injection bubble curtain
- Deterrent lighting
- Partial height bottom deterrent
- Acoustic goby trap
- Screened intake/bypass of Glens Falls Feeder Canal

Development of barriers and deterrents such as electric deterrents, traps or bubbler systems generally fall into the mid-term or long-term implementation categories. A temporary electric barrier may provide a significant deterrent to round goby migration but would require more significant effort to implement as a response action. Therefore, a basic framework for design and fabrication of a temporary electric barrier for potential deployment in the Champlain Canal is provided in Appendix G. Piscicide application does not require physical construction of a deterrent and therefore could be implemented more rapidly.

This list represents an initial list of opportunities to limit the expansion of round goby into the Champlain Canal system and will be revised and refined as additional data become available.

NYPA/Canals has initiated an evaluation of long-term deterrent technologies for use at Lock C8 and potentially other locks. In order to be successful, modifications or deployment of deterrent technologies at the Glens Falls Feeder Canal may also be necessary and will also be evaluated.

USACE and LCBP have undertaken a feasibility study for a permanent, all taxa barrier at the summit level of the Champlain Canal (USACE 2022). Evaluation of that study is outside the scope of this Plan; however, developments in the planning and design of this barrier will inform future Plan actions.

9.0 RESPONSE ACTION EFFECTIVENESS AND IMPLEMENTATION RISKS EVALUATION

The TARP in Section 1 was developed taking into consideration the anticipated effectiveness and potential implementation risks and impacts associated with each of the potential response actions discussed in Section 8.2. Response actions were developed to provide the best balance between urgency of threat based on detection point, effectiveness, and implementation risks.

The effectiveness evaluation considered:

- Effectiveness of deterring round goby dispersal by boat in the canal system
- Effectiveness of deterring round goby dispersal by swimming in the canal system

The evaluation of potential implementation risks and impacts considered:

- Potential public health and safety risks
- Potential environmental impacts within the canal system
- Potential financial impacts
- Potential impacts to canal system users

The detailed evaluation is included as Appendix B. Listed and protected species potentially present within the Champlain Canal and how they may be impacted by potential response actions were considered in the evaluation and are detailed in Appendix H. Historical recreational and commercial vessel usage of the locks and potential impacts to usage of the locks that would result from the potential response actions were also considered in the evaluation and are detailed in Appendix I.

The goal was to develop TARP response actions that were effective, progressive, and commensurate with the level of risk presented to dispersal via the canal system to Lake Champlain, taking into consideration round goby dispersal rates as discussed in Section 4.2, while minimizing potential response action implementation risks and impacts. The effectiveness and impacts assessment, as well as the TARP, will be updated as additional data and new response actions become available.

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APPENDIX A DESCRIPTIONS OF POTENTIAL RESPONSE ACTIONS

Champlain Canal Potential Round Goby Deterrents

Note, see Supplemental Information following listed deterrents for additional details

Deterrents Evaluated for Locks[9]

1. Extended alternating double draining

- To deter upstream movement of the round goby, the lock will be drained twice prior to opening of the lower gates to allow boat passage. Sequencing details are provided in Appendix C. The extended alternating double-draining process is more effective at preventing round goby from entering the lock than traditional single draining because it enhances sweeping of round goby downstream away from the lower gate as the lock is drained, as detailed in Appendix E.

2. Scheduled Lockages

- Scheduled lockages for northbound and southbound recreational vessels resulting in maximum of 4 or 5 lockages/day for northbound and 4 or 5 lockages/day for southbound recreational vessels.
- As-needed lockages for commercial and maintenance vessels, average of 1 to 2 lockages/day in each direction typical based on historical data.
- 5 lockages/day would result in less than 5% reduction in recreational lockages and less than 5% reduction in total lockages.
- 4 lockages/day would result in a 5% to 10% reduction in recreational lockages and a 5% to 10% reduction in total lockages.

3. Moderate Restrictions on Vessel Traffic

- Maximum of 3 lockages/day for northbound and 3 lockages/day for southbound recreational vessels.
- As-needed lockages for commercial and maintenance vessels, average of 1 to 2 lockages/day in each direction typical based on historical data.
- This would result in a 15% to 25% reduction in recreational lockages and a 10% to 20% reduction in total lockages.

4. Dramatic Restrictions on Vessel Traffic

- Maximum of 2 lockages/day for northbound and 2 lockages/day for southbound recreational vessels.
- As-needed lockages for commercial and maintenance vessels, average of 1 to 2 lockages/day in each direction typical based on historical data.
- This would result in a 30% to 40% reduction in recreational lockages and a 20% to 30% reduction in total lockages.

[9] The deterrents have varying levels of effectiveness as detailed in the implementation risk and effectiveness evaluation tables in Appendix B.

5. **Localized Use of Piscicide at Critical Areas**
    - Apply piscicide (e.g., rotenone or similar)) within a lock or targeted areas of the canal to eradicate round goby in the vicinity of lock gates. .

6. **Temporary Benthic (bottom) Electric Deterrent**

    - Install a temporary electric deterrent along the bottom and sides of a confined section of the channel, either in the lock approach or within the lock chamber, to create an electric field that would deter and/or immobilize round goby as they approach the deterrent. Mortality may occur if water currents do not promptly carry immobilized fish beyond the electric field to areas where they can recover.

7. **Air-Injection Bubble Curtain**

    - Install air-injection bubble curtain downstream of the lock approach to deflect round goby movement away from entrance to the lock chamber and into an area with bypass flows.
    - Could be combined with another behavioral deterrent to increase effectiveness.

8. **Deterrent Lighting**

    - Install underwater light array downstream of the lock approach to deflect round goby movement away from entrance to the lock chamber and into an area with bypass flows.
    - Could be combined with anther behavioral deterrent to increase effectiveness.

9. **Partial Height Bottom Deterrent**

    - Install one- to two-foot-high submerged weir attached to the floor of the sill downstream of the lock or at a location further downstream to deter upstream benthic dispersal by round goby. The downstream face of the weir should be vertical or have an adverse slope.
    - Could be combined with anther behavioral deterrent to increase effectiveness.

10. **Acoustic Goby Trap**

    - Installation of an acoustic system that produces species-specific mating sounds to attract reproductively active goby into a trap. Trapped goby would be removed.
    - Could be combined with anther behavioral deterrent to increase effectiveness.

11. **Enhanced Dewatering of Land Cut**

    - For the land cut upstream of Lock C6 and/or between C8-C9, dewater to expose substrate to freezing conditions over the winter. Dewatering may require installation of pump(s) to limit accumulation of water from seepage, groundwater or tributary inputs.

12. **Community Education/Outreach**

    - NYPA/Canals and NYSDEC has partnered with external agencies (e.g., LCBP) to develop consistent stakeholder outreach strategies and material including increased programs to educate the public about the dangers of transporting and introducing the round goby through bait buckets, etc.

- Canal Corporation will assist with dissemination of material and information through social media, canal guides/signage, and via distribution at locks or other canal events.

13. Lock Closure

- Closure of lock for all recreational and commercial traffic.
- Lock closure would not preclude users from operating above and below the closed lock
- There may be limited specific exceptions, such as Canal Corporation maintenance barges if needed for critical response action along canal.

Deterrents Evaluated for Glens Falls Feeder Canal (GFFC)

The following deterrents were evaluated specific to the GFFC. The deterrents discussed above are considered not applicable because there are no locks on the GFFC and/or the deterrents are designed to deter upstream movement of the round goby; movement into and through the GFFC would be in a downstream direction.

1. Intake Screen

- Install intake screen at Glens Falls Feeder Canal at the confluence with the Hudson River to deter round goby larvae and adults from entering canal. Installation of an intake screen may require installation of screened bypass pump(s) to maintain hydrology to support lock operations.

2. Glens Falls Feeder Canal Closure

- Closure and dewatering of GFFC; closure would not preclude trail use.

- GFFC closure would require a dramatic reduction in the number of lockages at Locks C7, C8 and C9. Locking schedules would be dictated by the amount of natural runoff in the Lock C8 to C9 pool and would likely not exceed more than 2 per day in each direction due to the reduction in available water for operation.

Supplemental Information

Temporary Benthic (bottom) Electric Deterrent

- Electric deterrents are commonly used in the upper Midwest U.S. for deterrence of upstream migration of carp. Electrical deterrents utilize in-water electrodes to create an electrical field in the water column. As a fish enters an electric field in a conductive environment (water), it becomes part of the circuit with a portion of the current flowing through its body. Multiple factors, including fish species, fish length, fish orientation to the electric field, swimming speed, water conductivity, water temperature, water velocity, voltage gradient, current, and waveform contribute to the negative stimulus that induces a response in the fish. This response can include avoidance, galvanotaxis, and immobilization (EPRI 2014).

- Modern electric deterrents utilize pulsed DC power. Multiple in-water electrodes create the electrical field; these electrodes can be deployed vertically (suspended from above the water or anchored to the bottom) or deployed along the bottom (and sometimes sides) of the channel. The deterrent equipment is typically housed on the bank adjacent to the deterrent and can be operated remotely. Electric deterrents with bottom-mounted electrodes can present little to no reduction of the cross-section area of a river channel and lack structures

that can locally impact boat traffic and be subject to debris fouling. However, full-depth deterrents may be more effective at controlling movement of target fish species. The temporary electrical deterrent would be bottom-mounted.

- Installations are typically designed and installed to create permanent deterrents; however, Smith-Root, a US-based manufacturer of electric deterrent systems, has a trailer-based deterrent system available for rental and seasonal deployment. The system includes the pulse generating equipment and ability for remote operation. At the site, the system would be connected to land power, and an electrode array would be designed and manufactured for the specific deployment location. Prior installations have involved attaching the electrode array to canvas, which was then draped across the channel bottom and sides and anchored in place.
- Risks to humans and animals swimming in a deterrent depend on factors including water velocity, water depth, water conductivity, voltage, current, waveform, and presence of human safety controls for the deterrent. A benthic deterrent at a lock channel presents a much lower risk than a full-depth deterrent because the more intense deterrent zone is limited to the bottom of the channel.

Air-Injection Bubble Curtain

- Air-injection bubble curtains rely on a wall of bubbles generated from the channel bottom with either an air-injection apparatus or cavitation bubbles produced from propellers. Air-injection curtains have been the historical preference for bubble deterrents, with cavitation deterrent technologies relatively untested in field applications.
- Air-injection bubble curtains will deflect fish under certain circumstances. Water temperature, turbidity, light intensity, water velocity, orientation in the channel, and fish species and behavioral response are factors in the effectiveness of these bubble curtains. Under optimal conditions, laboratory tests have resulted in 98% fish deflection, while less than optimal conditions (high velocity or high turbidity levels) resulted in 51% to 80% fish deflection. Site specific placement of the air-injection bubble curtains is crucial, as silt may clog air ducts or may be disrupted by flow related turbulence.
- Bubble curtains are commonly paired with another behavioral deterrent technology, such as an acoustic sound system. In the case of round goby, which lacks a swim bladder that is critical to the response to acoustic deterrents, pairing bubble curtains with acoustic deterrents is not recommended.
- Little research has been found on the use of bubble curtains to deter round goby dispersal. As such, bubble curtains cannot be recommended as a sole strategy for deterrence. However, this technology has promise as a component of a multi-technology behavioral deterrence system, for example being paired with lights and electricity.

Acoustic Trap

- An acoustic trap has been tested with some success and can be paired with other deterrent technologies to lure round goby into a trap for removal from the system.

- The acoustic trap uses a speaker broadcasting round goby reproductive calls. A study found a significant increase in goby trapping when these attractant sounds originate from the trap location.
- Acoustic traps cannot be recommended as a sole strategy for deterrence. However, this technology could be paired with another deterrent technology to improve effectiveness.
- Use of this technology may lead to an increase in trapping efficiency and could be used to draw round goby away from an upstream dispersal pathway (e.g., a lock entrance), where they could be trapped and removed from the system.

Deterrent Lighting

- The use of light to attract or repel fish has been evaluated in numerous studies. Studies suggest strobe lights can produce an avoidance response in fish. However, the use of lights to deter round goby is unknown, and likely dependent on life stage. Studies have found that adult round goby are significantly more active on rocky substrates during daylight hours than at night. A different study conducted in Lake Michigan found a diel vertical movement pattern with newly hatched round goby fry in which the fish remained near the substrate during the day and were present in surface waters only at night.

Partial Height Bottom Deterrent

- The concept of a partial height bottom deterrent is essentially a one- to two-foot-high submerged weir attached to the floor of the sill downstream of the lock or located at a location further downstream of the lock. The deterrent, which can be temporary and removable or permanent, can be made of a number of materials and have nearly any shape as long as the downstream face presents a vertical (or slightly adverse) slope to a fish.
- This approach takes advantage of the predominantly benthic (bottom-swimming) preference of the adult round goby, but it must be paired with other deterrent strategies as it is very unlikely to be effective on its own. Observations have been made of round goby using vertical walls as high as five meters above the bottom as habitat elements.
- Advantages of the partial height bottom deterrent approach as an element of a deterrence strategy include cost, flexibility in shape and material, relative ease of manufacture and deployment, and its unobtrusiveness to boat traffic.

APPENDIX B RESPONSE ACTION EFFECTIVENESS AND IMPLEMENTATION RISKS EVALUATION

ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

DOCUMENT CHANGE LOG

REVISION DATE	REVISION NO.	DESCRIPTION
7/15/2022	Rev. 0	Round Goby: Interim Rapid Response Plan for the Champlain Canal System in New York State
3/13/2023	Rev. 1	DRAFT - 2023 RRP Update
		1. Split Partial Height Bottom Barrier and Acoustic Goby Trap into separate potential actions. Renumbered and rescored actions.
		2. Formatting, including separating Effectiveness table out, for clarity.
		3. Text/numbers in blue revised to reflect additional data and further analysis during development of Facility Plan.

SUMMARY - LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL												Total Score	EFFECTIVENESS	
	PUBLIC HEALTH & SAFETY			ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)			FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)			CANAL SYSTEM USER IMPACTS				EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL	EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL
	Sev	Lik	Tot	Sev	Lik	Tot	Sev	Lik	Tot	Sev	Lik	Tot			
1. Double Flushing	1	1	1	2	1	2	1	1	1	2	2	4	8	1	2
2. Scheduled Lockages	1	1	1	1	1	1	2	3	6	2	3	6	14	1	1
3. Moderate reduction of vessel traffic above last known area of detection	1	1	1	2	2	4	3	3	9	3	3	9	23	2	2
4. Dramatic reductions of vessel traffic above last known area of detection	1	1	1	2	3	6	4	3	12	4	3	12	31	3	2
5. Localized use of piscicide at critical areas	2	1	2	3	2	6	2	1	2	2	2	4	14	1	1
6. Temporary Benthic (bottom) Electric Barrier	5	1	5	2	3	6	1	1	1	2	4	8	20	1	3
7. Air-Injection Bubble Curtain	1	1	1	2	1	2	1	1	1	1	1	1	5	1	2
8. Deterrent Lighting	5	1	5	2	2	4	1	1	1	1	1	1	11	1	2
9. Partial Height Bottom Barrier	1	1	1	2	1	2	1	1	1	3	1	3	7	1	1
10. Acoustic Goby Trap	2	1	2	1	1	1	1	1	1	1	1	1	5	1	1
11. Enhanced dewatering of land cut	1	1	1	4	3	12	2	1	2	2	2	4	19	1	2
12. Community Education/Outreach (Boat Stewards)	1	1	1	1	1	1	1	1	1	1	1	1	4	3	1
13. Lock Closure	1	1	1	2	3	6	5	3	15	5	3	15	37	5	5

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																	Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
1. Double Flushing	**No significant potential health or safety impacts identified.**	1	1	1			2	1	2			1	1	1	Would not reduce vessel traffic, therefore no impact		2	2	4	Would not reduce vessel traffic, minor impact due to longer time in lock	8
Assume locks flushed/emptied second time once vessel enters; locks kept full between vessels						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	1	1	1	No anticipated risk of action	**Fishing & other local recreational canal use**	1	1	1		**Impacts to recreational boating (wait time, difficulty, launching locations)**	2	2	4		
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	No anticipated risk of action	**Marinas**	1	1	1		**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	2	1	2	Passes more water through lock; would have little impact to hydrology at C2	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical experience considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
1. Double Flushing		1			2	
Assume locks flushed/emptied second time once vessel enters; locks kept full between vessels	**Effectiveness on goby hitchhiking inside boats**	1	No effect	**Deterrent Effectiveness at Normal Flows**	2	Potentially flush goby not yet settled in substate
	Effectiveness on goby hitchhiking outside of boats	1	No effect	**Deterrent Effectiveness at Flood Flows**	2	Potentially flush goby not yet settled in substate
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: Impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
2. Scheduled Lockages	**No significant potential health or safety impacts identified.**	1	1	1			1	1	1			2	3	6			2	3	6		14
Assume lock openings: recreational - 4-5/day each direction; commercial on demand 1-2/day each direction						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	1	1	1	No anticipated risk of action	**Fishing & other local recreational canal use**	2	3	6		**Impacts to recreational boating (wait time, difficulty, launching locations)**	2	3	6		
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	No anticipated risk of action	**Marinas**	2	3	6		**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	**Tourism, including long-haul boat passage**	2	3	6		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
2. Scheduled Lockages		1			1	
Assume lock openings: recreational - 4-5/day each direction; commercial on demand 1-2/day each direction	**Effectiveness on goby hitchhiking inside boats**	1	No effect	**Deterrent Effectiveness at Normal Flows**	1	Not effective during periods when lock is open. Assumes same number of boats use locks.
	Effectiveness on goby hitchhiking outside of boats	1	No effect	**Deterrent Effectiveness at Flood Flows**	1	Not effective during periods when lock is open. Assumes same number of boats use locks.
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
3. Moderate restriction of vessel traffic upstream of last known area of detection	**No significant potential health or safety impacts identified.**	1	1	1			2	2	4			3	3	9			3	3	9		23
Assume lock openings: recreational 2-3/day each direction; commercial on demand 1-2/day each direction						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	2	4	Would slightly limit species movement through lock	**Fishing & other local recreational canal use**	3	3	9		**Impacts to recreational boating (wait time, difficulty, launching locations)**	3	3	9	Longer waiting times due to reduced number of lockages upstream of last know detection area	
						Fisheries – sport, resident fish, aquatic ecosystems	1	2	2	Would slightly limit species movement through lock	**Marinas**	3	3	9		**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	1	1	1	Minor reduction in flushing and exchange in lock	**Tourism, including long-haul boat passage**	3	3	9		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
3. Moderate restriction of vessel traffic upstream of last known area of detection		2			2	
Assume lock openings: recreational 2-3/day each direction; commercial on demand 1-2/day each direction	**Effectiveness on goby hitchhiking inside boats**	1	Slight reduction in number of boats, thus hitchhiking	**Deterrent Effectiveness at Normal Flows**	2	Not effective during periods when lock is open. Assumes reduced number of boats use locks. Less opportunity for goby to move into lock
	Effectiveness on goby hitchhiking outside of boats	2	Slight reduction in number of boats, thus hitchhiking	**Deterrent Effectiveness at Flood Flows**	2	Not effective during periods when lock is open. Assumes reduced number of boats use locks. Less opportunity for goby to move into lock
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
4. Dramatic restriction of vessel traffic above last known area of detection	**No significant potential health or safety impacts identified.**	1	1	1			2	3	6			4	3	12			4	3	12		31
Assume lock openings: recreational max 2/day each direction; commercial on demand 1-2/day each direction						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	3	6	Would somewhat limit species movement through lock	**Fishing & other local recreational canal use**	4	3	12		**Impacts to recreational boating (wait time, difficulty, launching locations)**	4	3	12	No recreational use of 2 locks upstream of detection	
						Fisheries – sport, resident fish, aquatic ecosystems	2	2	4	Would somewhat limit species movement through lock	**Marinas**	4	3	12	Represent sport fishing industry	**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	2	1	2	Minor reduction in flushing and exchange in lock	**Tourism, including long-haul boat passage**	4	3	12		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	3	3	9		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	4	1	4		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
4. Dramatic restriction of vessel traffic above last known area of detection		3			2	
Assume lock openings: recreational max 2/day each direction; commercial on demand 1-2/day each direction	**Effectiveness on goby hitchhiking inside boats**	1	Slight reduction in number of boats, thus hitchhiking	**Deterrent Effectiveness at Normal Flows**	2	Would not affect swimming except via limiting time lock is open
	Effectiveness on goby hitchhiking outside of boats	3	Commercial vessels can offer more hiding places than recreational, but significantly reduced boat traffic reduces likelihood of short term dispersion	**Deterrent Effectiveness at Flood Flows**	2	Would not affect swimming except via limiting time lock is open
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
5. Localized use of piscicide at critical areas		2	1	2			3	2	6			2	1	2			2	2	4		14
Assume this would occur in a lock or in a localized area known to have goby: infrequent, non-routine treatment	**Biocide/ piscicide exposure during application, thru direct contact with water, drinking water intakes, irrigation**	2	1	2	Assumes measures would be taken to minimize likelihood of exposure	**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	3	2	6	Some mortality to RTE sp. anticipated if present within treatment area; no population level impacts anticipated	**Fishing & other local recreational canal use**	2	1	2	Fishing prohibited for periods after treatment	**Impacts to recreational boating (wait time, difficulty, launching locations)**	2	2	4	Increased waiting times near locks where applied; infrequent, non-routine treatment	
						Fisheries – sport, resident fish, aquatic ecosystems	2	1	2	Some mortality to sport/resident fish sp. anticipated if present within treatment area	**Marinas**	1	1	1		**Impacts to commercial shipping**	2	2	4	Increased waiting times near locks where applied	
						Water quality (DO, temp, turbidity)	1	1	1	Biocide is routinely used in AIS control; water quality effects would be localized and temporary	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	Fluctuation in water levels will be necessary for treatments	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	Some individuals could be impacted, especially piscivorous sp.	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		
																Impacts to irrigation and adjacent wells	3	2	6		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
5. Localized use of piscicide at critical areas		1			1	Potential reduction in goby population below/within lock
Assume this would occur in a lock or in a localized area known to have goby	**Effectiveness on goby hitchhiking inside boats**	1	No effect	**Deterrent Effectiveness at Normal Flows**	2	Fewer goby in area downstream of lock means fewer that will pass through the lock.
	Effectiveness on goby hitchhiking outside of boats	1	No effect	**Deterrent Effectiveness at Flood Flows**	1	Treatment would not be conducted during flood flows
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																		Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS				
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
6. Temporary Benthic (bottom) Electric Barrier		5	1	5			2	3	6			1	1	1	Would not reduce vessel traffic, therefore no impact		2	4	8	Possible minor impacts to draft/clearance	20
Assume temporary benthic barrier along bottom and sides, below lock or in lock chamber	**Immersion in Electric Field**	5	1	5	Pulse DC current reduces risk, well below electrocution thresholds, may cause muscle use interference, unknown effects to those with pacemakers/heart conditions	**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	3	6	Temporary deterrent intended to immobilize fish; will have incidental mortality on fish with no flow present	**Fishing & other local recreational canal use**	1	1	1		**Impacts to recreational boating (wait time, difficulty, launching locations)**	2	4	8	Canoes, kayaks, jet skis, and some open hull boats likely will be required to portage (approx. 15 boats/yr. each direction) Closed hull boats can pass with minor preparation	
	Stray current into built environment	2	2	4	Can be mitigated with proper deterrent design	**Fisheries – sport, resident fish, aquatic ecosystems**	2	3	6	Temporary deterrent intended to immobilize fish; will have incidental mortality on fish with no flow present	**Marinas**	1	1	1		**Impacts to commercial shipping**	2	3	6	Barges/commercial boats can pass with minor preparation	
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	2	3	6	Deterrent located downstream of lock and potential impacts limited to immediate area; potential impacts limited to work within deterrent zone	
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1	No anticipated risk of action	
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	2	2	4	Diving waterbirds, amphibians, mammals could be affected, may cause mortality if no flow present	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1	No anticipated risk of action	
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1	No anticipated risk of action	
																Stranded boats due to lock closure	1	1	1	No anticipated risk of action	
																Electrical current capture by lock components	3	1	3	Can be mitigated with design elements and potentially relocating/ coating metal appurtenances (e.g., bollards)	

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
6. Temporary Benthic (bottom) Electric Barrier		1	No anticipated affect on dispersion via boat/barge		3	Strong deterrent for goby swimming into lock; may not immobilize goby <20 mm in TL
Assume temporary benthic barrier along bottom and sides, below lock or in lock chamber	**Effectiveness on goby hitchhiking inside boats**	1	No effect Goby may be able to hide within small cavities, intakes, piping in boats	**Deterrent Effectiveness at Normal Flows**	4	Strong deterrent for goby swimming into lock. Goby can successfully hide within small cavities in boats or gaps in electric field from connected barges/boats. Not full-depth barrier, so goby could still move over top of electric field. Savino et al. (2001), Smith-Root Shiawassee Temporary Barrier.
	Effectiveness on goby hitchhiking outside of boats	4	Goby >20mm in TL would likely become immobilized Goby may be able to hide in gaps in electric field from connected barges/boats	**Deterrent Effectiveness at Flood Flows**	3	Strong deterrent for goby swimming into lock. Goby can successfully hide within small cavities in boats or gaps in electric field from connected barges/boats. Not full-depth barrier, so goby could still move over top of electric field. Goby less likely to be moving under flood flows.
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																		Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
7. Air-Injection Bubble Curtain	**No significant potential health or safety impacts identified.**	1	1	1			2	1	2			1	1	1	Would not reduce vessel traffic, therefore no impact		1	1	1		5
Assume air-injection bubble curtain downstream of the lock approach to deflect round goby away from entering lock						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	1	2	Minor risk or delay in upstream movement by sp.	**Fishing & other local recreational canal use**	1	1	1		**Impacts to recreational boating (wait time, difficulty, launching locations)**	1	1	1	No anticipated risk of action	
						Fisheries – sport, resident fish, aquatic ecosystems	2	1	2	Minor risk or delay in upstream movement by sp.	**Marinas**	1	1	1		**Impacts to commercial shipping**	1	1	1	No anticipated risk of action	
						Water quality (DO, temp, turbidity)	1	1	1	Bubbles would temporarily increase localized DO	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	1	1	1	No anticipated risk of action	
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1	No anticipated risk of action	
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1	No anticipated risk of action	
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1	No anticipated risk of action	
																Stranded boats due to lock closure	1	1	1	No anticipated risk of action	

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
7. Air-Injection Bubble Curtain		1			2	Theoretical deterrent for adult goby moving into lock; could be combined with other technologies
Assume air-injection bubble curtain downstream of the lock approach to deflect round goby away from entering lock	**Effectiveness on goby hitchhiking inside boats**	1	No effect	**Deterrent Effectiveness at Normal Flows**	2	Limited potential for reduction in goby moving into lock; no data available.
	Effectiveness on goby hitchhiking outside of boats	1	Bubble curtain may dislodge some gobies from boat; goby would likely swim freely away or dive to bottom	**Deterrent Effectiveness at Flood Flows**	2	Limited potential for reduction in goby moving into lock; no data available.
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																	Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
8. Deterrent Lighting		5	1	5			2	2	4			1	1	1	Would not reduce vessel traffic, therefore no impact		1	1	1		11
Assume underwater light array downstream of the lock approach to deflect round goby movement away from entrance to the lock chamber	Electric shock from malfunction	5	1	5	Can be mitigated with proper deterrent design	Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage	2	2	4	May deter all fishes; some acclimatization may occur over time, particularly those with strong migratory instinct. Only used during day/lock opening operations.	Fishing & other local recreational canal use	1	1	1		Impacts to recreational boating (wait time, difficulty, launching locations)	1	1	1	No anticipated risk of action	
						Fisheries – sport, resident fish, aquatic ecosystems	2	2	4	May deter all fishes; some acclimatization may occur over time. Only used during day/lock opening operations.	Marinas	1	1	1		Impacts to commercial shipping	1	1	1	No anticipated risk of action	
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	Tourism, including long-haul boat passage	1	1	1		Impacts to canal maintenance	1	1	1	No anticipated risk of action	
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	Commercial shipping	1	1	1		Impact to future use of GE Processing Facility	1	1	1	No anticipated risk of action	
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	Impact to future use of GE Processing Facility	1	1	1		Impacts to hydro-electric facilities (location specific, north of C9)	1	1	1	No anticipated risk of action	
						Algae blooms	1	1	1	No anticipated risk of action	Local employment opportunities related to tourism or commercial use	1	1	1		Cultural/historical considerations	1	1	1	No anticipated risk of action	
																Stranded boats due to lock closure	1	1	1	No anticipated risk of action	

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
8. Deterrent Lighting		1			2	Assumed potential to reduce adult goby from moving in to lock, larvae appear to be photosensitive but uncertain about adults (except they are benthic and hide under rocks)
Assume underwater light array downstream of the lock approach to deflect round goby movement away from entrance to the lock chamber	Effectiveness on goby hitchhiking inside boats	1	No effect	Deterrent Effectiveness at Normal Flows	2	Limited potential for reduction in goby moving into lock; no data available.
	Effectiveness on goby hitchhiking outside of boats	1	Likely no effect	Deterrent Effectiveness at Flood Flows	2	Limited potential for reduction in goby moving into lock; no data available.
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
9. Partial Height Bottom Barrier	**No significant potential health or safety impacts identified.**	1	1	1			2	1	2			1	1	1	Would not reduce vessel traffic, therefore no impact		3	1	3	Possible minor impacts to draft/clearance	7
Assume 1-2ft high weir (vertical/adverse slope on downstream face) added at downstream gate sill						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	1	2	Adult American eel are benthic swimmers and weir could deter upstream movement somewhat; juvenile eels use full water column	**Fishing & other local recreational canal use**	1	1	1		**Impacts to recreational boating (wait time, difficulty, launching locations)**	1	1	1	Maintain 12 ft draft/clearance	
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	Some sport/resident fish could be deterred from moving upstream via lock	**Marinas**	1	1	1		**Impacts to commercial shipping**	1	1	1	Maintain 12 ft draft/clearance	
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	2	1	2	Periodic sediment removal may be needed	
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1	No anticipated risk of action	
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1	No anticipated risk of action	
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1	No anticipated risk of action	
																Stranded boats due to lock closure	1	1	1	No anticipated risk of action	
																Liability for boat damage	3	1	3	Possible impacts to draft/clearance if not able to maintain >12' navigational depth	

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
9. Partial Height Bottom Barrier		1			1	
Assume 1-2ft high weir (vertical/adverse slope on downstream face) added at downstream gate sill	**Effectiveness on goby hitchhiking inside boats**	1	No effect	**Deterrent Effectiveness at Normal Flows**	1	Marginal effect as stand alone technology; could be combined with other technologies
	Effectiveness on goby hitchhiking outside of boats	1	No effect	**Deterrent Effectiveness at Flood Flows**	1	Marginal effect as stand alone technology; could be combined with other technologies
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
10. Acoustic Goby Trap	No significant potential health or safety impacts identified.	2	1	2			1	1	1			1	1	1	Would not reduce vessel traffic, therefore no impact		1	1	1		5
Assume trap added at location to draw goby away from downstream gate sill	Electric shock from malfunction	2	1	2	Can be mitigated with proper deterrent design	Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage	1	1	1	No anticipated impacts to species other than Round Goby	Fishing & other local recreational canal use	1	1	1		Impacts to recreational boating (wait time, difficulty, launching locations)	1	1	1	No anticipated risk of action	
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	No anticipated impacts to species other than Round Goby	Marinas	1	1	1		Impacts to commercial shipping	1	1	1	No anticipated risk of action	
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	Tourism, including long-haul boat passage	1	1	1		Impacts to canal maintenance	1	1	1	No anticipated risk of action	
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	Commercial shipping	1	1	1		Impact to future use of GE Processing Facility	1	1	1	No anticipated risk of action	
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated impacts to species other than Round Goby	Impact to future use of GE Processing Facility	1	1	1		Impacts to hydroelectric facilities (location specific – north of C9)	1	1	1	No anticipated risk of action	
						Algae blooms	1	1	1	No anticipated risk of action	Local employment opportunities related to tourism or commercial use	1	1	1		Cultural/historical considerations	1	1	1	No anticipated risk of action	
																Stranded boats due to lock closure	1	1	1	No anticipated risk of action	

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
10. Acoustic Goby Trap		1			1	
Assume trap added at location to draw goby away from downstream gate sill	Effectiveness on goby hitchhiking inside boats	1	No effect	Deterrent Effectiveness at Normal Flows	1	Marginal effect as stand alone technology; could be combined with other technologies
	Effectiveness on goby hitchhiking outside of boats	1	No effect	Deterrent Effectiveness at Flood Flows	1	Marginal effect as stand alone technology; could be combined with other technologies
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
11. Enhanced dewatering of land cut	**No significant potential health or safety impacts identified.**	1	1	1			4	3	12			2	1	2			2	2	4		19
Assume landcut upstream of Lock C6 and between C8-C9; dewater to expose substrate to freezing overwinter conditions						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	4	3	12	Potential for localized impact to all aquatic spp during dewatered period	**Fishing & other local recreational canal use**	2	1	2	Loss of fishing access in landcut	**Impacts to recreational boating (wait time, difficulty, launching locations)**	1	1	1		
						Fisheries – sport, resident fish, aquatic ecosystems	4	2	8	Potential for localized impact to all aquatic spp during dewatered period	**Marinas**	1	1	1		**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	3	3	9	Localized effect if chemicals used to remove goby from ponded water	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	2	2	4		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	3	2	6	Potential for localized impact during dewatered period	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	2	2	4	Potential for localized impact during dewatered period	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
11. Enhanced dewatering of land cut		1			2	
Assume landcut upstream of Lock C6 and between C8-C9; dewater to expose substrate to freezing overwinter conditions	**Effectiveness on goby hitchhiking inside boats**	1	No effect on goby hitch hiking on boats because would occur during non-navigation season	**Deterrent Effectiveness at Normal Flows**	2	Stops ability of goby to swim through lock and canal during dewatered period; less goby movement during non-navigation season
	Effectiveness on goby hitchhiking outside of boats	1	No effect on goby hitch hiking on boats because would occur during non-navigation season	**Deterrent Effectiveness at Flood Flows**	2	Slightly less effective if waste gates/floodwaters transport goby around lock
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
12. Community Education/Outreach (Boat Stewards)		1	1	1			1	1	1			1	1	1	Would not reduce vessel traffic, therefore no impact		1	1	1		4
Assume NYPA/Canals and NYSDEC partner with external agencies to develop outreach strategies and material						Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage	1	1	1	No anticipated risk of action	Fishing & other local recreational canal use	1	1	1		Impacts to recreational boating (wait time, difficulty, launching locations)	1	1	1		
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	No anticipated risk of action	Marinas	1	1	1		Impacts to commercial shipping	1	1	1		
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	Tourism, including long-haul boat passage	1	1	1		Impacts to canal maintenance	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	Commercial shipping	1	1	1		Impact to future use of GE Processing Facility	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	Impact to future use of GE Processing Facility	1	1	1		Impacts to hydro-electric facilities (location specific, north of C9)	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	Local employment opportunities related to tourism or commercial use	1	1	1		Cultural/historical considerations	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
12. Community Education/Outreach (Boat Stewards)		3			1	
Assume NYPA/Canals and NYSDEC partner with external agencies to develop outreach strategies and material	Effectiveness on goby hitchhiking inside boats	3	Potential reduction in assisted dispersal if inspection, cleaning and removal are elements of the program	Deterrent Effectiveness at Normal Flows	1	No affect on active dispersal anticipated
	Effectiveness on goby hitchhiking outside of boats	3	Potential reduction in assisted dispersal if inspection, cleaning and removal are elements of the program	Deterrent Effectiveness at Flood Flows	1	No affect on active dispersal anticipated
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C2 THROUGH C6 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																		Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
13. Lock Closure	**No significant potential health or safety impacts identified.**	1	1	1			2	3	6			5	3	15			5	3	15		37
Assume closure of lock for all recreational and commercial traffic; limited specific exceptions such as critical canal maintenance						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	3	6	Would prevent species movement through lock	**Fishing & other local recreational canal use**	4	3	12		**Impacts to recreational boating (wait time, difficulty, launching locations)**	4	3	12		
						Fisheries – sport, resident fish, aquatic ecosystems	2	2	4	Would prevent species movement through lock	**Marinas**	4	3	12		**Impacts to commercial shipping**	5	3	15		
						Water quality (DO, temp, turbidity)	2	1	2	Minor reduction in flushing and exchange in lock	**Tourism, including long-haul boat passage**	4	3	12		**Impacts to canal maintenance**	3	3	9		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	5	3	15		**Impact to future use of GE Processing Facility**	4	3	12		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	2	1	2	No anticipated risk of action	**Impact to future use of GE Processing Facility**	5	3	15		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	2	1	2	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	5	3	15		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
13. Lock Closure		5			5	
Assume closure of lock for all recreational and commercial traffic; limited specific exceptions such as critical canal maintenance	**Effectiveness on goby hitchhiking inside boats**	5	Stops potential dispersion via hitch hiking; effectiveness reduced if boats move around lock without cleaning	**Deterrent Effectiveness at Normal Flows**	5	Stops ability of goby to swim through lock; assumes boats not lifted over lock without disinfection
	Effectiveness on goby hitchhiking outside of boats	5	Stops potential dispersion via hitch hiking; effectiveness reduced if boats move around lock without cleaning	**Deterrent Effectiveness at Flood Flows**	5	Slightly less effective if waste gates/floodwaters transport goby around lock
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

SUMMARY - LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL													EFFECTIVENESS	
	PUBLIC HEALTH & SAFETY			ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)			FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)			CANAL SYSTEM USER IMPACTS			Total Score	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL	EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL
	Sev	Lik	Tot	Sev	Lik	Tot	Sev	Lik	Tot	Sev	Lik	Tot			
1. Double Flushing	1	1	1	3	3	9	1	1	1	2	2	4	15	1	2
2. Scheduled Lockages	1	1	1	1	1	1	2	3	6	2	3	6	14	1	1
3. Moderate reduction of vessel traffic above last known area of detection	1	1	1	2	2	4	3	3	9	3	3	9	23	2	2
4. Dramatic reductions of vessel traffic above last known area of detection	1	1	1	3	3	9	4	3	12	4	3	12	34	3	2
5. Localized use of piscicide at critical areas	2	1	2	3	2	6	2	1	2	2	2	4	14	1	1
6. Temporary Benthic (bottom) Electric Barrier	5	1	5	2	3	6	1	1	1	2	3	6	18	4	3
7. Air-Injection Bubble Curtain	1	1	1	2	1	2	1	1	1	1	1	1	5	1	2
8. Deterrent Lighting	5	1	5	2	2	4	1	1	1	1	1	1	11	1	2
9. Partial Height Bottom Barrier	1	1	1	2	1	2	1	1	1	3	1	3	7	1	4
10. Acoustic Goby Trap	2	1	2	1	1	1	1	1	1	1	1	1	5	1	4
11. Enhanced dewatering of land cut	1	1	1	4	4	16	1	1	1	2	2	4	22	1	2
12. Community Education/Outreach (Boat Stewards)	1	1	1	1	1	1	1	1	1	1	1	1	4	3	1
13. Lock Closure	1	1	1	4	4	16	5	3	15	5	3	15	47	5	5

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																	Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: Impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
1. Double Flushing	**No significant potential health or safety impacts identified.**	1	1	1			3	3	9			1	1	1	Would not reduce vessel traffic, therefore no impact		2	2	4	Would not reduce vessel traffic, minor impact due to longer time in lock	15
Assume locks flushed/emptied second time once vessel enters; locks kept full between vessels						Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage	1	1	1	No anticipated risk of action	Fishing & other local recreational canal use	1	1	1		Impacts to recreational boating (wait time, difficulty, launching locations)	2	2	4		
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	No anticipated risk of action	Marinas	1	1	1		Impacts to commercial shipping	1	1	1		
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	Tourism, including long-haul boat passage	1	1	1		Impacts to canal maintenance	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	3	3	9	Passes more water through lock; water supply at canal summit is limited, would have moderate impact to hydrology	Commercial shipping	1	1	1		Impact to future use of GE Processing Facility	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	Impact to future use of GE Processing Facility	1	1	1		Impacts to hydro-electric facilities (location specific, north of C9)	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	Local employment opportunities related to tourism or commercial use	1	1	1		Cultural/historical considerations	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
1. Double Flushing		1			2	
Assume locks flushed/emptied second time once vessel enters; locks kept full between vessels	Effectiveness on goby hitchhiking inside boats	1	No effect	Deterrent Effectiveness at Normal Flows	2	Potentially flush goby not yet settled in substate
	Effectiveness on goby hitchhiking outside of boats	1	No effect	Deterrent Effectiveness at Flood Flows	2	Potentially flush goby not yet settled in substate
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
2. Scheduled Lockages	**No significant potential health or safety impacts identified.**	1	1	1			1	1	1			2	3	6			2	3	6		14
Assume lock openings: recreational - 4-5/day each direction; commercial on demand 1-2/day each direction						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	1	1	1	No anticipated risk of action	**Fishing & other local recreational canal use**	2	3	6		**Impacts to recreational boating (wait time, difficulty, launching locations)**	2	3	6		
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	No anticipated risk of action	**Marinas**	2	3	6		**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	**Tourism, including long-haul boat passage**	2	3	6		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
2. Scheduled Lockages		1			1	
Assume lock openings: recreational - 4-5/day each direction; commercial on demand 1-2/day each direction	**Effectiveness on goby hitchhiking inside boats**	1	No effect	**Deterrent Effectiveness at Normal Flows**	1	Not effective during periods when lock is open. Assumes same number of boats use locks.
	Effectiveness on goby hitchhiking outside of boats	1	No effect	**Deterrent Effectiveness at Flood Flows**	1	Not effective during periods when lock is open. Assumes same number of boats use locks.
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
3. Moderate restriction of vessel traffic upstream of last known area of detection	**No significant potential health or safety impacts identified.**	1	1	1			2	2	4			3	3	9			3	3	9		23
Assume lock openings: recreational 2-3/day each direction; commercial on demand 1-2/day each direction						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	2	4	Would slightly limit species movement through lock	**Fishing & other local recreational canal use**	3	3	9		**Impacts to recreational boating (wait time, difficulty, launching locations)**	3	3	9	Longer waiting times due to reduced number of lockages upstream of last know detection area	
						Fisheries – sport, resident fish, aquatic ecosystems	1	3	3	Would slightly limit species movement through lock	**Marinas**	3	3	9		**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	2	2	4	Minor reduction in flushing and exchange in lock and in summit section	**Tourism, including long-haul boat passage**	3	3	9		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	2	1	2	Minor reduction in flushing and exchange in lock and in summit section	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	2	2	4	Minor reduction in flushing and exchange in lock and in summit section	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
3. Moderate restriction of vessel traffic upstream of last known area of detection		2			2	
Assume lock openings: recreational 2-3/day each direction; commercial on demand 1-2/day each direction	**Effectiveness on goby hitchhiking inside boats**	1	Slight reduction in number of boats, thus hitchhiking	**Deterrent Effectiveness at Normal Flows**	2	Not effective during periods when lock is open. Assumes reduced number of boats use locks. Less opportunity for goby to move into lock
	Effectiveness on goby hitchhiking outside of boats	2	Slight reduction in number of boats, thus hitchhiking	**Deterrent Effectiveness at Flood Flows**	2	Not effective during periods when lock is open. Assumes reduced number of boats use locks. Less opportunity for goby to move into lock
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
4. Dramatic restriction of vessel traffic above last known area of detection	**No significant potential health or safety impacts identified.**	1	1	1			3	3	9			4	3	12			4	3	12		34
Assume lock openings: recreational max 2/day each direction; commercial on demand 1-2/day each direction						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	3	6	Would somewhat limit species movement through lock	**Fishing & other local recreational canal use**	4	3	12		**Impacts to recreational boating (wait time, difficulty, launching locations)**	4	3	12	No recreational use of 2 locks upstream of detection	
						Fisheries – sport, resident fish, aquatic ecosystems	2	2	4	Would somewhat limit species movement through lock	**Marinas**	4	3	12	Represent sport fishing industry	**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	3	3	9	Minor reduction in flushing and exchange in lock and in summit section	**Tourism, including long-haul boat passage**	4	3	12		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	2	1	2	Minor reduction in flushing and exchange in lock and in summit section	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	2	3	6	Minor reduction in flushing and exchange in lock and in summit section	**Local employment opportunities related to tourism or commercial use**	3	3	9		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	4	1	4		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
4. Dramatic restriction of vessel traffic above last known area of detection		3			2	
Assume lock openings: recreational max 2/day each direction; commercial on demand 1-2/day each direction	**Effectiveness on goby hitchhiking inside boats**	1	Slight reduction in number of boats, thus hitchhiking	**Deterrent Effectiveness at Normal Flows**	2	Would not affect swimming except via limiting time lock is open
	Effectiveness on goby hitchhiking outside of boats	3	Commercial vessels can offer more hiding places than recreational, but significantly reduced boat traffic reduces likelihood of short term dispersion	**Deterrent Effectiveness at Flood Flows**	2	Would not affect swimming except via limiting time lock is open
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
5. Localized use of piscicide at critical areas		2	1	2			3	2	6			2	1	2			2	2	4		14
Assume this would occur in a lock or in a localized area known to have goby: infrequent, non-routine treatments	**- Biocide/ piscicide exposure during application, thru direct contact with water, drinking water intakes, irrigation**	2	1	2	Assumes measures would be taken to minimize likelihood of exposure	**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	3	2	6	Some mortality to RTE sp. anticipated if present within treatment area; no population level impacts anticipated	**Fishing & other local recreational canal use**	2	1	2	Fishing prohibited for periods after treatment	**Impacts to recreational boating (wait time, difficulty, launching locations)**	2	2	4	Increased waiting times near locks where applied; infrequent, non-routine treatments	
						Fisheries – sport, resident fish, aquatic ecosystems	2	1	2	Some mortality to sport/resident fish sp. anticipated if present within treatment area	**Marinas**	1	1	1		**Impacts to commercial shipping**	2	2	4	Increased waiting times near locks where applied	
						Water quality (DO, temp, turbidity)	1	1	1	Biocide is routinely used in AIS control; water quality effects would be localized and temporary	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	Fluctuation in water levels will be necessary for treatments	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	Some individuals could be impacted, especially piscivorous sp.	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		
																Impacts to irrigation and adjacent wells	3	2	6		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
5. Localized use of piscicide at critical areas		1			1	Potential reduction in goby population below/within lock
Assume this would occur in a lock or in a localized area known to have goby	**Effectiveness on goby hitchhiking inside boats**	1	No effect	**Deterrent Effectiveness at Normal Flows**	2	Fewer goby in area downstream of lock means fewer that will pass through the lock.
	Effectiveness on goby hitchhiking outside of boats	1	No effect	**Deterrent Effectiveness at Flood Flows**	1	Treatment would not be conducted during flood flows
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																	Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
6. Temporary Benthic (bottom) Electric Barrier		5	1	5			2	3	6			1	1	1	Would not reduce vessel traffic, therefore no impact		2	3	6	Possible minor impacts to draft/clearance	18
Assume temporary benthic barrier along bottom and sides, below lock or in lock chamber	- Electric shock	5	1	5	DC current which reduces risk, well below electrocution thresholds, may be muscle use interference, unknown effects to those with pacemakers/heart conditions	Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage	2	3	6	Temporary benthic barrier intended to stun fish; may have incidental mortality on immobilized fish if no flow present. RTE sp. may not be present	Fishing & other local recreational canal use	1	1	1		Impacts to recreational boating (wait time, difficulty, launching locations)	2	2	4		
						Fisheries – sport, resident fish, aquatic ecosystems	2	3	6	Temporary benthic barrier intended to stun fish; may have incidental mortality on immobilized fish if no flow present.	Marinas	1	1	1		Impacts to commercial shipping	2	3	6	Barges/commercial boats can pass with minor preparation	
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	Tourism, including long-haul boat passage	1	1	1		Impacts to canal maintenance	2	3	6	Deterrent located downstream of lock and potential impacts limited to immediate area; potential impacts limited to work within deterrent zone	
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	Commercial shipping	1	1	1		Impact to future use of GE Processing Facility	1	1	1	No anticipated risk of action	
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	3	2	6	Diving waterbirds, amphibians, mammals could be affected	Impact to future use of GE Processing Facility	1	1	1		Impacts to hydro-electric facilities (location specific, north of C9)	1	1	1	No anticipated risk of action	
						Algae blooms	1	1	1	No anticipated risk of action	Local employment opportunities related to tourism or commercial use	1	1	1		Cultural/historical considerations	1	1	1	No anticipated risk of action	
																Stranded boats due to lock closure	1	1	1	No anticipated risk of action	
																Electrical current capture by lock components	3	1	3	Can be mitigated with design elements and potentially relocating/ coating metal appurtenances (e.g., bollards)	

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
6. Temporary Benthic (bottom) Electric Barrier		4			3	Reduced potential for goby to move into lock
Assume temporary benthic barrier along bottom and sides, below lock or in lock chamber	Effectiveness on goby hitchhiking inside boats	1	No effect Goby may be able to hide within small cavities, intakes, piping in boats	Deterrent Effectiveness at Normal Flows	4	Strong deterrent for goby swimming into lock. Goby can successfully hide within small cavities in boats or gaps in electric field from connected barges/boats. Not full-depth barrier, so goby could still move over top of electric field. Savino et al. (2001), Smith-Root Shiawassee Temporary Barrier.
	Effectiveness on goby hitchhiking outside of boats	4	Goby >20mm in TL would likely become immobilized Goby may be able to hide in gaps in electric field from connected barges/boats	Deterrent Effectiveness at Flood Flows	3	Strong deterrent for goby swimming into lock. Goby can successfully hide within small cavities in boats or gaps in electric field from connected barges/boats. Not full-depth barrier, so goby could still move over top of electric field. Goby less likely to be moving under flood flows.
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
7. Air-Injection Bubble Curtain	**No significant potential health or safety impacts identified.**	1	1	1			2	1	2			1	1	1	Would not reduce vessel traffic, therefore no impact		1	1	1		5
Assume air-injection bubble curtain downstream of the lock approach to deflect round goby away from entering lock						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	1	2	Minor risk or delay in upstream movement by sp.	**Fishing & other local recreational canal use**	1	1	1		**Impacts to recreational boating (wait time, difficulty, launching locations)**	1	1	1		
						Fisheries – sport, resident fish, aquatic ecosystems	2	1	2	Minor risk or delay in upstream movement by sp.	**Marinas**	1	1	1		**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	2	1	2	Bubbles would temporarily increase localized DO	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
7. Air-Injection Bubble Curtain		1			2	Assumed potential for reduction in goby moving into lock, no data available.
Assume air-injection bubble curtain downstream of the lock approach to deflect round goby away from entering lock	**Effectiveness on goby hitchhiking inside boats**	1	No effect	**Deterrent Effectiveness at Normal Flows**	2	Limited potential for reduction in goby moving into lock; no data available.
	Effectiveness on goby hitchhiking outside of boats	1	Bubble curtain may dislodge some gobies from boat; goby would likely swim freely away or dive to bottom	**Deterrent Effectiveness at Flood Flows**	2	Limited potential for reduction in goby moving into lock; no data available.
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																		Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
8. Deterrent Lighting		5	1	5			2	2	4			1	1	1	Would not reduce vessel traffic, therefore no impact		1	1	1		11
Assume underwater light array downstream of the lock approach to deflect round goby movement away from entrance to the lock chamber	- Electric shock	5	1	5		Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage	2	2	4	May deter all fishes; some acclimatization may occur over time, particularly those with strong migratory instinct. Only used during day/lock opening operations. RTE sp. may not be present.	Fishing & other local recreational canal use	1	1	1		Impacts to recreational boating (wait time, difficulty, launching locations)	1	1	1		
						Fisheries – sport, resident fish, aquatic ecosystems	2	2	4	May deter all fishes; some acclimatization may occur over time. Only used during day/lock opening operations.	Marinas	1	1	1		Impacts to commercial shipping	1	1	1		
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	Tourism, including long-haul boat passage	1	1	1		Impacts to canal maintenance	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	Commercial shipping	1	1	1		Impact to future use of GE Processing Facility	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	Impact to future use of GE Processing Facility	1	1	1		Impacts to hydro-electric facilities (location specific, north of C9)	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	Local employment opportunities related to tourism or commercial use	1	1	1		Cultural/historical considerations	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
8. Deterrent Lighting		1			2	Assumed potential to reduce adult goby from moving in to lock, larvae appear to be photosensitive but uncertain about adults (except they are benthic and hide under rocks)
Assume underwater light array downstream of the lock approach to deflect round goby movement away from entrance to the lock chamber	Effectiveness on goby hitchhiking inside boats	1	No effect	Deterrent Effectiveness at Normal Flows	2	Limited potential for reduction in goby moving into lock; no data available.
	Effectiveness on goby hitchhiking outside of boats	1	Likely no effect	Deterrent Effectiveness at Flood Flows	2	Limited potential for reduction in goby moving into lock; no data available.
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																		Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: Impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
9. Partial Height Bottom Barrier	**No significant potential health or safety impacts identified.**	1	1	1			2	1	2			1	1	1	Would not reduce vessel traffic, therefore no impact		3	1	3	Possible minor impacts to draft/clearance	7
Assume 1-2ft high weir (vertical/adverse slope on downstream face) added at downstream gate sill						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	1	2	Adult American eel are benthic swimmers and weir could deter upstream movement somewhat; juvenile eels use full water column	**Fishing & other local recreational canal use**	1	1	1		**Impacts to recreational boating (wait time, difficulty, launching locations)**	1	1	1	Maintain 12 ft draft/clearance	
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	Some sport/resident fish could be deterred from moving upstream via lock	**Marinas**	1	1	1		**Impacts to commercial shipping**	1	1	1	Maintain 12 ft draft/clearance	
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	2	1	2	Periodic sediment removal may be needed	
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	2	2	4	No anticipated risk of action	
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1	No anticipated risk of action	
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1	No anticipated risk of action	
																Stranded boats due to lock closure	1	1	1	No anticipated risk of action	
																Liability for boat damage	3	1	3	Possible impacts to draft/clearance if not able to maintain >12' navigational depth	

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
9. Partial Height Bottom Barrier		1			4	
Assume 1-2ft high weir (vertical/adverse slope on downstream face) added at downstream gate sill	**Effectiveness on goby hitchhiking inside boats**	1	No effect	**Deterrent Effectiveness at Normal Flows**	4	Moderate effect for adults dispersing upstream; Potential to deter adult movement (Bergman 2022)
	Effectiveness on goby hitchhiking outside of boats	1	No effect	**Deterrent Effectiveness at Flood Flows**	4	Moderate effect for adults dispersing upstream
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: Impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
10. Acoustic Goby Trap	No significant potential health or safety impacts identified.	2	1	2			1	1	1			1	1	1	Would not reduce vessel traffic, therefore no impact		1	1	1		5
Assume trap added at location to draw goby away from downstream gate sill	Electric shock from malfunction	2	1	2	Can be mitigated with proper deterrent design	Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage	1	1	1	No anticipated impacts to species other than Round Goby	Fishing & other local recreational canal use	1	1	1		Impacts to recreational boating (wait time, difficulty, launching locations)	1	1	1	No anticipated risk of action	
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	No anticipated impacts to species other than Round Goby	Marinas	1	1	1		Impacts to commercial shipping	1	1	1	No anticipated risk of action	
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	Tourism, including long-haul boat passage	1	1	1		Impacts to canal maintenance	1	1	1	No anticipated risk of action	
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	Commercial shipping	1	1	1		Impact to future use of GE Processing Facility	1	1	1	No anticipated risk of action	
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated impacts to species other than Round Goby	Impact to future use of GE Processing Facility	1	1	1		Impacts to hydro-electric facilities (location specific, north of C9)	1	1	1	No anticipated risk of action	
						Algae blooms	1	1	1	No anticipated risk of action	Local employment opportunities related to tourism or commercial use	1	1	1		Cultural/historical considerations	1	1	1	No anticipated risk of action	
																Stranded boats due to lock closure	1	1	1	No anticipated risk of action	

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
10. Acoustic Goby Trap		1			4	
Assume trap added at location to draw goby away from downstream gate sill	Effectiveness on goby hitchhiking inside boats	1	No effect	Deterrent Effectiveness at Normal Flows	4	Moderate effect for adults dispersing upstream; Potential to deter adult movement (Bergman 2022)
	Effectiveness on goby hitchhiking outside of boats	1	No effect	Deterrent Effectiveness at Flood Flows	4	Moderate effect for adults dispersing upstream
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
11. Enhanced dewatering of land cut	**No significant potential health or safety impacts identified.**	1	1	1			4	4	16			1	1	1			2	2	4		22
Assume landcut upstream of Lock C6 and between C8-C9; dewater to expose substrate to freezing overwinter conditions						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	4	3	12	Potential for localized impact to all aquatic spp during dewatered period	**Fishing & other local recreational canal use**	2	1	2	Loss of fishing access in landcut	**Impacts to recreational boating (wait time, difficulty, launching locations)**	1	1	1		
						Fisheries – sport, resident fish, aquatic ecosystems	4	4	16	Potential for localized impact to all aquatic spp during dewatered period	**Marinas**	1	1	1		**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	3	3	9	Localized effect if chemicals used to remove goby from ponded water	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	2	2	4		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	3	2	6	Potential for localized impact during dewatered period	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	2	2	4	Potential for localized impact during dewatered period	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
11. Enhanced dewatering of land cut		1			2	
Assume landcut upstream of Lock C6 and between C8-C9; dewater to expose substrate to freezing overwinter conditions	**Effectiveness on goby hitchhiking inside boats**	1	No effect on goby hitch hiking on boats because would occur during non-navigation season	**Deterrent Effectiveness at Normal Flows**	2	Stops ability of goby to swim through lock and canal during dewatered period; less goby movement during non-navigation season
	Effectiveness on goby hitchhiking outside of boats	1	No effect on goby hitch hiking on boats because would occur during non-navigation season	**Deterrent Effectiveness at Flood Flows**	2	Slightly less effective if waste gates/floodwaters transport goby around lock
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: Impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
12. Community Education/Outreach (Boat Stewards)		1	1	1			1	1	1			1	1	1	Would not reduce vessel traffic, therefore no impact		1	1	1		4
Assume NYPA/Canals and NYSDEC partner with external agencies to develop outreach strategies and material						Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage	1	1	1	No anticipated risk of action	Fishing & other local recreational canal use	1	1	1		Impacts to recreational boating (wait time, difficulty, launching locations)	1	1	1		
						Fisheries – sport, resident fish, aquatic ecosystems	1	1	1	No anticipated risk of action	Marinas	1	1	1		Impacts to commercial shipping	1	1	1		
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	Tourism, including long-haul boat passage	1	1	1		Impacts to canal maintenance	1	1	1		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	Commercial shipping	1	1	1		Impact to future use of GE Processing Facility	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	Impact to future use of GE Processing Facility	1	1	1		Impacts to hydro-electric facilities (location specific, north of C9)	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	Local employment opportunities related to tourism or commercial use	1	1	1		Cultural/historical considerations	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
12. Community Education/Outreach (Boat Stewards)		3			1	
Assume NYPA/Canals and NYSDEC partner with external agencies to develop outreach strategies and material	Effectiveness on goby hitchhiking inside boats	3	Potential reduction in assisted dispersal if inspection, cleaning and removal are elements of the program	Deterrent Effectiveness at Normal Flows	1	No affect on active dispersal anticipated
	Effectiveness on goby hitchhiking outside of boats	3	Potential reduction in assisted dispersal if inspection, cleaning and removal are elements of the program	Deterrent Effectiveness at Flood Flows	1	No affect on active dispersal anticipated
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

LOCKS C7 THROUGH C8 ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
13. Lock Closure	**No significant potential health or safety impacts identified.**	1	1	1			4	4	16			5	3	15			5	3	15		47
Assume closure of lock for all recreational and commercial traffic; limited specific exceptions such as critical canal maintenance						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	2	3	6	Would prevent species movement through lock. RTE sp. may not be present	**Fishing & other local recreational canal use**	4	3	12		**Impacts to recreational boating (wait time, difficulty, launching locations)**	5	3	15		
						Fisheries – sport, resident fish, aquatic ecosystems	2	2	4	Would prevent species movement through lock	**Marinas**	4	3	12		**Impacts to commercial shipping**	5	3	15		
						Water quality (DO, temp, turbidity)	4	4	16	Significant reduction in flushing and exchange in lock and in summit section	**Tourism, including long-haul boat passage**	4	3	12		**Impacts to canal maintenance**	3	3	9		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	2	3	6	Significant reduction in flushing and exchange in lock and in summit section	**Commercial shipping**	5	3	15		**Impact to future use of GE Processing Facility**	4	3	12		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	2	1	2	No anticipated risk of action	**Impact to future use of GE Processing Facility**	5	3	15		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	4	4	16	Significant reduction in flushing and exchange in lock and in summit section	**Local employment opportunities related to tourism or commercial use**	5	3	15		**Cultural/historical considerations**	1	1	1		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING IN CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
13. Lock Closure		5			5	
Assume closure of lock for all recreational and commercial traffic; limited specific exceptions such as critical canal maintenance	**Effectiveness on goby hitchhiking inside boats**	5	Stops potential dispersion via hitch hiking; effectiveness reduced if boats move around lock without cleaning	**Deterrent Effectiveness at Normal Flows**	5	Stops ability of goby to swim through lock; assumes boats not lifted over lock without disinfection
	Effectiveness on goby hitchhiking outside of boats	5	Stops potential dispersion via hitch hiking; effectiveness reduced if boats move around lock without cleaning	**Deterrent Effectiveness at Flood Flows**	5	Slightly less effective if waste gates/floodwaters transport goby around lock
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

SUMMARY - FEEDER CANAL ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL													EFFECTIVENESS	
	PUBLIC HEALTH & SAFETY			ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)			FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)			CANAL SYSTEM USER IMPACTS			Total Score	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN FEEDER CANAL	EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING/ DRIFTING INTO FEEDER CANAL
	Sev	Lik	Tot	Sev	Lik	Tot	Sev	Lik	Tot	Sev	Lik	Tot			
1. Feeder Canal Closure	1	1	1	4	4	16	4	3	12	4	3	12	41	N/A	5
2. Screened Intake	1	1	1	2	1	2	1	1	1	2	2	4	8	N/A	5

FEEDER CANAL ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																	Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)				FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS				
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
1. Feeder Canal Closure	**No significant potential health or safety impacts identified.**	1	1	1			4	4	16	Would likely require reduction in number of lockages at Locks C7, C8 and C9 to no more than 2 per day in each direction.		4	3	12	Would likely require reduction in number of lockages at Locks C7, C8 and C9 to no more than 2 per day in each direction.		4	3	12	Would likely require reduction in number of lockages at Locks C7, C8 and C9 to no more than 2 per day in each direction.	41
Assume closure and dewatering of GFFC; reduce C7-C9 lockages to max 2/day; would not preclude trail use						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	1	1	1	No anticipated risk of action due to limited use of feeder canal by these species; impingement minimized through screen design	**Fishing & other local recreational canal use**	4	3	12		**Impacts to recreational boating (wait time, difficulty, launching locations)**	4	3	12		
						Fisheries – sport, resident fish, aquatic ecosystems	2	1	2	Minimal anticipated risk of action due to limited use of feeder canal by these species	**Marinas**	4	3	12		**Impacts to commercial shipping**	4	3	12	Loss of water may make passage difficult for commercial vessels	
						Water quality (DO, temp, turbidity)	4	4	16	Significant reduction in flushing and exchange in feeder canal and in summit section of canal	**Tourism, including long-haul boat passage**	4	3	12		**Impacts to canal maintenance**	3	3	9		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	3	3	9	Significant reduction in flushing and exchange in feeder canal and in summit section of canal	**Commercial shipping**	4	3	12	Loss of water may make passage difficult for commercial vessels	**Impact to future use of GE Processing Facility**	4	3	12	Loss of water may make passage difficult for commercial vessels	
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	3	1	3	Significant reduction in flushing and exchange in feeder canal and in summit section of canal; amphibian impacts	**Impact to future use of GE Processing Facility**	4	3	12	Loss of water may make passage difficult for commercial vessels	**Impacts to hydro-electric facilities (location specific, north of C9)**	2	2	4		
						Algae blooms	4	4	16	Significant reduction in flushing and exchange in lock and in summit section	**Local employment opportunities related to tourism or commercial use**	4	3	12		**Cultural/historical considerations**	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN FEEDER CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING/DRIFTING INTO FEEDER CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
1. Feeder Canal Closure		N/A			5	
Assume closure and dewatering of GFFC; reduce C7-C9 lockages to max 2/day; would not preclude trail use	**Effectiveness on goby hitchhiking inside boats**		No boats enter through head of GFFC; no effect on small boats used within confines of GFFC	**Deterrent Effectiveness at Normal Flows**	5	Stops ability of goby to swim or drift downstream through feeder canal
	Effectiveness on goby hitchhiking outside of boats		No boats enter through head of GFFC; no effect on small boats used within confines of GFFC	**Deterrent Effectiveness at Flood Flows**	5	Slightly less effective if floodwaters transport goby around feeder canal headworks
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

FEEDER CANAL ROUND GOBY DETERRENT RISK AND EFFECTIVENESS EVALUATION

POTENTIAL ACTION	NEGATIVE IMPACT OF MITIGATION MEASURE ON CANAL																			Total Score
	PUBLIC HEALTH & SAFETY					ENVIRONMENT (Note: impact on environment within lock segment within 1-yr)					FINANCIAL IMPACT (Note: does not consider capital or O&M costs to implement)					CANAL SYSTEM USER IMPACTS					
	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	IMPACTS	Sev	Lik	Tot	Risk Comments	
2. Screened Intake	**No significant potential health or safety impacts identified.**	1	1	1			2	1	2			1	1	1			2	2	4		8
Assume intake screen installed at head of GFFC to prevent round goby larvae and adults from entering canal						**Protected species, including Rare, Threatened, Endangered, and migratory species, including fish passage**	1	1	1	No anticipated risk of action due to limited use of feeder canal by these species; impingement minimized through screen design	**Fishing & other local recreational canal use**	1	1	1		**Impacts to recreational boating (wait time, difficulty, launching locations)**	1	1	1		
						Fisheries – sport, resident fish, aquatic ecosystems	2	1	2	Minimal risk of action due to limited use of feeder canal by these species; impingement minimized through screen design	**Marinas**	1	1	1		**Impacts to commercial shipping**	1	1	1		
						Water quality (DO, temp, turbidity)	1	1	1	No anticipated risk of action	**Tourism, including long-haul boat passage**	1	1	1		**Impacts to canal maintenance**	2	2	4		
						Hydrology (wetlands and streams, withdrawals for makeup water), including impacts on restoration projects	1	1	1	No anticipated risk of action	**Commercial shipping**	1	1	1		**Impact to future use of GE Processing Facility**	1	1	1		
						Unintended effect on non-fish species (e.g. amphibians, waterbirds, mammals, etc.)	1	1	1	No anticipated risk of action	**Impact to future use of GE Processing Facility**	1	1	1		**Impacts to hydro-electric facilities (location specific, north of C9)**	1	1	1		
						Algae blooms	1	1	1	No anticipated risk of action	**Local employment opportunities related to tourism or commercial use**	1	1	1		**Cultural/historical considerations**	2	1	2		
																Stranded boats due to lock closure	1	1	1		

POTENTIAL ACTION	EFFECTIVENESS					
	EFFECTIVENESS AT DETERRING GOBY DISPERSAL VIA BOAT IN FEEDER CANAL			EFFECTIVENESS AT DETERRING GOBY DISPERSAL BY SWIMMING/DRIFTING INTO FEEDER CANAL		
	EFFECTIVENESS	SCORE	Effectiveness Comments	EFFECTIVENESS	SCORE	Effectiveness Comments
2. Screened Intake		N/A			5	
Assume intake screen installed at head of GFFC to prevent round goby larvae and adults from entering canal	**Effectiveness on goby hitchhiking inside boats**		No boats enter through head of GFFC; no effect on small boats used within confines of GFFC	**Deterrent Effectiveness at Normal Flows**	5	Stops ability of goby to move downstream through feeder canal; stops larval drift and adult swimming
	Effectiveness on goby hitchhiking outside of boats		No boats enter through head of GFFC; no effect on small boats used within confines of GFFC	**Deterrent Effectiveness at Flood Flows**	5	Slightly less effective if waste gates/floodwaters transport goby around canal headworks
				Adaptive management/ ease of modification to address changing needs		Not scored; not related to biological effectiveness
				Operational effectiveness (staffing, training, coordination with others)		Not scored; not related to biological effectiveness
				Compatibility with infrastructure		Not scored; not related to biological effectiveness

APPENDIX C LOCK EXTENDED ALTERNATING DOUBLE DRAINING OPERATING PROCEDURES

Lock Extended Alternating Double Draining Procedures for Lock Operations

Goal:

To mitigate the spread of round goby from the Hudson River through the Champlain Canal to Lake Champlain.

Actions:

The NYS Canal Corporation will implement extended alternating double draining of Locks C1 and C2 in 2023. Extended alternating double draining may also be implemented consistent with the response actions listed in the TARP. Implementation of extended alternating double draining will deter round goby dispersion by increasing the likelihood that round goby will be swept from the area downstream of the lower gates prior to opening the lower gate for vessel passage. When not in operation, subject locks will remain in a default position of filled, with all valves and miter gates closed.

For a northbound vessel approaching a closed lock from downstream, the operational sequence will be as follows:

1. The water level within the lock will be lowered by opening the discharge valve ⅔ of the way on side one. After approximately 30 seconds, the valve on side two will be opened ⅔ of the way until the water level in the lock is completely lowered.
2. The lock will be refilled with water from upstream. The upper and lower gates will not be opened.
3. The water level within the lock will be lowered a second time by opening the discharge valve ⅔ of the way on side two. After approximately 30 seconds, the valve on side one will be opened ⅔ of the way until the water level in the lock is completely lowered.
4. The lower gates will be opened and the vessel will enter the lock.
5. The lower gates will be closed and the lock will be filled again.
6. The upper gates will be opened and the vessel will exit the lock.
7. All lock gates and valves will be closed and the lock will remain in the filled condition until the next scheduled locking.

For a southbound vessel approaching a closed lock from upstream, the operational sequence will be as follows:

1. The upper gates will not be opened.
2. The water level within the lock will be lowered by opening the discharge valve ⅔ of the way on side one. After approximately 30 seconds, the valve on side two will be opened ⅔ of the way until the water level in the lock is completely lowered.
3. The lock will be refilled with water from upstream.
4. The upper gates will be opened and the vessel will enter the lock.
5. The water level within the lock will be lowered a second time by opening the discharge valve ⅔ of the way on side two. After approximately 30 seconds, the valve on side one will be opened ⅔ of the way until the water level in the lock is completely lowered.
6. The lower gates will be opened and the vessel will exit the lock.
7. The lower gates will be closed and the lock will be filled again.
8. All lock gates and valves will be closed and the lock will remain in the filled condition until the next scheduled locking.

APPENDIX D DAM LOCATIONS ON THE HUDSON RIVER AND CHAMPLAIN CANAL

Dam Locations on the Hudson River and Champlain Canal

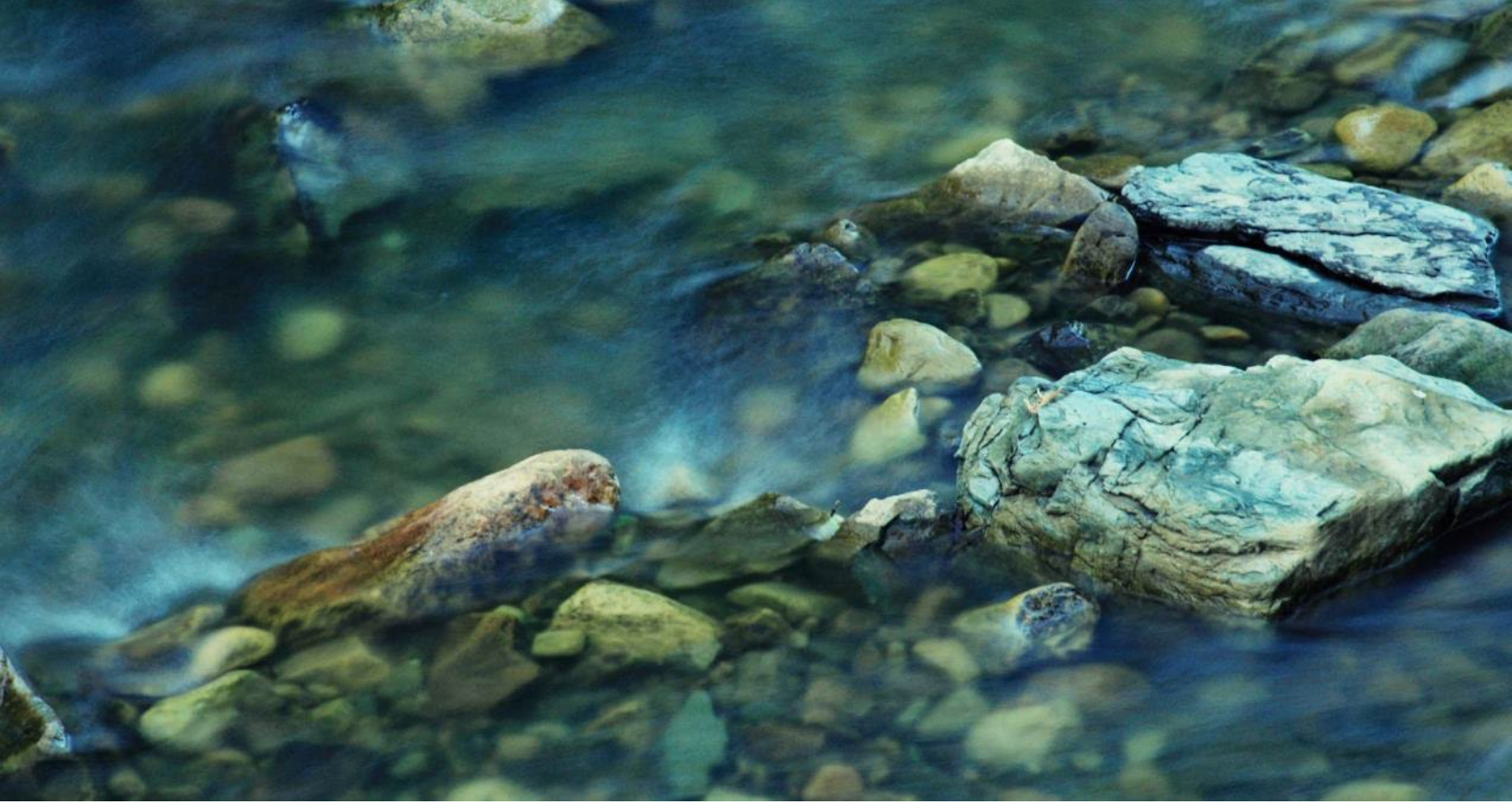
Going south to north…

1. Federal lock and dam at Troy (US Army Corps of Engineers)

Hudson River section of the Champlain Canal –

1. Lock C-1 (Waterford) – fixed crest dam with Tainter gates
2. Lock C-2 (Halfmoon) fixed crest dam with hydroelectric plant
3. Lock C-3 (Mechanicville) fixed crest dam with hydroelectric plant
4. Lock C-4 (Stillwater) fixed crest dam with hydroelectric plant
5. Just north of Lock C-5 (Schuylerville) – fixed crest dam
6. Lock C-6 (Fort Miller) – fixed crest dam with hydroelectric plant
7. Fixed crest dams at Thompson Island (between Locks C-6 in Fort Miller and C-7 in Fort Edward)

APPENDIX E LOCK C2 AIS DETERRENT COMPUTATIONAL FLUID DYNAMICS MODELING REPORT



March 2023
Lock 2 CFD Modeling

ANCHOR QEA

Lock 2 AIS Deterrent Computational Fluid Dynamics Modeling Report

Prepared for New York Power Authority / New York State Canal Corporation

March 2023
NYPA/Canals AIS Deterrent

Champlain Canal Lock 2 AIS Deterrent Modeling

Prepared for
New York Power Authority /
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30 South Pearl St.
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Project Number: 220648-01.01

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FIGURES

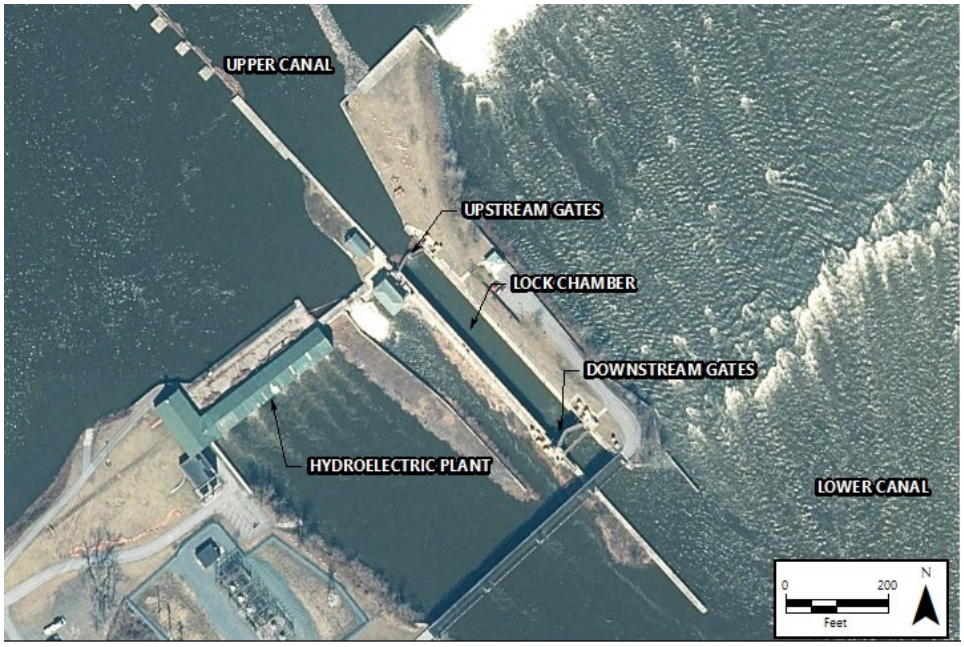
1 Introduction

The invasive round goby is a potential threat to the Lake Champlain ecosystem. The round goby is a small fish native to southeastern Europe. Once introduced, round goby can rapidly establish robust populations that may result in a variety of direct and indirect impacts on aquatic species. The round goby was recently detected in the Hudson River below Lock C1. The locks operated along the Hudson River are part of the Champlain Canal system and, as such, offer a pathway for goby expansion north toward Lake Champlain; however with some modification and/or operational changes these facilities could also present opportunities to deter upstream migration. .

As part of a comprehensive initiative to mitigate the potential risks presented by round goby movement within the Champlain Canal system, New York Power Authority/New York State Canal Corporation (NYPA/Canals) has implemented a "double draining" procedure at Locks C1 and C2 to deter the round goby from migrating upstream. Northbound vessels enter the lock, the lock is then filled, drained, and refilled, before allowing the vessel to pass through the upstream gate. Similarly, southbound vessels enter the lock, the lock is drained, refilled and drained again before allowing boats to pass through the downstream gates. The goal of the double-draining procedure, as opposed to the traditional single draining, is to increase the potential of flushing round goby out of the lock chamber and associated culverts before opening the upstream gates and flushing round goby from the lock discharge area located immediately downstream of the lower gates prior to opening the downstream gates. Double flushing of Locks C1 and C2, which are closest to the invasion front immediately downstream of Lock C1, was implemented in 2022.

This report describes a three dimensional (3D) hydraulic model that predicts possible result from double draining with a focus on Lock C2 which is located near Mechanicville, New York, and one of 11 locks along the Hudson River between Waterford and Lake Champlain. The lock chamber is 330 feet long and 45 feet wide. The lock raises or lowers vessels approximately 18 feet to travel upstream or downstream. Gravity-driven flow moves through culverts connecting the upper canal, lock chamber, and lower canal. The lock is operated by closing and opening two sets of valves located near the upstream and downstream extents of the main culverts.

Figure 1
Project Location



NYPA/Canals retained Anchor QEA, LLC to develop a computational fluid dynamics (CFD) model of Lock C2 to analyze the effectiveness of the "double draining" procedure and evaluate other draining scenarios. Anchor QEA performed a field investigation and developed a FLOW-3D model to simulate flows and velocities as the lock drains.

The following scenarios were modeled:

1. Both downstream valves open until lock chamber fully drained – this simulates the existing double draining procedure currently in place
2. One valve open for 30 seconds, both valves open until lock chamber fully drained
3. One valve open for 60 seconds, both valves open until lock chamber fully drained.
4. Modified downstream culvert openings, with 25 degree downstream deflection.
5. Modified downstream culvert opening, with 20 degree upstream deflection
6. Both values opened one-third
7. Both values opened two-thirds

This report details the CFD modeling and results from these scenarios.

2 Field Data

Anchor QEA performed a field investigation to gather necessary data to develop and calibrate the model. This included a bathymetric survey of the lock and downstream approach and using a depth sensor to record a time series of water levels inside the lock. While on site, Anchor QEA collected water surface elevations of the upper and lower canal to tie depth and bathymetric measurements to elevations.

2.1 Bathymetric Survey

The survey was completed using a SonTek RiverSurveyor M9 pseudo-multibeam echosounder (pMBES). The pMBES allows accurate, detailed hydrographic surveying by sending sound pulses into the water column toward the bed. The time it takes for the pulses to reflect off the bottom and return to the pMBES is used to determine water depth.

The M9 features multiple sonar heads, so it is able to map a swath of the bed, providing more coverage than a single-beam echosounder. Anchor QEA used the M9 pMBES to collect a closely-spaced grid of bathymetry data points. Location information was provided by differential global positioning system (DGPS) equipment.

Anchor QEA outfitted the M9 with a HydroBoard for bathymetric surveying. The lock survey was conducted by using a two-person team with ropes to maneuver the board inside the lock. Five transects were taken along the long axis of the lock. The survey of the downstream approach was conducted by attaching the HydroBoard to the side of a boat and collecting transects between the lock walls and the downstream dikes. The reported attributes of the M9 are shown in Table 1.

Table 1
SonTek RiverSurveyor M9 Reported Specifications

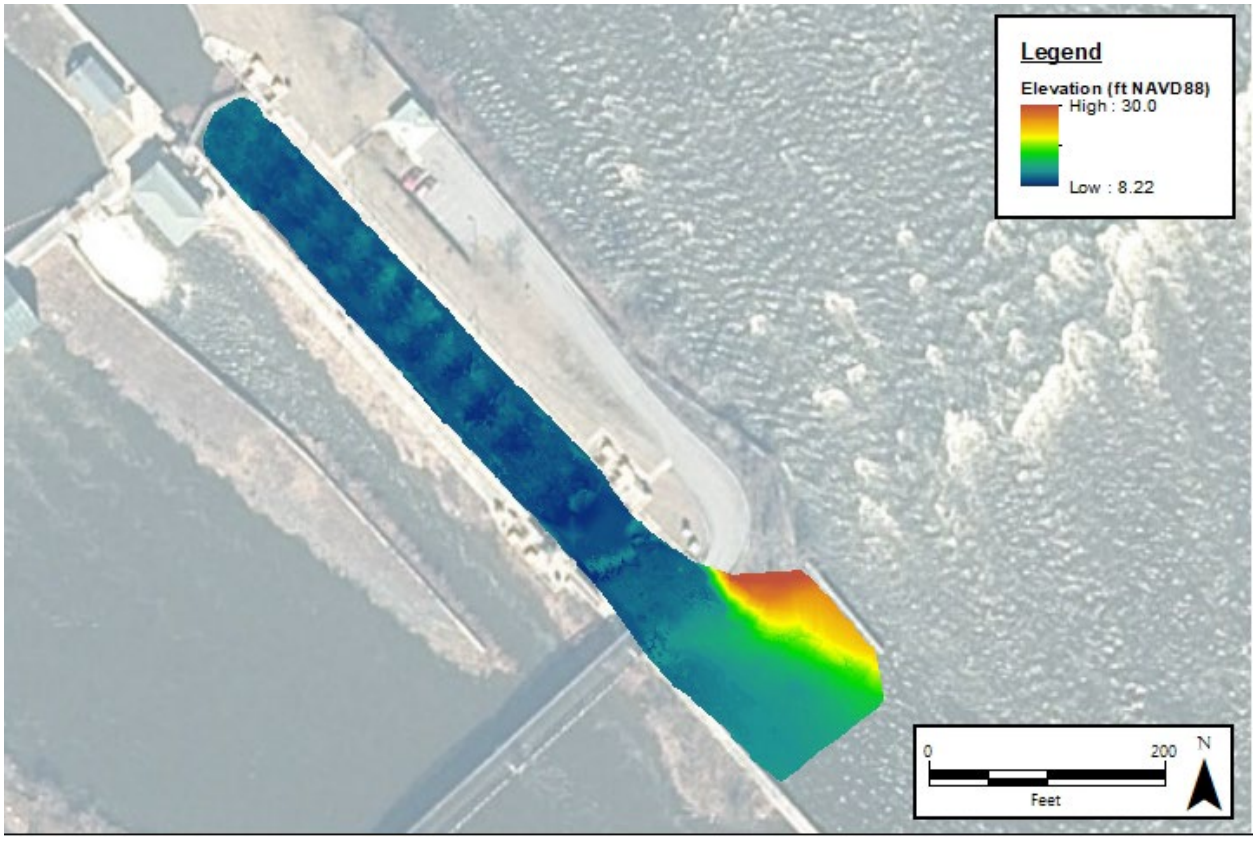
Transducer Configuration	
Dual 4-Beam 3.0 MHz/1.0MHz Janus at 25° Slant Angle	
0.5 MHz Vertical Beam Echosounder	
Depth Measurements	
Range	0.20 m to 80 m
Accuracy	1%
Resolution	0.001 m

Source: SonTek

Data was post-processed using Hypack to remove outliers and interference errors. The revised point files were then exported to AutoCAD Civil3D 2022 where Anchor QEA used the points to create a surface for use in FLOW-3D. Anchor QEA used engineering judgement to fill gaps in the bathymetric

data. The two surveys were combined into a single surface (Figure 2). The lock chamber bottom is mostly flat with elevations ranging from 8.5 – 11 feet above the North American Vertical Datum of 1988 (NAVD88). The downstream approach is slightly shallower.

Figure 2
Bathymetric Survey Results

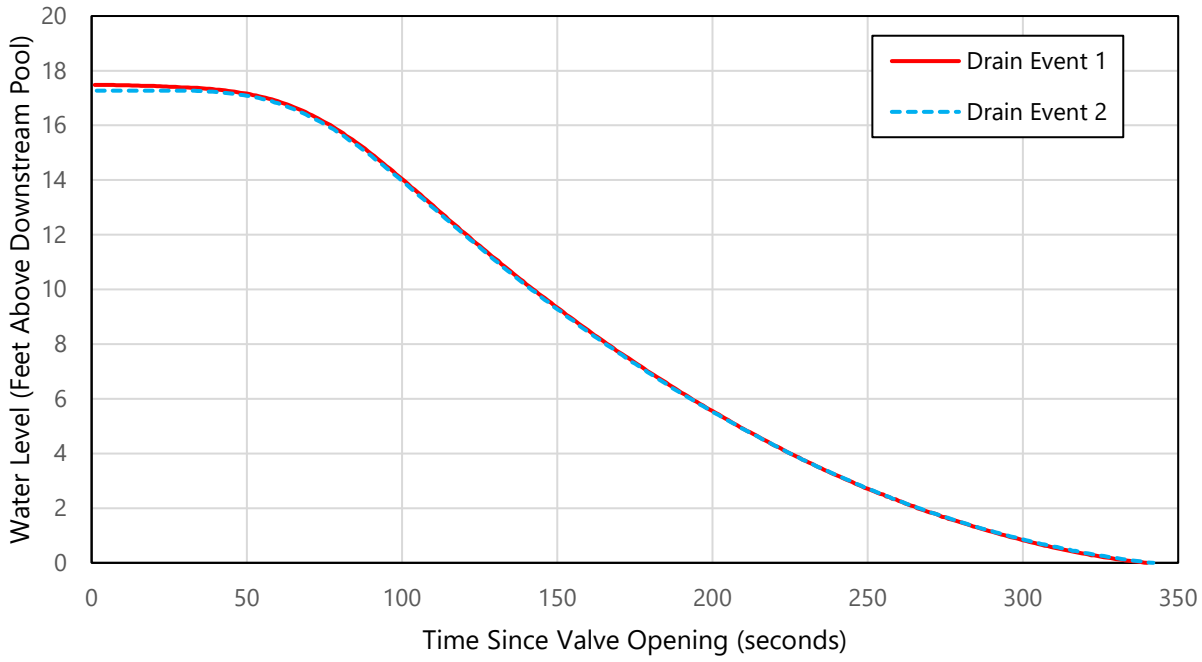


2.2 Fill/Drain Rate Observations

The rate of change of water level in the lock chamber is directly related to the flow rate in the culverts, since all water exiting the lock chamber moves through the culverts. Because the area of the culverts and downstream approach are known, measuring the rate of change of water level can also be used as a proxy for velocity. . By comparing time series of measured and modeled water surface elevations inside the lock chamber, the model can be calibrated.

Anchor QEA used a YSI EXO2 Multiparameter Water Quality Sonde to record a time series of water depth measurements as the lock filled and drained. The sonde was lowered into the lock below the downstream water level. The sonde records depth at 1 second intervals. Figure 3 displays the lock draining time series measurements for two separate drain events. The process takes approximately five minutes, and the rate of change water levels decreases as the lock chamber water level approaches the downstream water level.

Figure 3
Lock Draining Observations



3 Model Development

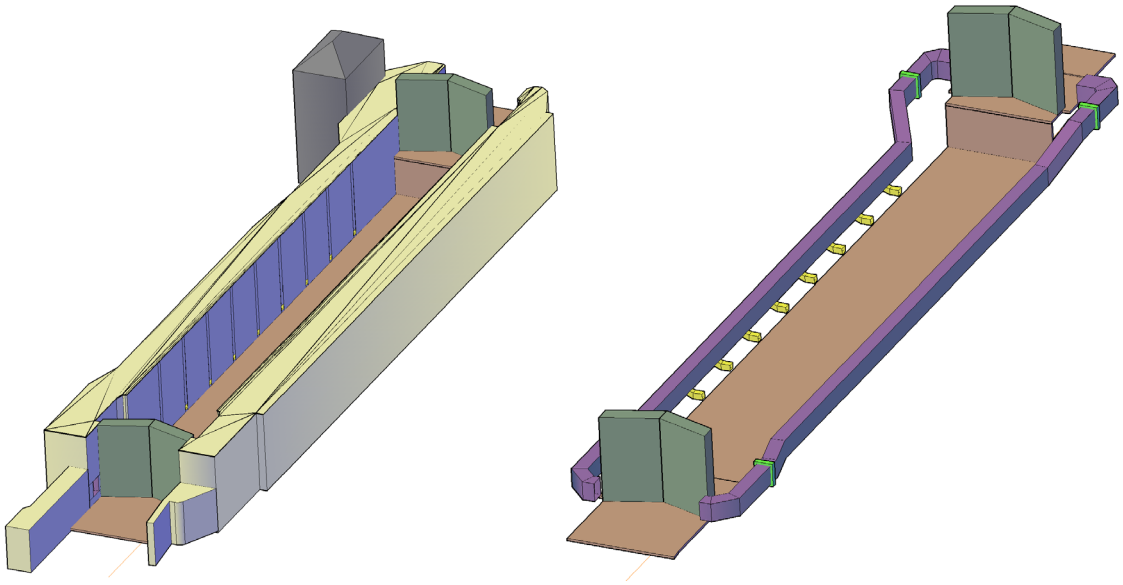
FLOW-3D version 12.0 was selected for modeling and analysis because of its proven capabilities in simulating free-surface flows. FLOW-3D is commonly used to simulate hydraulics and has been well-validated in many scenarios.

CFD modeling requires accurate inputs to generate meaningful outputs. Model geometry, hydraulic information, parameters, and boundary conditions were carefully considered. Model domains and computational mesh sizes were selected to optimize accuracy and simulation runtime on available computational resources. All elevations are reported in feet above NAVD88.

3.1 Geometry

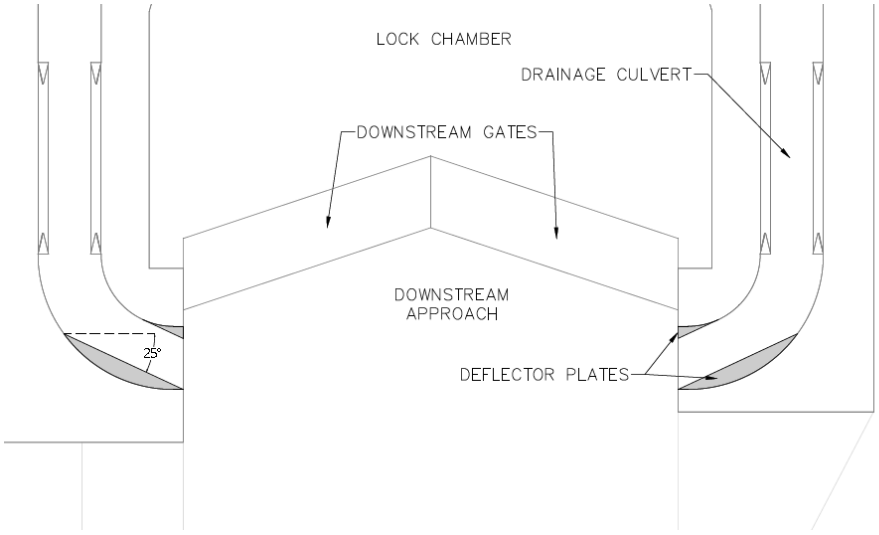
Anchor QEA georeferenced and digitized the original construction drawings developed in 1908. The digitized plans were then used to develop 3D structures using AutoCAD. The structures were exported as STL files for use in FLOW-3D. Figure 4 shows the 3D structures. The left image shows the concrete canal sides. The right image shows the main and sub-culverts with the concrete structures removed. Culverts measuring 6 x 8 feet located in the concrete lock sides create a hydraulic connection between the upstream and downstream pools. Nine individual 2.5 x 3.0 foot sub-culverts connect each of the main culverts to the lock chamber to allow the lock to fill and drain. The downstream outlets are aligned and perpendicular to the channel. The upstream and downstream valves were simulated using a rectangular prism to block flow in the culverts at the location of the actual valves. The valves are sluice gates that can be opened in one-third intervals and operated independently. These can be turned on and off as necessary in FLOW-3D to initiate lock filling or lock draining. Bathymetric data collected on site was used to define the bed in the downstream approach and lock chamber.

Figure 4
Model Structures



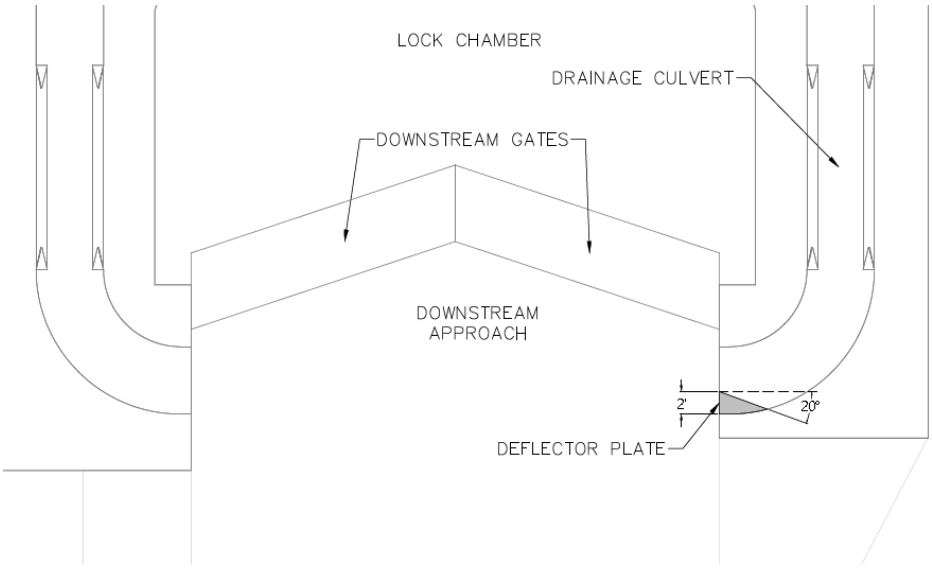
Modeling was also completed for a scenario where outlet flows were directed downstream using discharge deflectors. The modifed culvert openings were designed to smooth flow and reduce turbulent discharge patterns from the existing outlet geometries. Anchor QEA modeled deflector plates that that redirect flow 25 degrees downstream. Figure 5 shows the modified culvert openings, with the deflector plates shaded gray.

Figure 5
Deflected Downstream Outlet Geometry



Preliminary simulation results showed low velocities in the area between the culvert openings and the downstream gates. Therefore, modeling was also completed for a scenario where outlet flows were directed upstream using discharge deflectors. The upstream deflection geometry shown in Figure 6 used a 20-degree upstream deflection.

Figure 6
Deflected Upstream Outlet Geometry



3.2 Model Domain

The model domain was selected to capture the hydraulics of the culverts and the flushing effect in the downstream approach. The downstream extent of the model coincides with the existing jetty on the northeast side. Figure 7 displays the modeled area.

Figure 7
Model Domain

3.3 Boundary and Initial Conditions

FLOW-3D requires the user to specify how fluid moves across the model boundaries by dictating a water surface elevation, flow rate, velocity, or pressure for the fluid at a particular boundary. These simulations only required defining two boundary conditions: upstream and downstream water surface elevations. A water surface elevation boundary allows the model to determine fluid flow rates and velocities through the boundary. The other boundaries are defined by the structures. For these simulations, the water surface elevations from the site visit on October 5, 2022 were used.

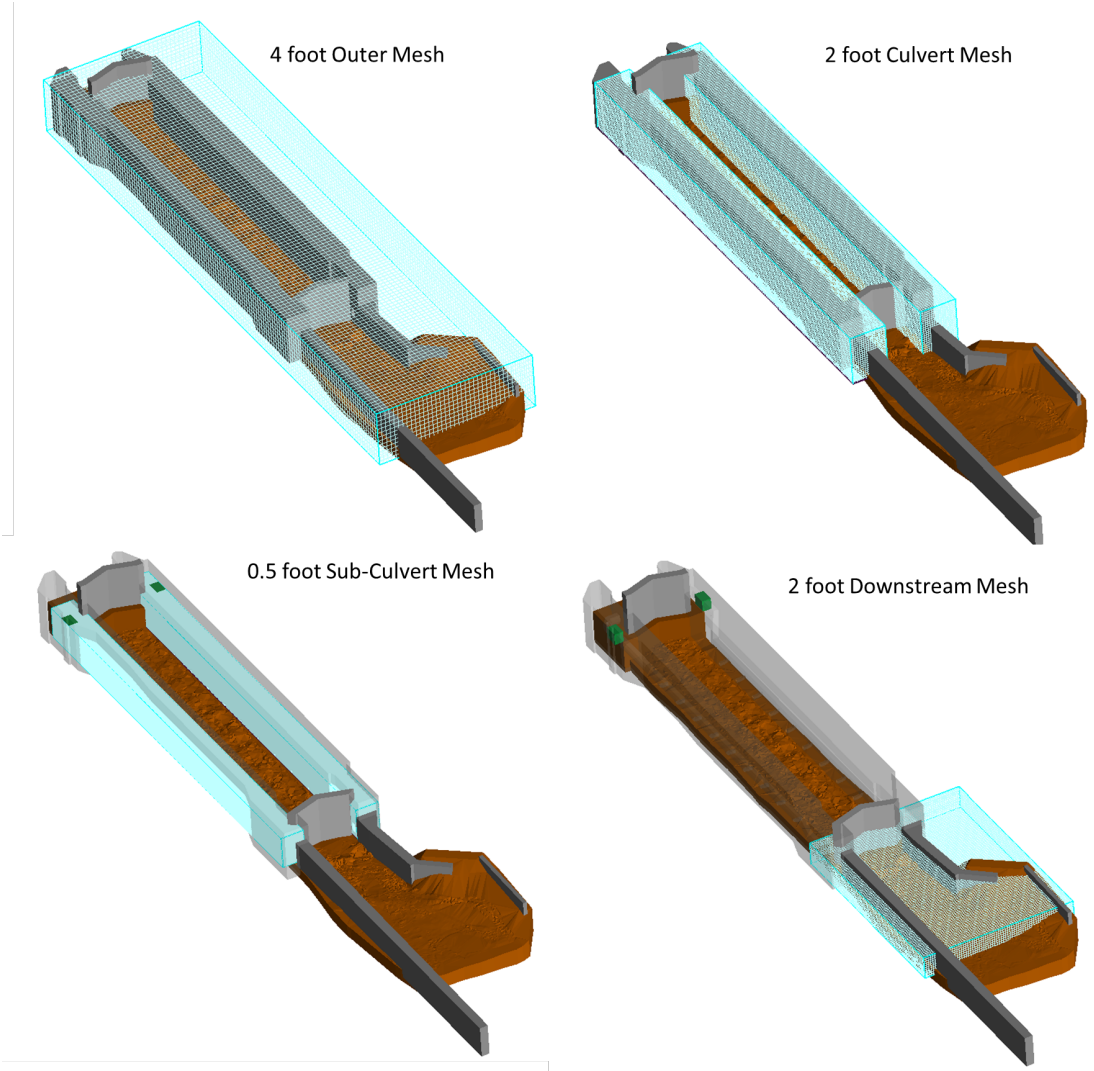
Upstream water surface elevation: 43.29 ft NAVD88

Downstream water surface elevation: 25.95 ft NAVD88

3.4 Mesh Grids

FLOW-3D allows users to define mesh blocks along orthogonal X, Y, and Z axes. Anchor QEA tested a series of nested blocks in the lock to determine the combination that fully resolves the culverts and sub-culverts while maintaining computational efficiency. The nested meshes follow the culverts to provide increased resolution in these critical areas. The sub-culverts are 2.5 x 3.0 feet. To resolve these smaller tunnels, Anchor QEA added a 0.5-foot mesh. Additionally, a 2-foot mesh was added to the downstream approach to allow for more detailed results. Figure 8 displays the mesh grids used in this project.

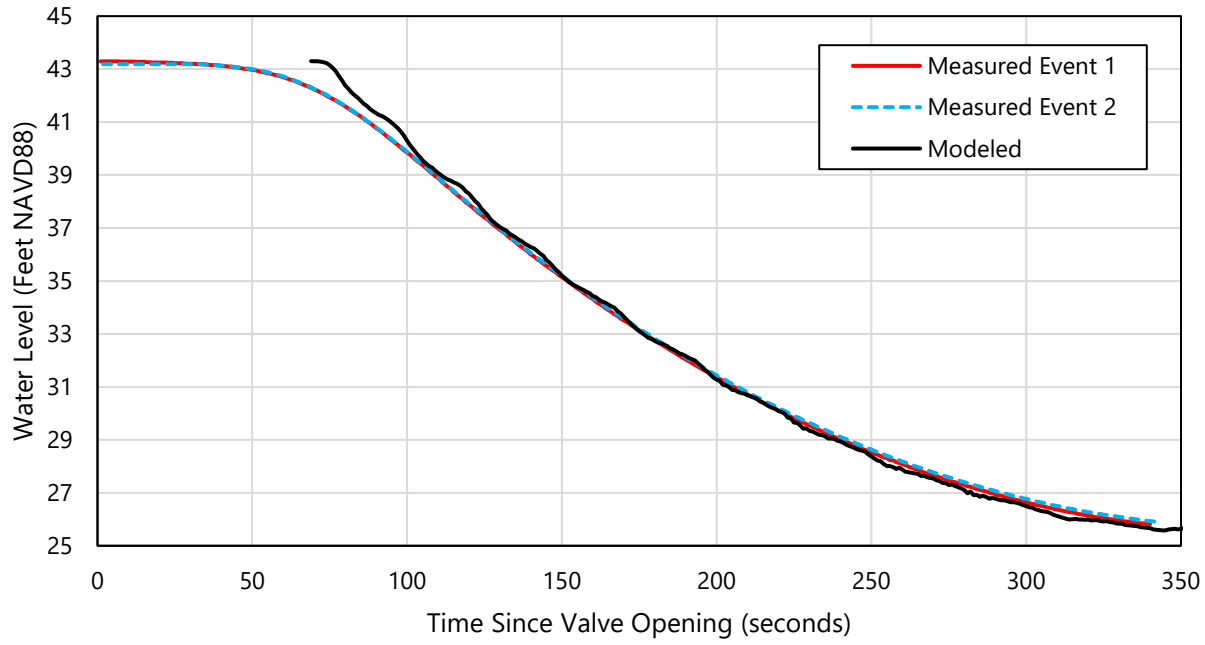
Figure 8
Flow 3D Mesh Grids



3.5 Calibration/Validation

Anchor QEA validated the model by comparing a time series of modeled water levels in the lock chamber to those measured on site. If the model performs well, the modeled lock should drain at the same pace as was measured in the field. Figure 9 shows the comparison. The modeled and measured water levels align well, other than immediately after the valve is opened. This is because the modeled valve instantaneously becomes fully open, while in reality the valve takes a few seconds to fully open. Based on this comparison, the modeled lock is draining at the correct pace, and calibration is acceptable.

Figure 9
Modeled Vs. Measured Lock Chamber Water Levels



4 Model Results

Due to the extreme turbulence in the downstream approach when the lock is drained, the exact flow patterns are unpredictable and will vary with each drain. The model results provide predictions of typical flow patterns and show the effects of different operational or geometry changes.

Velocities in the lock's culverts and in the downstream approach vary with time. At the instant the valves are opened, the head difference between the lock chamber and lower canal is at the maximum, and therefore velocities in the culverts and downstream approach are the highest. As the water level in the lock chamber (and therefore the head difference) decreases, the velocities decrease. Given the time-varying nature of the results, Anchor QEA analyzed outputs in various orientations, as listed below.

Oblique: These simulations show depth-averaged velocity, or velocity magnitude averaged over the water column, for the entire lock. Velocity increases from blue to red.

Section: These simulations focus on the downstream approach and display the downstream component of the velocity vector and include a top view and three section views. The top-view displays velocities at the water surface. Areas with a purple and pink color represent negative velocities, or water moving upstream towards the gates. Velocities increase from dark blue to red. Section locations are indicated in the top view. It is important to note that these simulations only display the *downstream* component, meaning high velocities moving cross channel will register as low downstream velocities. This is particularly evident near the culvert openings, where the flow is moving perpendicular to the channel.

Streamlines: Analysis of streamlines originating from the culverts. Streamlines are useful in showing the path of water rather than just the velocity magnitude. The goal of these animations is to assess the potential of flushing gobies from the area between the culvert outlets and the downstream gates.

Capture Velocities: The capture velocities simulations display sections parallel with the lock walls at distances 0.1, 5, and 10 feet from the wall.

Results from all simulations show very low velocities within the lock chamber. The highest velocities in the lock are limited to within approximately five feet of the sub-culverts as water moves from the lock chamber through the sub-culverts and into the main culvert.

All simulations show velocity in the main culverts increasing towards the downstream end. The velocity in the main culverts is directly related to the number of sub-culverts contributing flow. Because the flow area in the main culverts is constant along its length, velocity must increase as the flow increases according to the continuity equation:

$$Q = VA$$

Q = flow rate
V = velocity
A = Area

4.1 Current Operating Procedure – Two Valve Drain

The two valve drain with existing geometry simulation showed spatially-variable velocities in the downstream approach. Because the culvert openings are perpendicular to the channel, the flow is turbulent and unpredictable. The results indicate extreme turbulence between the culvert openings in the first thirty seconds after the valves are opened. The jets of water from the culvert openings meet to create a pocket of elevated water level. This flow is initially focused in the center of the channel, then oscillates between the channel walls.

Section view results indicate a flow path of high velocity that oscillates between the walls in the downstream approach. Areas outside of this flow path show low velocities or upstream flow. The area between the downstream gates and the culvert outlets consistently shows low or reverse velocity. Velocities near the downstream end of the culverts reach 22.5 ft/s, and the downstream approach velocities reach 12.5 ft/s in areas of the channel in the first 30 seconds after opening. At 120 seconds, maximum downstream velocity is reduced to 5 ft/s and continues to drop to 2 ft/s by 200 seconds from opening.

Capture velocity results indicate velocities greater than 5 ft/s immediately adjacent to the sub-culvert openings. The influence of the sub-culverts rapidly diminishes and is approximately 1 ft/s just five feet from the openings, even at the beginning of the drain cycle when the flow is the highest.

Streamlines results indicate that high-velocity flow occasionally passes in the area between the downstream gates and culverts. However, it is inconsistent and does not carry throughout the depth profile.

4.2 One Valve for 30 seconds, Two Valves Until Fully Drained

This section discusses the results of staggering the valve openings by 30 seconds. With one valve open, the flow favors the opposite side of the channel, creating high velocities along the opposite wall with low or reverse flow in the center and the open culvert side of the channel. Velocities reach 7 ft/s along the opposite wall and 4 ft/s in the center of the channel. The introduction of flow from the second valve creates turbulence when the flows meet and shifts the flow to the center of the channel. The flow then begins to oscillate similar to the two-valve drain simulation. Streamlines indicate that there is little flow in the area between the downstream gates and culvert openings.

4.3 One Valve for 60 seconds, Two Valves Until Fully Drained

The results of staggering the downstream valve opening by 60 seconds are discussed in this section. Similar to the 30 second stagger simulation, the flow hugs the opposite wall with one valve open, creating a large area of slow or reverse flow. When the second valve is opened, the high velocity flow path oscillates from side to side. Streamlines show a similar pattern to the 30 second staggered valve opening simulation.

4.4 Downstream Deflector Plate Geometry, Two Valve Drain

This section discusses the results of the 25-degree downstream deflector plate geometry. The deflector plate forces the two flows to meet at an angle further downstream than the existing geometry. By softening the angle at which the two flows come together, the flow can be more focused downstream. However, this results in high velocities only in the middle of the channel, with very low or upstream velocities along the channel sides. This design was not pursued further due to the low velocities along the sides of the channel.

4.5 Upstream Deflector Plate, Two Valve Drain

The upstream deflector plate simulation shows the flow effectively scouring the downstream gates, but also affecting the flow patterns in the downstream approach, resulting in a flow focused along the wall opposite of the deflector. The flow from the deflected culvert sweeps along the downstream gates before heading downstream. However, this impacts the general flow pattern by creating a vortex in front of the deflected culvert and confining the high velocities to the channel side opposite of the deflected culvert.

4.6 One valve open for 60 seconds, second valve with upstream deflector plate opened until fully drained

This section discusses the results of the staggered opening upstream deflector model. The simulation begins by opening one valve (non-deflected) for 60 seconds, then opening the second valve with the deflected culvert opening. The results show the flow favoring the opposite side of the channel when the first valve is opened. When the deflected culvert is opened, the flow sweeps the area between the downstream gates and intersects with the flow from the non-deflected culvert. The resultant flow vector focuses water along the side of the channel below the non-deflected culvert. Using the upstream deflector plate in combination with a staggered valve opening created high velocities on both sides of the downstream approach at different points during the drain. However, there are areas of low velocity within the downstream approach at all time points. This includes the side of the non-deflected culvert when one valve is open, and the side of the deflected culvert when both valves area open.

4.7 One-third valve opening, 2-valves for 150 seconds

This section discusses the results of opening both downstream valves one-third. Results indicate that the constricted flow does not generate velocities higher than 3 ft/s in the downstream approach. The highest flow is consistently near the center of the channel.

4.8 Two-third valve opening, 2-valves until fully drained

This section discusses show the results of opening both downstream valves two-thirds. Maximum downstream velocities reach 10 ft/s approximately 30 seconds after valve opening. The results showed less oscillation than the fully-opened valves, with flow favoring the northeast side of the channel. Based on other simulations, this may not always be the preferential flow path and the areas of high velocity will likely vary with each drain. Restricting the valve openings resulted in an extended duration of high velocities. At section B-B', 50 feet from the downstream gates, maximum downstream velocities exceed 4 ft/s for 176 seconds, compared to 147 seconds for fully-opened valves.

5 Discussion

A FLOW-3D model of Lock C2 was created using survey data and design drawings to evaluate velocities in the lock chamber and downstream entry area. The rate of change of water level inside the lock was validated using field measurements. Anchor QEA modeled the current operating procedures as well as seven operational or geometry changes to inform operational changes that may deter round goby upstream migration.

Results from all simulations show little to no velocity within the lock chamber during the flushing, except within five feet of the sub-culvert openings. The flow exiting the lock chamber from the sub-culverts is a small fraction of the large volume of water in the chamber, resulting in only localized areas of high velocity around the sub-culverts. The CFD model results indicate that round goby deterrent methods should focus on preventing the fish from entering the lock chamber as velocities within the chamber are insufficient to entrain round goby and flush them out of the lock.

In all simulations, areas of low or reverse flow were present throughout the entire drain process. However, several simulations showed improvement to the current double draining procedures. These include:

1. **One valve for 60 seconds, two valves until fully drained:** Opening one valve focuses the flow on the opposite side of the channel. Before an upstream bound vessel enters the lock, the lock could be drained twice, alternating the valve that is opened first. This would allow for both sides to be swept by the high velocity flows at different time points during the double-draining procedure.

2. **Two-third valve opening:** Restricting the valve opening to two/thirds extends the duration of velocities that exceed goby bursting capabilities by approximately 20% (thirty seconds).

3. **Upstream deflector:** The upstream deflector geometry redirects flow to sweep the area between the culvert openings and the downstream gates. When combined with a staggered opening, this approach also yields high velocities along both sides and in the center of the channel at different points during the drain process.

Given the extreme turbulence of the downstream approach upon opening the valves, the exact flow patterns are unpredictable and likely vary with each drain. This report provides useful predictions of the general flow patterns created by the different operational or geometry changes.

APPENDIX F IMPLICATIONS OF WATER TEMPERATURE AND GOBY MOVEMENT ON TIMING OF LOCK C1 TAINTER GATE SEASONAL OPENING AND CLOSING

Implications of Water Temperature and Goby Movement on Timing of Lock C1 Tainter Gate Seasonal Opening and Closing

NYPA/Canals engineering staff indicate that while the Tainter gates are typically opened in October or early November, they can remain closed as late as mid-December. The Tainter gates are typically closed in early May to facilitate navigation once ice flows and spring flows have diminished. When closed, the Tainter gates at Lock C1 provide a deterrent to upstream movement of round goby. Round goby sampling by USGS has recently detected fish below Lock C1 but not above.

While information on round goby movement related to specific water temperatures is limited, several relevant journal articles note seasonal movement patterns, with goby moving into shallower, inshore/upstream areas during the summer and retreating downstream into deeper waters during the winter. Similar movement patterns were noted in fall 2022 below Lock C1 when water temperatures fell below 40/50 F. A summary of relevant studies is provided below. These, along with a general understanding of fish behavior, energetics, and ecology, indicate that there would be a benefit in timing the seasonal operation of the gates to match the lower ambient water temperatures associated with winter conditions.

In fall of 2022, USGS and NYSDEC monitored water temperatures immediately below Lock C1 as part of their round goby monitoring program. Through November 7th, they had consistently captured goby immediately below the Tainter gates at the C1 dam. The water temperature on November 7th was 61 ^{0}F. No round goby were captured during their final two surveys, conducted on November 21st and November 28th, when the water temperature was 41 ^{0}F and 42 ^{0}F, respectively. At their positive control site on the Mohawk River at Peebles Island where goby are normally abundant, sampling efforts produced only 1 goby on 11/21 and no goby on 11/28. These findings provide supporting evidence that round goby may be moving out of the shallow/higher velocity areas when temperatures are lower.

NYSCC has selected 40 ^{0}F as a trigger criteria for the seasonal opening and closing of the Tainter gates at Lock C1 to reduce the risk of goby migration through the open gates during the winter low water condition.

Fish Ecology Studies

- The round goby a Review of European and North American Literature (Charlebois et al. 1997.)
    - **The metabolic rate of the goby during summer (20-24°C) is 5-6 times higher than during the winter (0.5-3.5°C**).
    - The round goby is eurythermal. In its native habitats, its **temperature tolerance is between -1 and +30°C** (Moskal'kova 1996)

- Identifying high-risk areas for introduction of new alien species: the case of the invasive round goby, a door-knocker for Norway (Forsgren and Hanssen 2022)
    - The round goby has a broad temperature tolerance and a high level of thermal resilience (Wellband & Heat, 2017; Christensen et al., 2021). It may tolerate temperatures between 0 and 30 °C (Kornis et al., 2012) **but seems to prefer relatively warm water as its energetic optimum temperature was estimated to 26 °C** (Lee & Johnson, 2005).
    - The round goby is a benthic shallow water species, which in marine habitats mainly occurs at depths down to 20 m (Kullander et al., 2012). In the southern Baltic Sea (Sweden) it was most abundant at depths < 10 m (Florin et al., 2018). I**t is found in shallow water during**

the reproductive season and migrates to deeper waters over winter (Sapota, 2004; Gertzen et al., 2016; Christoffersen et al., 2019; Behrens et al., 2021).

- Dynamics of the seasonal migration of round goby (Neogobius melanostomus, Pallas 1814) and implications for the Lake Ontario food web (Pennuto et al. 2021)
    - The round goby (*Neogobius melanostomus*) arrived in Lake Ontario (USA/Canada) about 20 years ago with a documented history of **annual offshore–inshore migrations** in its native range
    - **This behavior was correlated with seasonal, nearshore temperature changes**. Goby outmigrate to deeper water in winter.
- Seasonal migration and fine-scale movement of invasive round goby (Neogobius melanostomus) in a Great Lakes tributary (Blair et al. 2019)
    - **Adult round goby movement patterns were positively associated with changes in water temperature, but this was not the case for juveniles.** Juveniles displayed a preference for shallow, upstream habitats
    - The individual **movement was primarily upstream in spring, and there was little net movement in summer, likely during reproduction.**

Swim speed studies: (provides general guidance for fish movement as a function of water temperature. Water temperatures noted are typical of those observed during late spring through early fall and does not necessarily inform the question)

- Related to growth: warmer temperatures may lead to faster growth rate in a study of tributary vs. Lake Michigan populations (Kornis et al. 2017).
    - Mean daily water temperatures at the tributary sites approached the **round goby's energetic optimum of 26°C** during summer but was much colder at the Lake Michigan site.
- Hoover et al. (2003) swimming speed study tested time to fatigue at 17°C and 20°C. "Small gobies exhibited sustained station holding at 15 cm/s, prolonged station holding (from 0.5 to 44 min) at 20 to 50 cm/s, and burst station holding at 55 to 75 cm/s. Large gobies exhibited sustained swimming at 20 cm/s, prolonged swimming (from 0.5 to 72 min) at 20 to 50 cm/s, and burst station holding at 55 to 75 cm/s (larger fish having greater endurance than smaller cohorts). At 20°C, small gobies exhibited prolonged station holding (0.5 to 61 min) at 15 to 55 cm/s, with burst station holding behavior at 60 cm/s."
    - **A swimming speed performance difference was noted for smaller gobies when temperature was increased from 17°C to 20°C.**
    - Predictive endurance models were presented for water temperatures of 17°C and 20°C. "There were notable differences in swimming speeds between temperatures."
    - "**Overall, station-holding endurance at lower water velocities (<30 cm/s) was higher at the cooler temperature; endurance at higher water velocities (> 30 cm/s) was higher at the warmer temperature**. Definitive statements regarding differences in swimming performance at different water temperatures cannot be made at this time, since tests were discontinued at 20°C due to apparent stress experienced by gobies at that temperature (based on aberrant behavior and post-test mortality). Because endurance decreased curvilinearly with increased water velocity, polynomial models were used to describe the relationship between the two variables (Table 1)."
- Tierney et al. (2011) swimming speed study
    - "Gobies were…kept in filtered, dechlorinated municipal water on an 8:00-20:00 light:dark schedule, temperature 20-22°C."
    - Discussion section said test temperature was approximately the same, so no intra-study temperature differences in swimming performance can be inferred.

- Gilbert et al. (2016) swimming speed study
    - Follow up to Tierney et al. (2011) swimming speed study
    - "Gobies were held for no less than 6 months in 20-22°C filtered, dechlorinated municipal water aquaria under an 8:00:20:00 light:dark cycle…"
- Egger et al. (2020) swimming speed study
    - Ucrit study was conducted at 16°C. Presumably Usprint as well but that doesn't appear to be explicitly stated.
- US Army Corps of Engineers (2011)
    - "There has been little research on the effects of water temperature on electrical exposure-induced behaviors in fish."

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APPENDIX G DRAFT FRAMING DOCUMENT FOR TEMPORARY ELECTRIC BARRIER INFORMATION NEEDS, DESIGN REQUIREMENTS, AND SCHEDULE

Draft Framing Document for Temporary Electric Barrier Information Needs, Design Requirements, and Schedule

This document provides a basic framework for design and fabrication of a temporary electric barrier for potential deployment in the Champlain Canal.

Outstanding information needs

- Condition of area that the electrode array will be affixed to:
  - What is the channel width and side wall geometry?
  - What is the range of channel depths?
  - Is anchoring possible? How can anchoring be done?
  - Are there metal appurtenances that can disrupt the electrical field?
  - If reinforced concrete, what is cover over rebar? Is any rebar exposed?
  - Will sediment or debris need to be removed?
  - What is rate of sediment aggradation? What is conductivity of sediment?
- Range of potential water depths over the barrier
- Range of potential velocities in the vicinity of the barrier
- Water conductivity: long-term records & basic statistical analysis
- Understand the process and costs for extending 240V power to the barrier equipment trailer
- Understand human safety and exclusion requirements in the barrier zone
- Understand risks to aquatic organisms other than target species, and likely protocols in the event an organism of concern enters the barrier zone and/or is affected by the barrier
- Understanding of the operation and maintenance requirements

Design requirements

- Assumption is to rent or purchase portable barrier trailer, pulse generators, and barrier control equipment (Smith-Root, Inc.)
- Design size of electrodes, diameter and length of pulse delivery cable
- Design electrode array, insulator (if needed), and deployment method (i.e., canvas?)
- Design anchoring for electrode array on channel bottom and walls
- OPTIONAL: Sizing for backup power generator and fuel tank
- OPTIONAL: Assess risk of electrical field capture and corrosion on nearby conductive objects
- OPTIONAL: Design monitoring and human safety features

Example sequence and duration of major tasks (months after notice to proceed)

Task	Month 1	Month 2	Month 3	Month 4	Month 5
Information review					
Design					
Trailer outfitting					
Electrode array manufacture[1]					
Shipping and site prep					
Installation					
System commissioning					

[1] – Assumes Smith-Root has sufficient stock of BP-1.5 POW pulse generators. Availability and potential manufacturing time is dependent on sales.

APPENDIX H POTENTIAL LISTED AND ENDANGERED SPECIES PRESENT WITHIN THE CHAMPLAIN CANAL

Protected Species in Vicinity of Champlain Canal Control Points

Publicly Available Information on Federal and State Listed Species

A list of aquatic species that may be present in the vicinity of control points (*e.g.,* lock locations) along the Champlain Canal was developed to support evaluation of round goby control actions. Species occurrences were obtained from publicly available information sources, such as the USFWS's IPaC - Information for Planning and Consultation system, the NYSDEC Environmental Mapper, and the NY Nature Explorer county-level records for Rensselaer, Saratoga, and Washington Counties. The list was further refined through consultation with NYSDEC who provided a list of potentially affected species (Stephen S. Hurst, Chief, Bureau of Fisheries, Division of Fish and Wildlife, personal communication, 6/23/2022).

Species	Federal Status	State Status*	C1	C2	C3	C4	C5	C6	C7	C8	C9	C11
Fish												
Atlantic sturgeon (*Acipenser oxyrinchus*)	n/a	P										
shortnose sturgeon (*Acipenser brevirostrum*)	n/a	E										
blackchin shiner (*Notropis heterodon*)	n/a	HP	x	x	x	x	x	x	x	x	x	x
eastern sand darter (*Ammocrypta pellucida*)	n/a	T					x	x	x	x	x	x
lake chub (*Couesius plumbeus*)	n/a	HP					x	x	x	x	x	x
sauger (*Sander canadensis*)	n/a	HP					x	x	x	x	x	x
American eel (*Anguilla rostrata*)	n/a	HP	x	x	x	x	x	x	x	x	x	x
alewife (*Alosa pseudoharengus*)	n/a	n/a										
blueback herring (*Alosa aestivalis*)	n/a	n/a										
Mollusks												
eastern pondmussel (*Ligumia nasuta)*	n/a	HP		x	x	x						
tidewater mucket (*Leptodea ochracea*)	n/a	HP	x	x	x	x						
yellow lampmussel (*Lampsilis cariosa*)	n/a	HP	x	x	x	x						
eastern pearlshell (*Margaritifera margaritifera*)	n/a	HP	x	x	x	x	x	x	x			
black sandshell (*Ligumia recta*)	n/a	HP					x	x	x	x	x	X

* P = Protected, E = Endangered, T = Threatened, HP = High Priority Species of Greatest Conservation Need

List of Potentially Affected Species

- **American eel** – Hudson River hydropower projects are currently installing or planning on installing eel-specific ladders at multiple locations (Federal Dam, Upper Mechanicville) and may eventually be installed at other locations (Stillwater, Lower Mechanicville). Closure of locks from C2 through C7 may not negatively impact American eels long-term as eel ladders are installed.

- **Regulated Species** - The list of regulated species below occur throughout the Hudson River from the Federal Dam up to Fort Edward and into the Champlain Canal. Due to their non-migratory life histories, closure at any lock would not be likely to impact the populations or recreation for these species; all are managed as catch and release from below C1 (Troy Dam) up to Bakers Falls on Hudson River (upstream of entrance to land cut section of canal at C7).
    - northern pike (*Esox lucius*)
    - chain pickerel (*Esox niger*)

- redbreast sunfish (*Lepomis auritus*)
- green sunfish (*Lepomis cyanellus*)
- pumpkinseed (*Lepomis* gibbosus)
- bluegill (Lepomis macrochirus)
- smallmouth bass (Micropterus dolomieu)
- largemouth bass (Micropterus salmoides)
- black crappie (Pomoxis nigromaculatus)
- yellow perch (Perca flavescens)
- walleye (Sander vitreum)
- redfin pickerel (Esox americanus americanus)

- **Known native mussel species within the system -** Closure at any of the listed locks could potentially impact upstream movement of host fish species that transport native mussels during the larval stage of their life cycle.
    - C2 (Mechanicville, NY) – eastern pondmussel (S2/S3)
    - C3 (Mechanicville, NY) - eastern pondmussel (S2/S3)
    - C4 (Stillwater, NY) - eastern pondmussel (S2/S3)

APPENDIX I HISTORICAL DATA ON VESSEL USAGE AND LOCKAGES ON THE CHAMPLAIN CANAL

Appendix: Summary of Champlain Canals Boat Traffic (2014-2021)
June 2022

Data collected by NYS Canal Corporation staff were analyzed to characterize northbound and southbound boat traffic at selected lock locations during the period 2014-2021.

Total Number of Boats

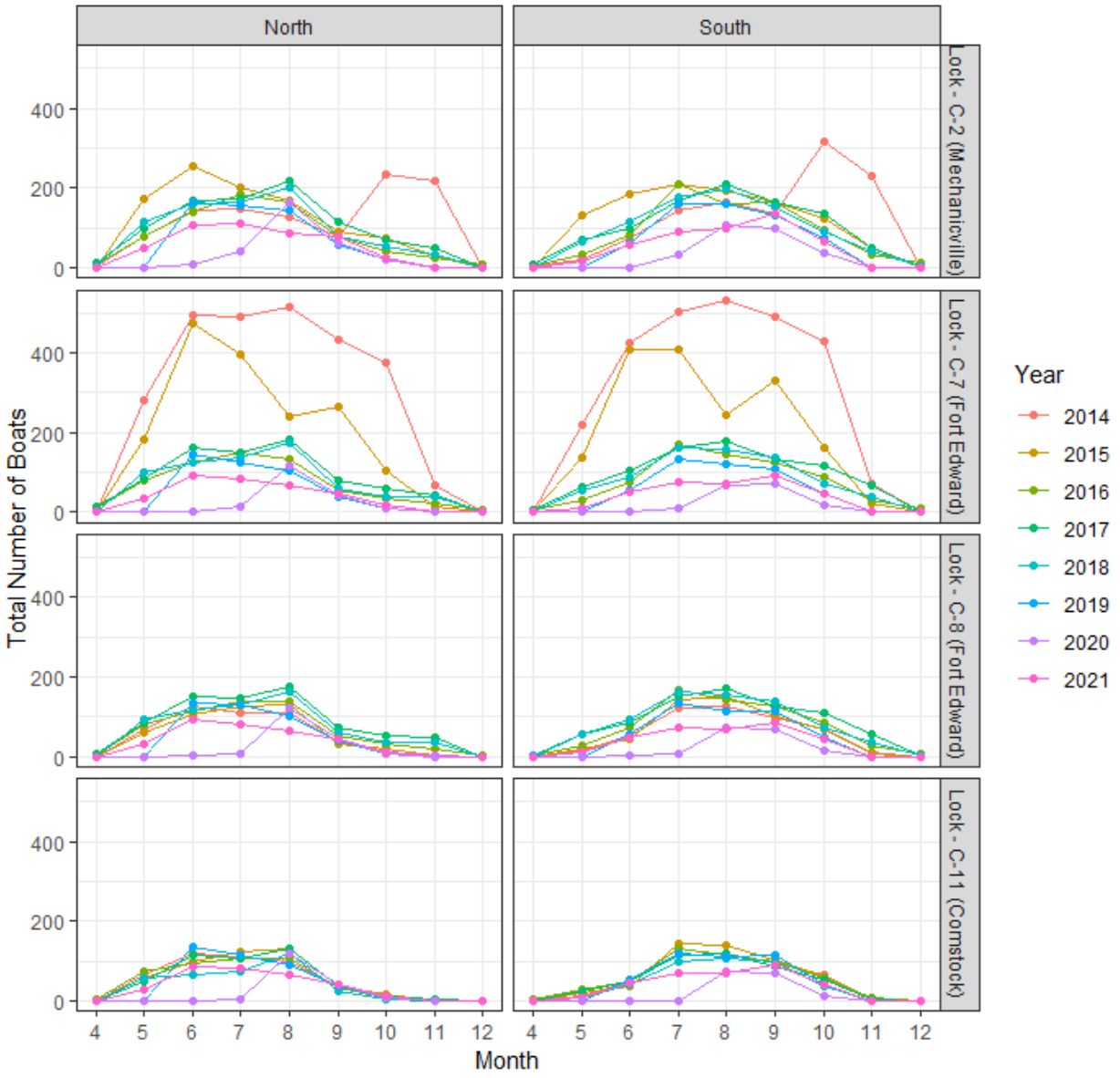

Figure 1. Total number of boats counted passing four Champlain Canal locks in each direction by month (2014-2021).

This figure shows that number of boats at Lock C-7 was very high in 2014 and 2015, which was apparently due to construction barges working in the local area near this lock. Corresponding data are provided in Table 1.

This figure also shows that all locks had zero traffic from April through mid-July 2020, and reduced traffic in 2021, apparently due to the COVID pandemic.

Table 1. Total number of boats counted passing four Champlain Canal locks in each direction by month (2014-2021).

		North								South							
Lock	Month	2014	2015	2016	2017	2018	2019	2020	2021	2014	2015	2016	2017	2018	2019	2020	2021
C-2	4	5	1	8	11	5	0	0	0	2	1	3	6	1	0	0	0
	5	79	174	78	100	113	0	0	47	22	131	31	69	65	0	0	18
	6	144	254	138	167	161	162	6	106	74	185	82	100	113	61	1	56
	7	148	201	186	171	163	155	41	111	142	209	210	170	178	161	31	88
	8	126	168	163	217	202	144	162	87	162	191	159	211	196	160	107	98
	9	78	89	77	113	77	56	63	78	134	164	165	165	152	133	99	136
	10	234	75	42	70	55	19	21	23	317	123	94	135	90	74	36	64
	11	219	27	24	48	33	0	0	0	228	47	32	47	39	0	0	0
	12	0	0	6	1	0	0	0	0	0	0	10	5	3	0	0	0
C-7	4	0	2	8	12	0	0	0	0	0	2	4	7	0	0	0	0
	5	280	183	78	85	100	0	0	33	219	135	31	62	54	0	0	11
	6	493	472	124	161	125	144	2	92	426	408	73	102	88	55	0	51
	7	492	397	148	148	137	126	12	83	503	407	171	162	161	133	11	76
	8	517	241	132	183	173	103	118	65	531	245	145	177	159	120	67	71
	9	431	263	54	78	59	36	44	46	489	331	123	134	136	109	71	91
	10	374	102	35	59	39	9	10	16	428	163	88	115	70	48	17	45
	11	66	15	23	44	39	0	0	1	72	20	28	68	38	0	0	0
	12	0	0	7	1	0	0	0	0	0	0	10	3	0	0	0	0
C-8	4	0	0	4	6	0	0	0	0	0	0	3	4	0	1	0	0
	5	68	62	80	86	92	0	0	32	14	18	29	56	58	0	0	9
	6	126	104	115	152	117	136	1	91	53	44	73	86	91	55	1	49
	7	110	126	140	148	131	130	8	82	121	144	167	152	164	133	6	72
	8	108	130	137	175	164	100	121	64	124	151	141	170	156	113	72	70
	9	34	32	53	74	59	39	44	43	97	101	125	125	140	113	70	86
	10	11	20	33	50	35	8	8	11	67	67	83	108	72	46	15	44
	11	2	2	20	46	36	0	0	1	9	5	26	54	34	0	0	0
	12	0	0	4	0	0	0	0	0	0	0	8	1	1	0	0	0
C-11	4	0	0	4	0	0	0	0	0	0	0	3	0	0	1	0	0
	5	66	59	73	51	57	0	0	29	11	19	27	24	10	0	0	9
	6	119	99	96	113	64	134	0	86	49	38	50	49	40	54	0	46
	7	112	122	107	107	72	115	4	84	116	143	131	115	98	121	1	71
	8	99	130	106	131	120	92	118	67	120	141	113	120	105	110	75	71
	9	35	35	31	38	25	36	41	41	96	104	100	86	99	114	68	90
	10	12	17	9	11	5	7	8	12	66	62	57	55	35	43	14	41
	11	2	0	1	2	0	0	0	1	5	2	7	2	1	0	0	0
	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Boats Per Day

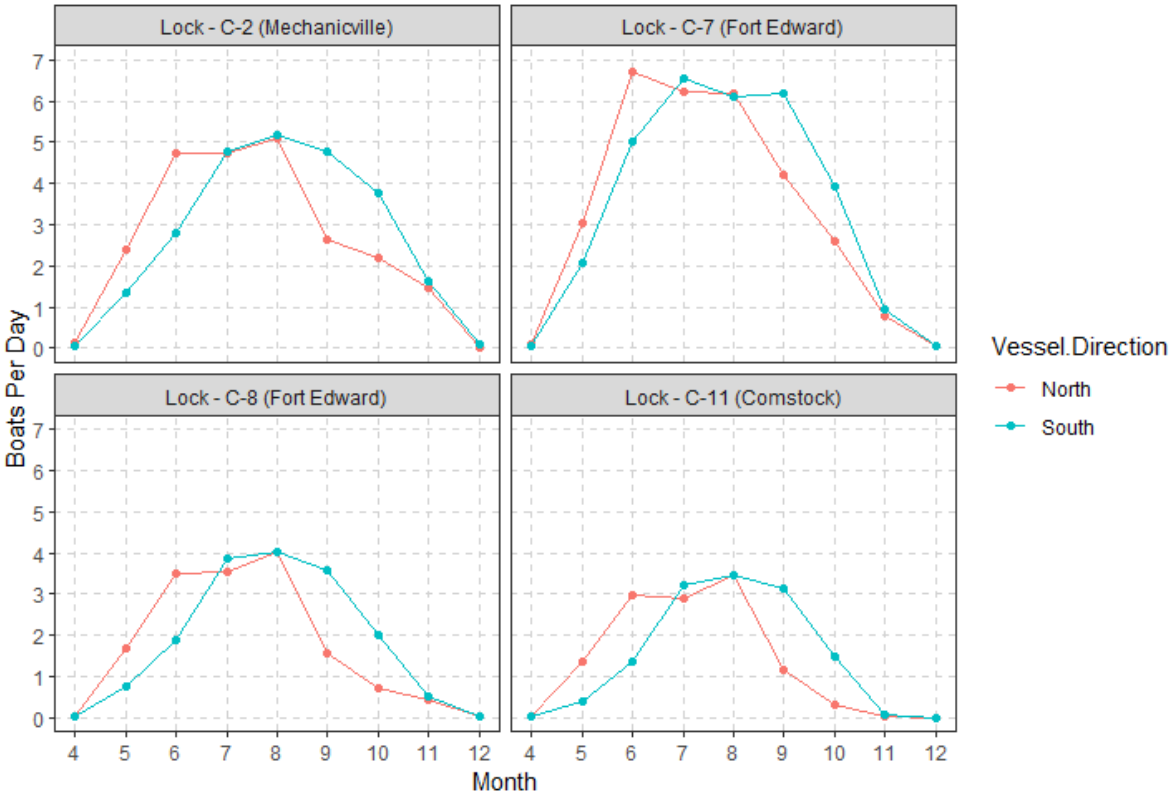

Figure 2. Average number of boats per day in each direction at four Champlain Canal locks (2014-2021). Boat counts were summed for each month in each year, divided by the number of days in the month, then averaged across 8 years (including zeros in some years).

This plot shows that there is a distinct seasonal trend in boat traffic, which rises to peak levels June-August for boats travelling North, and July-September for boats travelling South. Corresponding data are provided in the table below.

		Month								
Direction	Lock	4	5	6	7	8	9	10	11	12
North	C-2	0.13	2.4	4.7	4.7	5.1	2.6	2.2	1.5	0.03
	C-7	0.09	3.1	6.7	6.2	6.2	4.2	2.6	0.78	0.03
	C-8	0.04	1.7	3.5	3.5	4.0	1.6	0.71	0.45	0.02
	C-11	0.02	1.4	3.0	2.9	3.5	1.2	0.33	0.03	0
South	C-2	0.05	1.4	2.8	4.8	5.2	4.8	3.8	1.6	0.07
	C-7	0.05	2.1	5.0	6.5	6.1	6.2	3.9	0.94	0.05
	C-8	0.03	0.74	1.9	3.9	4.0	3.6	2.0	0.53	0.04
	C-11	0.02	0.40	1.4	3.2	3.4	3.2	1.5	0.07	0

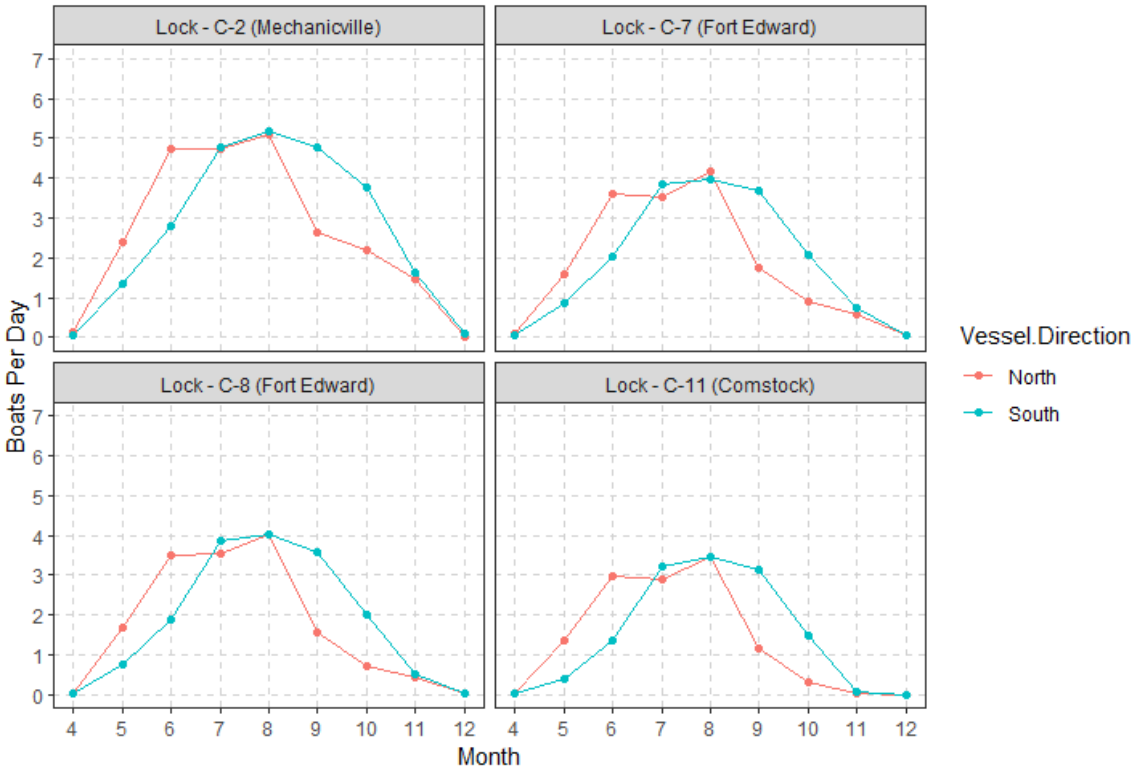

Figure 3. Average number of boats per day in each direction at four Champlain Canal locks (2014-2021), with 2014 and 2015 data removed for Lock C-7 because of unusual construction-related boat traffic.

Boat counts were summed for each month in each year, divided by the number of days in the month, then averaged across 8 years (including zeros in some years; 6 years only for Lock C-7).

This plot shows the reduction in estimated number of boats per day at Lock C-7 when years with high bias are removed. Corresponding data are provided in the table below.

		Month								
Direction	Lock	4	5	6	7	8	9	10	11	12
North	C-2	0.13	2.4	4.7	4.7	5.1	2.6	2.2	1.5	0.03
	C-7	0.09	3.1	6.7	6.2	6.2	4.2	2.6	0.78	0.03
	C-8	0.04	1.7	3.5	3.5	4.0	1.6	0.71	0.45	0.02
	C-11	0.02	1.4	3.0	2.9	3.5	1.2	0.33	0.03	0
South	C-2	0.05	1.4	2.8	4.8	5.2	4.8	3.8	1.6	0.07
	C-7	0.05	2.1	5.0	6.5	6.1	6.2	3.9	0.94	0.05
	C-8	0.03	0.74	1.9	3.9	4.0	3.6	2.0	0.53	0.04
	C-11	0.02	0.40	1.4	3.2	3.4	3.2	1.5	0.07	0

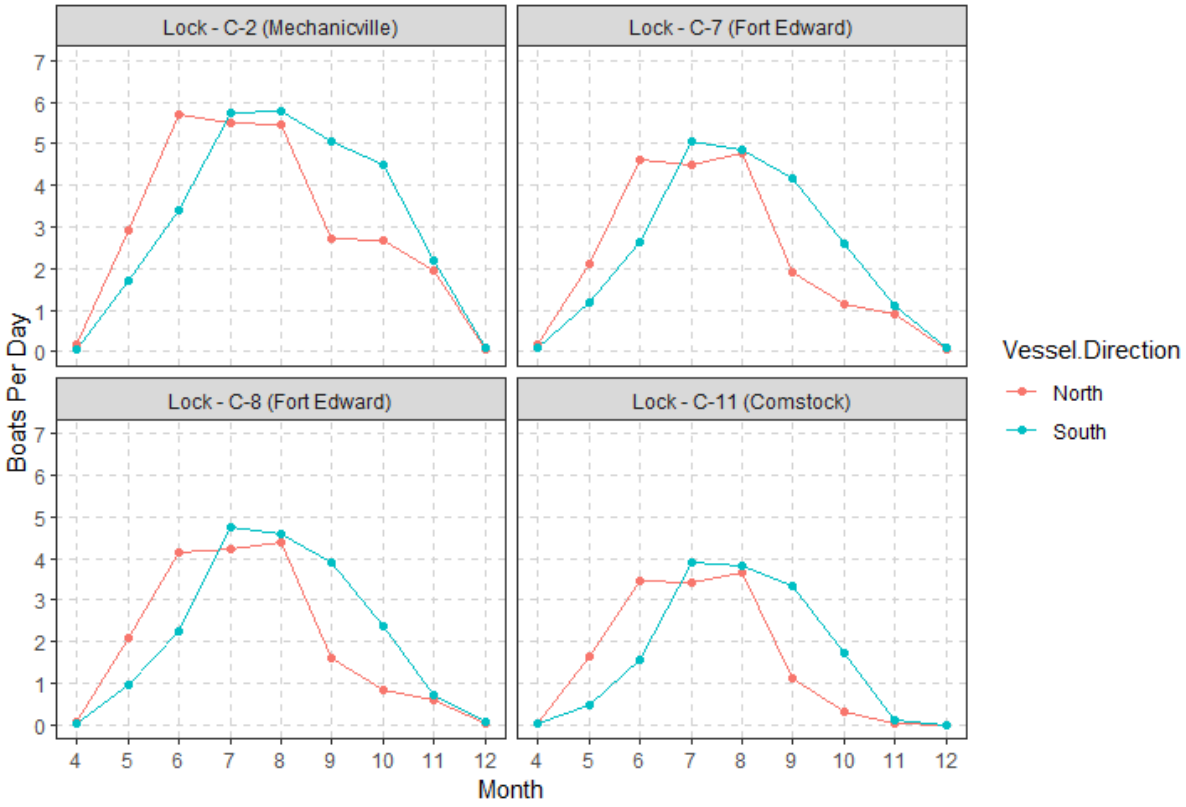

Figure 4. Average number of boats per day in each direction at four Champlain Canal locks for 2014-2019, excluding 2020 and 2021 due to impact of the COVID pandemic. These plots also exclude 2014 and 2015 data for Lock C-7 because of unusual construction-related boat traffic.

Boat counts were summed for each month in each year, divided by the number of days in the month, then averaged across 6 years (including zeros in some years; 4 years only for Lock C-7).

This plot shows the increase in estimated number of boats per day when the pandemic-influenced years are removed. Corresponding data are provided in the table below.

		Month								
Direction	Lock	4	5	6	7	8	9	10	11	12
North	C-2	0.17	2.9	5.7	5.5	5.5	2.7	2.7	2.0	0.04
	C-7	0.12	3.9	8.4	7.8	7.3	5.1	3.3	1.04	0.04
	C-8	0.06	2.1	4.2	4.2	4.4	1.6	0.84	0.59	0.02
	C-11	0.02	1.6	3.5	3.4	3.6	1.1	0.33	0.03	0
South	C-2	0.07	1.7	3.4	5.8	5.8	5.1	4.5	2.2	0.10
	C-7	0.07	2.7	6.4	8.3	7.4	7.3	4.9	1.26	0.07
	C-8	0.04	0.94	2.2	4.7	4.6	3.9	2.4	0.71	0.05
	C-11	0.02	0.49	1.6	3.9	3.8	3.3	1.7	0.09	0

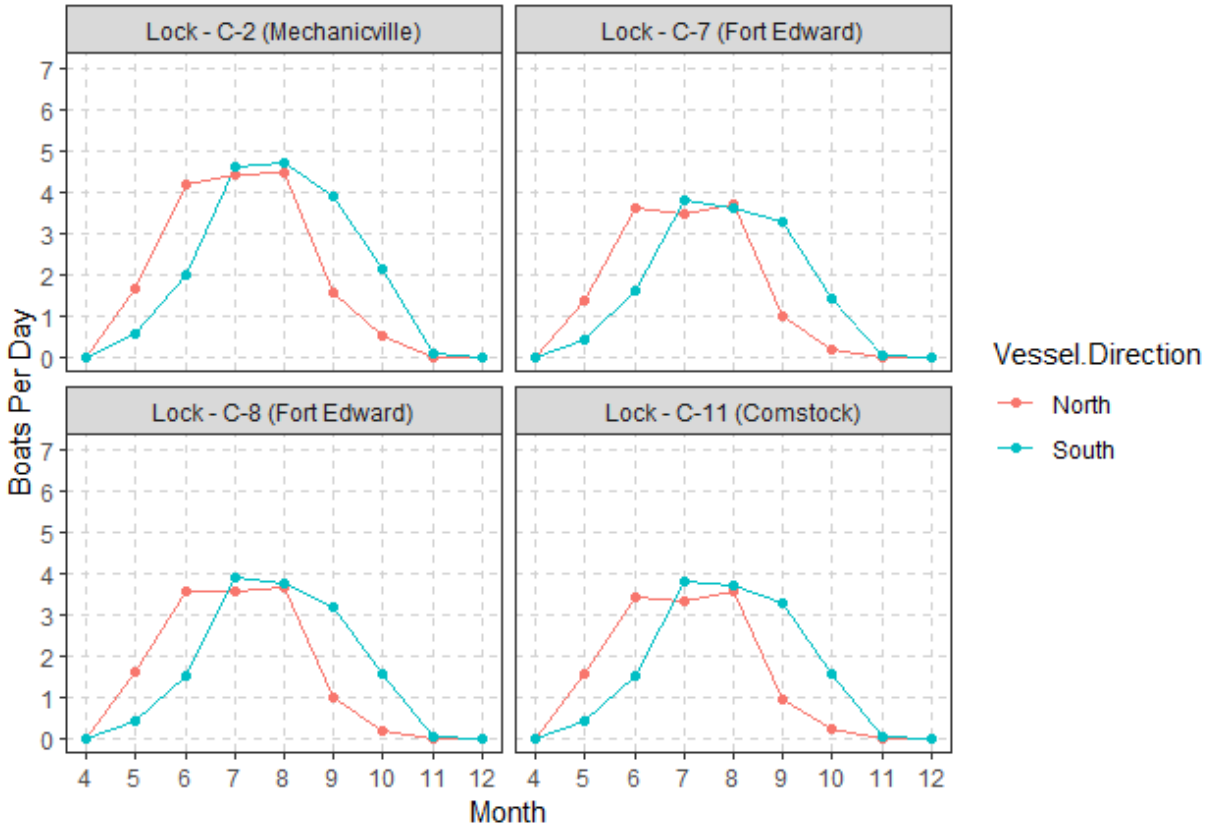

Figure 5. Average number of Recreational boats per day in each direction at four Champlain Canal locks for 2014-2019, excluding 2020 and 2021 due to impact of the COVID pandemic. These plots also exclude 2014 and 2015 data for Lock C-7 because of unusual construction-related boat traffic.

Boat counts were summed for each month in each year, divided by the number of days in the month, then averaged across 6 years (including zeros in some years; 4 years only for Lock C-7). The recreational boat category includes boats identified with Vessel.Type=="Employee / Retiree", "General Traffic", "Pleasure", or "Pleasure – No motor".

This plot shows that recreational boats account for most traffic at these four locks, especially at Lock C-11. Corresponding data are provided in the table below.

		Month								
Direction	Lock	4	5	6	7	8	9	10	11	12
North	C-2	0.02	1.7	4.2	4.4	4.5	1.6	0.5	0.02	0
	C-7	0.03	1.4	3.6	3.5	3.7	1.0	0.2	0.00	0
	C-8	0.02	1.6	3.6	3.5	3.7	1.0	0.22	0.01	0
	C-11	0.02	1.6	3.4	3.3	3.6	1.0	0.24	0.01	0
South	C-2	0.00	0.55	2.0	4.6	4.7	3.9	2.2	0.10	0
	C-7	0.01	0.42	1.6	3.8	3.6	3.3	1.4	0.06	0
	C-8	0.01	0.43	1.5	3.9	3.8	3.2	1.6	0.07	0
	C-11	0.01	0.44	1.5	3.8	3.7	3.3	1.6	0.06	0

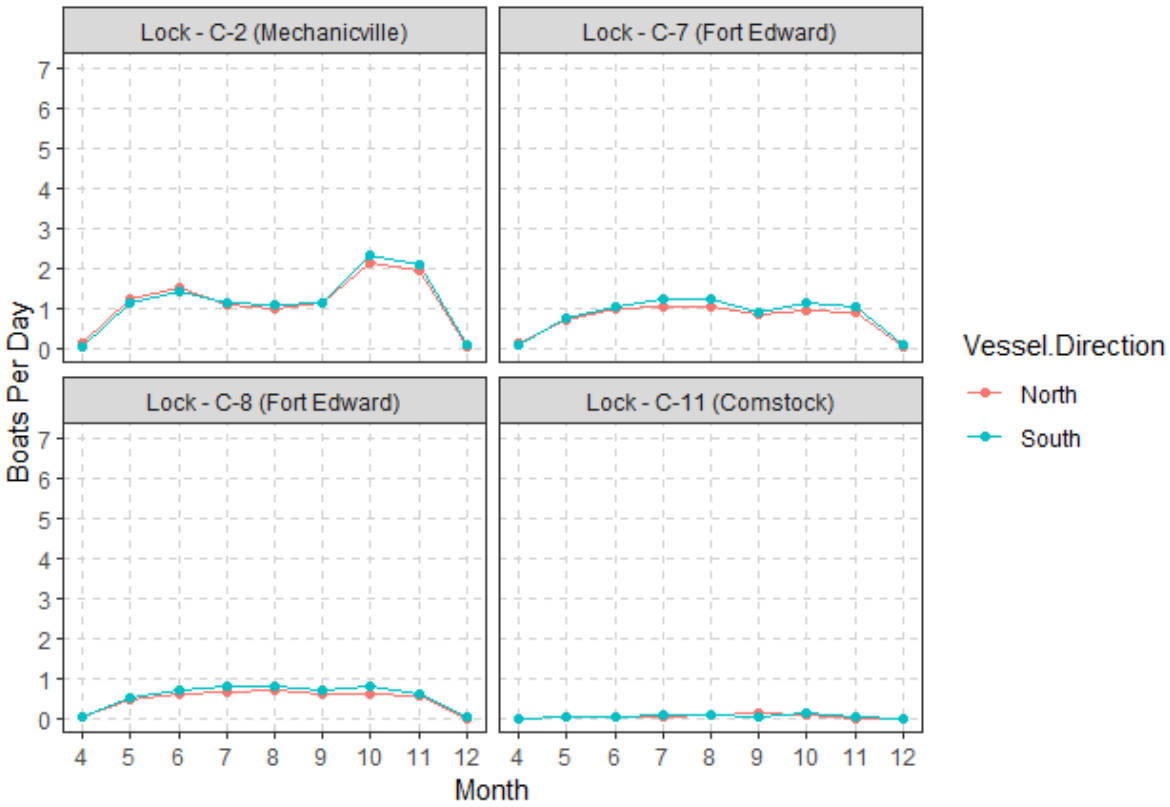

Figure 6. Average number of **Commercial** boats per day in each direction at four Champlain Canal locks for 2014-2019, excluding 2020 and 2021 due to impact of the COVID pandemic. These plots also exclude 2014 and 2015 data for Lock C-7 because of unusual construction-related boat traffic.

Boat counts were summed for each month in each year, divided by the number of days in the month, then averaged across 6 years (including zeros in some years; 4 years only for Lock C-7). The commercial boat category **excludes** boats identified with Vessel.Type=="Employee / Retiree", "General Traffic", "Pleasure", or "Pleasure – No motor".

This plot shows that commercial boats account for a small proportion of the boat traffic in general, and the commercial traffic is highest at Lock C-2, and almost non-existent at Lock C-11. There is also less of a seasonal trend in the commercial traffic. Corresponding data are provided in the table below.

		Month								
Direction	Lock	4	5	6	7	8	9	10	11	12
North	C-2	0.15	1.2	1.5	1.1	1.0	1.2	2.1	1.9	0.04
	C-7	0.14	0.73	1.0	1.1	1.1	0.87	0.94	0.88	0.06
	C-8	0.04	0.47	0.60	0.68	0.72	0.61	0.63	0.58	0.02
	C-11	0.01	0.06	0.04	0.06	0.08	0.14	0.09	0.02	0
South	C-2	0.07	1.2	1.4	1.1	1.1	1.2	2.3	2.1	0.10
	C-7	0.08	0.77	1.0	1.2	1.2	0.92	1.1	1.06	0.10
	C-8	0.03	0.51	0.69	0.83	0.82	0.69	0.80	0.64	0.05
	C-11	0.01	0.05	0.03	0.11	0.10	0.07	0.12	0.03	0

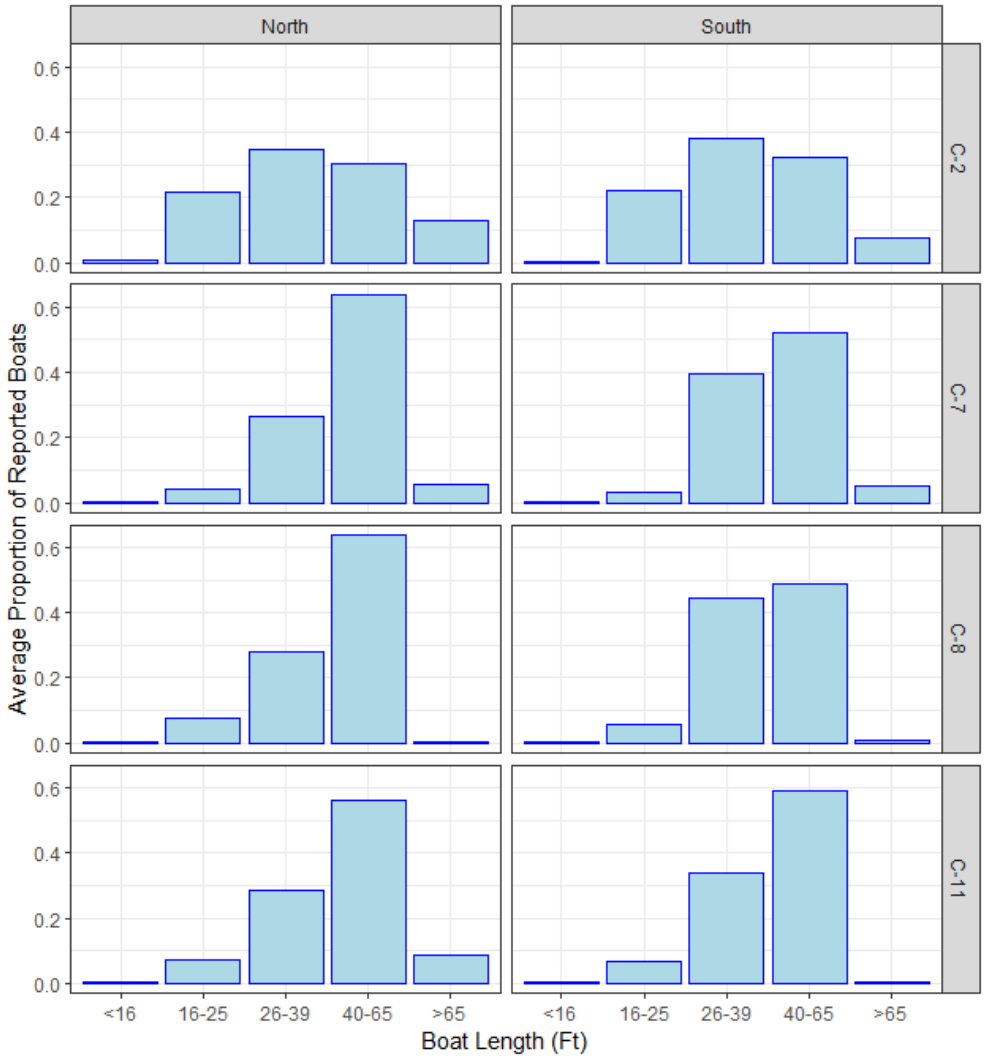

Figure 7. Estimated proportions of boats of different size classes (measured in feet) passing through each lock in each direction over the May-October season (2014-2019), excluding 2020 and 2021 due to impact of the COVID pandemic. These plots also exclude 2014 and 2015 data for Lock C-7 because of unusual construction-related boat traffic.

The proportion of boats (of those given lengths) in each length category were estimated for the May-October Season and averaged across 6 years (4 years for Lock C-7). Only about 25% of total boat passages were classified by length, and the percentage varies by year, including some years with no lengths recorded. Therefore, these estimates are imprecise due to low sample size and may be inaccurate due to bias in selection of boats that are given lengths. Corresponding data are provided in the table below.

	Northbound					Southbound				
Lock	**<16ft**	**16-25**	**26-39**	**40-65**	**>65 ft**	**<16**	**16-25**	**26-39**	**40-65**	**>65**
C-2	0.53%	22%	34%	30%	13%	0.35%	22%	38%	32%	7.3%
C-7	0.31%	4.2%	26%	64%	5.6%	0.19%	3.3%	39%	52%	5.1%
C-8	0.42%	7.5%	28%	64%	0.41%	0.35%	5.7%	45%	49%	0.66%
C-11	0.31%	7.0%	28%	56%	8.4%	0.21%	6.5%	34%	59%	0.21%