Vermont Fish and Wildlife Department
Annual Report

State: Vermont **Project No.**: F-35-R-15

Grant Title: Lake Champlain Fisheries Restoration and Management

Study No. II **Study Title**: Forage Fish Monitoring

Period Covered: July 1, 2012 to June 30, 2013

Summary of Activity:

Lake Champlain forage fish assessment sampling in 2012 was carried out beginning on July 25 and ending on August 13. Calculated mean CPUE's at the main lake stations were well above average but remained low in the Northeast Arm and Malletts Bay. The Northeast Arm station again had the lowest CPUE at 40 smelt per net. Floating gill nets were utilized to sample alewife. Alewives were captured at all stations with the greatest catch being at the Barber Point station. Results from Acoustic sampling agree with patterns found at the five stations for rainbow smelt. The acoustic sampling is also showing an increase in fish above the thermocline which, based on gillnets and shallow trawls, is likely a combination of alewife and white perch.

INTRODUCTION

In the fall of 1990, an 8-year experimental program for management of sea lamprey (*Petromyzon marinus*) in Lake Champlain began. In conjunction with sea lamprey control measures, several assessment programs were initiated to help determine the overall effect of the program on the lake's fisheries. Rainbow smelt (*Osmerus mordax*) are the primary food for salmonid predators in the lake and also comprise an important winter recreational fishery. Lake Champlain fishery managers predicted that as sea lamprey populations were reduced there could be accompanying changes in predator mortality rates and growth and thus increased consumption rates of rainbow smelt by predators. Thus, an 8-year program was initiated to monitor rainbow smelt stocks in several areas of the lake using the technique of stepped-oblique midwater trawling (Kirn and LaBar 1991, LaBar 1999). At the conclusion of the 8-year experimental sea lamprey control program, the Lake Champlain Technical Committee recommended that the smelt monitoring program be continued by the Vermont Department of Fish and Wildlife (VTDFW). This document reports the findings of the VTDFW's forage fish sampling efforts.

PROCEDURES

Standard Rainbow Smelt Monitoring

Five stations were sampled in 2012 for rainbow smelt in Lake Champlain (Figure 1, Table1). These sites include three main lake stations, one station in Malletts Bay, and one station in the Inland Sea (also known as the Northeast Arm). The five sites are stations that have

been historically sampled.

Midwater trawling was carried out at night as described by Kirn and LaBar (1991). The midwater trawl used measures 5 meters (m) by 5 m with large mesh near the mouth grading to smaller mesh near the end, and terminating in a cod end with a 0.6 cm square mesh liner. For each trawl, the net was lowered to approximately 35 m depth or to just above the bottom, whichever came first. The net was towed at the maximum depth for 10 minutes allowing it to stabilize. The net was then raised about 3 m and towed for an additional 5 minutes. This step is repeated until the net was 10 m below the surface and then it is hauled back to the boat. Thus, in deep-water sites, each trawl lasted for 55 minutes, and at the shallower sites, 40-45 minutes. Four trawls were conducted at each site. During each trawl, the net was monitored for depth using a remote transmitter affixed to the head rope on the net. Prior to sampling at each station a temperature profile was taken.

Catch-per-unit-effort (CPUE) is expressed in terms of catch per 55-minutes of trawling (catch X 55 min/trawling time). A sample of 50 fish was randomly selected from each haul and frozen for later otolith extraction. In the laboratory, the smelt were thawed, measured, weighed, and otoliths were extracted. Otoliths were placed in an ethanol/glycerine mixture (70:30) to help clear them and later aged with a binocular dissecting scope at 10 - 45X magnification.

Young-of-year (YOY) smelt and alewife *(Alosa pseudoharengus)* were saved and later measured to the nearest millimeter in the laboratory. Any adult alewife or cisco (*Coregonus artedi*) collected were also counted and measured on the boat. All other fish species collected are identified and counted.

Alewife Monitoring

Alewives were first discovered in Lake Champlain in 2004 and their numbers have increased since. A sampling program is being developed to monitoring their abundance and population characteristics. Floating gill nets were utilized to collect alewife samples for age and growth analysis. These nets were set in the early evening (1 per night) prior to the standard smelt trawling or acoustic sampling (when possible) and retrieved at the conclusion of the night's sampling. The net measured 6m deep by 21m in length with 7 panels of mesh sizes 6.25, 8, 10, 12, 15, 18 and 25mm.

Catch-per-unit-effort is expressed in terms of catch per 4-hour net set (catch X 4 hr/net set time). Captured alewives were frozen for later otolith extraction. In the laboratory, alewife were thawed, measured, weighed, and otoliths were extracted. The otoliths were stored dry in vials and later aged with a binocular dissecting scope at 10 - 45X magnification.

Hydro Acoustics

Starting 2005 a lake wide hydroacoustic survey was added to the forage fish monitoring program. Using a 120 kHz split beam Biosonics echosounder a series of transects were created which cover a large portion of Lake Champlain (Figure 1). The transects are repeated each year follows a Lake Champlain acoustics SOP which is based on the Standard operating procedures for fisheries acoustics surveys in the Great Lakes (Parker-Stetter et al. 2009). The unit was set to log data down to -100 dB with a ping rate of 1 ping per second for main lake transects and 4

pings per second for Malletts Bay and NEA. The pulse width was set to 0.4ms. All hydroacoustics were performed at night (1 hour past sunset until 1 hour before sunrise). During acoustic survey fish samples were collected to confirm acoustic targets using two different nets. An opening/closing tucker trawl (1m x 1m) with 1000 um mesh was used to collected young of the year and the standard 5m x 5 m mid water was used for larger fish. During each trawl, the net was monitored for depth using a remote transmitter affixed to the head rope on the net. Either prior or during sampling temperature profiles were taken in that night sampling area.

FINDINGS

Standard Monitoring

Catch-Per-Unit-of-Effort --- A total of 20 midwater trawls were conducted between July 25 and August 13, 2012 (Table 2). Calculated mean CPUE's in 2012 at the main lake stations were well above average but remained low in the Northeast Arm and Malletts Bay (Figure 2). All three main lake stations had large numbers of smelt but of only one year class – age 1. The Northeast Arm station had the lowest CPUE at only 40 smelt per net. Table 3 compares CPUE long-term mean and median values with values before and after alewife invasion.

Age and Growth --- Mean age of smelt sampled in 2012 ranged from 1.0 to 2.0 years old (Table 4 and Figures 3 and 4). Nearly all the smelt saved from the main lake stations were identical in length (~100 mm) and thus a subsample was aged. These smelt were age 1 and represented a sharp decrease in length-at-age for this age (Table 5 and Figures 9-11). Typically, main lake age 1 smelt are about 120 mm. Age composition of the samples from each station is illustrated in Figure 5 and compared to previous years in Figures 6-8. Age one smelt, which were absent in the 2008 and in low numbers in 2010 and 2011 samples, were again present in the Northeast Arm and Malletts Bay. Only half of the usual number of smelt was collected from Malletts Bay for age analysis.

Young-of-Year Rainbow Smelt --- It's important to note that the sampling gear is not designed to effectively sample YOY smelt and that the YOY data must be viewed cautiously. Fewer numbers of YOY smelt were found at all stations in 2012 (Table 6 and 7). Smelt YOY mean lengths were similar at most stations ranging from 40 to 43 mm.

Hydro Acoustics

Acoustic work was performed lake-wide in 2012, which include the three basins of Lake Champlain (Malletts Bay, Northeast Arm and Main Lake) and resulted in over 76.6 km of sampling. The survey sampled 7.7 km in Malletts Bay, 14.1 km in Northeast Arm and 54.8 km in Main Lake. Data were visually examined to ensure data integrity and backup. Physical samples were also taken using a Sea Bird CTD (conductivity, temperature, depth, pH) profiler. In 2012 a total of 29 profiles were taken: 17 Main Lake, 8 Inland Sea and 4 Malletts Bay. Additional physical samples were performed using various trawls (tucker – young of year, midwater – older) to confirm species of acoustic targets (Table 8). A total of 3 tucker trawls and 17 midwater trawls were performed in 2012. Samples have been processed but CPUE has not

been calculated. Additionally acoustics were also performed during stepped-oblique midwater trawling.

Processed Data --- In both Malletts Bay and Northeast Arm adult smelt numbers (acoustic targets below the thermocline) appear to be staying low (2008 – 2012) compared to early years (2005 - 2007) (Figure 16). In the Northeast Arm the targets above the thermocline showed a strong increase in 2008 - 2011 but 2009 and 2012 was similar to earlier years. Malletts Bay targets above the thermocline were higher in 2008 and 2011 than earlier years. The Malletts Bay estimate in 2009 is not display on the graph due to noise problems. Operation of a new sonar unit on the boat caused slight noise interference. Examination of the noise suggests that with time the noise can be manually removed from the data. Based on shallow midwater trawls and floating gillnets catches we suspect that most of the acoustic targets above the thermocline are a mix of alewife and white perch. The Main Lake Area seems to have annual fluctuations in acoustic targets but there are no overarching trends in fish numbers. North main lake showed low smelt numbers but south main lake had higher numbers. Main Lake seemed to stay consistent.

Targeted Trawls --- Fish from 2012 targeted trawls have been processes but length information and final trawl CPUE have not been calculated.

Alewife

Catch-Per-Unit-of-Effort --- Eight floating gill nets were set in 2012 (Table 9). Three nets were fished in the main lake with the Barber Point station recording the greatest CPUE of YOY and adult alewife at 3.2 and 399 fish, respectively. Two nets were fished in Malletts Bay and 2 nets were set in the Northeast Arm. Fewer adult alewife were recorded in Malletts Bay then in 2011 while greater numbers of alewife were collected in the Northeast Arm.

Age and Growth --- Alewife collected by gill net ranged in age from YOY (0+) to 2 year-olds (Table 10, Figure 12). Similar to smelt, age 1 alewife in the main lake were smaller than in previous years (Figure 13). Most stations were dominated by age 1 alewives.

Midwater trawl numbers --- Seventeen adult alewives were collected by midwater trawl in 2012. All of the alewives were collected at the Juniper Island station. Alewife YOY were also collected at all stations (Table 6). The largest number of YOY alewife was collected in Malletts Bay (1,581 fish).

Cisco

A total of 31cisco were collected during the 2012 forage fish sampling effort (Table 11). Twelve cisco were collected at Barber Point, 11 at Valcour Island and 8 at Juniper Island. It should be noted that data prior to 1999 should be viewed cautiously as it's uncertain how well cisco numbers were monitored in earlier years. As in previous years, nearly all of the measured cisco fell into the 240 – 330 mm length class (mean length = 294 mm, SD=8).

Temperature

Figure 19 shows temperature profiles for the sampling period. Temperature profiles varied slightly at different stations. Thermoclines generally were determined to exist below 12 meters in depth.

RECOMMENDATIONS

1. Continue to monitor rainbow smelt populations.
2. Develop means of sampling alewife populations.

Prepared By: Nicholas R. Staats, Fisheries Biologist
U.S. Fish and Wildlife Service

Bernie Pientka, Fisheries Biologist
Vermont Department of Fish and Wildlife

Date: August 19, 2013

This project was made possible by fishing license sales and matching Dingell-Johnson/Wallop-Breaux funds, available through the Federal Aid in Sport Fish Restoration Act.

Acknowledgment: This project was conducted in partnership with staff from the US Fish and Wildlife Service working under the Lake Champlain Special Designation Act.

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Table 1. Rainbow smelt sampling station locations in Lake Champlain. North and south refer to the approximate location of the northern and southern ends of the trawled transect.

Station name	Depth (meters)	Location (latitude and longitude)	
		North	South
Main Lake			
Barber Point	50 - 60	44 º 10.85' 73 º 23.64'	44 º 08.97' 73 º 23.74'
Juniper Island	70 - 90	44 º 28.87' 73 º 18.33'	44 º 26.75' 73 º 18.09'
Valcour Island	56 - 62	44 º 38.50' 73 º 23.50'	44 º 36.50' 73 º 23.50'
Malletts Bay			
Malletts Bay	22 - 32	44 º 36.07' 73 º 16.59'	44 º 34.65' 73 º 16.82'
Inland Sea			
Northeast Arm	22 - 40	44 º 47.02' 73 º 15.39'	44 º 45.36' 73 º 14.69'

Table 2. Mean catch per 55 minute trawl (CPUE with 95% confidence interval) of rainbow smelt in 2012 and comparison to long-term mean and median CPUE.

Station	Number of trawls	CPUE	Mean	Median	N years
Main Lake					
Barber Point	4	811 ± 608	288	209	19
Juniper Island	4	387 ± 84	182	111	23
Valcour Island	4	595 ± 330	272	155	13
Malletts Bay					
Malletts Bay	4	66 ± 31	917	614	23
Inland Sea					
Northeast Arm	4	40 ± 19	973	690	23

Table 3. Mean catch per 55 minute trawl of rainbow smelt in 2012 and comparison to long-term mean and median CPUE, pre- and post-alewife invasion.

	Barber Pt.	Juniper Is.	Valcour Is.	Malletts Bay	Northeast Arm
All Years					
Mean	288	182	272	917	973
Median	209	111	155	614	690
N	19	23	13	23	23
1990-2004: Pre-Alewife Invasion					
Mean	206	180	423	1124	1363
Median	138	111	285	654	1103
N	11	15	5	15	15
2005-2012: Post-Alewife Invasion					
Mean	400	188	177	529	243
Median	279	104	99	167	130
N	8	8	8	8	8

Table 4. Mean and maximum age of rainbow smelt sampled by station in 2012. Number in parenthesis is change from previous year.

Station	Mean age	Maximum age
Main Lake Stations		
Barber Point	---	---
Juniper Island	1.0 (-0.6)	2
Valcour Island	---	---
Malletts Bay		
Malletts Bay	2.0 (-0.8)	6
Inland Sea Station		
Northeast Arm	1.5 (-1.6)	5

Table 5. Mean length and standard deviation in millimeters, by age class of rainbow smelt sampled in 2012. Number of smelt aged in parenthesis.

Station	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
Main Lake Stations						
Barber Point Juniper Island Valcour Island	89 ± 9 (63)	130 ± 7 (2)	160 ± 35 (3)	139 ± 8 (2)	---	---
Malletts Bay						
Malletts Bay	100 ± 7 (60)	132 ± 10 (9)	154 ± 12 (13)	166 ± 16 (9)	191 ± 8 (3)	189 ± 27 (4)
Inland Sea						
Northeast Arm	111 ± 9 (91)	138 ± 12 (18)	155 ± 13 (5)	164 ± 11 (8)	192 ± 25 (3)	---

Table 6. Summary of young-of-year rainbow smelt and alewife (in parenthesis) collected during midwater smelt trawls, 1999-2012. Larger numbers are estimated based on weighed and counted subsamples.

Year	Barber	Juniper	Valcour	Malletts Bay	Northeast Arm
1999	4172	2588	830	3095	1690
2000	5667	1350	774	3629	881
2001	7961	13253	7378	103000	6015
2002	29	10	23	65	8
2003	3	109	397	57	230
2004	15	400	NA	102	397
2005	9717 (1)	700	6283	1022	798
2006	31350 (2)	624	561	1529	916
2007	129	109	1447 (1728)	5	392
2008	201 (1)	36	3796 (60)	187 (2308)	796 (244)
2009	0 (0)	450 (0)	349 (91)	485 (383)	35 (57)
2010	6 (75)	39 (74)	202 (659)	0 (0)	0 (est. 1400)
2011	est. 8990 (10)	3078 (15)	1034 (88)	est. 3240 (est. 2258)	986 (290)
2012	5 (23)	0 (43)	4 (26)	223 (1581)	30 (51)

Table 7. Number, mean length (standard deviation) and range of young-of-year smelt sampled in 2012.

Station	Number Collected	Mean Length	Number Measured	Range
Main Lake				
Barber Point	5	41 ± 5	5	32 - 45
Juniper Island	0	---	---	---
Valcour Island	4	40 ± 4	4	37 - 45
Malletts Bay				
Malletts Bay	223	40 ± 3	50	34 - 48
Inland Sea				
Northeast Arm	30	43 ± 5	30	30 - 51

Table 8. CPUE of targeted acoustic trawls in 2012. For example sampling number AT120803001 is sample collected on 08/03/12 and is net number 001.

				CPUE (10 minutes)							
Sample	Gear	Area	Depth (m)	Alewife	Smelt	White Perch	Yellow Perch	Cypr Sp.	Centr Sp	Unknown Larval fish	Other
AT12073101	Mid	NEA	4.3								
AT12073102	Tucker	NEA	8.3								
AT12080101	Mid	NEA	1.6								
AT12080102	Mid	NEA	18.8								
AT12080103	Mid	NEA	13.6								
AT12080201	Mid	North Main Lake	3.5								
AT12080202	Mid	North Main Lake	8.6								
AT12080203	Mid	North Main Lake	13.9								
AT12080204	Tucker	North Main Lake	17								
AT12080601	Tucker	South Main Lake	10.2								
AT12080602	Mid	South Main Lake	27.5								
AT12080603	Mid	South Main Lake	15.4								
AT12080604	Mid	South Main Lake	13.2								
AT12080801	Mid	Main Lake	5.4								
AT12080802	Mid	Main Lake	14.2								
AT12080803	Mid	Main Lake	17.7								
AT12080804	Mid	Main Lake	5.7								
AT12081301	Mid	Malletts	3.6								
AT12081302	Mid	Malletts	12								
AT12081303	Mid	Malletts	17.1								

Table 9. Floating gill net catch per 4 hour set (expanded from total minutes fished) of alewife in 2008 - 2012. YOY = young of year; YAO = yearling and older.

2008			
Station	Sample No.	YOY	YAO
Main Lake			
Barber Point	FGN08080401	2.5	0
Potash Bay	FGN08080501	16.6	60.7
Juniper Island	FGN08072101	0	101.6
Valcour Island	FGN08081201	305.2	155.2
Malletts Bay			
Malletts Bay	FGN08081101	33.8	2.2
Inland Sea			
Ladd Point	FGN08072801	0	0
Knight Island	FGN08073001	0.7	7.4

2009			
Station	Sample No.	YOY	YAO
Main Lake			
Barber Point	FGN09081001	0	119.1
Barber Point (same location as above)	FGN09081201	0	6.7
Button Bay	FGN09081202	0	2.3
Juniper Island	FGN09081701	17.4	106
Valcour Island	FGN09081801	14	93
Cumberland Head	FGN09080601	4.5	35.6
Malletts Bay			
Malletts Bay	FGN09073001	5.4	47.9
Inland Sea			
Ladd Point	FGN09080301	3.1	30.9
Hyde Point	FGN09080501	20.8	13.2
Savage Island	FGN09080502	4.2	8.9

Table 9. Continued.

2010			
Station	Sample No.	YOY	YAO
Main Lake			
Barber Point	FGN10080901	172.7	193.6
Hunter Bay	FGN10081001	136.3	77.7
Juniper Island	FGN10082301	26.9	7.0
Starr Farm Beach	FGN10081201	28.5	3.2
Valcour Island	FGN10072901	44.7	226.0
Valcour Island	FGN10072902	19.6	279.3
Cumberland Head	FGN10080501	101.7	121.5
Malletts Bay			
Malletts Bay	FGN10072701	8.1	77.0
Inland Sea			
Ladd Point - South	FGN10080201	34.6	74.2
Woods Island	FGN10073001	3.0	40.7

Table 9. Continued.

2011			
Station	Sample No.	YOY	YAO
Main Lake			
Barber Point	FGN11081501	lost	lost
Shelburne Point	FGN11081701	14.9	0
Juniper Island	FGN11082301	31	42.2
Valcour Island	FGN11080101	130.4	87
Martin Point	FGN11081101	53.6	0
Malletts Bay			
Malletts Bay	FGN11080201	12.5	33.7
Malletts Bay	FGN11080301	61.3	58
Inland Sea			
Northeast Arm	FGN11080801	1.1	11.7
Savage Island	FGN11081001	7.5	7.5

Table 9. Continued.

2012			
Station	Sample No.	YOY	YAO
Main Lake			
Barber Point	FGN12080601	3.2	399
Juniper Island	FGN12072501	0	57.9
Valcour Island	FGN12072601	2.6	25.8
Martin Point	FGN12080201	0.9	2.7
Malletts Bay			
Malletts Bay	FGN12081301	68.1	1.9
Malletts Bay	FGN12081401	3.8	0.9
Inland Sea			
Northeast Arm	FGN12073001	91.8	96.3
Savage Island	FGN12073101	16.3	70.6

Table 10. Mean total length and standard deviation in millimeters, by age class of alewife sampled by floating gill net in 2012. Number of alewife aged in parenthesis.

YOY	Age 1	Age 2	Age 3	Age 4
Main Lake Stations				
60 ± 12 (5)	107 ± 14 (49)	172 ± 16 (10)	---	---
Malletts Bay				
67 ± 5 (33)	125 ± 11 (2)	---	---	---
Inland Sea				
67 ± 11 (81)	146 ± 11 (96)	180 ± 19 (18)	---	---

Table 11. Summary of total numbers of cisco collected, 1990-2012. Only one cisco has been collected in the Inland Sea (in 1991). Data prior to 1999 should be viewed cautiously. N/A = no sampling occurred.

Year	Barber Point	Juniper Island	Valcour Island	Malletts Bay
1990	N/A	15	N/A	1
1991	N/A	25	N/A	3
1992	N/A	34	N/A	12
1993	22	0	N/A	0
1994	0	0	N/A	0
1995	30	14	N/A	3
1996	19	15	N/A	4
1997	11	25	N/A	11
1998	N/A	45	N/A	2
1999	122	13	31	7
2000	51	20	31	1
2001	47	26	152	3
2002	26	94	139	1
2003	49	40	7	0
2004	65	37	N/A	0
2005	43	22	31	3
2006	17	10	17	0
2007	7	0	15	0
2008	16	13	10	1
2009	0	9	13	0
2010	4	9	16	0
2011	3	13	29	0
2012	12	8	11	0

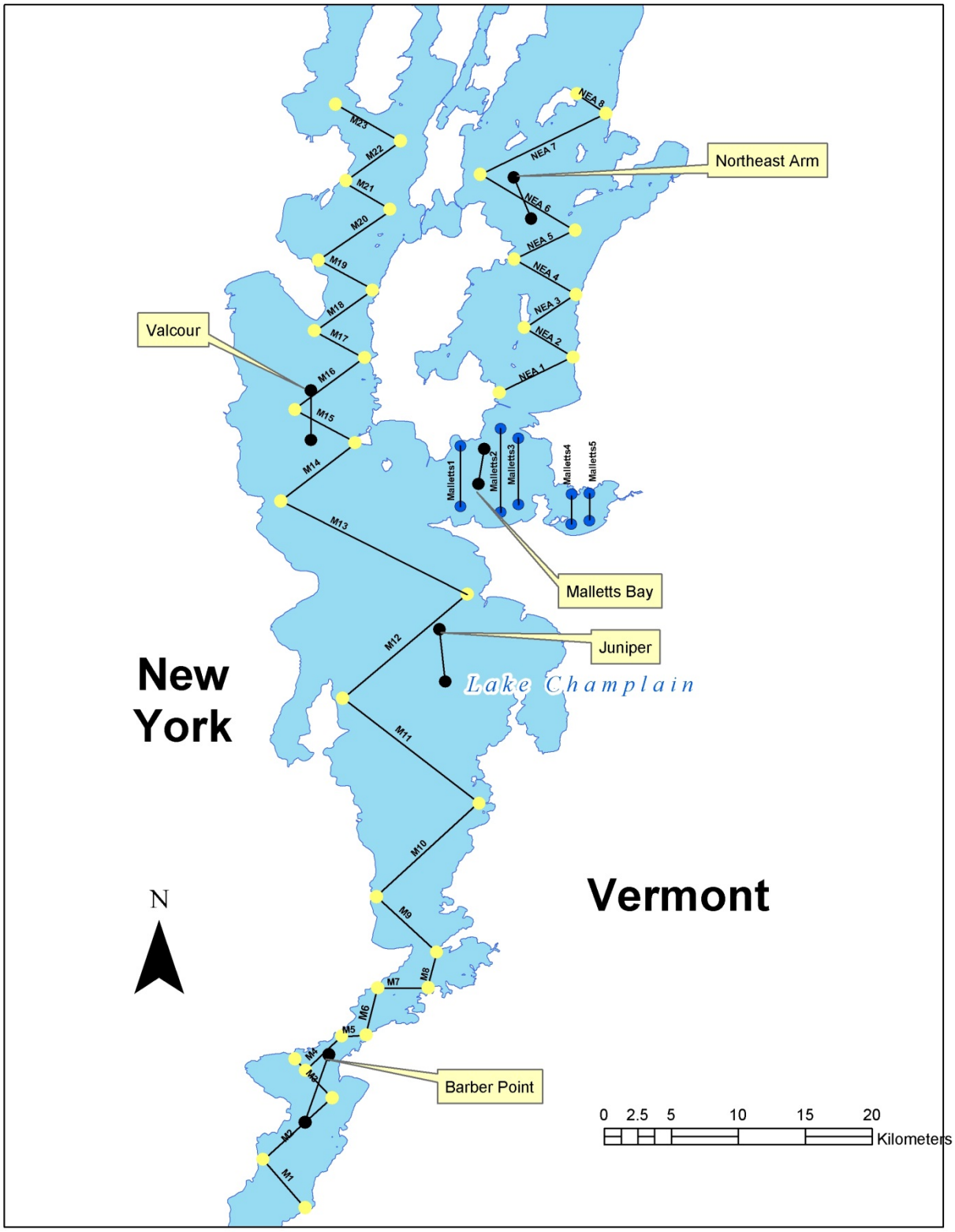
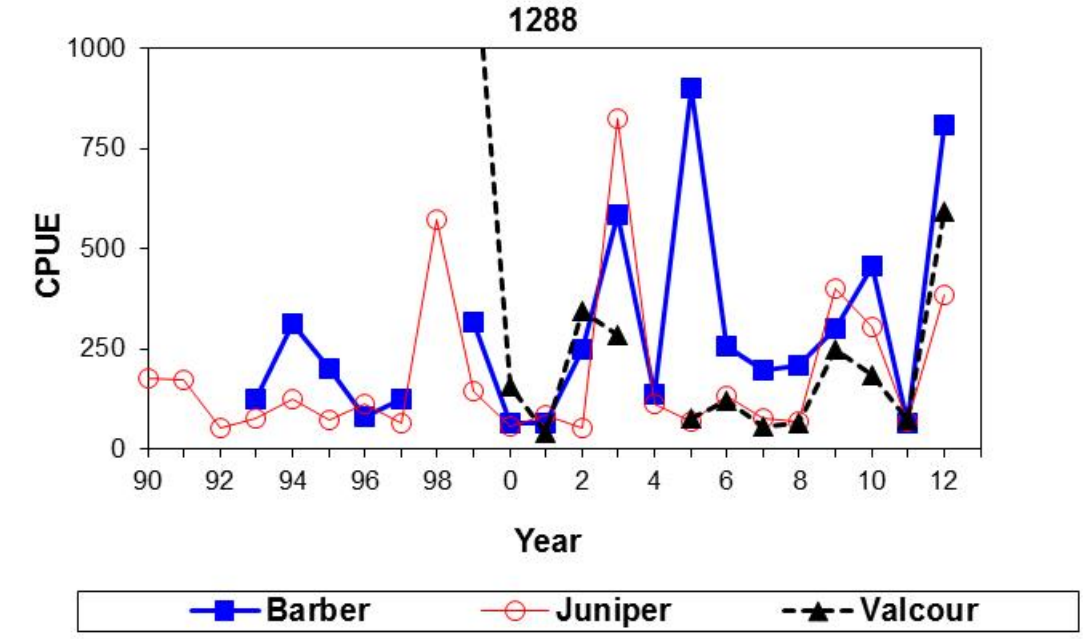


Figure 1. Rainbow smelt sampling stations (text boxes) and acoustic transects with transect name.



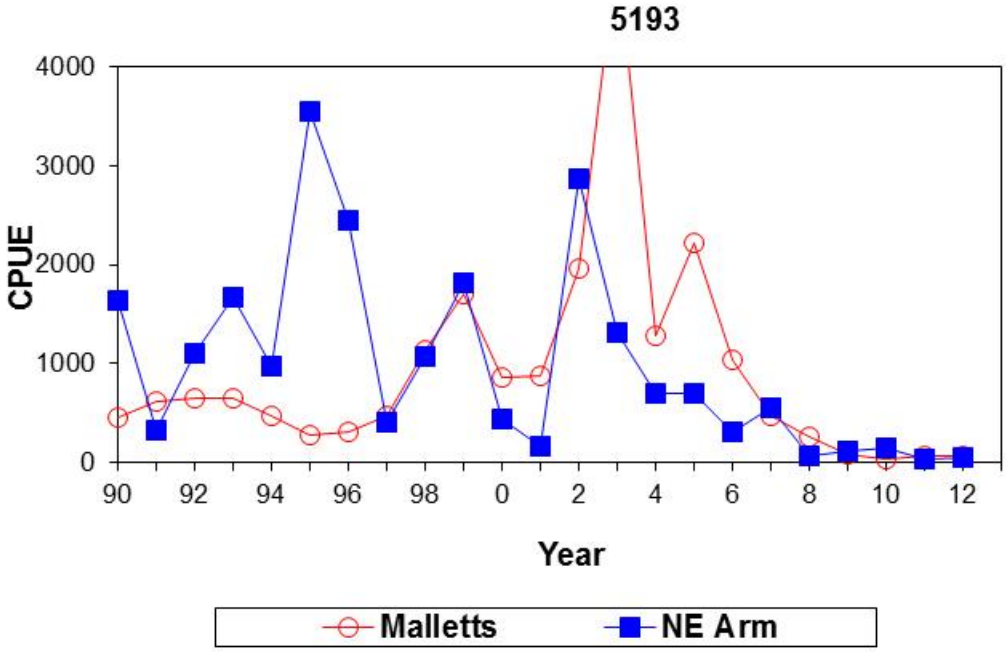


Figure 2. Mean CPUE of smelt for Lake Champlain, 1990-2012.

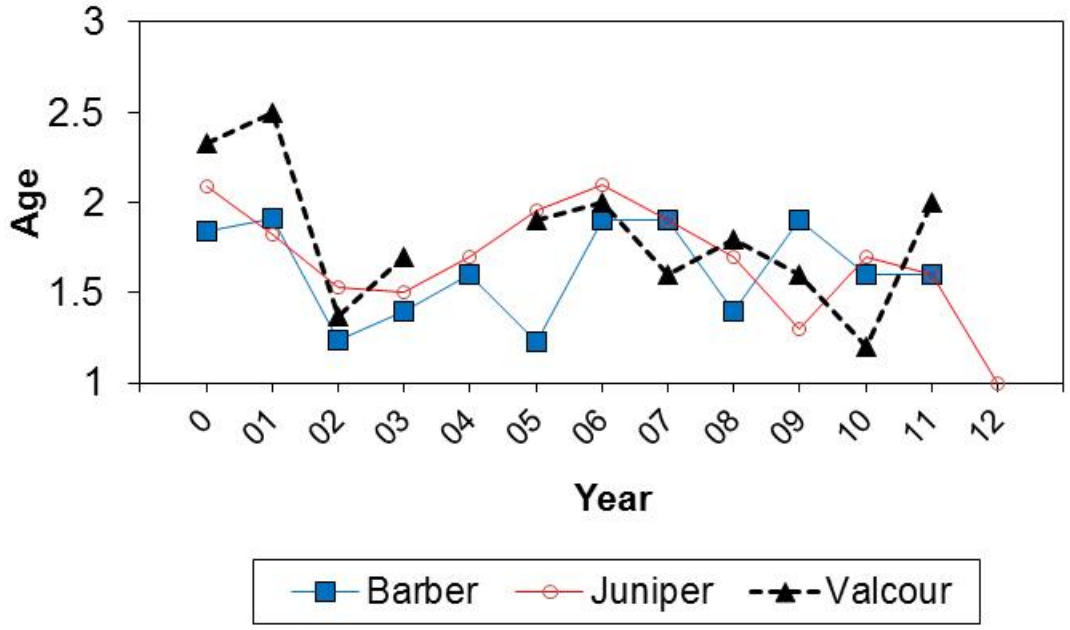


Figure 3. Mean age of rainbow smelt sampled at three main lake stations, 2000-2012.

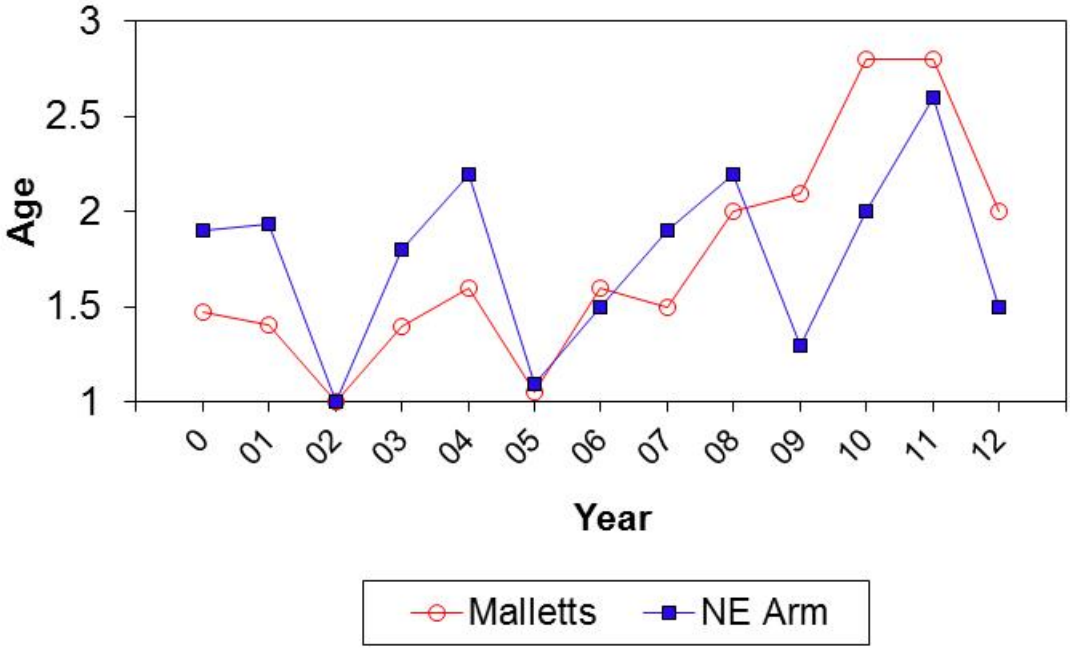


Figure 4. Mean age of rainbow smelt sampled at Malletts Bay and the Northeast Arm stations, 2000-2012.

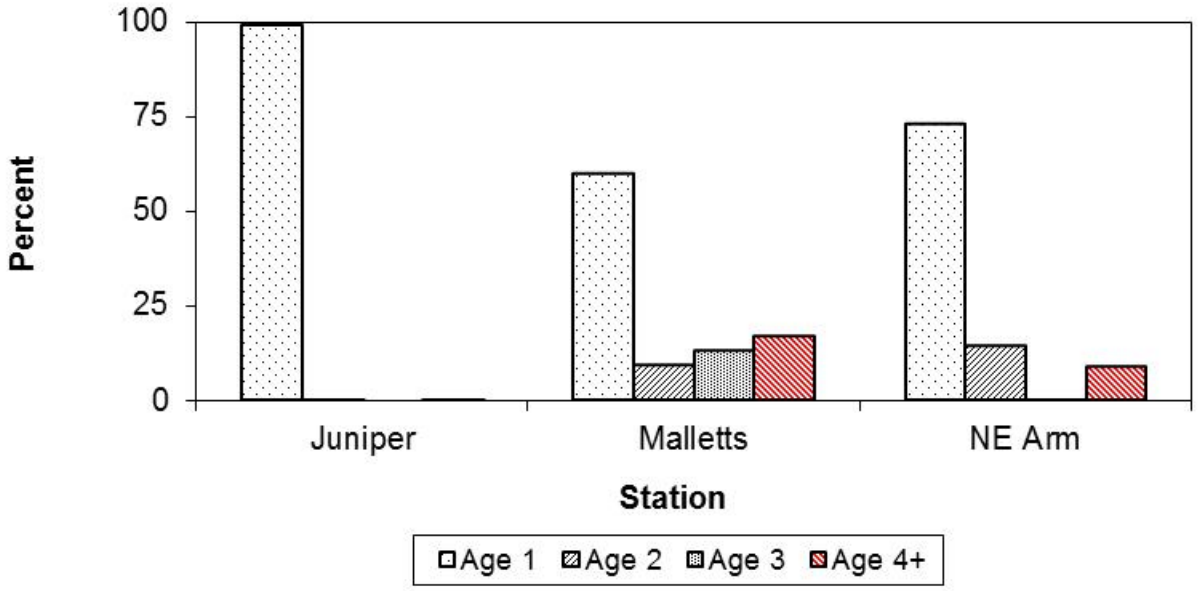


Figure 5. Percent composition by age class of rainbow smelt sampled in Lake Champlain in 2012.

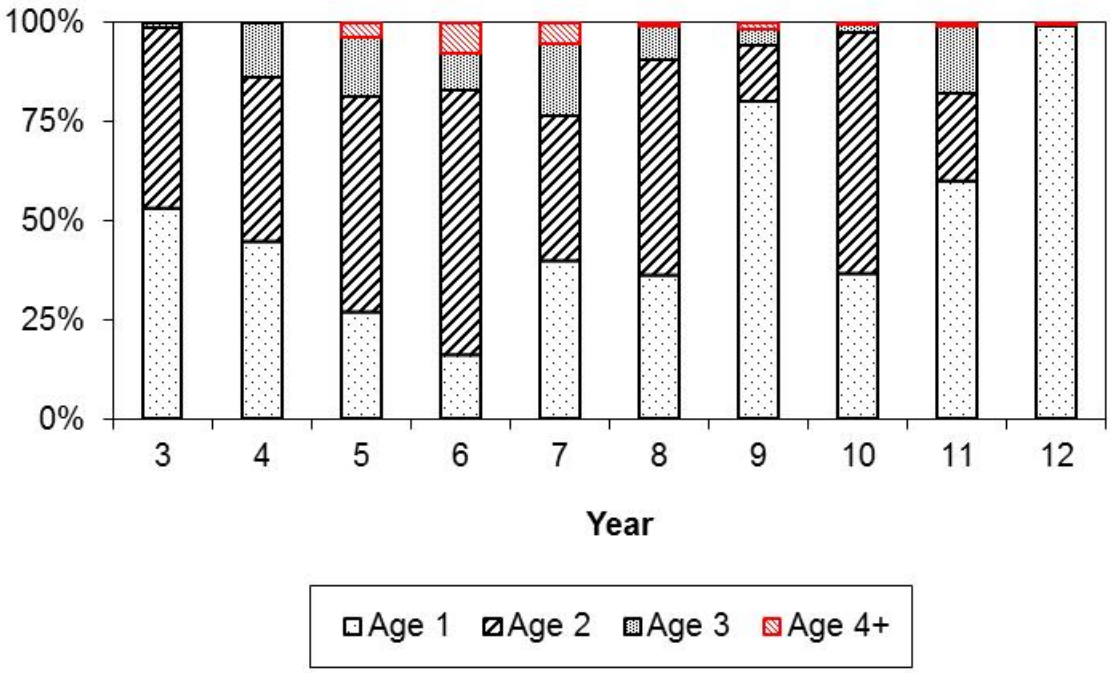


Figure 6. Percent composition by age class for rainbow smelt sampled at Juniper Island, 2003 - 2012.

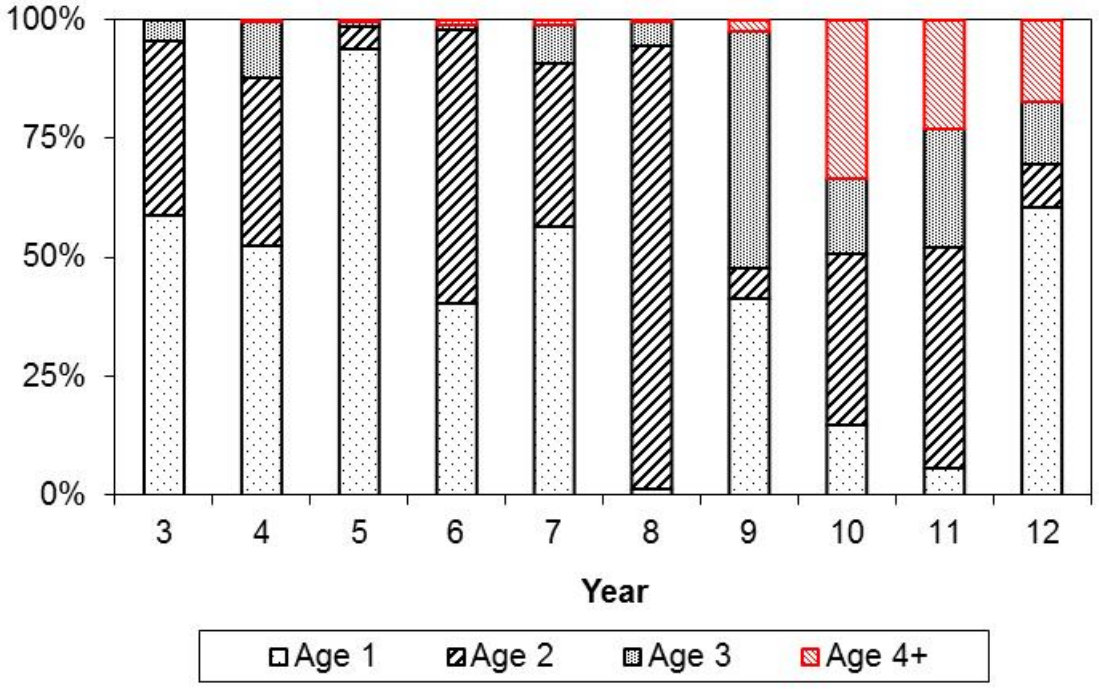


Figure 7. Percent composition by age class for rainbow smelt sampled in Malletts Bay, 2003 - 2012.

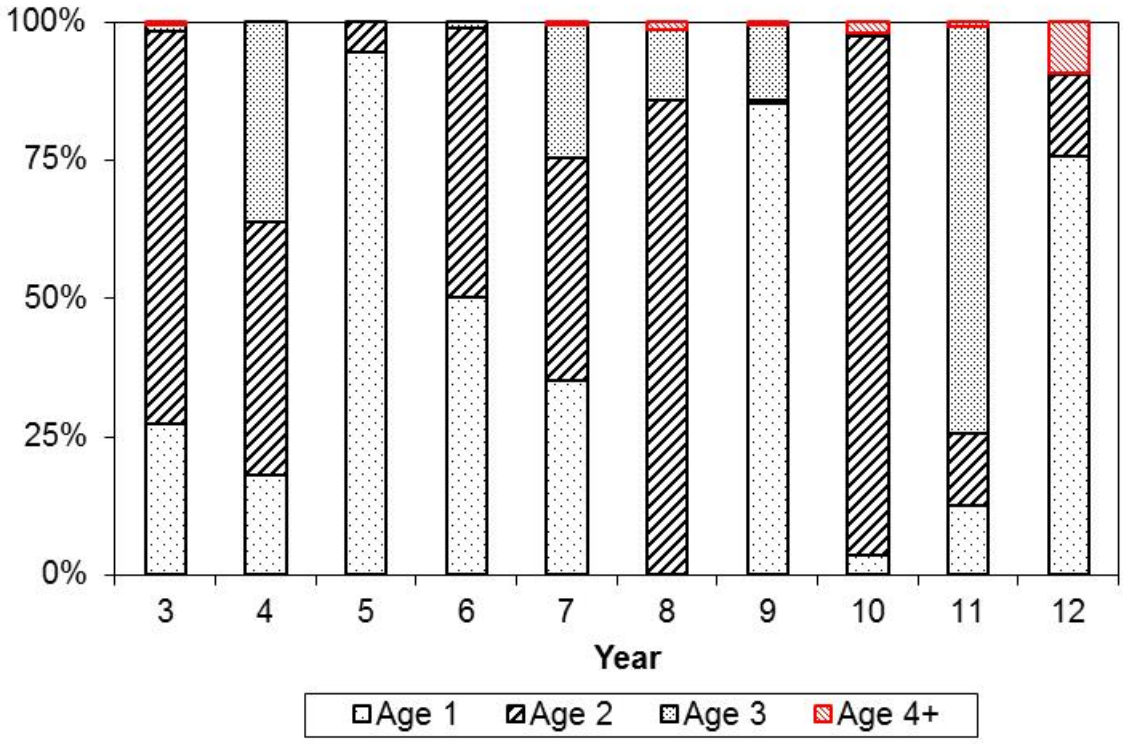


Figure 8. Percent composition by age class for rainbow smelt sampled in the Northeast Arm 2003 - 2012.

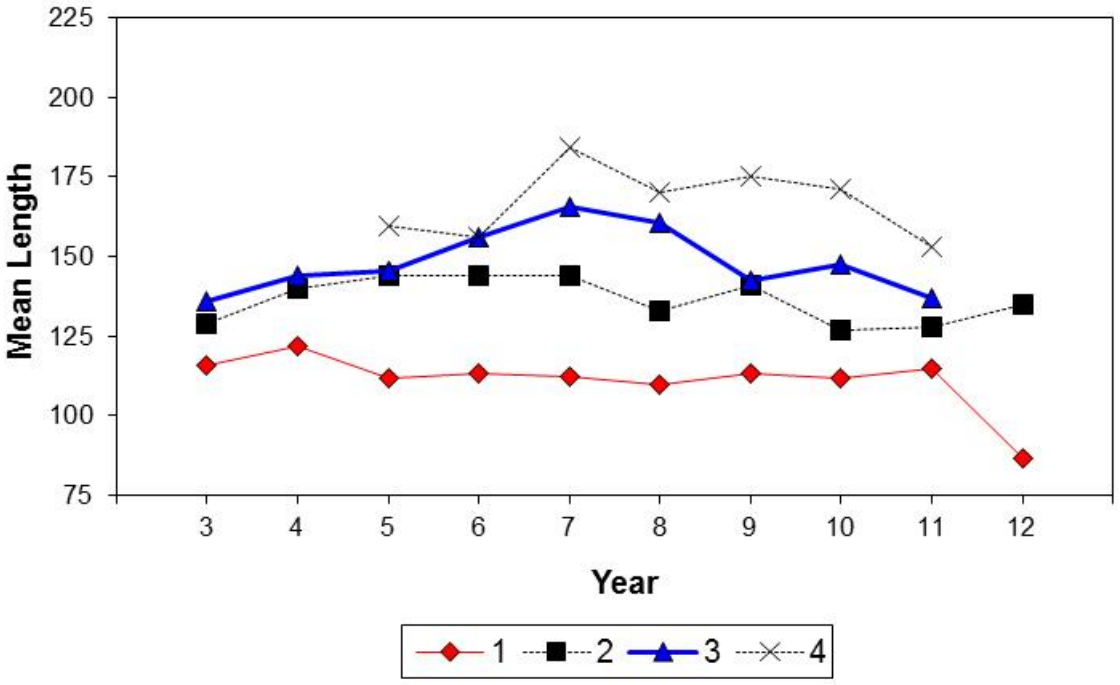


Figure 9. Mean length (mm) at age of rainbow smelt sampled at Juniper Island, 2003 - 2012.

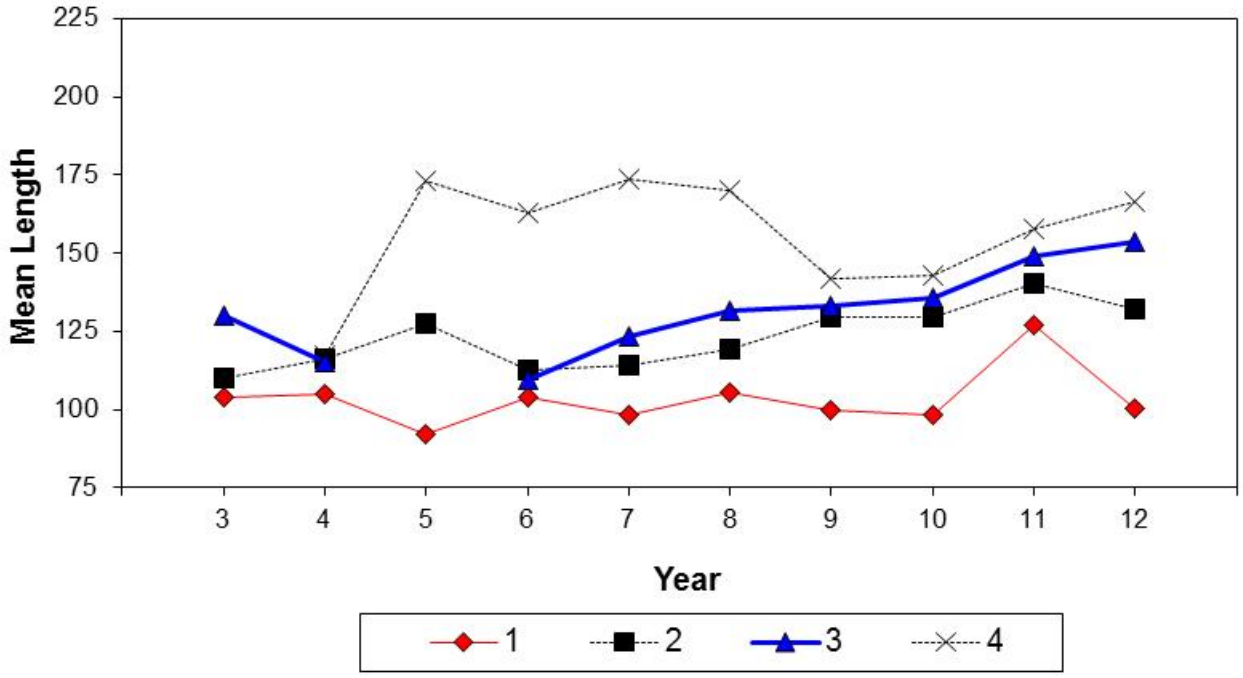


Figure 14. Mean length (mm) at age of rainbow smelt sampled in Malletts Bay, 2003 - 2012.

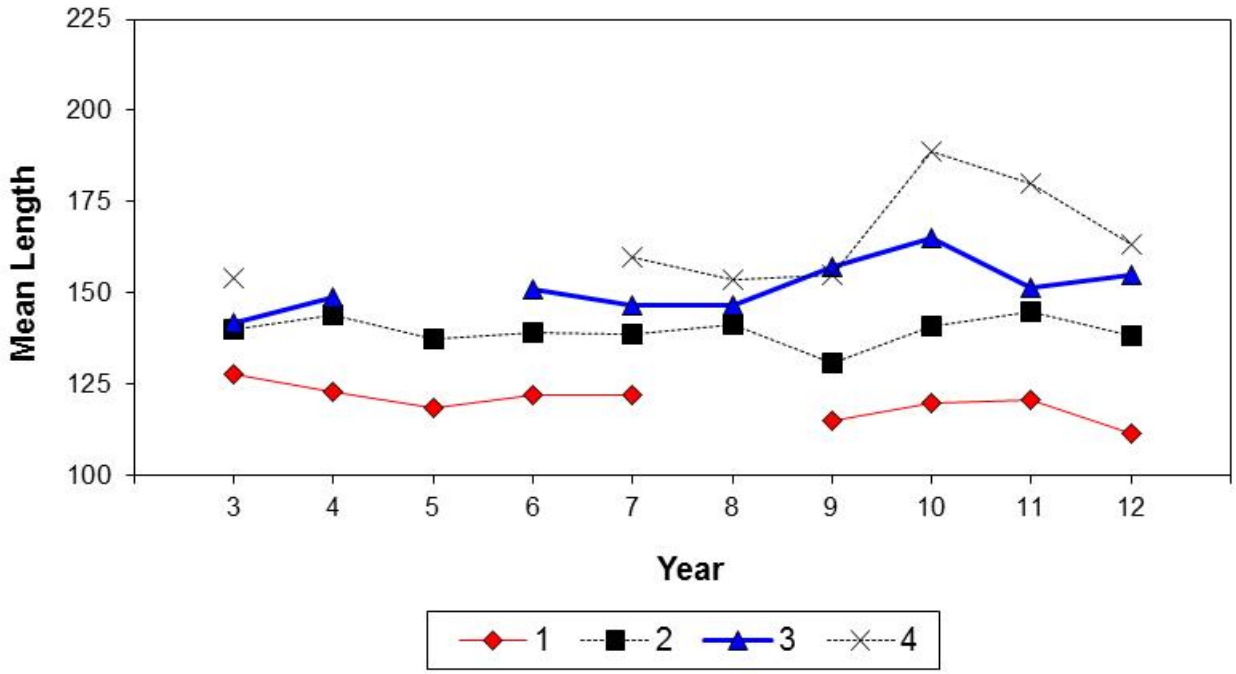


Figure 15. Mean length (mm) at age of rainbow smelt sampled in the Northeast Arm, 2003 - 2012.

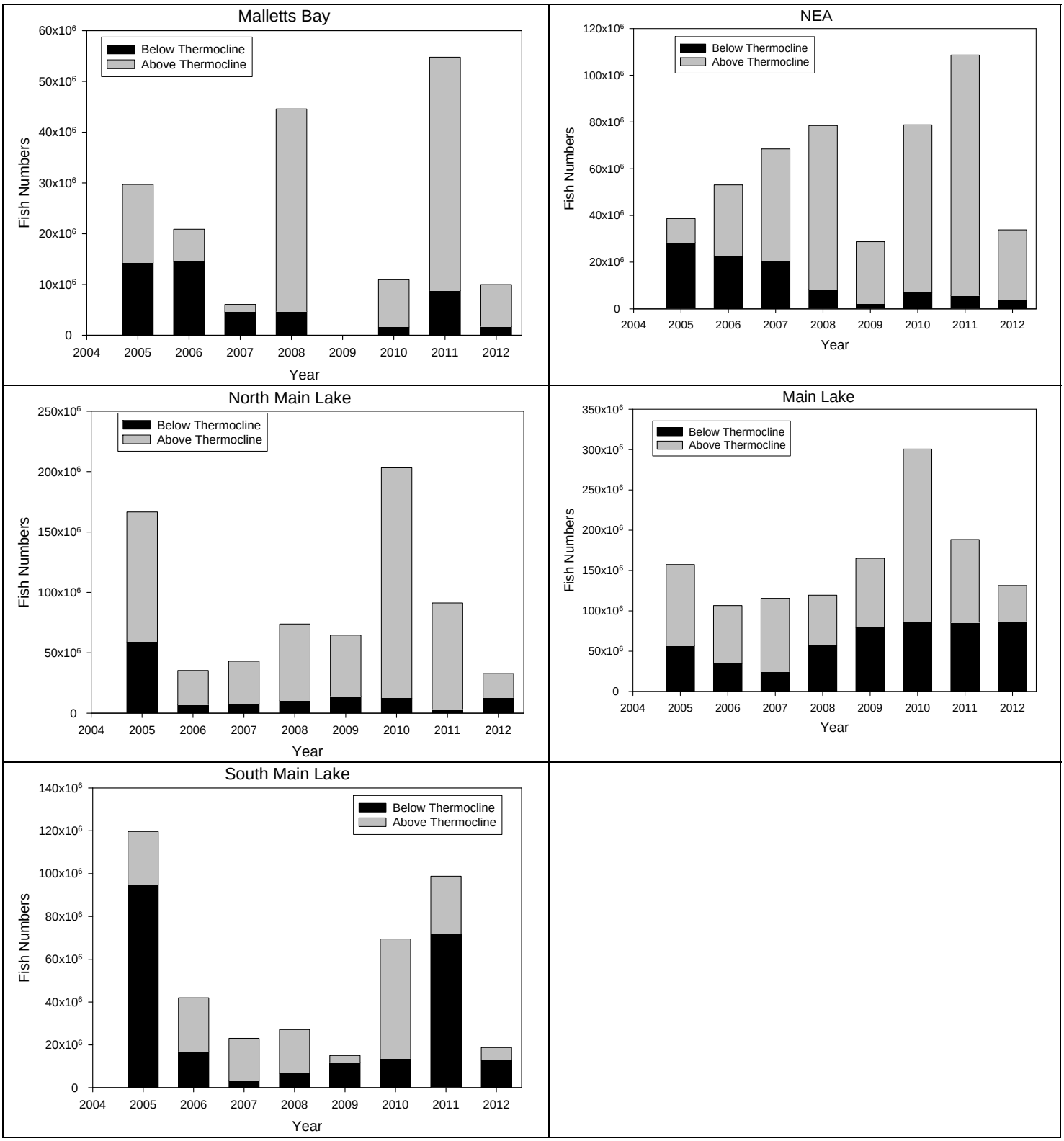


Figure 16. Estimated numbers of yearling and older fish (>-61 dB) in different areas of Lake Champlain from Acoustic data. Rainbow smelt are the primary fish found below the thermocline. Common species found above the thermocline include white perch and alewives.

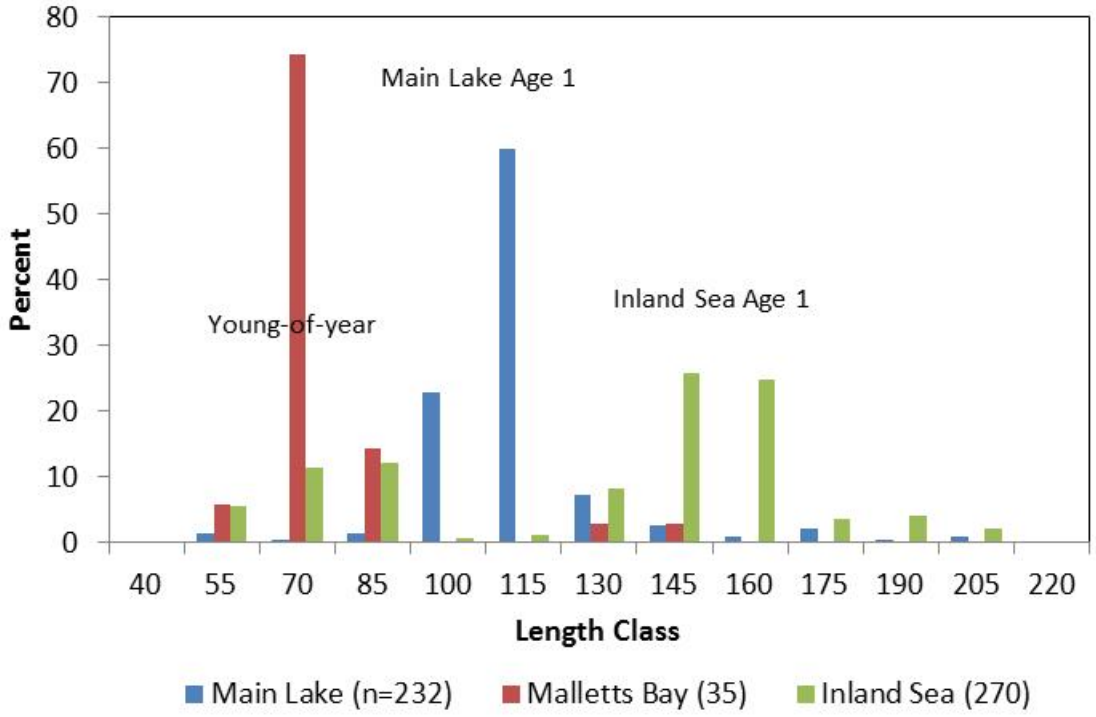


Figure 17. Length Frequency by lake basin of alewife collected by floating gill net in 2012.

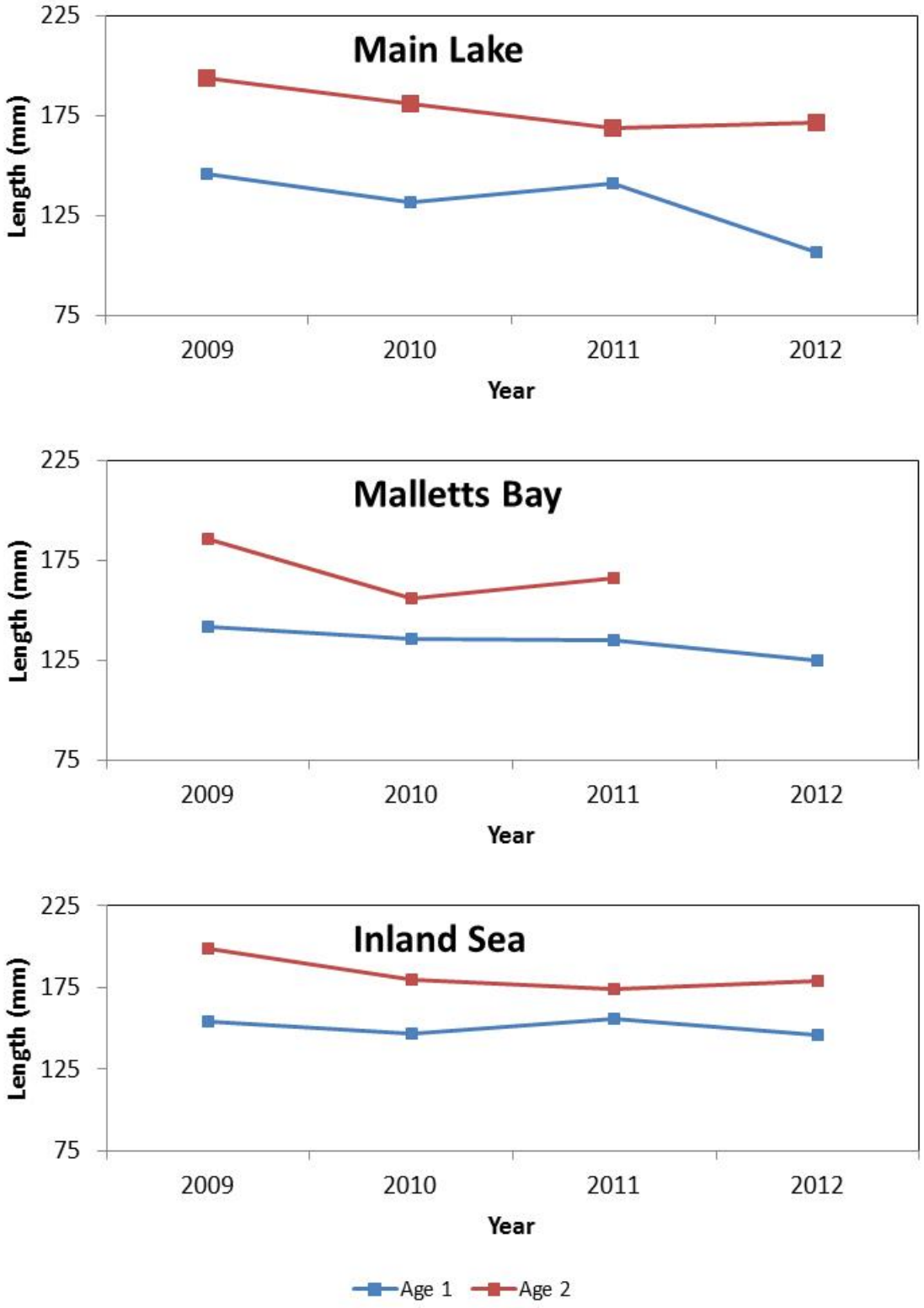


Figure 18. Mean length (mm) at age of alewife sampled by floating gillnet, 2009 – 2012.

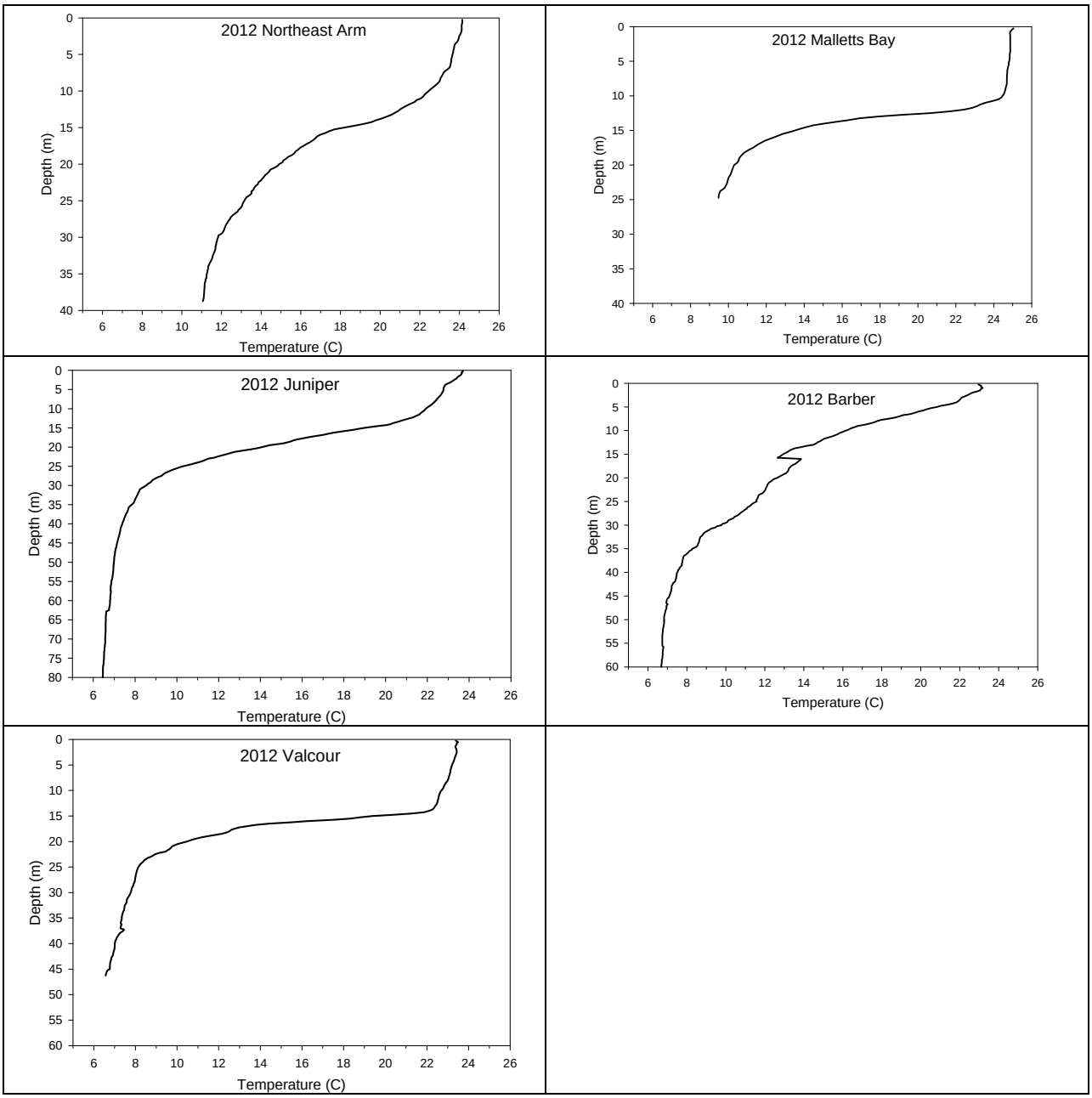


Figure 19. Temperature profiles collected in 2012 at the five standard trawling stations: Northeast Arm, Malletts Bay, Juniper, Barber Point, and Valcour.