

American Eel Sampling in Lake Champlain 2014 Progress Report

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Introduction

American eel *Anguilla rostrata* support important commercial fisheries where populations remain at harvestable levels. However, downward trends in harvest data have raised concern for the population of eel in the United States and Canada. Organizations such as the Great Lakes Fishery Commission and the Atlantic States Marine Fisheries Commission have identified the eel as a high research priority and/or have prepared management plans for the species. Furthermore, the United States Fish and Wildlife Service (Service) received a petition seeking to extend federal protection to the American eel. The Service is now conducting a status review of this species.

The Richelieu River connects northern Lake Champlain to the St. Lawrence River and supported a commercial eel fishery until it was closed in 1998 because harvest dramatically declined. The rebuilding of two dams on the river has been partly to blame for the decline (Verdon et al. 2003). The Dams at Saint-Ours, Québec and Chambly, Québec were refurbished in the mid-1960s. Evidence of these dams' impacts on eel recruitment to Lake Champlain can be seen in eel surveys in 1979 and 1985. Mark-recapture studies conducted in three Lake Champlain bays, Paradise Bay, Keelers Bay and Converse Bay, indicated a decline in estimated population size (Labar and Facey 1983, Labar 1987) and an increase in average size of eel caught, reflecting an aging population that has not been sufficiently supplemented by recruits. Total catch in Paradise Bay declined from 85 eels captured in 1979 to 50 in 1985. Keeler Bay eel catch dropped from 146 eels captured to 81 eels; and Converse Bay catch dropped from 138 to 78 eels.

In 1997 an eel ladder was constructed at the dam in Chambly and in 2001 a fish ladder and an eel ladder were built at St Ours. Faune Québec, in cooperation with a commercial fishermen union and Hydro- Québec, initiated a ten-year eel stocking program in 2005 in the Richelieu River to further enhance eel recruitment. From 2005 to 2008 an average of about 692 thousand elvers (50-65 millimeters in length) were transferred annually from the Atlantic Coast (Nova Scotia, Canada) to the Richelieu River (Table 1), where they were scatter stocked during the daytime in the first 15 km of the river, between Saint-Paul-de-l'Île-aux-Noix and the Canada-US border. All the eels were marked with oxytetracycline which leaves a permanent mark on calcified structures (ex: otoliths). Marks can be observed under a microscope using a fluorescent light source.

In order to monitor the success of these stocking efforts and new passage facilities, Québec asked the Service's Lake Champlain Fish and Wildlife Resources Office in Essex Junction, Vermont for assistance by repeating the Lake Champlain surveys. The Service conducted eel surveys in 2007, 2010, 2012 and 2014. This report presents the findings of the 2014 sampling efforts.

Study Area

Lake Champlain (1,140 km²) borders New York and Vermont and extends into Québec (Figure 1). Keeler and Paradise Bays are situated on the eastern side of South Hero, Vermont in what is described as the Northeast Arm of the lake. Converse Bay is located further south in the town of Charlotte/Ferrisburg. All the bays varied in substrate from mud with vegetation to bear rock.

Methods

Electrofishing was conducted by boat with a pulsed direct current of ~2.5 amps. Sampling was conducted after dark when eels were presumed to be most active. Sampling transects were electronically recorded using a global positioning system unit and followed the shoreline generally staying in less than 2 meters depth. An effort of one hour was selected as the sampling time which covered approximately 2 kilometers of shoreline. Collected eels were anesthetized, measured, weighed and checked for presence of a passive integrated transponder tag (PIT). Eels collected in Converse Bay were implanted with a passive integrated transponder tags (Biomark, model TX1405L) near the back of the head and released.

Results/Discussion

Eel sampling occurred on the nights of July 22 (Converse Bay) and July 24 (Paradise and Keeler Bay) in 2014 (Figures 2 and 3). Sampling was not conducted along Grand Isle shoreline in 2014. Numbers of eels collected or observed at each location were similar or greater relative to sampling in 2012 (Table 2). The greatest increase in numbers of eels encountered were in Paradise and Keeler bays where few eels were collected in 2012.

Eels collected ranged in size from 320 millimeters (mm) to 760 mm. Appendix 1 contains the raw American eel data and PIT numbers. Mean length was 509 mm (SD = 81) and mean weight was 297 grams (SD = 167) (Table 3). Smaller eels (< 300 mm) were not collected or observed in 2014 as they were in the previous two sampling years.

Figure 4 compares length frequencies for the last three sampling years. In 2014, slightly larger eels were collected while the number of smaller eel observed or collected decreased. This shift in length is similar to what was observed at the eel ladder in Chambly between 2009 and 2013. In 2013, 1,353 eels migrated upstream and 404 eels measured averaged 340.1 mm (SD=99.7) (Verreault et al. 2014). This compares to average lengths of 317.8 (SD=86.9) in 2009 and 273.5 (SD=61.0) in 2011. Much larger eels were collected by Facey and Labar (1981) in 1979 (Figure 5). They found lengths ranged from 430-900 mm with a mean of 670 mm (SD=91.0).

One American eel tagged with a PIT tag in 2010 was collected in Paradise Bay 2014. This eel was originally tagged in Paradise Bay and was the only eel collected in the bay

in 2010. Total length and weight of the eel increased from 560 to 675 mm and 400 to 680 gm, respectively.

In 2012, a sample of eels was collected for age analysis by Thomas Pratt from Fisheries and Oceans Canada, Great Lakes Laboratory for Fisheries and Aquatic Sciences. Otoliths from 39 eels were extracted and aged. Eel ages ranged from 4 to 7 (Table 4). The age 4 eels are likely the eels from the final glass eel stocking in 2008. Eels sampled by Facey and Labar (1981) ranged from age 8 to 23 with a mean of 15.9.

It would appear that recruitment of eels to the main lake portion of Lake Champlain has been good. However, movement of eel into the Northeast Arm (Keeler and Paradise Bay) has been less successful but numbers are increasing. The Northeast Arm is somewhat isolated from the main lake by highway and old railroad causeways. Access into the Northeast Arm is limited to small openings in these causeways that allow boat traffic to pass. It would be expected that recruitment into this portion of the lake would be less rapid than the main lake.

Although the number of eels collected at each sampling location has increased (or at least are similar to previous years as in the case of Converse Bay), to suggest that recruitment to Lake Champlain is good is not necessarily the case. Numbers of eels migrating past the dam at Chambly has been quite variable since 2003. The total number of eels passing the dam has varied from 434 in 2006 to a high of 6476 in 2010 (Table 5) (Guillemette et al. 2013). Furthermore, the proportion of these eels marked as stocked eels is estimated to be 38.9% in 2009, 33.4% in 2011 and 59.6% in 2013 (Verreault et al. 2014). Given these percentages, Verreault estimates the number of eels resulting from natural recruitment at the dam to be 378 eels in 2009, 710 in 2011 and 547 in 2013, which he considers being poor natural recruitment and far from what seems necessary to rebuild the eel stock in Lake Champlain.

Miscellaneous Eel Sightings and Collections

Several other projects on Lake Champlain have reported eels being observed or collected.

Adult sea lamprey trapping in the spring conducted by the Service's Lake Champlain sea lamprey assessment team have seen an increase of eels captured in their traps. The assessment crew annually traps several tributaries to Lake Champlain for spawning-phase sea lamprey. In 2014, 15 American eels were recorded (Table 6). The majority of which are larger eels (> 600 mm), but some smaller eels are also handled (Anthony Curtis, USFWS, personal communication).

The Vermont Department of Fish and Wildlife surveys bass populations in lower Lake Champlain (Bridport, Vermont to West Haven, Vermont). In 2014, eels were too numerous to process as this hindered the bass sampling (Shawn Good, Vermont Department of Fish and Wildlife, personal communication). Good also reported 3 eels collected from bass sampling on Lake Hortonia (Figure 7). Two eels were collected in

2012 and one eel in 2014 which was 940 mm and 1945 g. Mr. Good describes the path to Hortonia in the following:

“The path from Lake Champlain would involve entering the Poultney River at the extreme southern end of Lake Champlain, and ascending the Poultney River approximately 8 miles to the Hubbardton River. From there, they would have to ascend over 14 miles of the Hubbardton River (a fairly shallow, narrow, muddy river) to Mill Pond, where they would need to climb or go around a dam and into Mill Pond. From there, they had to continue up the Hubbardton another 13 miles or so to the confluence of the outlet stream from Lake Hortonia. From there, it is another 5 miles in a very small stream to the outlet of Lake Hortonia, where they would have to navigate around the outlet dam and into the lake. Of course, this doesn’t include the 120 miles of Lake Champlain they had to swim across to get to the mouth of the Poultney from the Richelieu River!”

Stonecat *Noturus flavus* sampling by graduate student Elizabeth Puchala from the University of Vermont has also shown continued eel movement within the Lake Champlain basin. Utilizing minnow traps, Puchala has collected several eels in the Missisquoi River ranging from about 450 mm to 700 mm. Eels have been trapped below the first dam, Swanton Dam as well as below the next dam upstream, the Highgate Dam (Figure 7). Eels have also been collected by electrofishing in the LaPlatte River which enters the Vermont side of Lake Champlain in Shelburne, VT.

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Date: August, 2014

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Table 1. Summary of American eel stocking in the upper Richelieu River.

| Year | Number of glass eels |
|-------------|-----------------------------|
| 2005 | 600,000 |
| 2006 | 1,000,000 |
| 2007 | 425,500 |
| 2008 | 746,000 |
| 2009 | 0 |
| 2010 | 0 |

Table 2. Comparison of American eel sampling efforts in Lake Champlain.

| Year | Number of eels collected (observed but not collected) | | | |
|-------------|--|--------------|--------------|----------------------|
| | Keeler Bay | Paradise Bay | Converse Bay | Grand Isle shoreline |
| 2007 | 0 | 0 | 0 | 1 |
| 2010 | 1 | 1(1) | 25(17) | 14 (3-5) |
| 2012 | 1 (13) | 2 (4) | 57 (98) | 21 (12) |
| 2014 | 12 (12) | 17 (18) | 54 (39) | Not sampled |

Table 3. Summary of mean length (mm) and weight (g) of American eel sampled in Lake Champlain.

| Year | Mean | SD | Min | Max | Number |
|-------------|-------------|-----------|------------|------------|---------------|
| Length | | | | | |
| 2007 | 665 | --- | | | 1 |
| 2010 | 458 | 83 | 282 | 672 | 41 |
| 2012 | 430 | 87 | 232 | 638 | 92 |
| 2014 | 509 | 81 | 320 | 760 | 82 |
| Weight | | | | | |
| 2007 | 930 | --- | | | 1 |
| 2010 | 208 | 131 | 20 | 640 | 41 |
| 2012 | 164 | 108 | 20 | 560 | 92 |
| 2014 | 297 | 167 | 40 | 1040 | 82 |

Table 4. Summary of mean length (mm) by age of American eel sampled in Lake Champlain in 2012.

| Age | Length | SD | Min | Max | Number |
|------------|---------------|-----------|------------|------------|---------------|
| 4 | 353 | 73 | 283 | 499 | 9 |
| 5 | 477 | 103 | 311 | 614 | 7 |
| 6 | 436 | 72 | 307 | 560 | 14 |
| 7 | 519 | 87 | 404 | 635 | 9 |

Table 5. Summary of the number of American eels migrating through the fishway at the Chambly dam, 2003-2013.

| Year | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 |
|-----------------------|------|------|------|------|------|------|------|------|------|------|------|
| Number of eels | 1353 | 663 | 1066 | 6476 | 619 | 3333 | 1340 | 434 | 2177 | 727 | 3336 |

Table 6. Summary of American eel captured during annual sea lamprey trapping conducted in the spring, 2010-2014.

| Stream | 2014 | 2013 | 2012 | 2011 | 2010 |
|--------------------------|-------------|-------------|-------------|-------------|-------------|
| Main Lake | | | | | |
| Great Chazy River, NY | 7 | 0 | 0 | 1 | 1 |
| Sunderland Brook, VT | 0 | 2 | 1 | --- | 0 |
| Potash Brook, VT | --- | --- | 0 | --- | --- |
| Mullen Brook, NY | 0 | 0 | 0 | 0 | 0 |
| Beaver Brook, NY | 1 | 0 | 0 | 0 | 0 |
| Rea Brook, NY | 0 | 1 | 0 | --- | |
| Northeast Arm, VT | | | | | |
| Stone Bridge Brook | 5 | 24 | 12 | 11 | 2 |
| Trout Brook | 0 | 0 | 1 | 0 | 0 |
| Morpion Stream (QC) | 2 | | | | |
| Malletts Bay, VT | | | | | |
| Malletts Creek | 0 | 0 | 0 | 0 | 0 |
| Pond Brook | 0 | 1 | 0 | 3 | 0 |
| Indian brook | --- | --- | 5 | --- | --- |

Figure 1. Map of Lake Champlain showing sampling areas.

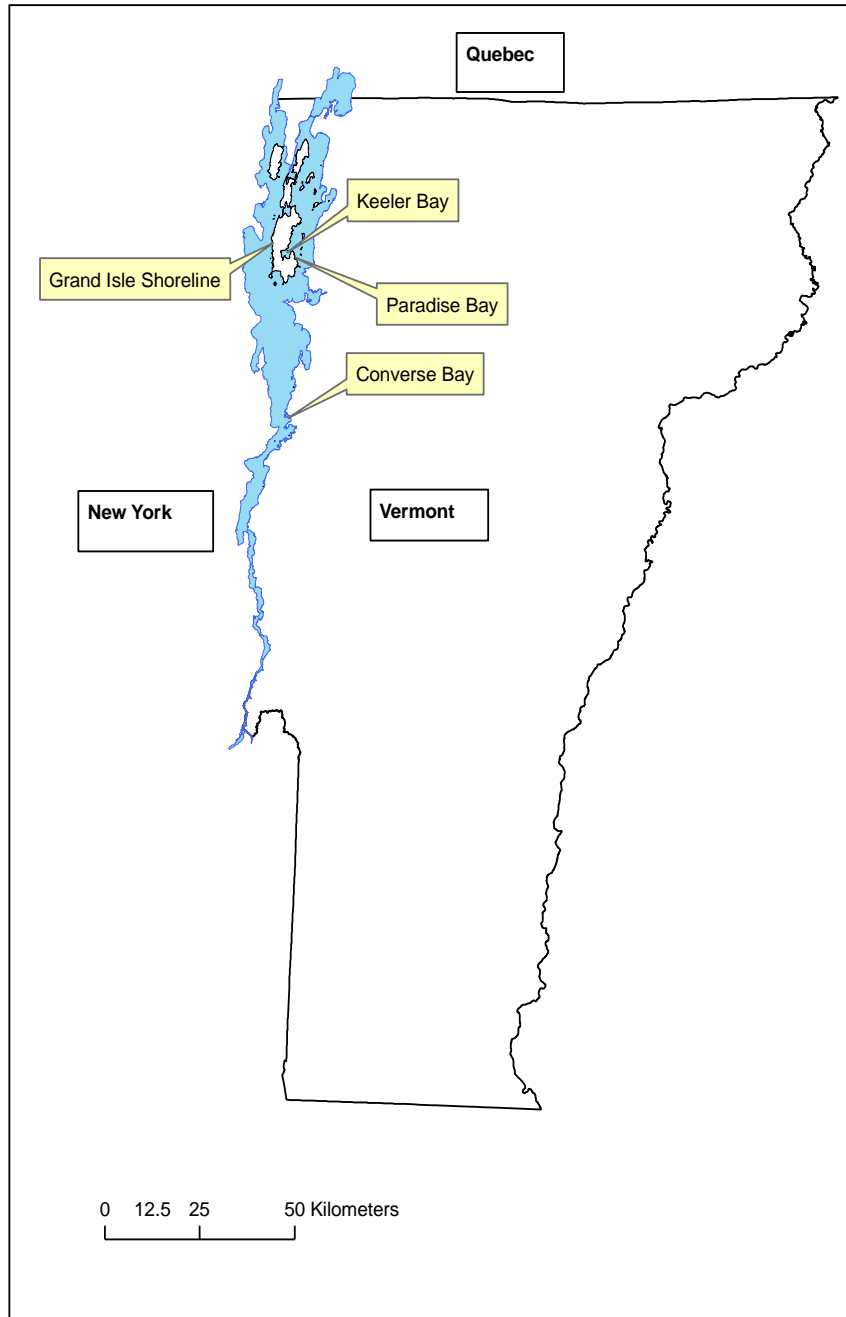


Figure 2. Map of Keeler and Paradise Bay showing 2014 electrofishing transects.

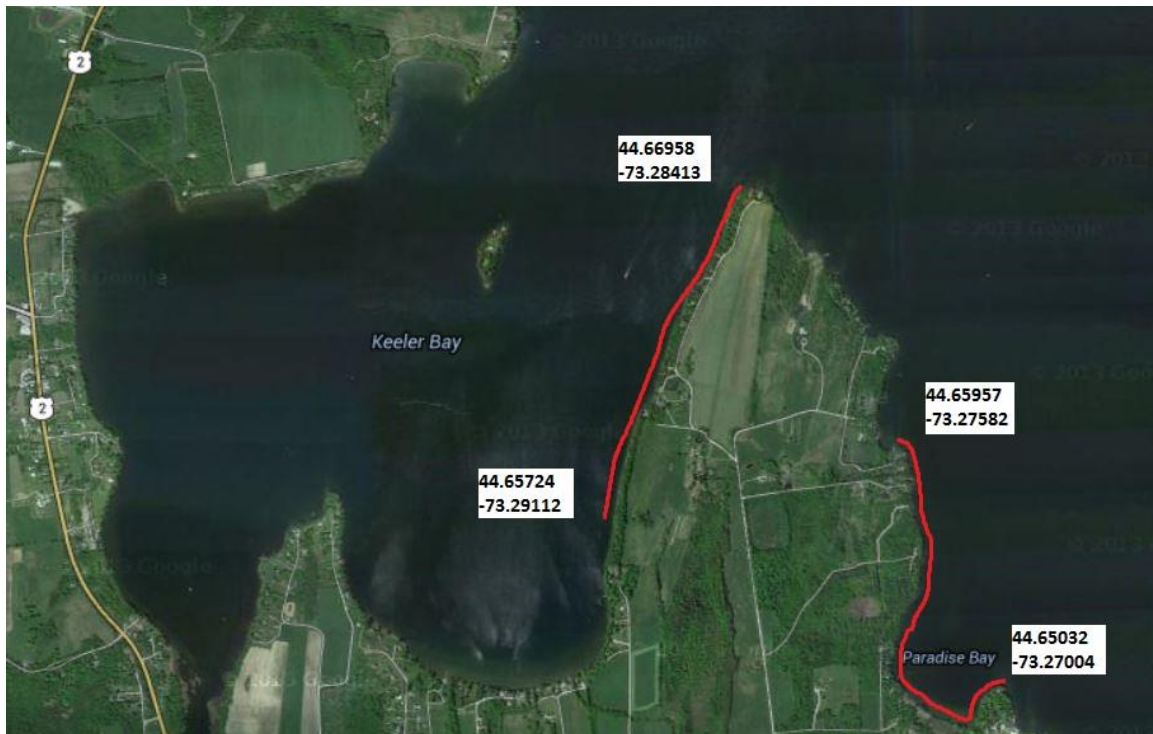


Figure 3. Map of Converse Bay showing 2014 electrofishing transect.



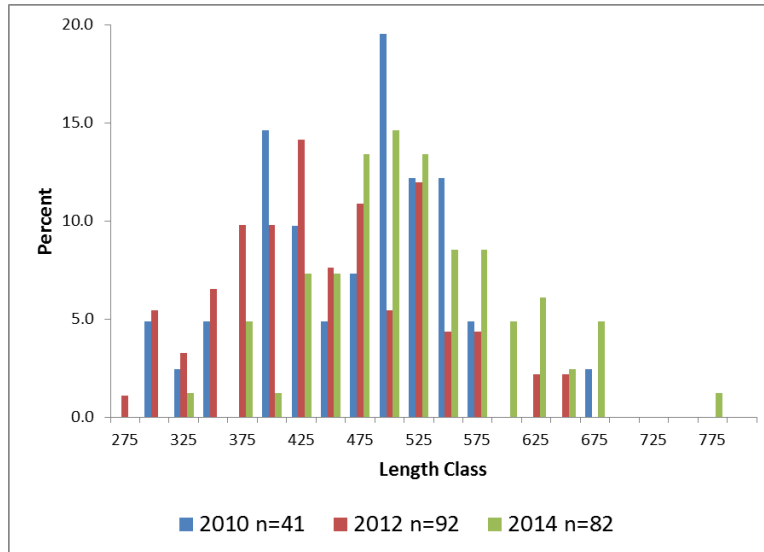


Figure 4. Comparison of length frequency distributions of American eel sampled in Lake Champlain, 2010, 2012 and 2014.

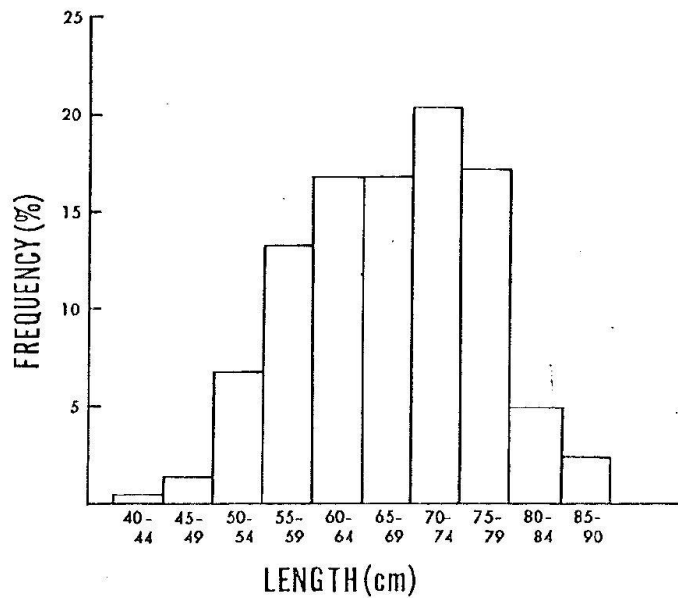


Figure 5. Length frequency distribution of American eel sampled (n = 426) in 1979, from Facey and Labar 1981.

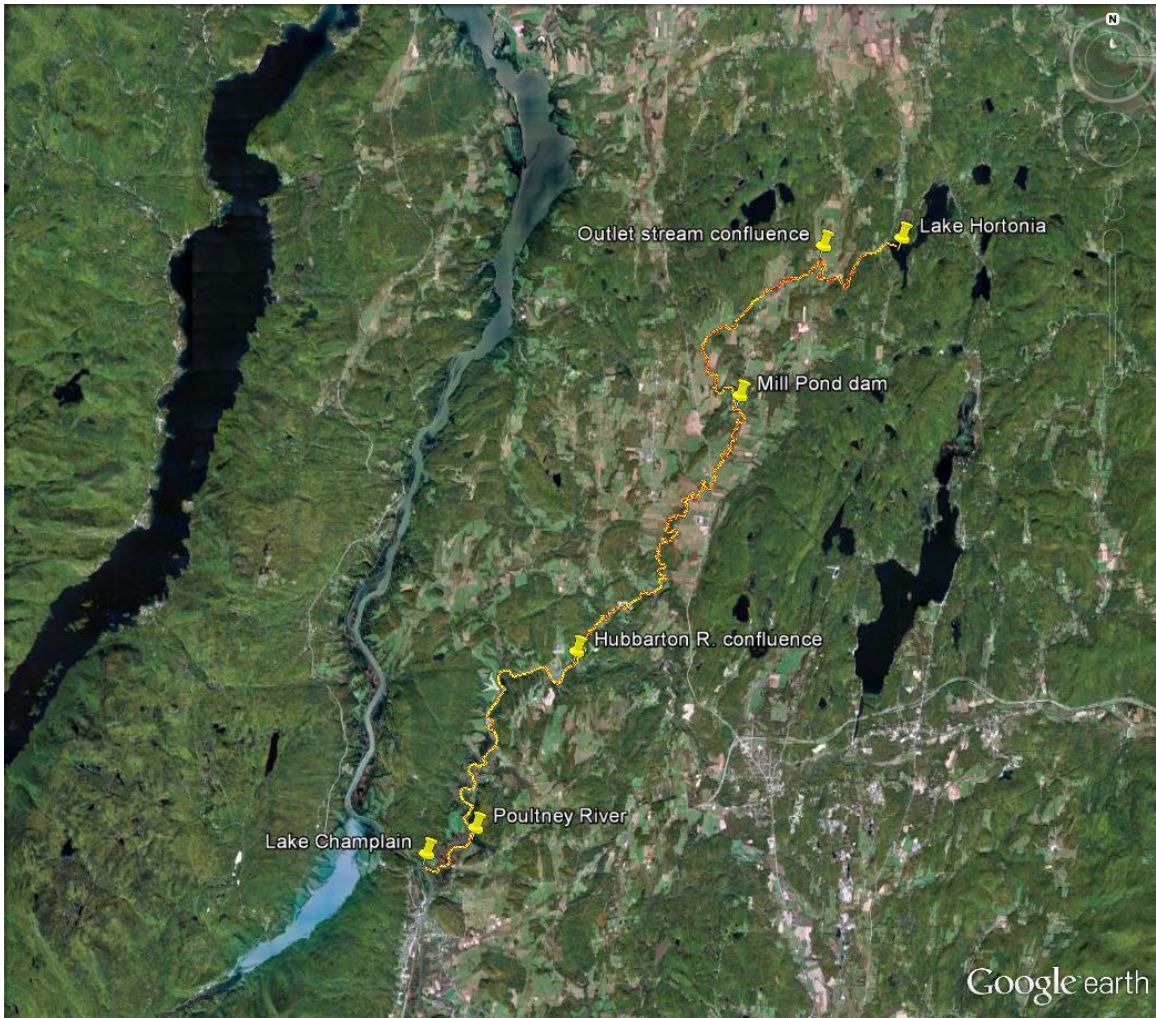


Figure 6. Location of Lake Hortonia and suspected path American eel would travel to the lake from lower Lake Champlain.

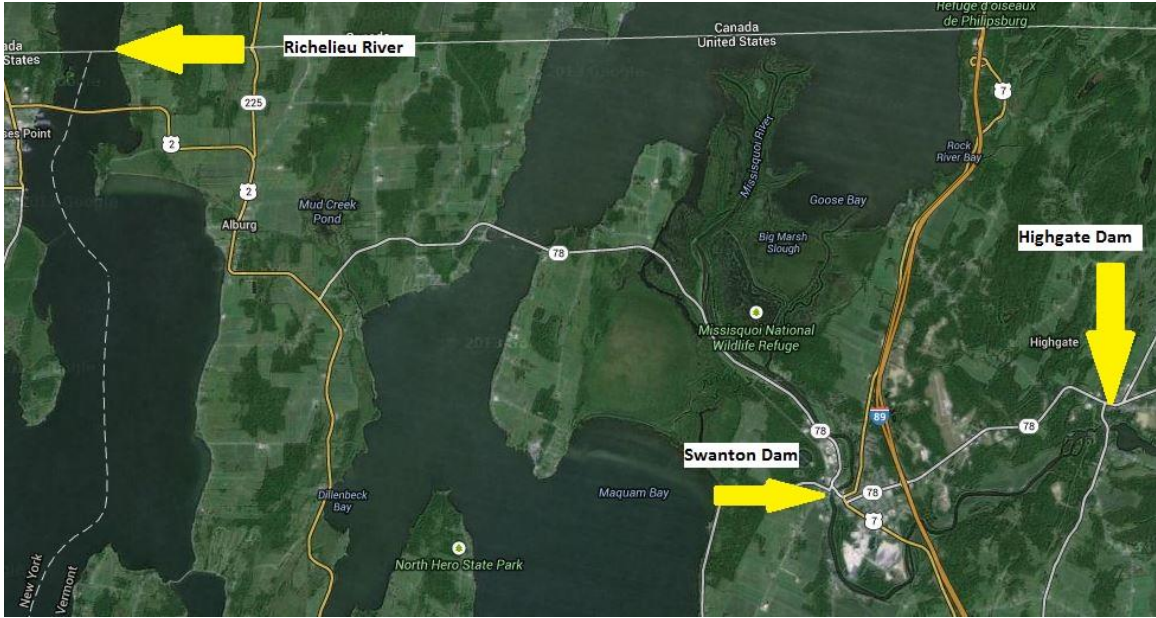


Figure 7. Location of where American eels were trapped in the Missisquoi River, 2014.

Appendix 1- 2014 American eel data.

| Location | Year | Sample | Number | Recap | Len (mm) | Wt (g) | PIT number | Comment |
|--------------|------|------------|--------|-------|----------|--------|------------|---------|
| Converse Bay | 2014 | EF14072201 | 1 | No | 603 | 480 | 48760B3A36 | |
| Converse Bay | 2014 | EF14072201 | 2 | No | 590 | 360 | 48752E2E4E | |
| Converse Bay | 2014 | EF14072201 | 3 | No | 502 | 220 | 48753E7279 | |
| Converse Bay | 2014 | EF14072201 | 4 | No | 480 | 180 | 486A3A6565 | |
| Converse Bay | 2014 | EF14072201 | 5 | No | 535 | 240 | 4875352640 | |
| Converse Bay | 2014 | EF14072201 | 6 | No | 485 | 240 | 487536455E | |
| Converse Bay | 2014 | EF14072201 | 7 | No | 612 | 440 | 486A4D4614 | |
| Converse Bay | 2014 | EF14072201 | 8 | No | 532 | 300 | 4875203D1B | |
| Converse Bay | 2014 | EF14072201 | 9 | No | 420 | 140 | 486A3F1274 | |
| Converse Bay | 2014 | EF14072201 | 10 | No | 454 | 180 | 486A490C13 | |
| Converse Bay | 2014 | EF14072201 | 11 | No | 375 | 100 | 486A502906 | |
| Converse Bay | 2014 | EF14072201 | 12 | No | 519 | 280 | 48765A2D5C | |
| Converse Bay | 2014 | EF14072201 | 13 | No | 627 | 580 | 486A37206A | |
| Converse Bay | 2014 | EF14072201 | 14 | No | 460 | 180 | 4875424914 | |
| Converse Bay | 2014 | EF14072201 | 15 | No | 480 | 240 | 4875317F2E | |
| Converse Bay | 2014 | EF14072201 | 16 | No | 510 | 280 | | |
| Converse Bay | 2014 | EF14072201 | 17 | No | 590 | 400 | | |
| Converse Bay | 2014 | EF14072201 | 18 | No | 420 | 140 | 48752B6164 | |
| Converse Bay | 2014 | EF14072201 | 19 | No | 461 | 160 | 4877356143 | |
| Converse Bay | 2014 | EF14072201 | 20 | No | 602 | 380 | 48775D6E29 | |
| Converse Bay | 2014 | EF14072201 | 21 | No | 565 | 340 | 4875211B22 | |
| Converse Bay | 2014 | EF14072201 | 22 | No | 449 | 180 | 4875394455 | |
| Converse Bay | 2014 | EF14072201 | 23 | No | 431 | 360 | 487553765A | |
| Converse Bay | 2014 | EF14072201 | 24 | No | 516 | 260 | 48755C4336 | |
| Converse Bay | 2014 | EF14072201 | 25 | No | 481 | 260 | 486A314F30 | |
| Converse Bay | 2014 | EF14072201 | 26 | No | 598 | 480 | 48753E1320 | |
| Converse Bay | 2014 | EF14072201 | 27 | No | 516 | 300 | 487518250F | |
| Converse Bay | 2014 | EF14072201 | 28 | No | 465 | 220 | 486A507F2F | |
| Converse Bay | 2014 | EF14072201 | 29 | No | 431 | 180 | 486A435C24 | |
| Converse Bay | 2014 | EF14072201 | 30 | No | 532 | 380 | 48751B6731 | |
| Converse Bay | 2014 | EF14072201 | 31 | No | 451 | 240 | 486B102145 | |
| Converse Bay | 2014 | EF14072201 | 32 | No | 391 | 140 | 48753D345D | |
| Converse Bay | 2014 | EF14072201 | 33 | No | 558 | 360 | | |
| Converse Bay | 2014 | EF14072201 | 34 | No | 630 | 620 | 4876091E48 | |
| Converse Bay | 2014 | EF14072201 | 35 | No | 414 | 160 | 48754E433D | |
| Converse Bay | 2014 | EF14072201 | 36 | No | 532 | 200 | 486A467825 | |
| Converse Bay | 2014 | EF14072201 | 37 | No | 662 | 760 | 4877597956 | |
| Converse Bay | 2014 | EF14072201 | 38 | No | 498 | 260 | 487531555F | |
| Converse Bay | 2014 | EF14072201 | 39 | No | 546 | 380 | 486A5C5959 | |
| Converse Bay | 2014 | EF14072201 | 40 | No | 440 | 180 | 48757E010B | |

| Location | Year | Sample | Number | Recap | Len (mm) | Wt (g) | PIT number | Comment |
|--------------|------|------------|--------|-------|----------|--------|------------|----------------|
| Converse Bay | 2014 | EF14072201 | 41 | No | 512 | 280 | 4875542B0D | |
| Converse Bay | 2014 | EF14072201 | 42 | No | 546 | 380 | 487546253E | |
| Converse Bay | 2014 | EF14072201 | 43 | No | 484 | 260 | 487519043B | |
| Converse Bay | 2014 | EF14072201 | 44 | No | 532 | 300 | 4875505127 | |
| Converse Bay | 2014 | EF14072201 | 45 | No | 404 | 160 | 48752D2813 | |
| Converse Bay | 2014 | EF14072201 | 46 | No | 504 | 280 | 4875335122 | |
| Converse Bay | 2014 | EF14072201 | 47 | No | 495 | 200 | 486A430651 | |
| Converse Bay | 2014 | EF14072201 | 48 | No | 655 | 600 | 48751F373A | |
| Converse Bay | 2014 | EF14072201 | 49 | No | 490 | 220 | 48754D551E | |
| Converse Bay | 2014 | EF14072201 | 50 | No | 609 | 400 | 4875694042 | |
| Converse Bay | 2014 | EF14072201 | 51 | No | 558 | 340 | 487565064E | |
| Converse Bay | 2014 | EF14072201 | 52 | No | 473 | 180 | 486A7D0F73 | |
| Converse Bay | 2014 | EF14072201 | 53 | No | 500 | 220 | 48751F4110 | |
| Converse Bay | 2014 | EF14072201 | 54 | No | 468 | 160 | 487531276F | |
| Paradise Bay | 2014 | EF14072401 | 1 | No | 491 | 220 | | |
| Paradise Bay | 2014 | EF14072401 | 2 | No | 664 | 620 | | |
| Paradise Bay | 2014 | EF14072401 | 3 | No | 518 | 380 | | |
| Paradise Bay | 2014 | EF14072401 | 4 | No | 598 | 480 | | |
| Paradise Bay | 2014 | EF14072401 | 5 | No | 370 | 100 | | |
| Paradise Bay | 2014 | EF14072401 | 6 | No | 497 | 260 | | |
| Paradise Bay | 2014 | EF14072401 | 7 | No | 565 | 400 | | |
| Paradise Bay | 2014 | EF14072401 | 8 | No | 567 | 440 | | |
| Paradise Bay | 2014 | EF14072401 | 9 | No | 474 | 240 | | |
| Paradise Bay | 2014 | EF14072401 | 10 | No | 462 | 240 | | |
| Paradise Bay | 2014 | EF14072401 | 11 | No | 445 | 220 | | |
| Paradise Bay | 2014 | EF14072401 | 12 | No | 507 | 260 | | |
| Paradise Bay | 2014 | EF14072401 | 13 | No | 485 | 240 | | |
| Paradise Bay | 2014 | EF14072401 | 14 | No | 425 | 180 | | |
| Paradise Bay | 2014 | EF14072401 | 15 | Yes | 675 | 680 | 4875461C26 | Tagged in 2010 |
| Paradise Bay | 2014 | EF14072401 | 16 | No | 524 | 320 | | |
| Paradise Bay | 2014 | EF14072401 | 17 | No | 620 | 580 | | |
| Keeler Bay | 2014 | EF14072402 | 1 | No | 560 | 320 | | |
| Keeler Bay | 2014 | EF14072402 | 2 | No | 437 | 180 | | |
| Keeler Bay | 2014 | EF14072402 | 3 | No | 473 | 200 | | |
| Keeler Bay | 2014 | EF14072402 | 4 | No | 760 | 1040 | | |
| Keeler Bay | 2014 | EF14072402 | 5 | No | 524 | 260 | | |
| Keeler Bay | 2014 | EF14072402 | 6 | No | 606 | 420 | | |
| Keeler Bay | 2014 | EF14072402 | 7 | No | 417 | 120 | | |
| Keeler Bay | 2014 | EF14072402 | 8 | No | 357 | 40 | | |
| Keeler Bay | 2014 | EF14072402 | 9 | No | 555 | 320 | | |
| Keeler Bay | 2014 | EF14072402 | 10 | No | 364 | 40 | | |
| Keeler Bay | 2014 | EF14072402 | 11 | No | 320 | 40 | | |
| Keeler Bay | 2014 | EF14072402 | 12 | No | 452 | 200 | | |