Vermont Fish and Wildlife Department
Annual Report

State: Vermont **Project No.**: F-35-R-12

Grant Title: Lake Champlain Fisheries Restoration and Management

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

Period Covered: July 1, 2009 to June 30, 2010

Summary of Activity:

Forage fish assessment sampling in 2009 was carried out beginning on July 28 and ending on August 20. Calculated mean CPUE in 2009 increased 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 again collected in the Northeast Arm and Malletts Bay samples. Floating gill nets were utilized to sample alewife. Alewives were captured at all stations with the greatest catch being at the Juniper Island station.

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 2009 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. In 2008 and 2009, 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 6.26, 8, 10, 12, 15, and 25mm.

Catch-per-unit-effort (CPUE) 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 20 midwater trawls were conducted between July 28 and August 18, 2009 (Table 2). Calculated mean CPUE in 2009 increased 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 2009 CPUE with long-term mean and median values.

Age and Growth --- Mean age of smelt sampled in 2009 ranged from 1.3 to 2.1 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 collected in the Northeast Arm and Malletts Bay samples. 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 2009 is summarized in Table 5.

Young-of-Year Rainbow Smelt --- It's important to note that the sampling gear is not designed to sample young-of-year (YOY) smelt and that the YOY data must be viewed cautiously. YOY smelt were found at most stations in 2009 (Table 6 and 7). Barber Point was the only station that no YOY were collected and only 35 were found at the Northeast Arm station. Smelt YOY mean lengths were similar at most stations ranging from 43 to 51 mm. The largest YOY were collected at main lake stations.

Hydro Acoustics

Acoustic work was performed lake-wide in 2009, which include the three basins of Lake Champlain (Malletts Bay, Inland Sea and Main Lake) and resulted in over 100 nautical miles of sampling. The survey sampled 10.3 nautical miles in Malletts Bay, 22 nautical miles in Northeast Arm and 70.7 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 2009 a total of 25 profiles were taken: 15 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 6 tucker trawls were performed and 21 midwater trawls (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 (2005-2009) (Figure 16). In the Northeast Arm the targets above the thermocline showed a strong increase in 2008 but 2009 was similar to earlier years. The Malletts Bay estimate above the thermocline is high but we suspect much of this is due to interference from another sonar unit. The data is currently being screened and edited to remove this interference. Based on shallow midwater trawls and floating gillnets catches we suspect that most of the acoustic targets above the thermocline are either alewife or 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.

Targeted Trawls --- In 2009 alewife were collected in many of the trawls. 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 --- Nine floating gill nets were set in 2009 (Table 9). Five nets were fished in the main lake with the Juniper Island station recording the greatest CPUE of YOY and

adult alewife at 17 and 106 fish, respectively. No YOY alewives were captured at Barber Point or Button Bay (near Barber Point). One net was fished in Malletts Bay and three nets were set in the Northeast Arm. Larger numbers of alewife were collected in the Northeast Arm in 2009.

Age and Growth --- Alewife collected by gill net ranged in age from YOY (0+) to 4 years (Table 10, Figure 17). Most stations were dominated by age one and older alewife with the oldest alewives collected at Barber Point. Mean lengths were similar across sampling stations; age 1 alewives were slightly larger in the Northeast Arm, however.

Midwater trawl numbers --- Seventy-four adult alewives were collected by midwater trawl in 2009. Most of the alewives (66) were collected at Valcour Island; 4 were collected at both the Juniper Island and Malletts Bay stations; one was collected at Barber Point. Alewife YOY were also collected at 3 of the 5 midwater trawl stations (Table 6). The largest numbers of YOY alewife were collected at Malletts Bay (383 fish) while no YOY were collected at the Juniper or Barber stations.

Cisco

A total of 22 cisco were collected during the 2009 forage fish sampling effort (Table 11). Thirteen 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 2009 sampling season. The length frequency of the 2007 and 2008 cisco sampled is also presented in Figure 17 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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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 2009 and comparison to long-term mean and median CPUE.

Station	Number of trawls	CPUE	Mean	Median	N years
Main Lake					
Barber Point	4	301 ± 211	258	206	16
Juniper Island	4	400 ± 79	172	97	20
Valcour Island	4	248 ± 52	268	138	10
Malletts Bay					
Malletts Bay	4	82 ± 41	1047	654	20
Inland Sea					
Northeast Arm	4	108 ± 14	1108	835	20

Table 3. Mean and maximum age of rainbow smelt sampled by station in 2009. Number in parenthesis is change from previous year.

Station	Mean age	Maximum age
Main Lake Stations		
Barber Point	1.9 (+0.5)	5
Juniper Island	1.3 (-0.4)	4
Valcour Island	1.6 (-0.2)	4
Malletts Bay		
Malletts Bay	2.1 (+0.1)	5
Inland Sea Station		
Northeast Arm	1.3 (-0.9)	4

Table 4. Mean length and standard deviation in millimeters, by age class of rainbow smelt sampled in 2009. Number of smelt aged in parenthesis.

Station	Age 1	Age 2	Age 3	Age 4	Age 5
Main Lake Stations					
Barber Point	114 ± 6 (65)	138 ± 6 (87)	148 ± 12 (33)	177 ± 28 (6)	182 (1)
Juniper Island	113 ± 6 (157)	141 ± 8 (28)	142 ± 12 (8)	175 ± 12 (3)	---
Valcour Island	118 ± 7 (106)	141 ± 8 (68)	150 ± 8 (22)	192 (1)	---
Malletts Bay					
Malletts Bay	100 ± 6 (93)	129 ± 13 (14)	133 ± 9 (112)	142 ± 7 (4)	180 (1)
Inland Sea Station					
Northeast Arm	115 ± 7 (167)	131 (1)	157 ± 12 (27)	155 (1)	---

Table 5. Mean weight and standard deviation in grams, by age class of rainbow smelt sampled in 2009. Number of smelt in parenthesis.

Station	Age 1	Age 2	Age 3	Age 4	Age 5
Main Lake Stations					
Barber Point	8 ± 1 (65)	14 ± 2 (87)	17 ± 5 (33)	29 ± 12 (6)	35 (1)
Juniper Island	8 ± 1 (157)	16 ± 3 (28)	17 ± 5 (8)	35 ± 11 (3)	---
Valcour Island	9 ± 2 (106)	15 ± 2 (68)	18 ± 3 (22)	39 (1)	---
Malletts Bay					
Malletts Bay	6 ± 1 (93)	12 ± 3 (14)	13 ± 4 (112)	15 ± 3 (4)	34 (1)
Inland Sea					
Northeast Arm	9 ± 2 (167)	14 (1)	20 ± 6 (27)	19 (1)	---

Table 6. Summary of young-of-year rainbow smelt and alewife (in parenthesis) collected during midwater smelt trawls, 1999-2009. 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)

Table 7. Number, mean length (standard deviation) and range of young-of-year smelt sampled in 2009.

Station	Number Collected	Mean length	Numbered Measured	Range
Main Lake				
Barber Point	0	---	---	---
Juniper Island	450	51.4 ± 5.0	100	42- 65
Valcour Island	349	50.8 ± 5.7	80	39 - 67
Malletts Bay				
Malletts Bay	485	45.0 ± 4.5	99	32 - 55
Inland Sea				
Northeast Arm	35	43.1 ± 8.1	35	24 - 52

Table 8. CPUE of targeted acoustic trawls in 2009. For example sampling number AT090730001 is sample collected on 7/30/09 and is net number 001.

			CPUE (10 minutes)							
Sample	Gear	Area	Alewife	Smelt	White Perch	Yellow Perch	Cypr Sp.	Centr Sp	Unknown Larval fish	Other
AT090730001	Mid	Malletts01	50.0	50.0	-	-	8.0	-	-	-
AT090730002	Mid	Malletts02	47.6	17.6	-	-	21.4	-	-	-
AT090730003	Tucker	Malletts04	7.0	20.0	-	-	7.0	-	-	-
AT090805001	Mid	NEA01	40.0	4.5	-	-	-	-	-	-
AT090805002	Mid	NEA01	26.7	3.3	-	-	10.7	-	-	-
AT090805003	Mid	NEA02	2.0	3.3	-	-	3.3	1.3	-	-
AT090805004	Tucker	NEA03	-	-	-	-	-	5.0	-	-
AT090805005	Mid	NEA06	20.5	0.5	-	1.0	-	-	-	-
AT090806001	Mid	M23	4.0	2.0	-	-	-	-	-	-
AT090806002	Mid	M23	19.0	15.0	-	-	-	-	-	-
AT090806003	Tucker	M22	76.0	57.0	-	-	10.0	-	-	-
AT090806004	Tucker	M21	48.9	86.7	-	-	-	-	-	-
AT090806005	Mid	M19	37.3	26.4	-	-	-	-	-	-
AT090811001	Mid	M02	4.0	10.0	-	-	-	-	-	-
AT090811002	Mid	M02	-	437.0	-	-	-	-	-	Cisco-3
AT090811003	Mid	M03	2.3	2.3	-	-	1.0	-	-	Emerald- 2.3
AT090813001	Mid	M07	31.3	3.0	0.4	-	-	-	-	Emerald- 1.7
AT090813002	Tucker	M09	-	5.3	-	-	-	-	-	-
AT090813003	Tucker	M10	-	0.5	-	-	-	-	-	-
AT090813004	Mid	M10	6.0	34.0	-	-	-	-	-	Sculpin-1
AT090814001	Mid	M11	43.5	2.5	-	-	5.0	-	-	-
AT090814002	Mid	M12	66.0	10.0	-	-	-	-	-	-
AT090814003	Mid	M12	1.0	84.0	-	-	-	-	-	-
AT090814004	Mid	M12	3.0	357.0	-	-	-	-	-	-
AT090820001	Mid	M13	344.7	2.4	-	-	-	-	-	-
AT090820002	Mid	M13	728.9	15.6	-	-	-	-	-	-
AT090820003	Mid	M13	223.0	516.0	-	-	-	-	-	-

Table 9. Floating gill net catch per 4 hour set (expanded from total minutes fished) of alewife in 2008 and 2009. 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			
Northeast Arm	FGN08072801	0	0
Knight Island	FGN08073001	0.7	7.4

2009			
Station	Sample No.	YOY	YAO
Main Lake			
Barber Point	FGN09081001*	0	42.5
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			
Northeast Arm	FGN09080301	3.1	30.9
Hyde Point	FGN09080501	20.8	13.2
Savage Island	FGN09080502	4.2	8.9

*** Two sets combined.**

Table 10. Mean total length and standard deviation in millimeters, by age class of alewife sampled by floating gill net in 2009. Number of alewife aged in parenthesis.

Station	YOY	Age 1	Age 2	Age 3	Age 4
Main Lake Stations					
Barber Point	---	149 ± 18 (62)	195 ± 21 (23)	230 ± 16 (4)	246 ± 2 (2)
Juniper Island	70 ± 9 (13)	146 ± 9 (73)	---	---	---
Valcour Island	68 ± 8 (11)	147 ± 9 (59)	188 (1)	250 (1)	---
Malletts Bay					
Malletts Bay	54 ± 3 (28)	142 ± 13 (84)	186 ± 19 (2)	---	---
Inland Sea Station					
Northeast Arm	56 ± 6 (17)	154 ± 13 (34)	192 ± 14 (9)	202 (1)	---

Table 11. Summary of total numbers of cisco collected, 1990-2009. 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

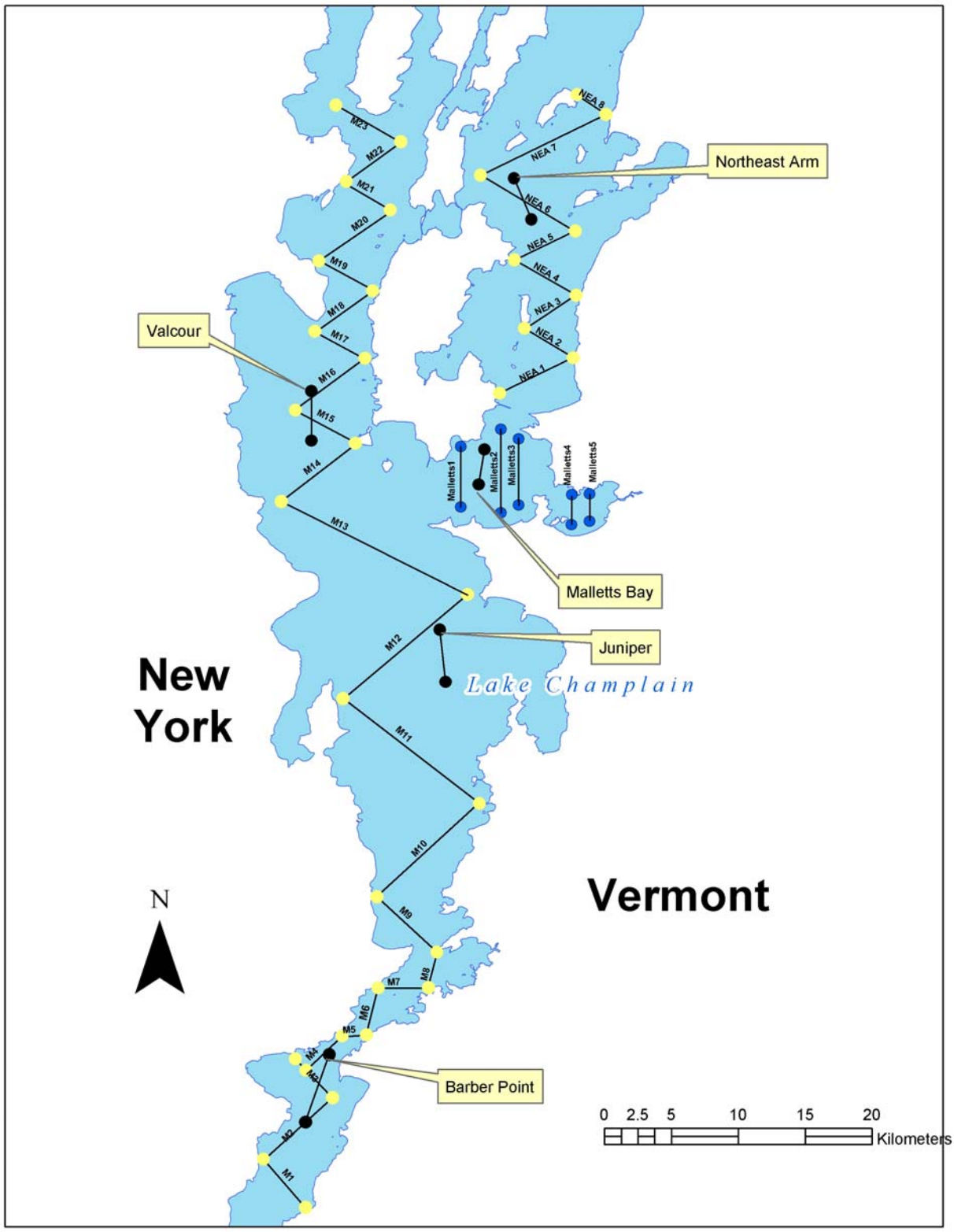
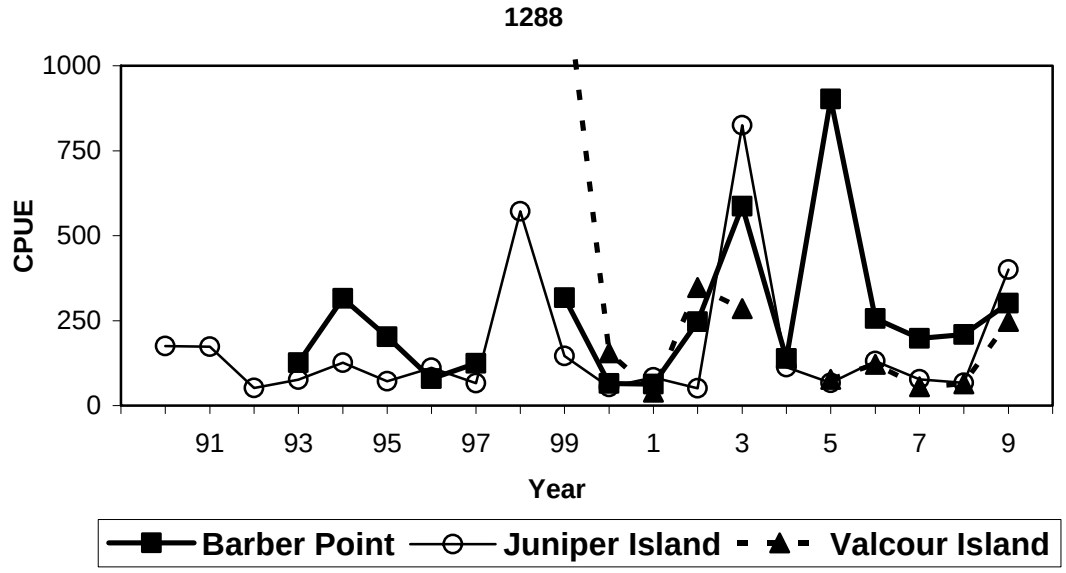


Figure 1. Rainbow smelt sampling stations (text boxes) and acoustic transects with transect name.



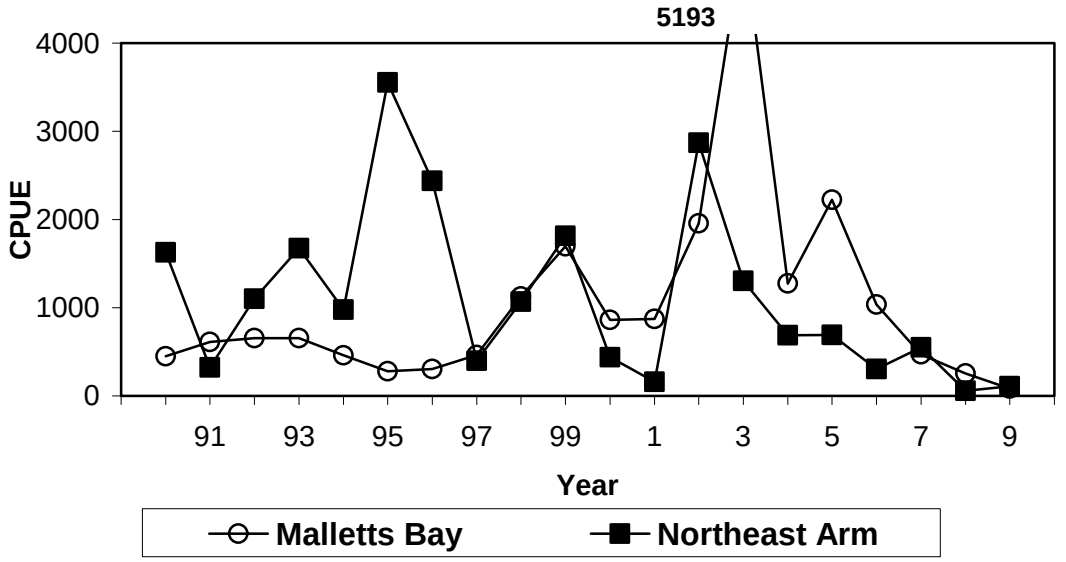


Figure 2. Mean CPUE of smelt for Lake Champlain, 1990-2009.

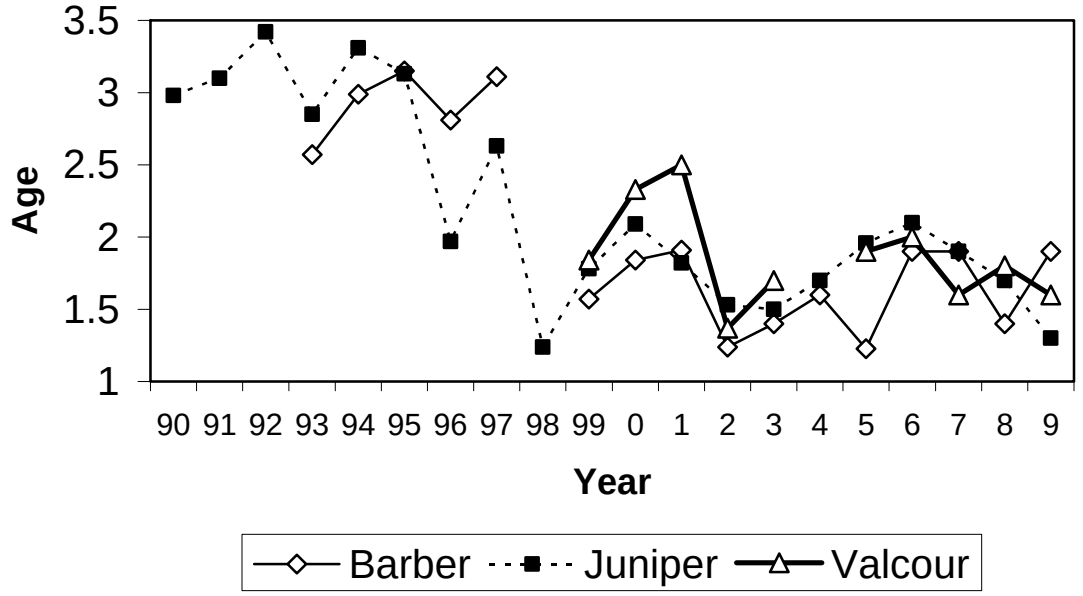


Figure 3. Mean age of rainbow smelt sampled at three main lake stations, 1990-2009.

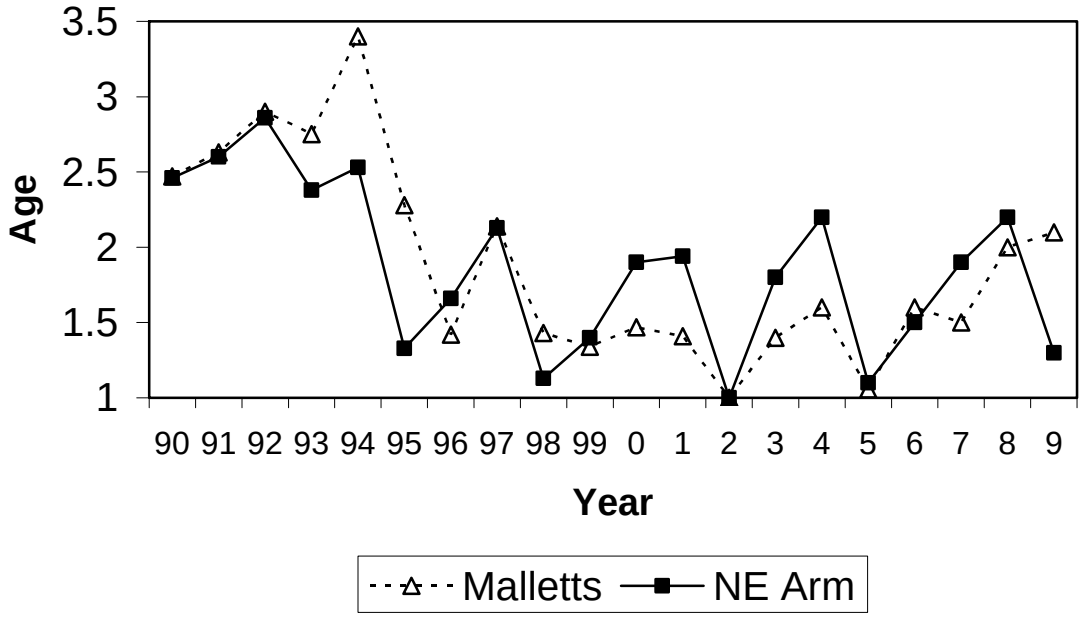


Figure 4. Mean age of rainbow smelt sampled at Malletts Bay and the Northeast Arm stations, 1990-2009.

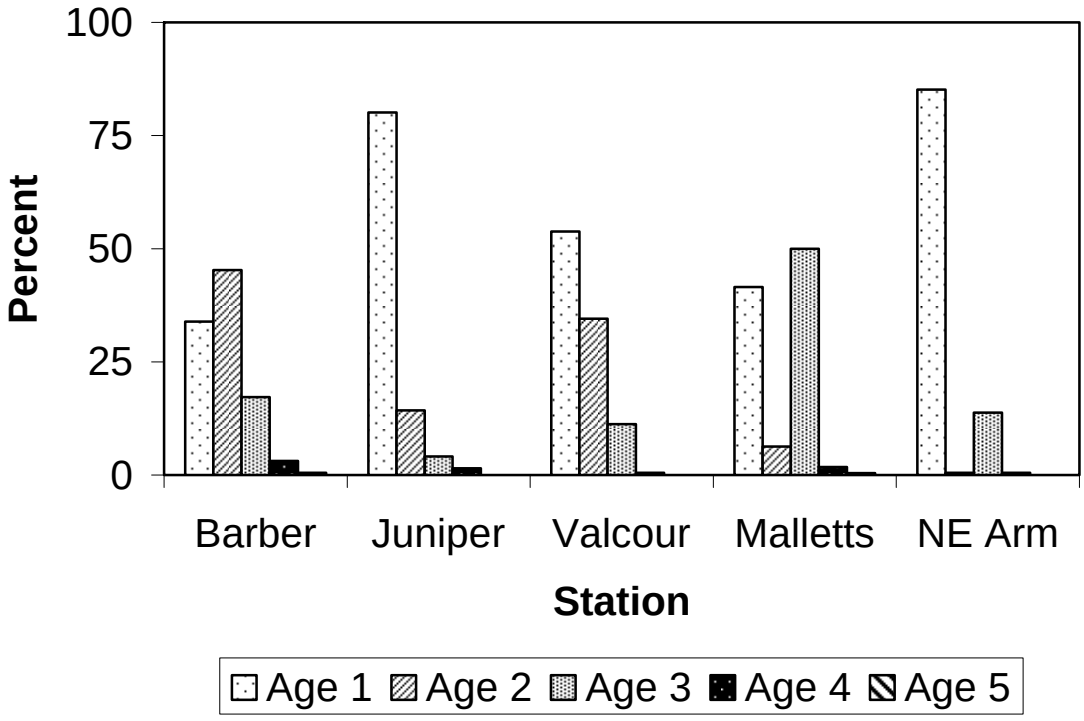


Figure 5. Percent composition by age class of rainbow smelt sampled in Lake Champlain in 2009.

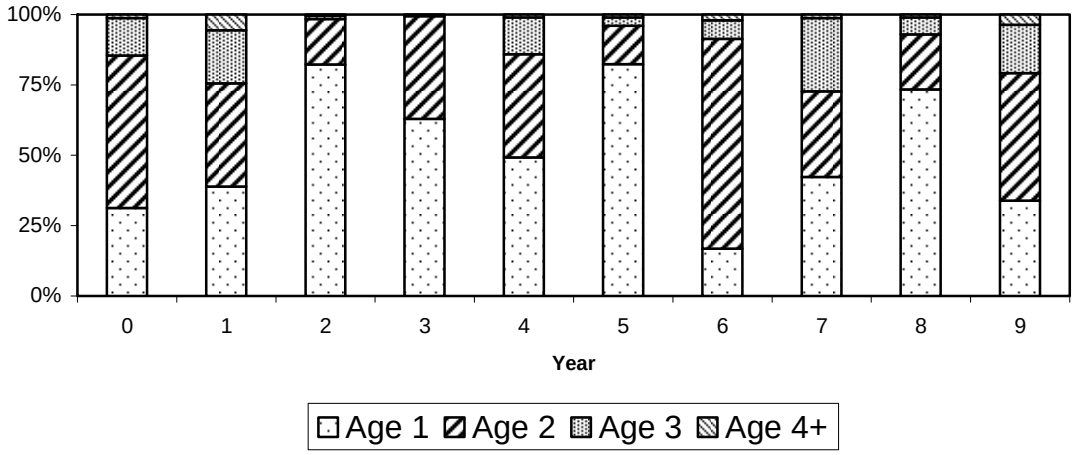


Figure 6. Percent composition by age class for rainbow smelt sampled at Barber Point, 2000 - 2009.

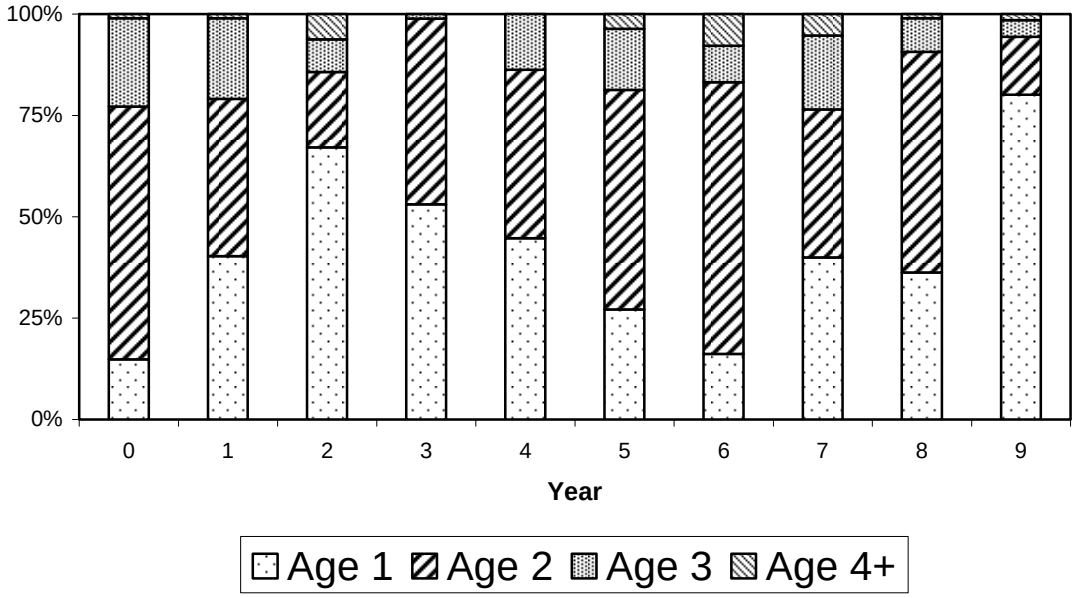


Figure 7. Percent composition by age class for rainbow smelt sampled at Juniper Island, 2000 - 2009.

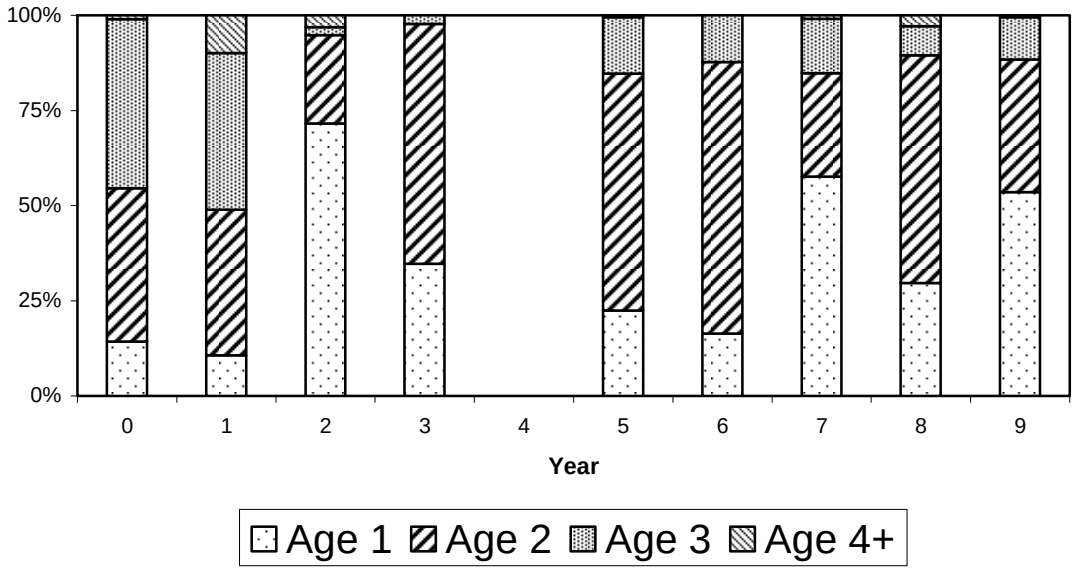


Figure 8. Percent composition by age class for rainbow smelt sampled at Valcour Island, 2000 - 2009.

Figure 9. Percent composition by age class for rainbow smelt sampled in Malletts Bay, 2000 - 2009.

Figure 10. Percent composition by age class for rainbow smelt sampled in the Northeast Arm 2000 - 2009.

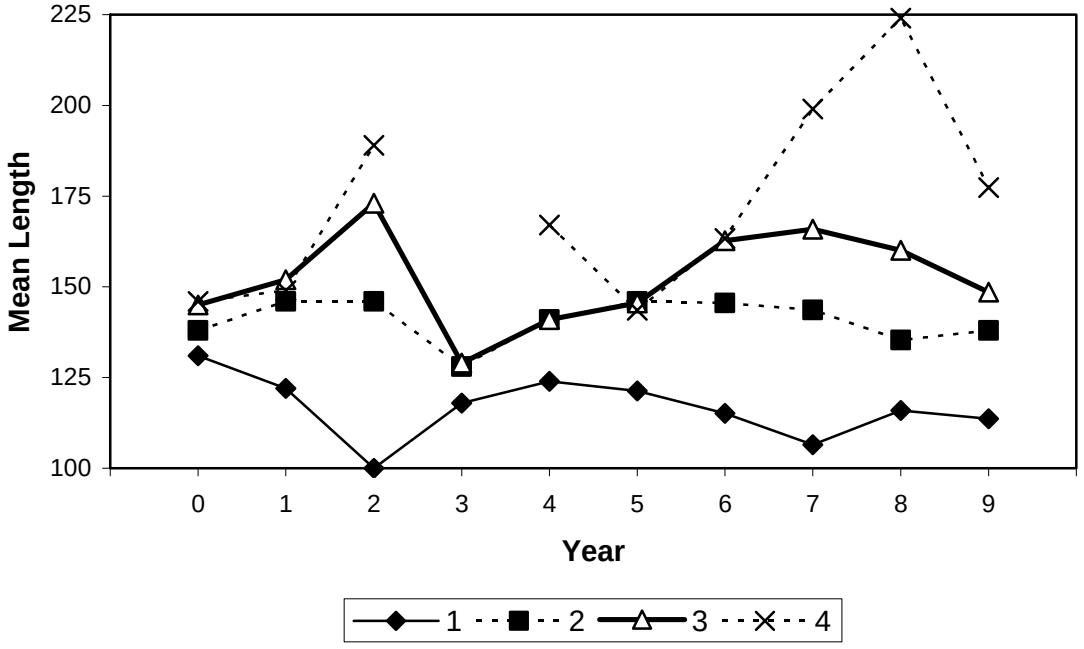


Figure 11. Mean length at age of rainbow smelt sampled at Barber Point, 2000 - 2009.

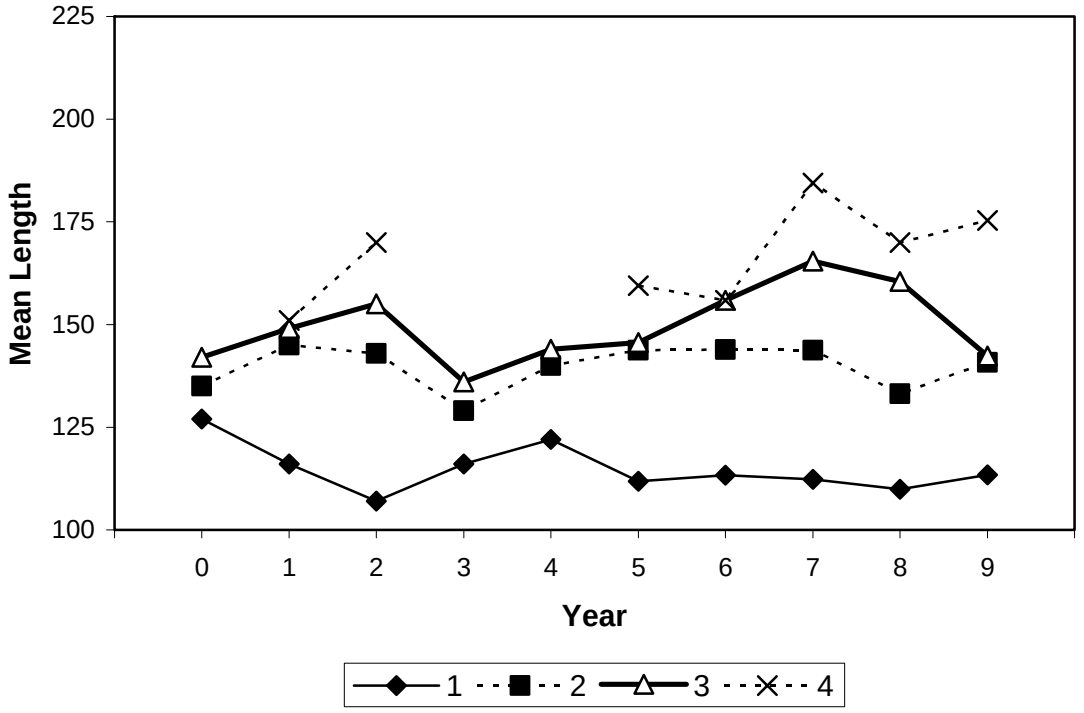


Figure 12. Mean length at age of rainbow smelt sampled at Juniper Island, 2000 - 2009.

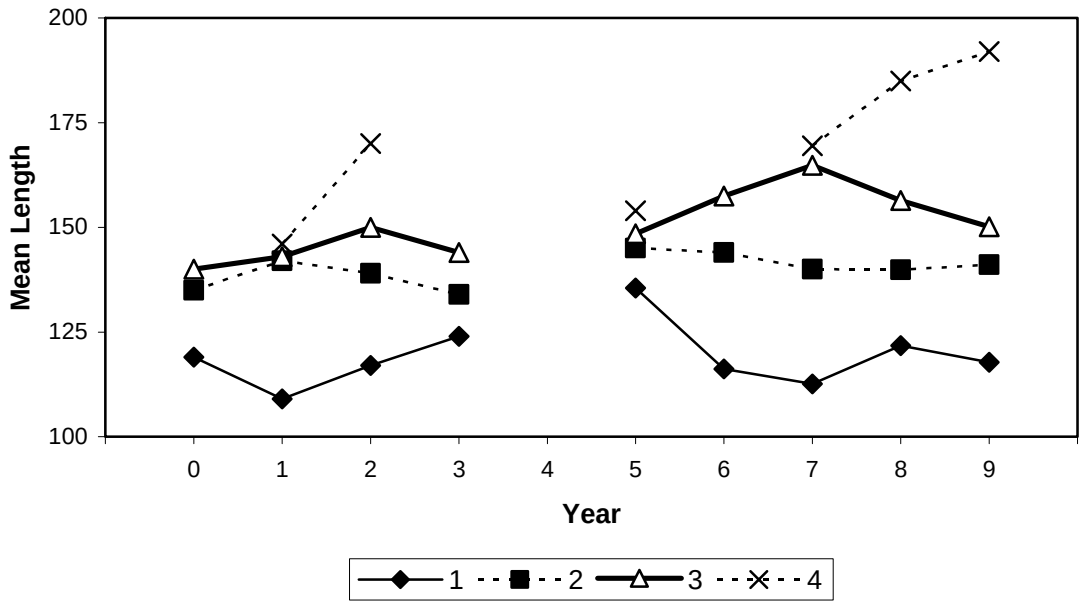


Figure 13. Mean length at age of rainbow smelt sampled at Valcour Island, 2000 - 2009.

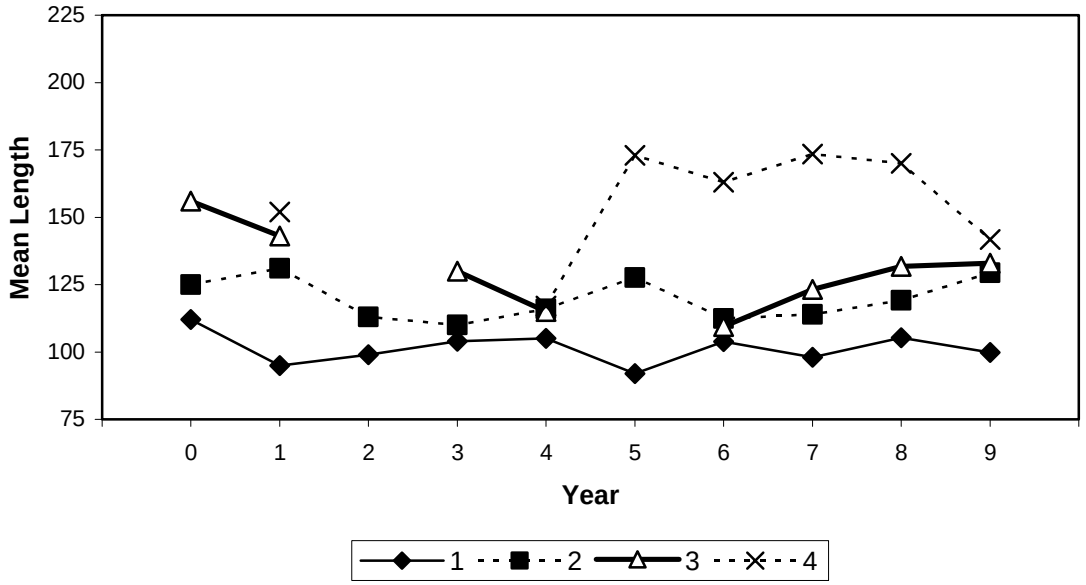


Figure 14. Mean length at age of rainbow smelt sampled in Malletts Bay, 2000 - 2009.

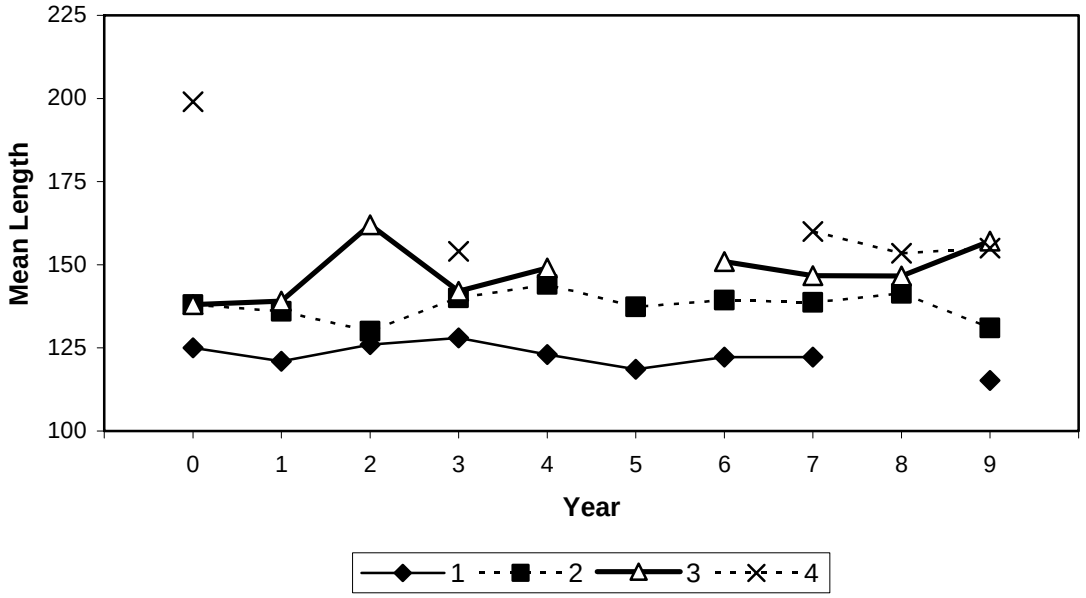


Figure 15. Mean length at age of rainbow smelt sampled in the Northeast Arm, 2000 - 2009.

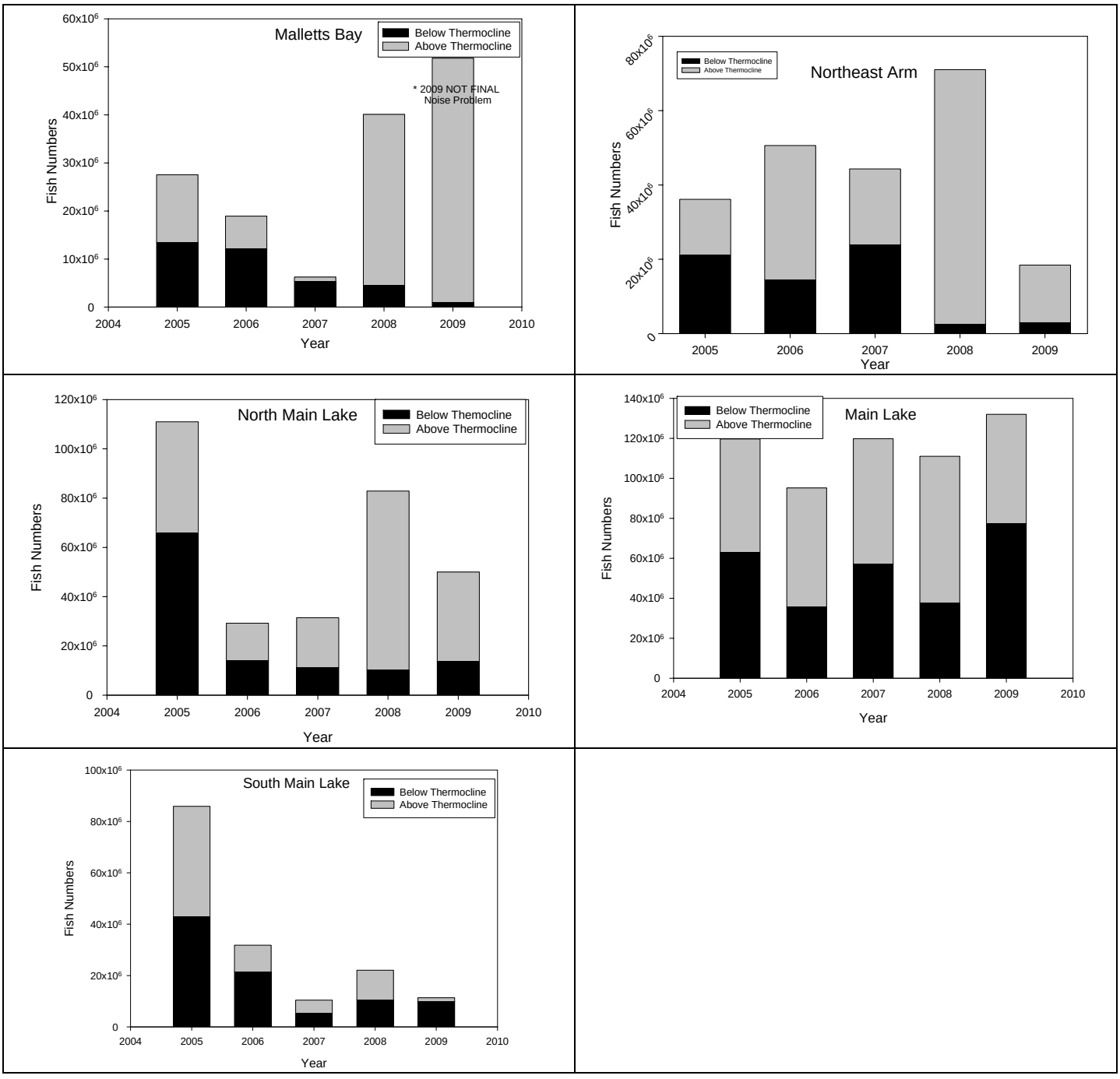


Figure 16. Preliminary estimated of numbers of yearling and older fish (>-61 dB) in different areas of Lake Champlain from Acoustic data. Rainbow smelt are the primary fish found below the thermocline and above the thermocline consists of white perch, alewives, etc.

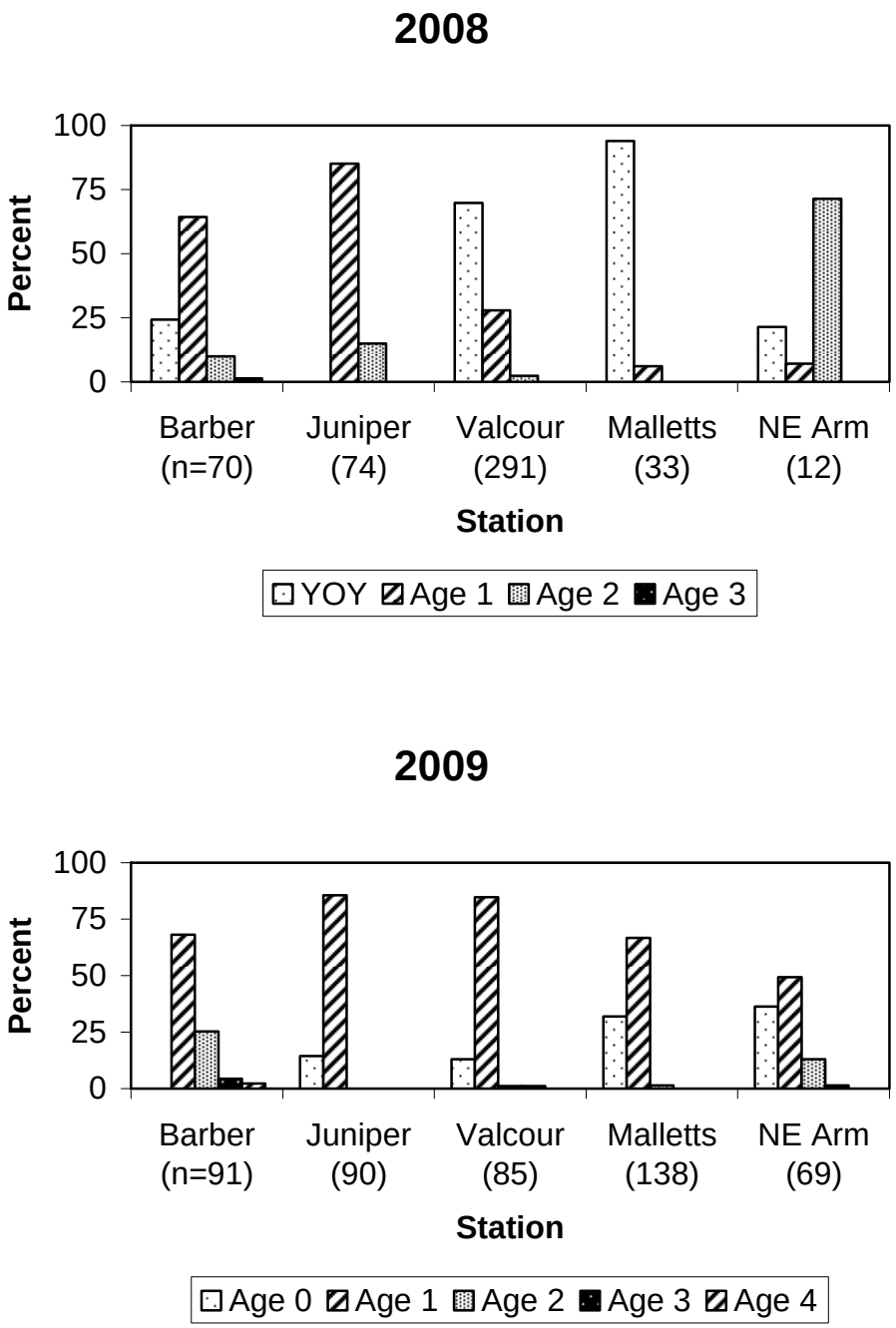


Figure 17. Age composition by station of alewife collected by floating gill net in 2008 and 2009.

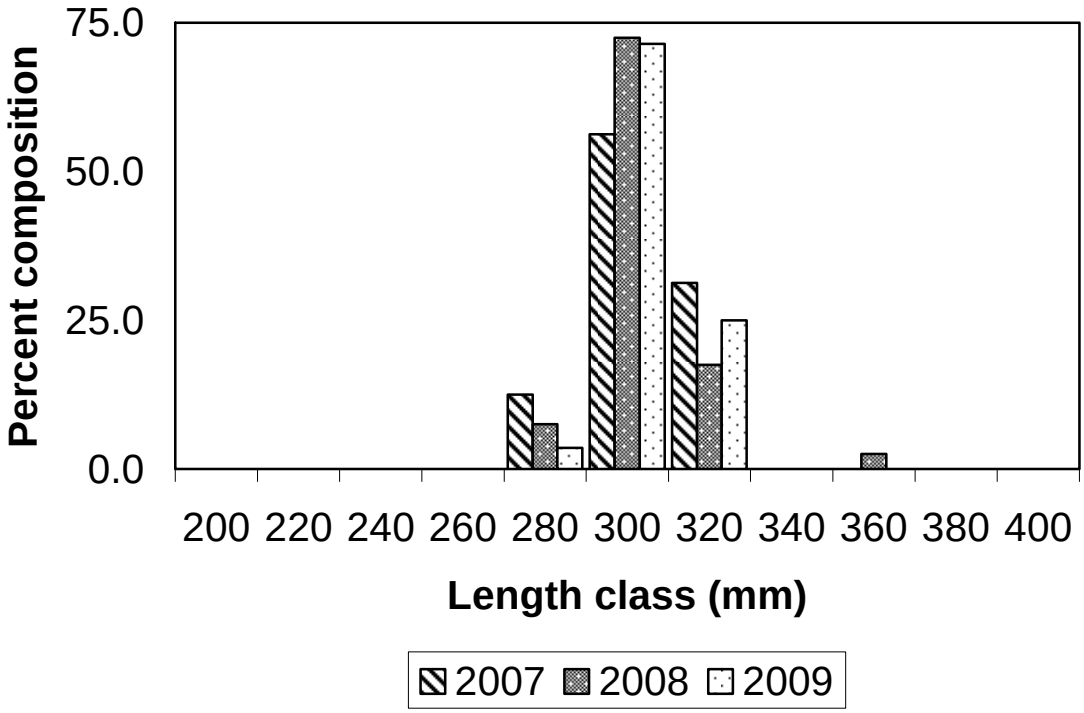


Figure 18. Length frequency composition of cisco collected, 2007 - 2009.

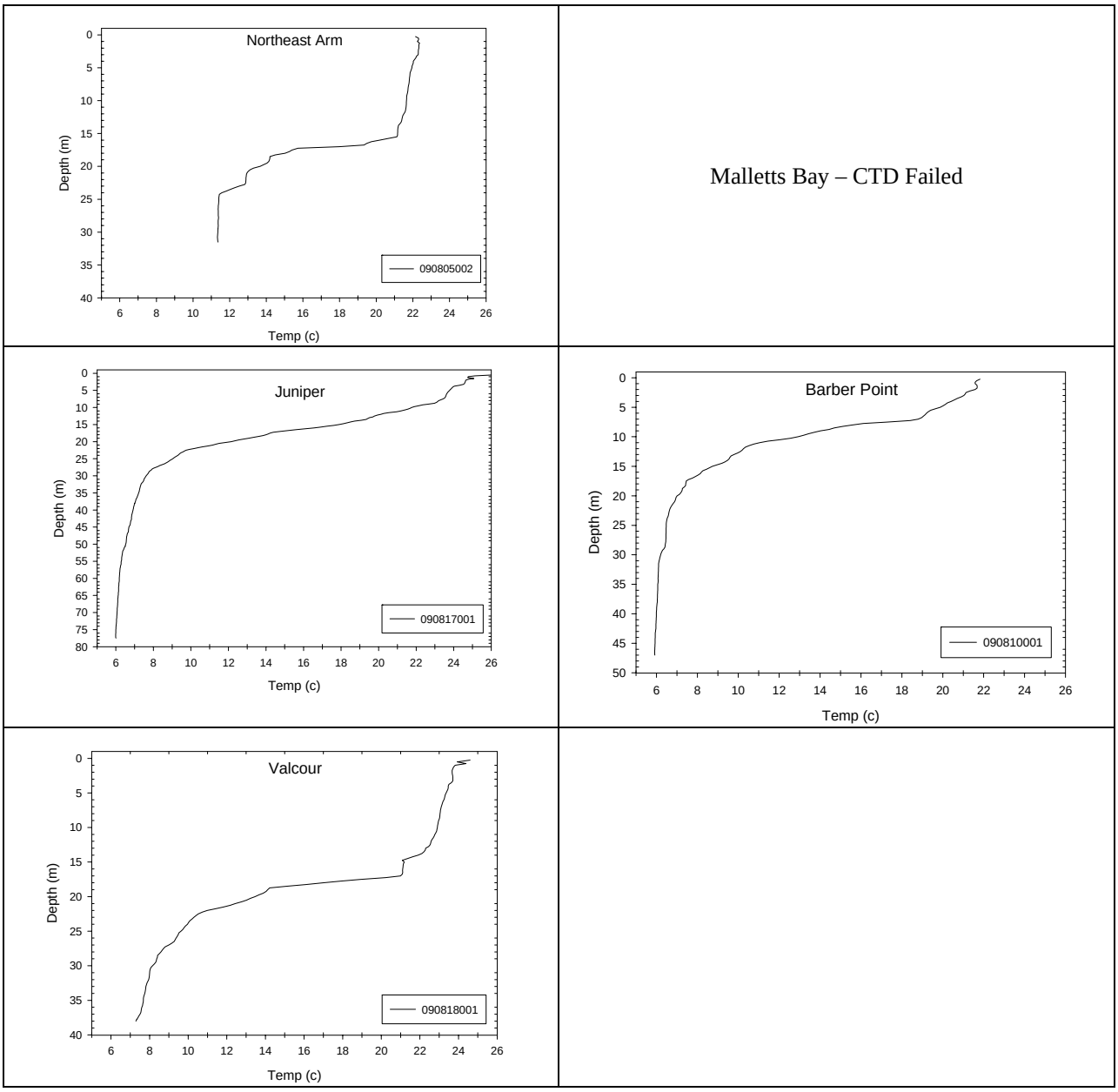


Figure 19. Temperature profiles collected in 2009 at the five standard trawling stations: Northeast Arm (8/5), Malletts Bay (CTD failed), Juniper (8/17), Barber Point (8/10), and Valcour (8/18).