Alewife (*Alosa pseudoharengus*) abundance in Onondaga Lake, 2011.

A report to Onondaga County.

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Abstract: The alewife (*Alosa pseudoharengus)* population in Onondaga Lake was surveyed June 9, 2011 using small mesh pelagic gill nets and hydroacoustics (123 kHz split beam). Catches in vertical gill nets averaged 56 fish/hr (range 37 to 112 fish/hr) with the majority of fish caught being alewife (96%). This is a lower catch rate than in 2010. Other species included seven golden shiner and ten white perch. Average length and weight of alewife was 119 mm (range 89-137 mm) and 12.9 g. There were two length groups of alewives in the net catches: 31% of the fish were in the 89-116 mm size group (age-1) and 69% were 117-137mm (age-2). No older alewife was caught. Thus most of the fish left in the lake were from the 2009 and 2010 year classes. Growth rates have returned to the slow growth rates observed in 2005-2007. Bubbles were not a problem in 2011. Alewife density was estimated with hydroacoustics to be 525 fish/ha of age 1 and older alewife, corresponding to 6.8 kg/ha. Both density and biomass were lower in the spring of 2011 than in 2010 and for the period 2005-2007, but higher than in 2008 and 2009.

Introduction

Alewife, *Alosa pseudoharengus*, increased dramatically in Onondaga County's electrofishing samples in 2003 and remained high in 2004 to 2007 (OCDWEP 2008, Wang et al. 2010). This increase was due to a strong 2002 year class. As these young fish grew through the summer of 2002, alewife biomass increased and alewife predation is the most likely cause for the concomitant decline in large *Daphnia* and large calanoid copepods (Wang et al. 2010). Additional year classes of alewife were produced in 2004 – 2007 and the abundance of alewife remained high from spring of 2005 through the spring of 2007 (over 1600 fish/ha) (Wang et al. 2010). Large *Daphnia* were mostly absent from the lake between 2003 and 2007, although the smaller *Daphnia retrocurva* was present in 2007. Alewife declined to low abundance (<100 fish/ha) in the spring of 2008, remained low in the spring of 2009 and increased again due to a strong year class in 2009 to around 1000 fish/ha in 2010. This was directly correlated with changes in zooplankton – large Daphnia returned in 2008 and 2009 and disappeared in the fall of 2009 and in 2010. Water clarity was high in 2008 and early 2009 and relatively low in 2010. Such cascading trophic interactions have been observed with increases in alewife elsewhere (Brooks and Dodson 1965, Harman et al. 2002). This report presents the results of the 2011 spring survey of alewife.

Materials and Methods

Fish were sampled using vertical gill nets set at four locations (Table 1). The 6 m deep and 21 m long nets consisted of 7 panels, each with a different mesh size (6.25, 8, 10, 12.5, 15, 18.75, 25 mm bar mesh). This set of mesh sizes will catch alewife between 50 and 240 mm (Warner et al. 2002). The nets were set from the surface to 6 m depth for approximately 2 h in water with bottom depth of about 8 m (Table 1). Fish were identified to species and depth of catch recorded in 2 m intervals. A random subsample of 30 alewives or all individuals (other species) were measured (total length in mm, weight in g) from each net site. The proportion of age-1 fish were estimated from aged fish and size distributions. Alewives were aged using whole otoliths extracted from a subsample of the fish. Dry weight was obtained after drying for 5-7 days in 70 C.

Onondaga Lake was surveyed using a 123 kHz split beam echo sounder (Biosonics DtX, full half-power beam angle 7.2^o, 0.2 ms pulse length, pulse rate 2 ping/sec) along seven roughly parallel SW to NE transects (total transect length 10.8 km). The survey was conducted on the night of June 9, 2011 between 20:44 and 23:40. Spatial location of the data was measured with a GPS that recorded latitude and longitude directly to the acoustic data stream. One transducer was towed at 0.5 m depth looking downwards.

Acoustic data were recorded directly to a laptop computer in the field and analyzed with the EchoView software (version 4.9, Myriax Inc. Hobart, Tasmania, Australia). The unit was calibrated in August 2011 with a standard -40.6 dB 33.2 mm tungsten sphere. Separate gains were applied to the echo integration (measured as area backscattering coefficient, ABC) and target strength (TS) data based on this calibration (Sa-Offset of 1.19 dB and TS-Offset of 1.66 dB, both for 0.2 ms pulse length). All data were visually inspected for consistent bottom detection, interference from surface bubbles and aquatic vegetation and corrected when needed. Surface noise varied and was a problem for transect 5 and 6. The ambient noise level measured was -122.9 dB (Sv domain). This is low enough to register fish with a TS of -60 dB without bias at all depths present in Onondaga Lake (maximum depth 19.5 m). Analysis was done for each transect from 2 m depth to the bottom. The near-field of this transducer is approximately 1.5 m and the transducer was mounted on a rigid pole 0.5 m below the surface. Therefore, the acoustic analysis is restricted to depth below 2 m from the surface.

Target density in June 2011 was calculated from the average measured in situ TS and ABC following the standard operating procedure for Great Lakes acoustics (GL-SOP, Parker-Stetter et al. 2009). The low threshold for fish TS was chosen to be -56 dB based on the in situ TS distributions. These showed a peak in smaller targets between -66 and -56 dB (probably larval fish). Appropriate depth varying thresholds were applied to the Sv data (-60dB TS threshold in EchoView). All calculations are made in the linear domain and back transformed to dB unit when appropriate.

To account for the proportion of targets <-56dB that were alewife, we converted the alewife catch in the gill nets to an expected TS distribution based on the net cage observations by Brooking and Rudstam (2009). The expected TS distribution from each 5 mm size group was calculated, weighted by the number of fish in each 5 mm group caught in the gill nets, summed, and normalized to obtain an expected TS distribution of alewife from the alewife population present in 2011. The proportion of expected targets <-56dB was then calculated and the alewife density based on fish >-56dB increased to account for these smaller targets. This approach was used in several other lakes by Brooking and Rudstam (2009) and Rudstam et al. (2011).

Alewives were caught between the surface and 2 m depth in the vertical gill nets; depths that were not surveyed with acoustics. To account for these fish, we assumed that catchability per unit area of netting was the same in water 0-2 m as in 2-6 m and calculated the density in 0-2 m based on the ratio of the catch and acoustic density in 2 to 6 m depth (see Rudstam et al. 2011).

Results

Net sampling. A total of 475 fish were caught in the gill nets (Table 1, 37 to 112 fish/hr, average 58 fish/hr). Other fish species caught in 2011 include 7 golden shiners and 10 white perch. Alewife represented 96 % of the catch (91 – 99%). Catches in the three depth layers averaged 24% (0-2m), 28% (2-4m) and 48 % (4-6m) (Table 1). The average percent catch in each depth layer is based on the average observed at the four net sites. These catches suggest the fish were caught deeper in the water column than previous years, possibly a response to the windy conditions present during the second part of the night.

The alewife size distribution had two distinct modes: fish larger than 115 mm and fish smaller than 115 mm (Figure 1). The smaller length mode consisted of age-1 fish, and represented 28% of the catch. Average length of all measured alewife was 119 mm (N=120, range 89-137 mm). The size of age-1 and age-2 fish was the smallest on record for Onondaga Lake (Table 3, Figure 1). Average length of age-1 fish was 105 mm (Table 3). Alewives typically reach lengths of 60 to 90 mm by September of their first year of life in New York inland lakes (Rudstam and Brooking 2005), but can get larger, up to 140 mm, in productive lakes with large zooplankton (Oneida Lake and Canadarago Lake, Rudstam et al. 2011). The length distribution suggests that growth rates of age-0 fish returned to the rates typical for abundant alewife populations in productive lakes

(Rudstam et al. 2011). Dry weight to wet weight ratio (an indicator of condition) declined in 2011 (23-28%) compared to 2010 (26-31%) and 2009 (30-33%).

Acoustic data. Target density for targets larger than -56 dB ranged from 159 to 1370 targets/ha. We used -56 dB as the lower threshold because of a large number of smaller targets present, likely larval fish (Rudstam et al. 2002). About 5% of the expected targets from the alewife caught in the gill nets would be between -60 and -56 dB, and the total density was therefore increased by 5% (Brooking and Rudstam 2009). Surface correction represented 1.32 times the density in 2-6 m depth; this was applied to each transect. Resulting fish density ranged from 203 to 1603 fish/ha in the 7 transects for an average fish density weighted by transect length of 526 (SE 181 calculated from the transect densities, Table 4). Assuming all of these fish were alewife with an average weight of 12.9 g (Table 1), the alewife biomass was 6.8 kg/ha (Table 4). Alewife biomass in 2011 was lower than in 2005-2007 and 2010 and similar to 2009 (Table 5).

Discussion

Densities obtained from the 2011 survey were higher than in 2008 and 2009, but lower than in 2005–2007 and 2010 (Table 5, Figure 3). Net catches also decreased in 2011 compared to 2010. Most of the alewives caught were from the 2009 year class with the rest from the 2010 year class. No older alewife was caught.

The return to a *Bosmina* and cyclopoid dominated system in late summer of 2009 is consistent with the observed increase in age-1 alewife in the spring of 2010 and continued abundance of the 2009 year class in the spring of 2011. It remains to be seen what the zooplankton community structure will be during 2011.

Alewife abundance through this data set is closely related to the abundance of large and small zooplankton, with Daphnia and calanoid copepods being abundant when alewife density is lower than 150 fish/ha, and Bosmina and cyclopoid copepods abundant with alewife density is higher than 150 fish/ha. Although alewife has returned to Onondaga Lake after the decline from 2007 to 2008, densities appear to be lower in 2011 than during the high years 2005-2007. Recruitment including over winter survival of the 2010 year class was modest. Even so, we expect that planktivory of alewife in 2010 and 2011 to be sufficient to maintain low abundance of large zooplankton and therefore relatively low water clarity (see Wang et al. 2010).

Acknowledgment

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Table 1. Summary of fish catches in the four vertical gill nets with variable mesh size set in Onondaga Lake on June 9, 2011. Nets were set after dark and retrieved 2 hours later. Proportion by depth layer is based on alewife only. 96% of the fish caught were alewife.

	Net 1	Net 2	Net 3	Net 4	Averages
Latitude N	N 43° 04.952'	N 43° 05.384'	N 43° 06.554'	N 43° 05.996'	
Longitude W	W 76° 12.647'	W 76° 11.775'	W 76° 13.704'	W 76° 14.283'	
Soak time (h)	2	2	2.1	2.1	2.05
# fish caught	81	224	77	93	118.8
Water depth (m)	8.0	8.1	8.2	8.0	8.1
Catch / hour	40.5	112.0	36.7	44.3	57.9
Proportion 0-2 m	0.49	0.17	0.22	0.09	0.24
2-4 m	0.29	0.30	0.24	0.28	0.28
4-6 m	0.21	0.54	0.54	0.62	0.48
Alewife					
Catch / hour	37.5	111.0	36.2	40.5	56.3
Mean Length (mm)	118	123	116	119	119
Range of lengths (mm)	98-135	101-137	89-134	97-134	89-137
Mean Weight (g)	12.7	14.0	11.6	13.6	12.9
Golden shiner					
Catch / hour	2.50	0.50	0.48	0.48	0.99
Mean Length (mm)	155	164	178	167	158
White perch					
Catch / hour	0.50	0.50	0.00	3.33	1.08
Mean Length (mm)	173	135	0.00	189	181

Table 2.–Average fish catches in the vertical gill nets with variable mesh size set in Onondaga Lake in 2004-11. Four nets were set in each survey. Details on the sets for 2011 are in Table 1.

Date	**5/17 2005**	**6/4 2006**	**6/6 2007**	**6/4 2008**	**6/4 2009**	**5/20 2010**	**6/9 2011**
Soak time (h)	2.4	5.6[a]	2.3	2.0	2.1	2.0	2.1
Proportion (0-2m)	0.38	0.43	0.42	0.37	0.23	0.20	0.24
(2-4m)	0.41	0.24	0.31	0.46	0.44	0.38	0.28
(4-6m)	0.21	0.32	0.27	0.17	0.33	0.42	0.48
Alewife (#/h)							
Catch/hour	75.4	56[a]	95	66	42	97	58
Mean length (mm)	149	132	153	145	170	135	119
Min length (mm)	108	110	104	115	123	95	89
Max length (mm)	164	169	195	176	204	219	137
Mean weight (g)	33.7	24.9	28.4	28.0	49.2	26.5	12.9
Other sp. (#/h)							
Gizzard shad	0	6.7	1.0	0	0	0	0
White perch	0.1	0.1	0.4	1.4	0.3	0	1.2
Yellow perch	0	0	0.5	0.1	0	0	0
Walleye	0	0	0	0.2	0	0	0
Emerald shiner	0	1.4	0	0.1	0	0	0
Golden shiner	0	0	0	0	0.4	1.5	0.9
Smallmouth bass	0	0	0.2	0.2	0	0	0
Pumpkinseed	0	0	0	0	0	0	0
Brown trout	0.1	0.02	0	0.1	0	0	0
Channel catfish	0	0	0	0	0	0	0
Longnose gar	0	0	0	0	0.5	0	0
Rock bass	0	0	0	0	0	0.12	0
Rainbow smelt	0	0	0	0	0.2	0	0

a) One net left overnight for 12 hours. Excluding that net yields a catch per hour of 64 fish/hr

Table 3 Age distribution and length-at-age of alewife in Onondaga Lake from 2005 to 2010. All ages were assigned using otoliths.

Age	1	2	3	4	5	Total # aged
Proportions (%)						
2005[a]	0	10	84	6	0	50
2006	46	31	23	0	0	26
2007	25	20	33	18	5	40
2008	46	14	24	14	2	50
2009	40	26	10	19	5	25
2010	60	24	10	6	0	50
2011	26	74	0	0	0	50
Length-at-age (mm)						
2005[a]		133	138	152		
2006	122	151	161			
2007	123	155	157	159	162	
2008	127	148	156	162	162	
2009	145[b]	179	181	196	194	
2010	111	174	192	200		
2011	103	123				

a) Age structure and length at age from October 2004 translated to ages for spring of 2005. Lengths assumes no over winter growth or size selective over winter mortality.
b) Estimated from the size structure

Table 4. Results from acoustics estimate of alewife in Onondaga Lake May 20, 2010, using a 123 kHz split beam unit. Fish Density includes the whole water column accounting for alewife in the surface layer (see methods). ABC is the area back scattering coefficient (from 2 m depth). Target Density is calculated from ABC/σ_{bs}, where σ_{bs} is the backscattering cross section of all targets > -54dB. Target Density does not include 0-2m. Fish density is corrected for surface (density in 2-6m multiplied by 0.32), and the lower tail of the TS distribution from alewife (predicted number alewife TS below -56dB equals to 1.05). Mean values are weighted by transect length or number of targets. Biomass is the mean fish density multiplied with the average weight of alewives caught in gill nets.

Transect #	Transect Length (m)	Average TS (dB)	ABC (m^2/ha)	Target Density (#/ha)	Fish Density (fish/ha)
1	1975	-47.8	0.003	159	203
2	1880	-42.8	0.020	378	450
3	1455	-46.0	0.005	217	239
4	1513	-45.8	0.005	204	347
5	1589	-44.3	0.020	534	609
6	1261	-46.4	0.011	473	612
7	1137	-45.0	0.044	1370	1603
Average	1544	-44.8	0.014	430	526 (SE 181)
Biomass (kg/ha)					6.8

Table 5. Results from May-June acoustic-gillnet surveys of alewife in Onondaga Lake 2005 to 2011. Bubbles were not present in the 2005-2007 and 2011 surveys, but occurred from 2008-2010. Lower limit used in calculations are given (TS minimum). Proportion of age-1 estimated from size structure and length-at-age data and therefore vary some from Table 3, where proportions are based on the number of fish aged.

	# net sites	Soak time (h)	Average proportion alewife % (range)	Alewife catch per net-hour Total (range)	Age-1 (%)	0-2 m % (range)	TS minimum (dB)	Abundance 2m-bottom (fish/ha)	Abundance surface-bottom (fish/ha)	Biomass (kg/ha)
5/17/2005	4	2.4	99	75 (35-174)	4	38 (29-49)	-60	1890	2242	75.5
6/4/2006	4	5.6	88	56 (11-92)	62	43 (35-54)	-60	1656	2328	50.4
6/6/2007	4	2.3	98	99 (44-148)	17	42 (26-57)	-60	1084	1632	46.2
6/4/2008	4	2.0	97	66 (22-87)	32	37 (29-42)	-47	60	94	2.7
6/4/2009	4	2.1	97	43 (24-66)	38	22 (4-43)	-45	95	122	6.0
5/20/2010	4	2.0	98	97 (73-147)	69	20 (13-26)	-47	708	912	24.2
6/9/2011	4	2.05	96	56 (36-111)	29	24 (9-49)	-56	498	525	6.8

Figure 1. Length distribution of alewife in vertical gill nets in May-June sampling of 2005 to 2010.

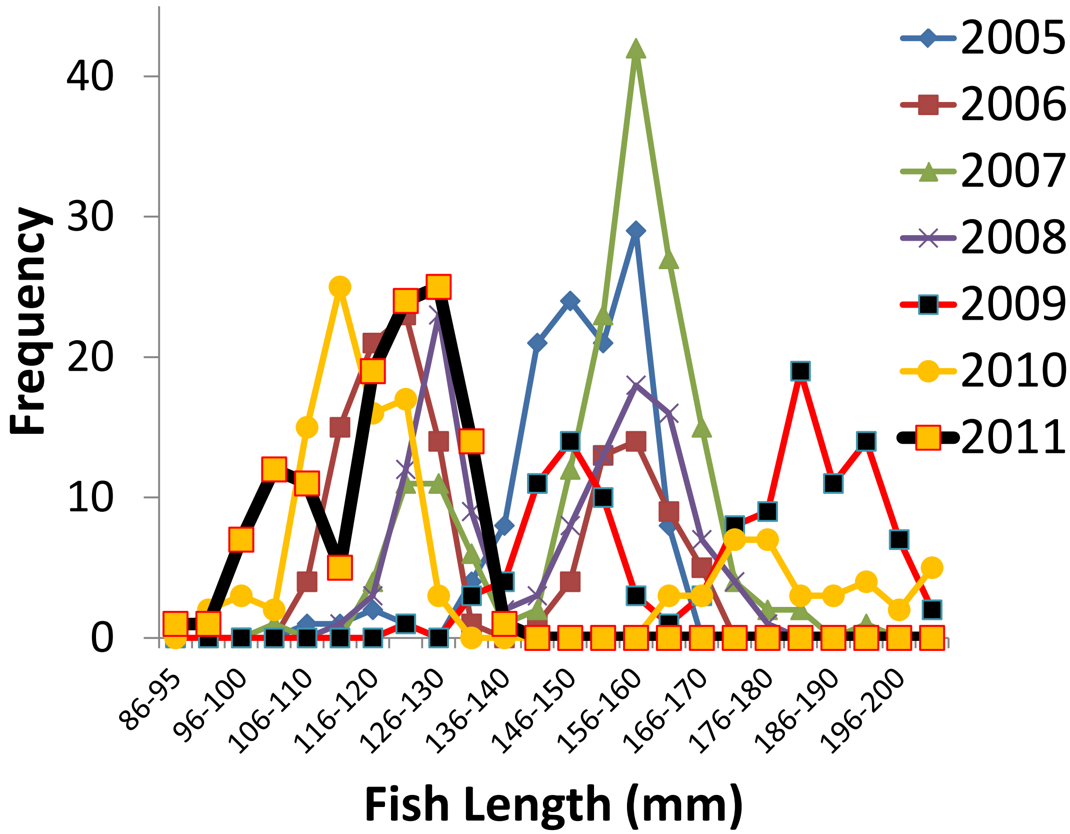

Figure 2. Probability density functions for the observed and expected TS distributions in Onondaga Lake. "Bubbles" represents the target strength of targets identified as bubbles in stationary acoustics surveys in June 2010 (based on 1258 single targets). "Overall" is the observed TS distribution from the survey (based on 3881 single targets). "Fish" is the expected TS distribution from the alewife population caught in vertical gill nets using the probability density function in Brooking and Rudstam (2009).

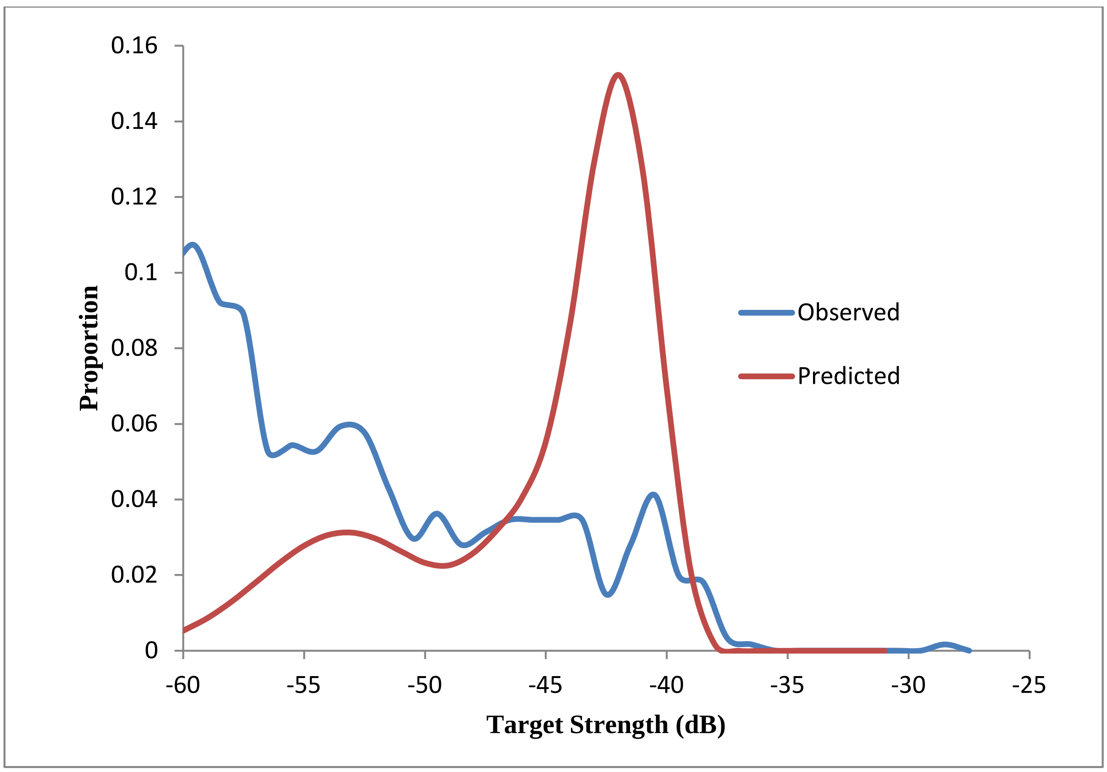

Figure 3. Alewife densities obtained with hydroacoustics (fish/ha) and the gill net catch per hour (Net Catch, Catch/hr) from May-June surveys in 2005 to 2011. Error bars for net catches represent the range observed in the four nets.

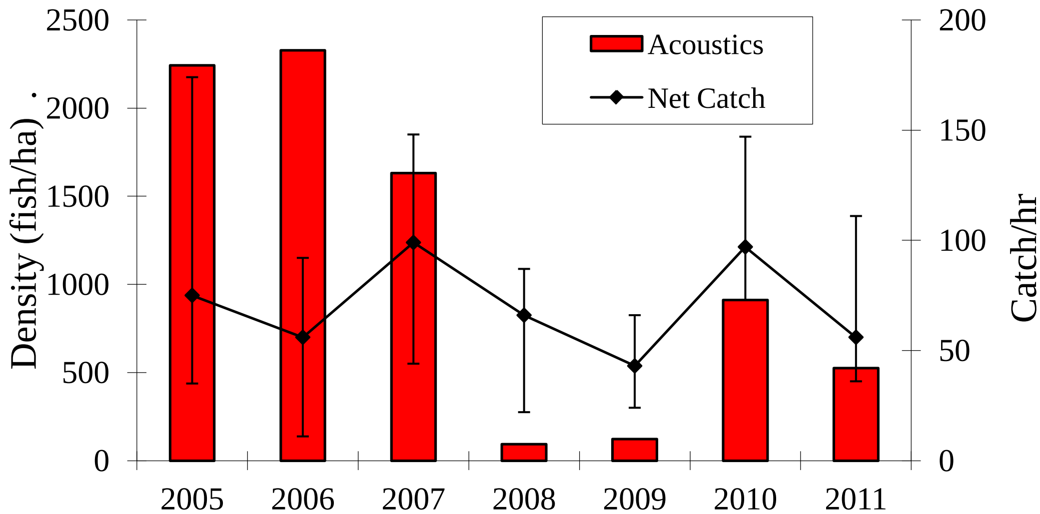

Figure 4. Distribution of alewife from 2 m to the bottom along the transects in 2011. Travel time between transects are included. Maximum bubble size represents 5650 fish/ha. Densities are higher in the northern part of the lake and along the western shore. Net catches are in red, with maximum bubble size 111 fish caught per hour.