Vermont Fish and Wildlife Department
Annual Report

State: Vermont **Project No.**: F-35-R-13

Grant Title: Lake Champlain Fisheries Restoration and Management

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

Period Covered: July 1, 2010 to June 30, 2011

Summary of Activity:

Forage fish assessment sampling in 2010 was carried out beginning on July 27 and ending on August 23. Calculated mean CPUE in 2010 remained relatively high at the main lake stations but have continued to remain well below historic numbers in Malletts Bay and at the Northeast Arm station. Age-one smelt, which were absent in the 2008 sample, were nearly absent from the Northeast Arm. For the first time no YOY smelt were collected from the Northeast Arm and Malletts Bay stations. 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 2010 for rainbow smelt in Lake Champlain (Figure 1).

These sites include three main lake stations, one station in Malletts Bay, and one station in the Inland Sea. The five sites are stations that have been historically sampled. Station locations are shown in Figure 1 and Table1.

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 were saved and later measured to the nearest millimeter in the laboratory. Any cisco (*Coregonus artedi*) collected were also counted and measured. All other fish species collected are identified and counted.

Alewife Monitoring

Alewife *(Alosa pseudoharengus* 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.

FINDINGS

Standard Monitoring

Catch-Per-Unit-of-Effort --- A total of 19 midwater trawls were conducted between July 27 and August 23, 2010 (Table 2). Calculated mean CPUE in 2010 remained relatively high at the main

lake stations but have continued to remain well below historic numbers in Malletts Bay and at the Northeast Arm station (Figure 2). Table 2 compares 2010 CPUE with long-term mean and median values.

Age and Growth --- Mean age of smelt sampled in 2010 ranged from 1.2 to 2.8 years (Table 3 and Figures 3 and 4). Age composition of the samples from each station is illustrated in Figure 5 and compared to previous years in Figures 6-10. Age one smelt, which were absent in the 2008 sample, were again nearly absent in the Northeast Arm with age 2 smelt making up 94 percent of the aged sample. Only half of the usual number of smelt were collected from Malletts Bay for age analysis and older aged smelt dominated the sample. Mean length of smelt at age 1 and 2 remained similar to previous years (Table 4, Figures 11 - 15). Mean weight at age of smelt collected in 2010 is summarized in Table 5.

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 YOY smelt were found at most stations in 2010 (Table 6 and 7). For the first time no YOY smelt were collected from the Northeast Arm and Malletts Bay stations. Smelt YOY mean lengths were similar at the main lake stations ranging from 22 to 61 mm.

Hydro Acoustics

Acoustic work was performed lake-wide in 2010, which include the three basins of Lake Champlain (Malletts Bay, Northeast Arm and Main Lake) and resulted in over 82 nautical miles of sampling. The survey sampled 7.5 nautical miles in Malletts Bay, 17 nautical miles in Northeast Arm and 57.8 nautical miles 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 2010 a total of 29 profiles were taken: 19 Main Lake, 6 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. A total of 8 tucker trawls and 13 midwater trawls were performed (Table 8).

Processed Data --- Processing is ongoing but some general trends have appeared. Generally fish density is highest in the upper 10 to 15 meters of water. In both Malletts Bay and Northeast Arm adult smelt numbers (acoustic targets below the thermocline) appear to be declining (2005-2010) (Figure 16). In the Northeast Arm the targets above the thermocline showed a strong increase in 2008 and 2010 but 2009 was similar to earlier years. The Malletts Bay estimate above the thermocline in 2009 was high but this is due to interference from another sonar unit. The data is currently being screened and edited to remove this interference. The 2010 Malletts Bay estimate above the thermocline is much lower than 2008 or 2009 levels. 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. Both the North and South Main Lake Areas had high smelt numbers in 2005 followed by a decline. In 2010 all three Main Lake areas showed the highest fish numbers above the thermocline in the six years of acoustic sampling.

Targeted Trawls --- In 2010 alewife were collected in many of the trawls but trawl data is still being processed in the lab. The CPUE is difficult to compare because trawls are targeting acoustic targets, therefore they typically are sampling high density areas. Compared to earlier years more shallow midwater trawls were performed in an effort to better understand the shallow acoustic targets.

Alewife

Catch-Per-Unit-of-Effort --- Ten floating gill nets were set in 2010 (Table 9). Seven nets were fished in the main lake with the Barber Point station recording the greatest CPUE of YOY and adult alewife at 173 and 194 fish, respectively. One net was fished in Malletts Bay and 2 nets were set 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 17). Most stations were dominated by age-one alewives. Mean lengths were similar across sampling stations; age-1 alewives were slightly larger in the Northeast Arm, however.

Midwater trawl numbers --- Thirty-eight adult alewives were collected by midwater trawl in 2010. Most of the alewives (14) were collected in the Northeast Arm site followed by Barber Point (11); 6 were collected at Juniper Island, 4 at Valcour and 3 in Malletts Bay. Alewife YOY were also collected at all but the Malletts Bay station (Table 6). The largest numbers of YOY alewife were collected in the Northeast Arm (estimated 1,400 fish) while Valcour Island had the highest numbers of the main lake stations (659).

Cisco

A total of 29 cisco was collected during the 2010 forage fish sampling effort (Table 11). Sixteen were collected at Valcour Island and 9 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.

Nearly all of the measured cisco fall into the 280 – 320 mm length class (Figure 18). No YOY were collected during the 2010 sampling season. The length frequency of the 2008 and 2009 cisco sampled is also presented in Figure 18 for comparison.

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. During initial sampling in Malletts Bay the CTD failed to collect data due to some software/hardware issues.

RECOMMENDATIONS

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

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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 2010 and comparison to long-term mean and median CPUE.

Station	Number of trawls	CPUE	Mean	Median	N years
Main Lake					
Barber Point	4	459 ± 147	270	209	17
Juniper Island	4	305 ± 71	178	111	21
Valcour Island	3	185 ±38	261	155	11
Malletts Bay					
Malletts Bay	4	38 ± 10	999	654	21
Inland Sea					
Northeast Arm	4	151 ± 63	1062	693	21

Table 3. Mean and maximum age of rainbow smelt sampled by station in 2010. Number in parenthesis is change from previous year.

Station	Mean age	Maximum age
Main Lake Stations		
Barber Point	1.6 (+0.3)	5
Juniper Island	1.7 (+0.4)	4
Valcour Island	1.2 (-0.4)	3
Malletts Bay		
Malletts Bay	2.8 (+0.7)	6
Inland Sea		
Northeast Arm	2.0 (+0.7)	5

Table 4. Mean length and standard deviation in millimeters, by age class of rainbow smelt sampled in 2010. Number of smelt aged in parenthesis.

Station	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
Main Lake Stations						
Barber Point	112 ± 8 (98)	126 ± 7 (81)	151 ± 15 (16)	183 ± 36 (3)	175 (1)	---
Juniper Island	112 ± 6 (73)	127 ± 7 (122)	148 ± 5 (4)	171 (1)	---	---
Valcour Island	123 ± 7 (171)	133 ± 8 (27)	153 ± 11 (3)	---	---	---
Malletts Bay						
Malletts Bay	98 ± 9 (15)	129 ± 8 (37)	135 ± 8 (16)	143 ± 10 (22)	161 ± 12 (10)	168 ± 4 (2)
Inland Sea						
Northeast Arm	119 ± 7 (7)	141 ± 6 (186)	165 (1)	189 ± 54 (3)	163 (1)	---

Table 5. Mean weight and standard deviation in grams, by age class of rainbow smelt sampled in 2010. Number of smelt in parenthesis.

Station	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
Main Lake Stations						
Barber Point	8 ± 1 (98)	10 ± 2 (81)	14 ± 5 (15)	36 ± 29 (3)	30 (1)	---
Juniper Island	8 ± 1 (72)	11 ± 2 (122)	15 ± 2 (4)	28 (1)	---	---
Valcour Island	10 ± 2 (171)	15 ± 2 (27)	17 ± 6 (3)	---	---	---
Malletts Bay						
Malletts Bay	6 ± 2 (15)	13 ± 2 (37)	14 ± 3 (16)	17 ± 4 (22)	23 ± 6 (10)	27 ± 2 (2)
Inland Sea						
Northeast Arm	10 ± 2 (7)	17 ± 2 (186)	21 (1)	44 ± 40 (3)	23 (1)	---

Table 6. Summary of young-of-year rainbow smelt and alewife (in parenthesis) collected during midwater smelt trawls, 1999-2010. 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)

Table 7. Number, mean length (standard deviation) and range of young-of-year smelt sampled in 2010.

Station	Number Collected	Mean Length	Number Measured	Range
Main Lake				
Barber Point	6	38 ± 8	6	24 - 45
Juniper Island	39	50 ± 6	39	39 - 61
Valcour Island	202	39 ± 4	42	22 - 46
Malletts Bay				
Malletts Bay	0	na		
Inland Sea				
Northeast Arm	0	na		

Table 8. CPUE of targeted acoustic trawls in 2010. For example sampling number AT100803001 is sample collected on 08/03/10 and is net number 001. Sample processing is still ongoing so no results are presented.

			CPUE (10 minutes)							
Sample	Gear	Area	Alewife	Smelt	White Perch	Yellow Perch	Cypr Sp.	Centr Sp	Unknown Larval fish	Other
AT10080301	Mid	NEA								
AT10080302	Tucker	NEA								
AT10080303	Tucker	NEA								
AT10080304	Tucker	NEA								
AT10080305	Mid	NEA								
AT10080401	Mid	NEA								
AT10080402	Mid	NEA								
AT10080403	Tucker	NEA								
AT10080404	Tucker	NEA								
AT10080501	Mid	Main lake								
AT10080502	Mid	Main lake								
AT10080503	Mid	Main lake								
AT10081001	Mid	Main lake								
AT10081002	Mid	Main lake								
AT10081003	Mid	Main lake								
AT10081004	Tucker	Main lake								
AT10081101	Tucker	Main lake								
AT10081102	Mid	Main lake								
AT10081201	Mid	Main lake								
AT10081202	Tucker	Main lake								
AT10081801	Mid	Malletts								

Table 9. Floating gill net catch per 4 hour set (expanded from total minutes fished) of alewife in 2008 - 2010. 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	FGN08073001	3.0	40.7

Table 10. Mean total length and standard deviation in millimeters, by age class of alewife sampled by floating gill net in 2010. Number of alewife aged in parenthesis.

Station	YOY	Age 1	Age 2	Age 3	Age 4
Main Lake Stations					
Barber Point	56 ± 8 (40)	134 ± 8 (58)	198 ± 14 (2)	---	---
Valcour Island	56 ± 5 (35)	131 ± 6 (121)	170 ± 6 (3)	---	---
Malletts Bay					
Malletts Bay	55 ± 4 (8)	136 ± 6 (38)	156 (1)	---	---
Inland Sea					
Ladd Point	55 ± 5 (24)	147 ± 11 (44)	180 ± 20 (14)	---	---

Table 11. Summary of total numbers of cisco collected, 1990-2010. 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

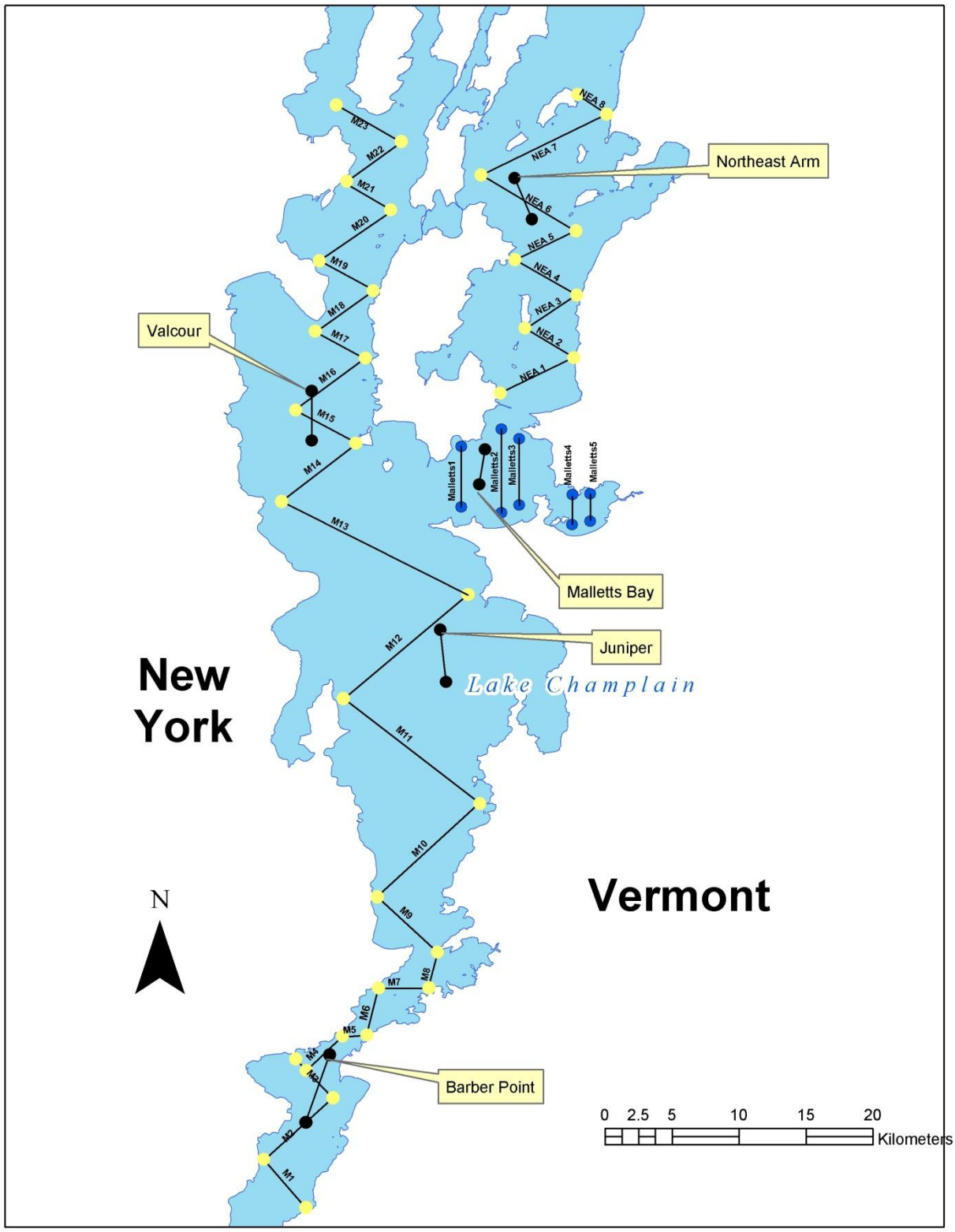

Figure 1. Rainbow smelt sampling stations (text boxes) and acoustic transects with transect name.

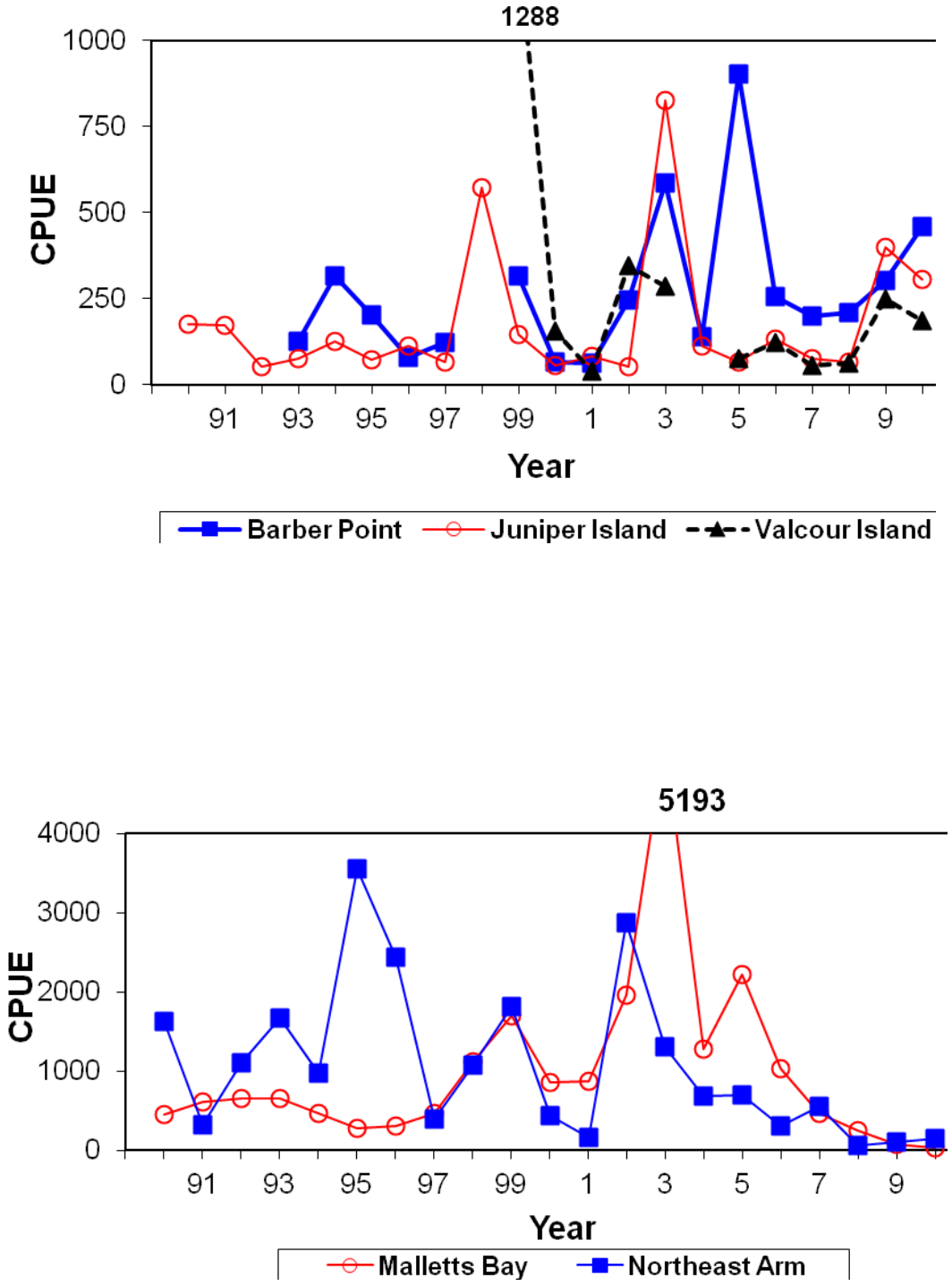

Figure 2. Mean CPUE of smelt for Lake Champlain, 1990-2010.

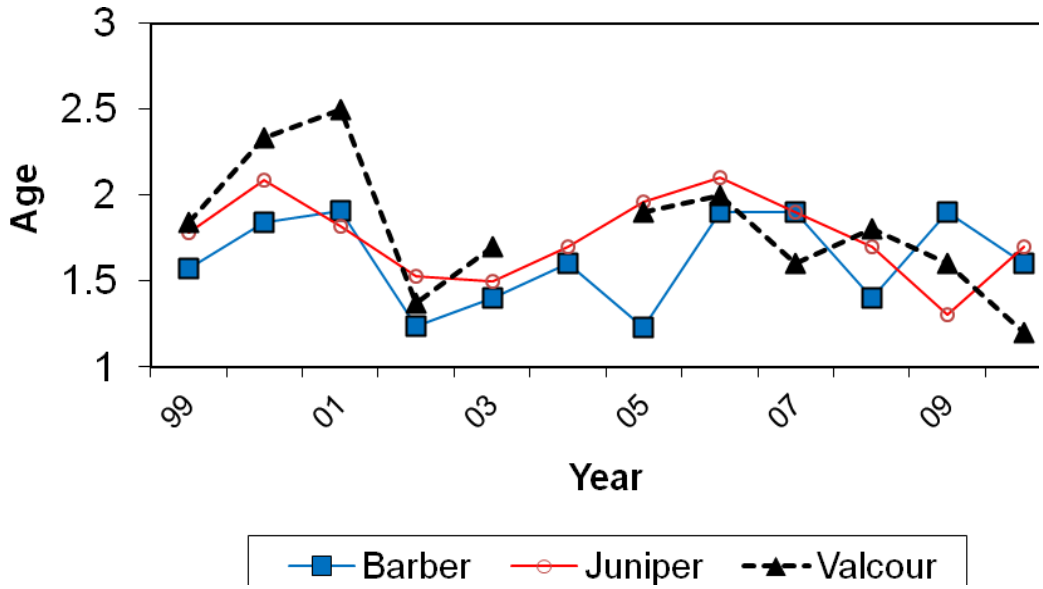

Figure 3. Mean age of rainbow smelt sampled at three main lake stations, 1999-2010.

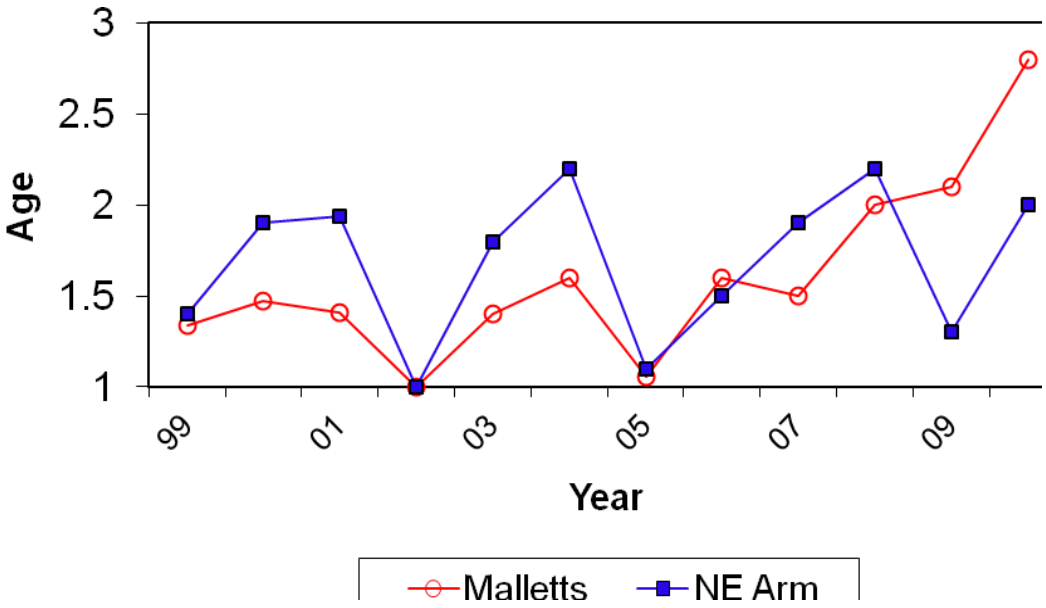

Figure 4. Mean age of rainbow smelt sampled at Malletts Bay and the Northeast Arm stations, 1999-2010.

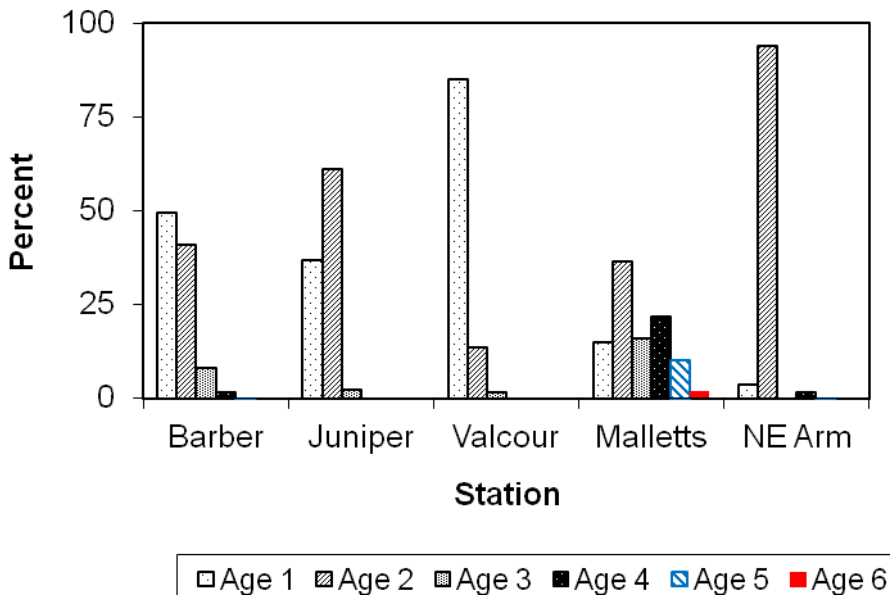

Figure 5. Percent composition by age class of rainbow smelt sampled in Lake Champlain in 2010. Sample size approximately 200 except for Malletts Bay (n=102).

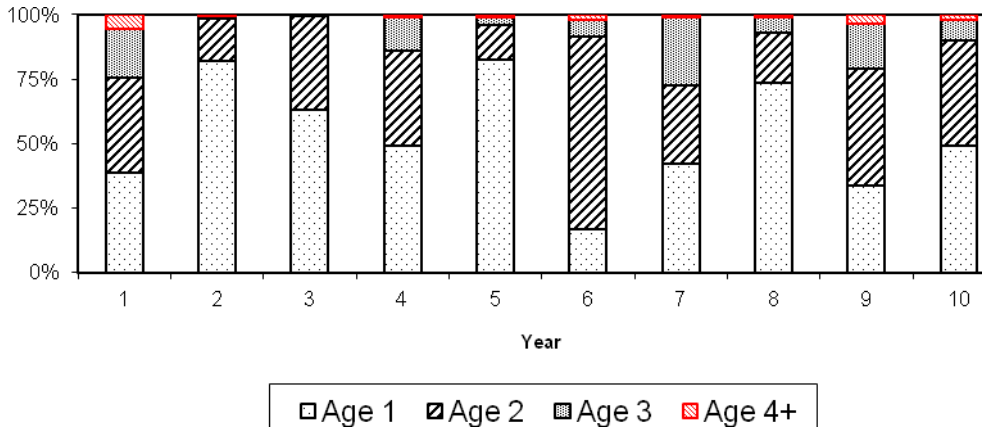

Figure 6. Percent composition by age class for rainbow smelt sampled at Barber Point, 2001 - 2010.

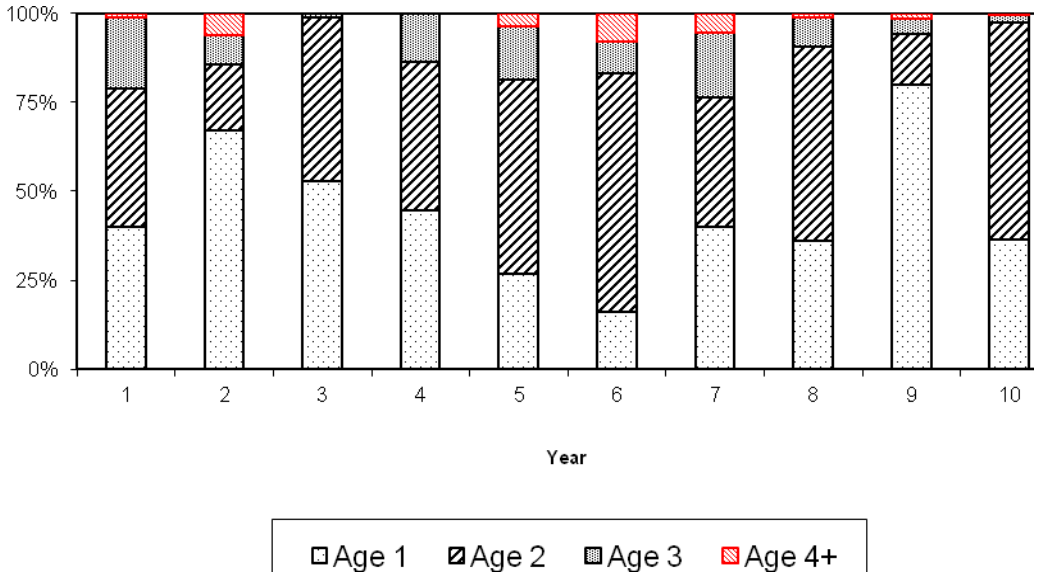

Figure 7. Percent composition by age class for rainbow smelt sampled at Juniper Island, 2001 - 2010.

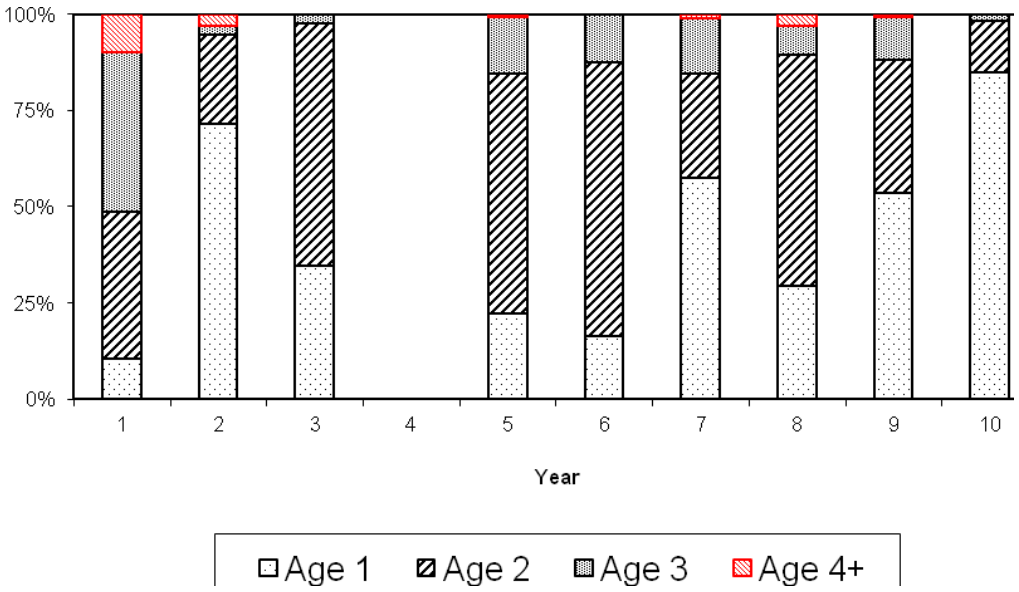

Figure 8. Percent composition by age class for rainbow smelt sampled at Valcour Island, 2001 - 2010.

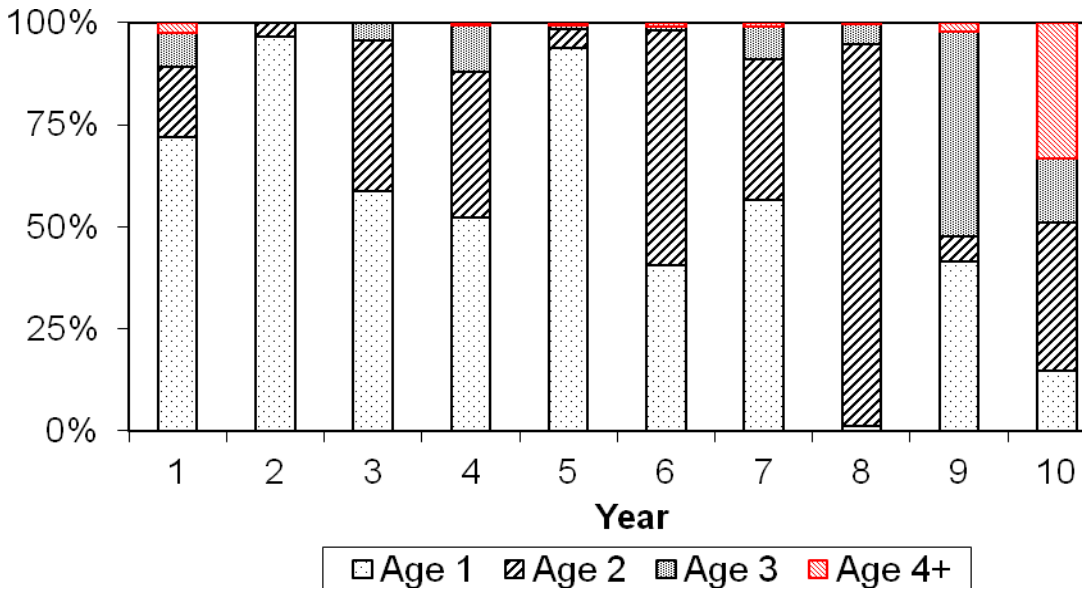

Figure 9. Percent composition by age class for rainbow smelt sampled in Malletts Bay, 2001 - 2010.

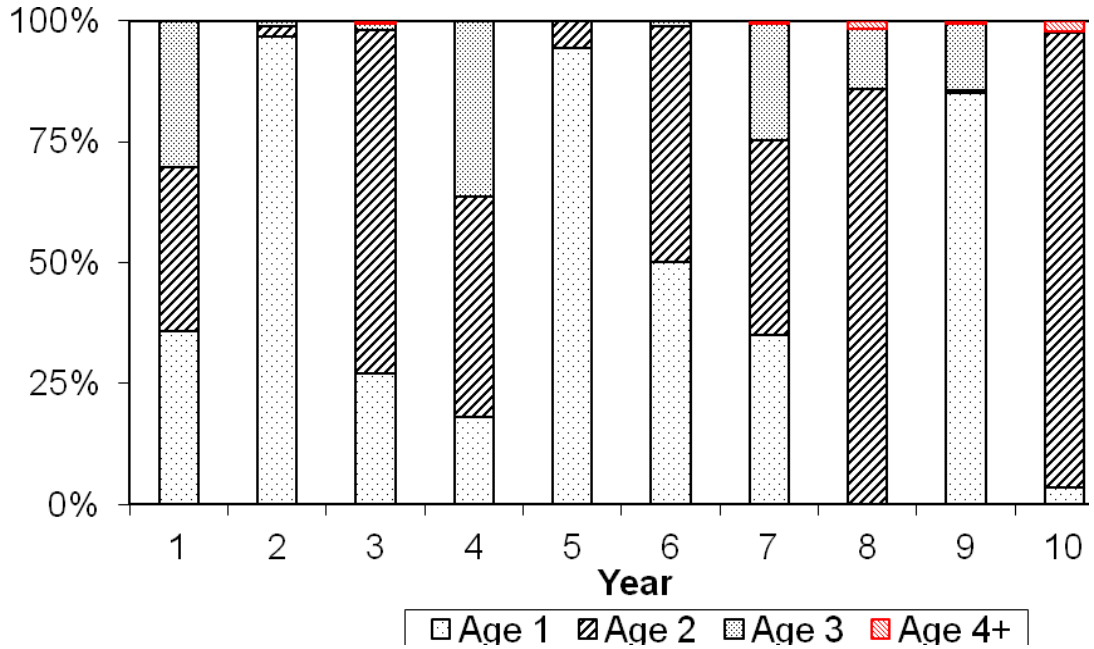

Figure 10. Percent composition by age class for rainbow smelt sampled in the Northeast Arm 2001 - 2010.

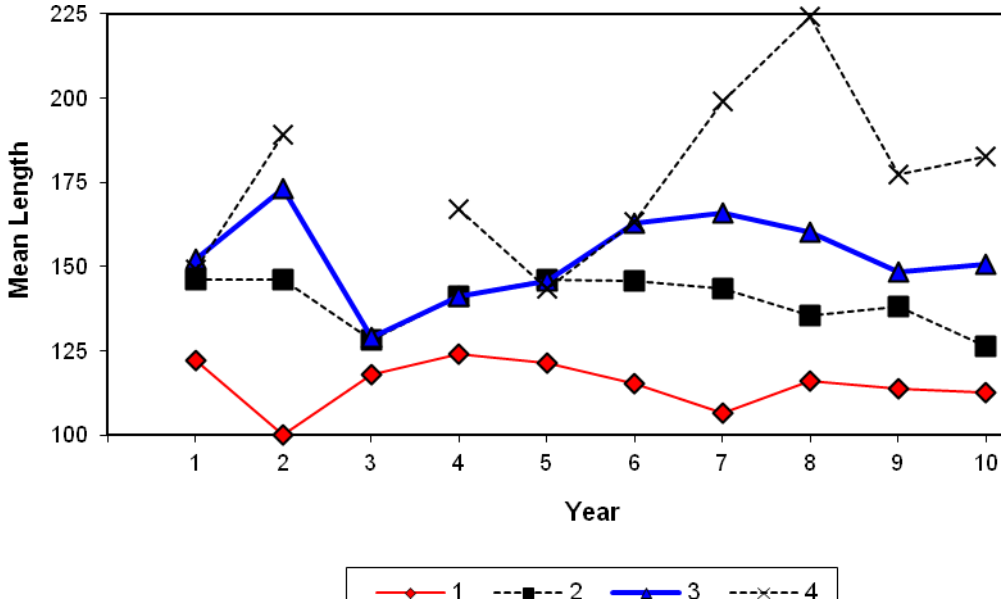

Figure 11. Mean length (mm) at age of rainbow smelt sampled at Barber Point, 2001 - 2010.

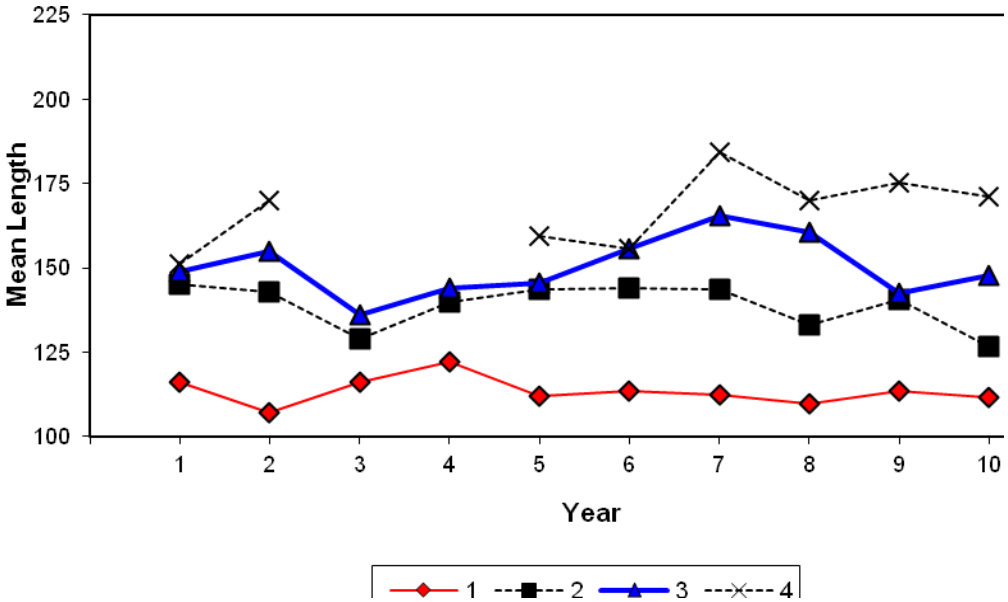

Figure 12. Mean length (mm) at age of rainbow smelt sampled at Juniper Island, 2001 - 2010.

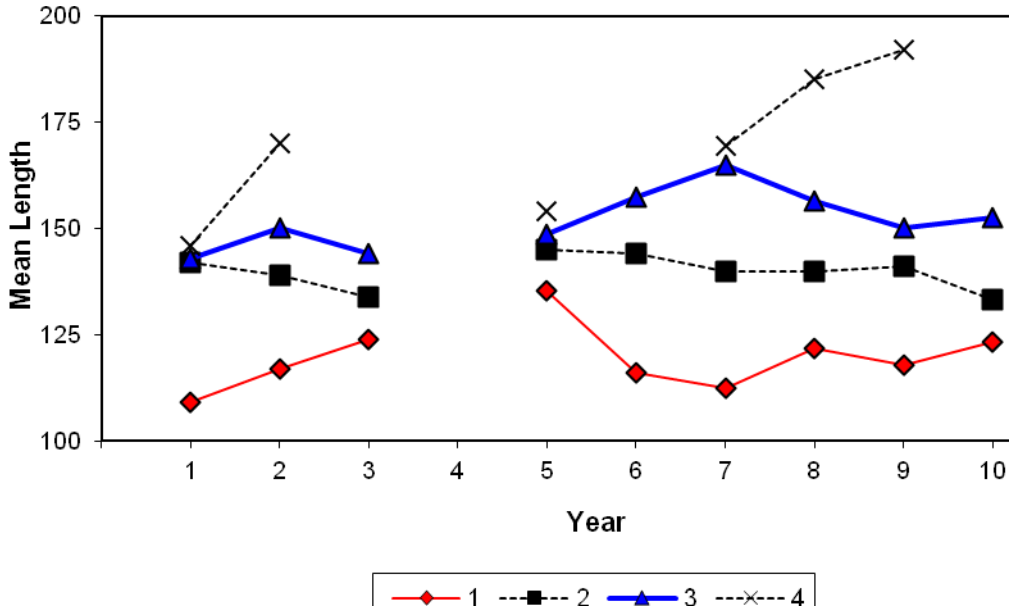

Figure 13. Mean length (mm) at age of rainbow smelt sampled at Valcour Island, 2001 - 2010.

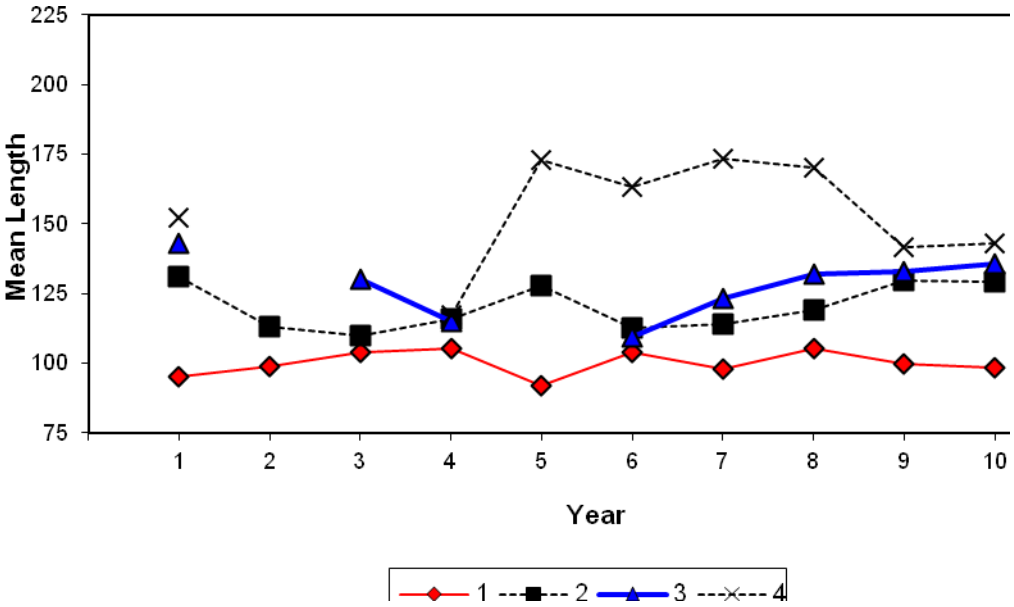

Figure 14. Mean length (mm) at age of rainbow smelt sampled in Malletts Bay, 2001 - 2010.

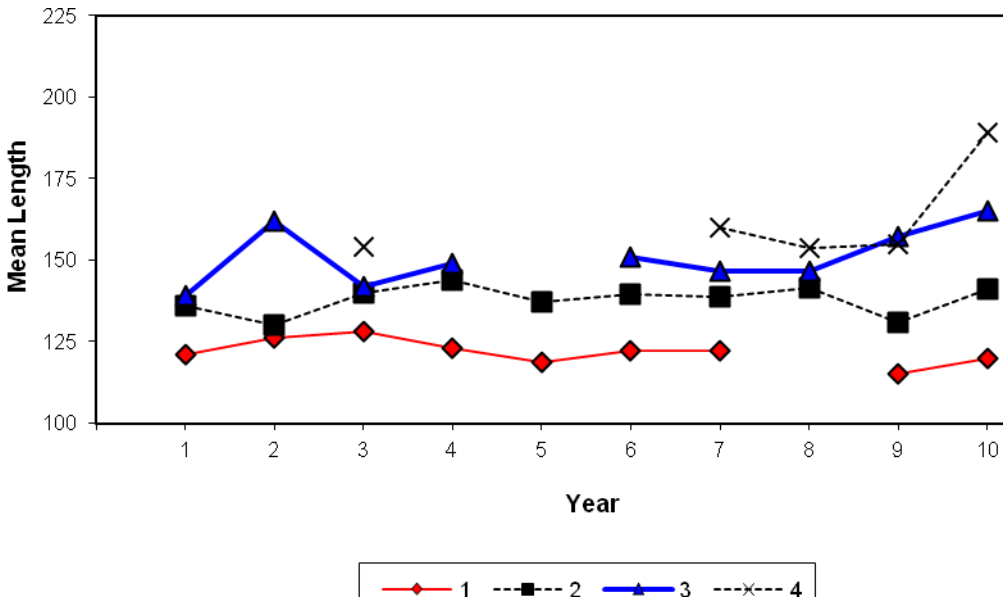

Figure 15. Mean length (mm) at age of rainbow smelt sampled in the Northeast Arm, 2001 - 2010.

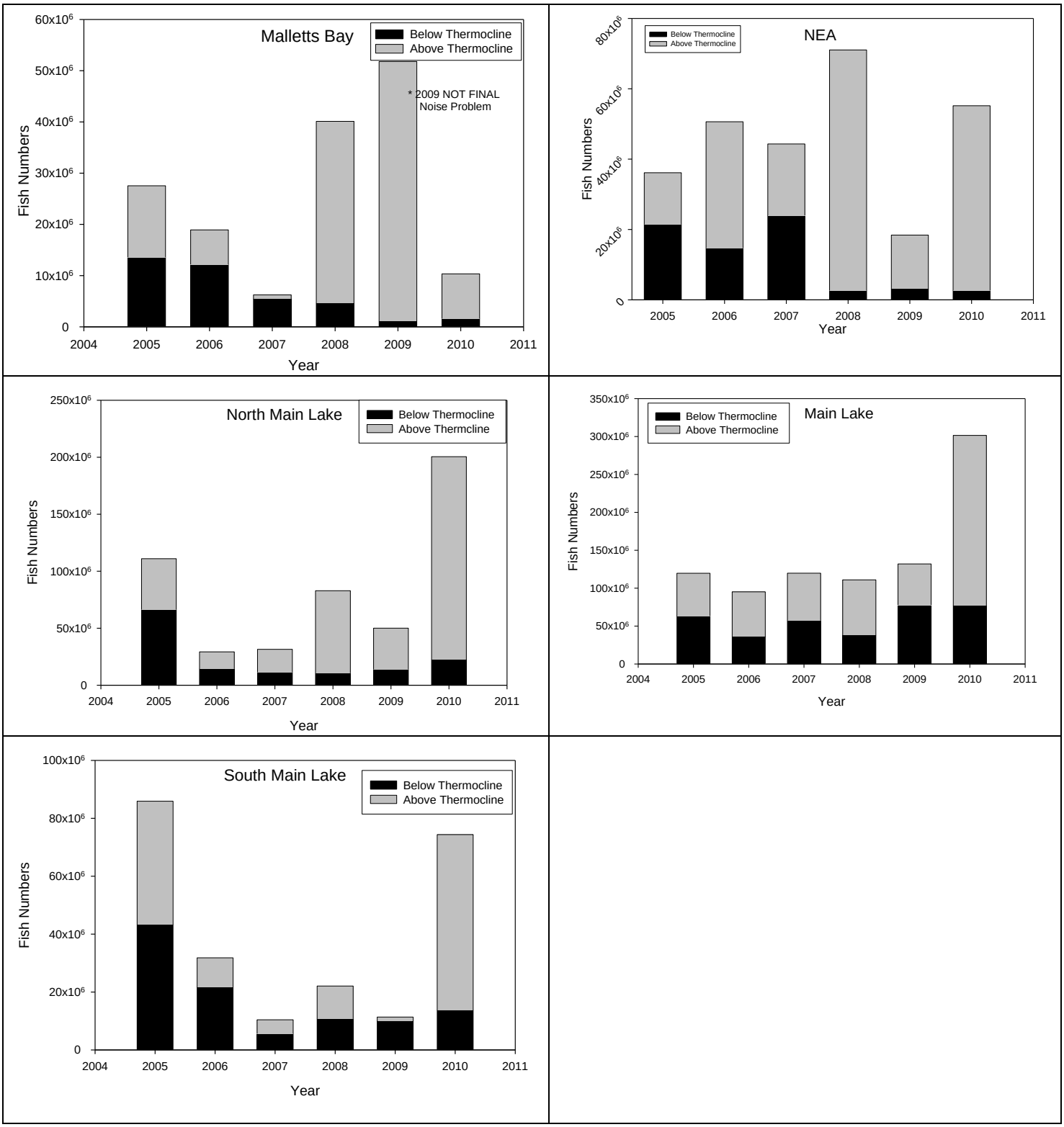

Figure 16. Estimated numbers of yearling and older fish (>-61 dB) in different areas of Lake Champlain from Acoustic data. Rainbow smelt are the primary fish found below the thermocline. Common species found above the thermocline include white perch and alewives.

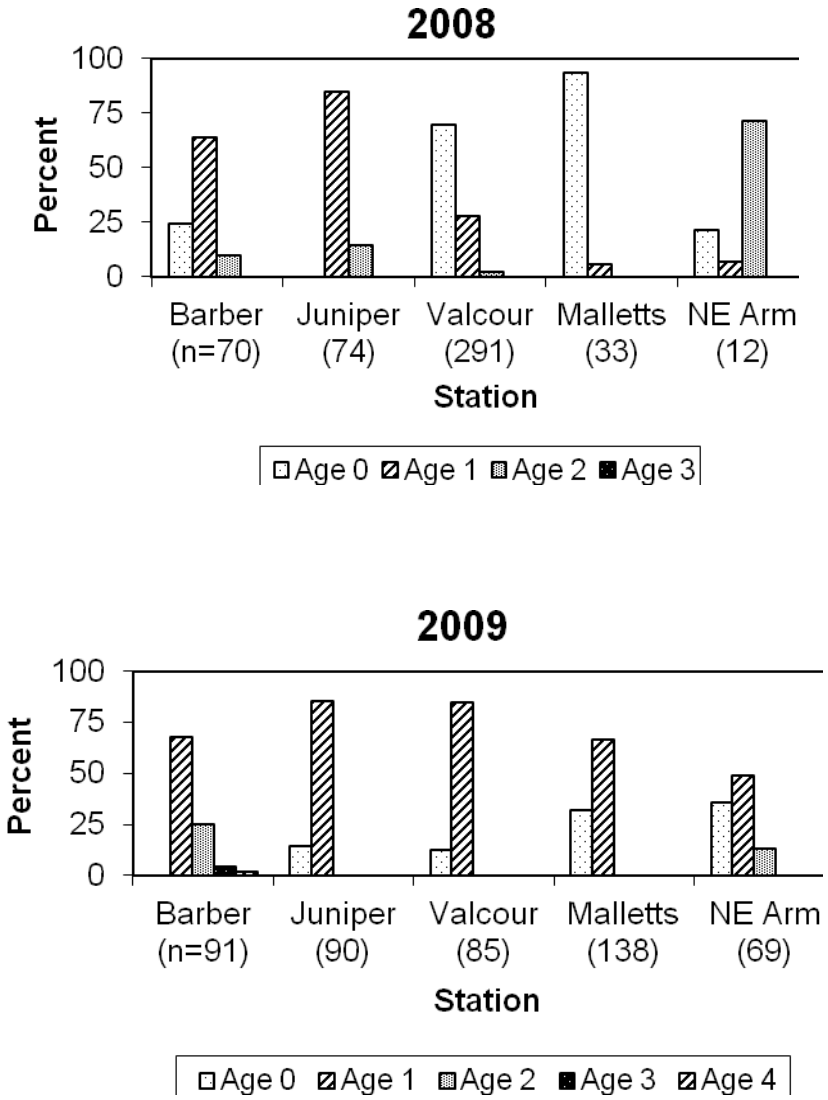

Figure 17. Age composition by station of alewife collected by floating gill net in 2008 - 2010.

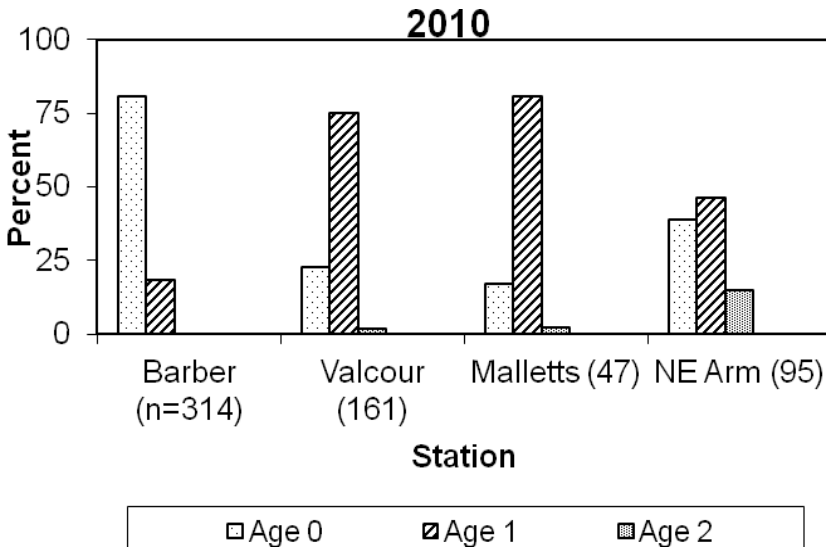

Figure 17. Continued.

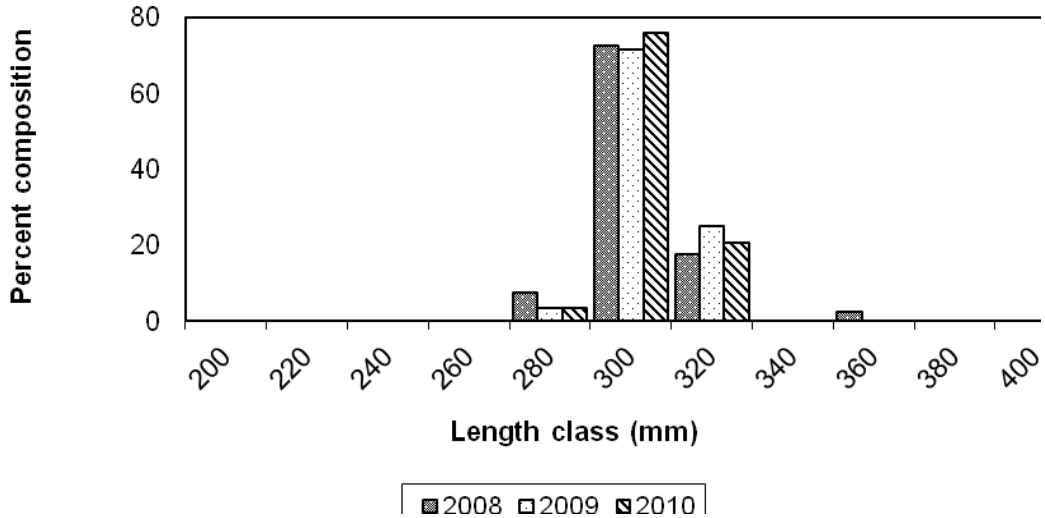

Figure 18. Length frequency composition of cisco collected, 2007 - 2010.

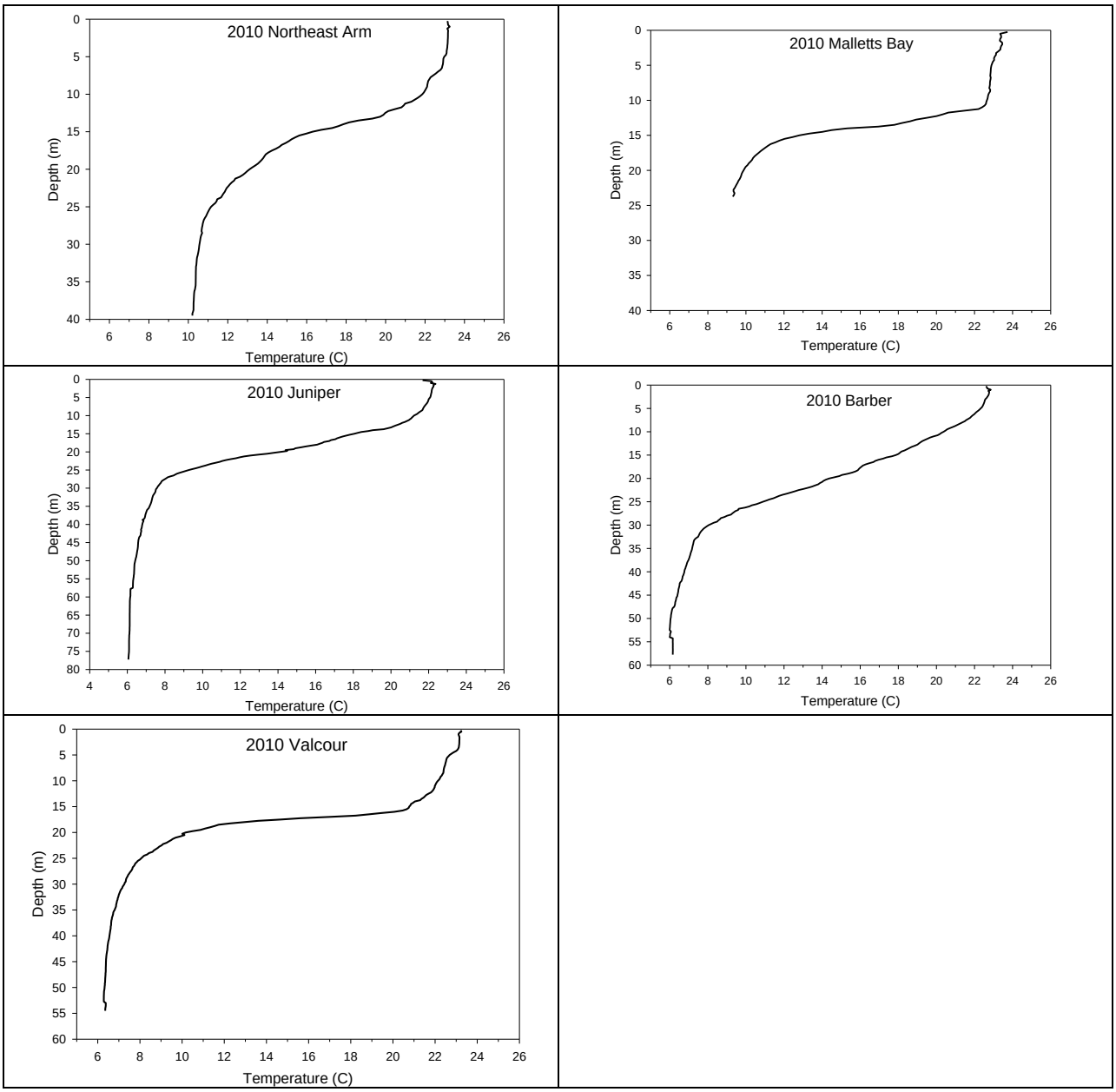

Figure 19. Temperature profiles collected in 2010 at the five standard trawling stations: Northeast Arm, Malletts Bay, Juniper, Barber Point, and Valcour.