Tiber Reservoir Hydroacoustic Surveys
2001-2002

Introduction/Methods

Hydroacoustic surveys in 2001 were conducted between 2029 hours on September 11th and 0208 hours on September 12th. Tiber Reservoir forebay elevation during the 2001 survey was 2980.13 mean sea level. The 2002 survey was conducted between 2034 hours on September 9th and 0322 hours on September 10th. Tiber Reservoir forebay elevation during the 2001 survey was 2988.8 msl. Forebay elevations were used to determine reservoir volume from approximately one meter below the surface to one meter above the reservoir bottom by five-meter intervals. Fish were weighted according to where they fell in the acoustic beam followed by volumetric expansion of fish densities across all transects to the entire reservoir. Fish densities were collected along 18 equally spaced transects suggested by Gunderson (1993) and the same transects used since 1996 (Hill and Teuscher, 1997).

Minimum target thresholds have consistently been set at –55dB (1.2 inches). The HTI system can't detect fish smaller than –55dB, unless they are directly on axis. Fish larger than –50dB (2.2 inches) can be detected throughout the esonified beam. During post-processing of raw acoustic data, targets can be filtered such that estimates are based on size range of verified (vertical gillnets) targets. Cisco population estimates in 2001 and 2002 were based on acoustic targets larger than –45 dB (four inches) and smaller than –34.5dB (14 inches). The relationship between fish size in the dorsal/ventral aspect to their length was developed by Love (1971)

In an attempt to more accurately estimate the Tiber cisco population, analysis has removed all targets less than 4 inches from previous years estimates. Furthermore, estimates of pelagic (>21 meters) abundance have been corrected for proportion of cisco in gillnets and fish greater than 4 inches. This report includes population parameters from previous years acoustic estimates that are markedly different from previous years reports. The reason for this is that estimates since 1996 (pre-cisco introduction) to 2000 included targets of all sizes. In many cases, targets less than 4 inches comprised the majority. Based on gillnet, beach seine and trawling data, these small targets are not cisco. Targets from 1.2 inches to 4 inches are difficult to identify. However, it is common in acoustic surveys regardless of location, to encounter large numbers of small targets and in many cases they are treated simply as "forage".

Cisco Estimates stated in this report deal only with targets greater than –45dB (four inches).

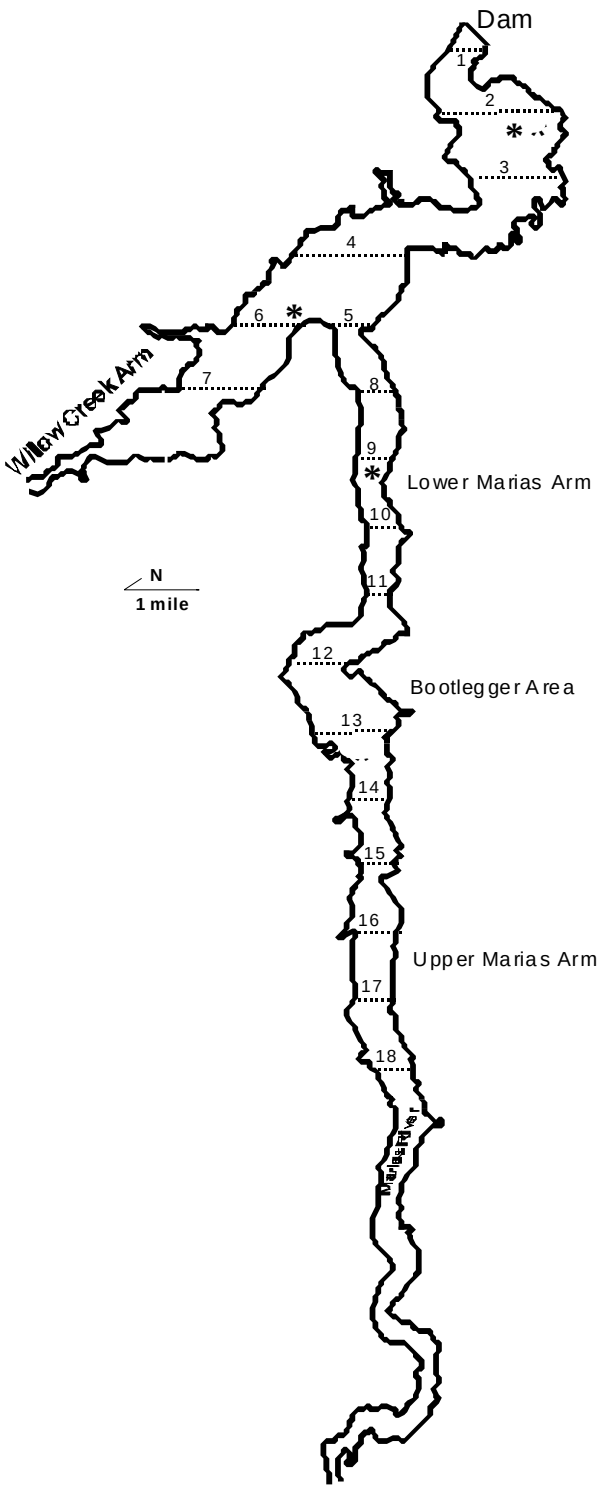

Figure 1. Hydroacoustic transects and vertical gillnet locations on Tiber Reservoir. Vertical gillnet locations are indicated with *.

Results

Cisco Abundance

The 2001 Tiber cisco estimate was 1.48 million. This estimate includes only acoustic targets between 4 and 14 inches and is corrected for proportion of cisco in vertical gillnets (3.4 million fish * 44% greater than 4 inches * 98.7% cisco in verticals). The 2002 Tiber cisco estimate was 2.67 million (9.25 million total fish * 29% between 4 and 14 inches * 99.5% cisco in verticals). This compares to previous years estimates (calculated in the same fashion) of 1.60 million (2000), 743,000 (1999), 2.31 million (1998) and 166,000 in 1997 (Table1).

In 2001, abundance of age zero cisco (4-7 inches) was 968,000 while the adult cisco (7-14 inches) estimate was 489,000. This estimate includes age 2, 3 and 4 cisco as these ages were clustered around 10-13 inches in length. Estimates of adult cisco declined by half from 2000 levels (1.14 million). The highest estimate of adult cisco was measured in 1998 at 1.61 million. This coincides with the excellent survival of the initial 1997 cisco introduction.

The 2002 age zero cisco (4-7 inches) estimate was 1.98 million; the highest level measured since acoustic surveys were initiated in 1996. Abundance of yearling and adult cisco (7"-14") was estimated at 690,000. The 2002 pelagic (water depths greater than 21 meters) estimate for cisco was 1.1 million (3.8 million pelagic targets * 29% greater than 4 inches* 99.5% cisco in verticals) (Table 1).

Cisco Distribution

In 2001, acoustic targets were vertically distributed with 49% of all targets in the top 69 feet (21 meters) while 49% were counted between 21 and 31 meters. (Appendix I). Densities in this depth range have varied through the years with only 22% counted during the 1999 and 2000 estimates, 26% (1998), 24% (1997) and only 5.2% in pre-cisco 1996.

In 2002, fish densities were highest in the hypolimnion (water deeper than 21 meters (Figure 3). Targets counted from 21 meters to 41 meters of water represented 61% of the total with the majority of these fish occupying the depth zone from 21 meters to 36 meters. Proportion of targets in the mesolimnion (16m-21m) represented 25% of targets. Near surface targets (1m-6m) accounted for 13% of targets.

Cisco densities in 2001 were highest in the Upper Marias Arm and Lower Marias Arm (Figure 2). Transects T6 and T7 in the Willow creek arm recorded 46 % and 47% YOY cisco respectively. Transects 15 and 16, in the Upper Marias Arm also recorded 43% and 44% YOY cisco. Adult cisco (>10 inches) densities were highest in the Upper Marias area with 55% and 45% recorded in transects T18 and T17 respectively (Appendix I). Density estimates in these Upper Marias transects should include the caveat that volume of water esonified is relatively small when compared to near-dam transects.

Cisco densities in 2002 were highest in the Lower Marias and mouth of Willow Creek. Transects 5, 8, 11 and 18 recorded the highest densities while the near dam transects 1, 2 and 3 recorded the lowest (Figure 2). Young of the year cisco densities were highest in the shallow transects; T6 (Mouth of Willow Creek) followed by T16 and T18 (Upper

Marias Arm). Deep water transects, those in the Dam Area had the lowest proportion of young of the year cisco and conversely the highest proportion of adult cisco (Figure 8).

Length frequency of targets between 4 and 14 inches reveals a mean of 6.3 inches in 2001 and 5.9 inches in 2002 (Figures 4 and 5). Interestingly, 44% of these fish were between 4" and 5" in length, which would encompass the majority of Age 0 cisco, measured in vertical net (Figure 7). This is a notable shift from 2000 and 2001 acoustic sampling when the length/age structure appeared to be more diverse. Average length of targets between 4 and 14 inches in 2000 was 8.5 inches and 6.4 inches in 2001.

Discussion

Acoustic surveys in 2002 corroborate vertical netting, which indicates an increase in the cisco population (Figure 6). In 2002, vertical gillnets recorded the highest cisco catch since introduction collecting 1,111 cisco. Acoustic sampling in 2002 recorded a cisco population of 2.67 million with an age 0 estimate of 1.98 million. This is the highest population estimate since acoustic sampling was initiated in 1996. Acoustic estimates for cisco have mirrored vertical netting relative abundance estimates with the exception of 1999 when acoustic estimates were lower than anticipated based on relative vertical catch.

The strength of acoustic sampling is in determining a lake wide population estimate as opposed to discriminating between species and age groups of fish. The role of acoustics in this instance is to provide an additional piece of data to the standardized netting series. The acoustic equipment and methods used to conduct these estimates are the same used successfully throughout the world to enumerate fish populations.

Size distributions of fish encountered by acoustic sampling do not directly reflect length distributions of fish measured in vertical gillnets. This is due to limitations in acoustic sampling namely that during acoustic surveys, the acoustic beam randomly encounters fish. Fish size (target strength) is based on the dorsal (with a down looking transducer) aspect of fish. During acoustic surveys, both fish and the boat are moving resulting in a scattering of target strengths based on the unlimited aspects that fish encounter the acoustic beam. Computer algorithms are capable of accounting for a portion of this scattering but direct a relationship between measured fish and acoustics targets is not possible at this time.

A total of 9.3 million targets were enumerated in 2002 with 71% (6.6 million) of these being smaller than four inches. These targets have been identified as non-cisco based on vertical gillnetting results (Figure 7). Sub-four inch targets counted in acoustic estimates since 1997 have ranged from a low of 27% in 1998 to a high of 86% in 1997 (average=62%).

Traditional sampling (vertical and horizontal gillnets and trawling) has yet to qualify what these sub-four inch targets are and as a result there is some doubt as to their legitimacy. These targets could be comprised of a mix of the various species in Tiber whether as larval or adults. It is common in acoustic surveys to encounter abundant small targets, which are often simply classified as "forage" fish given their average size (2002=2.82 inches).

Table __. Summary of population parameters derived from acoustic monitoring on Tiber Reservoir (1996 through 2002).
*Approximately 5 million age 0 cisco were introduced in 1997 and again in 1998.

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Total targets-million	2.0	1.2	3.2	2.7	4.3	3.4	9.3
% Cisco in vertical gillnets	0%	72%	99.2%	98.8%	99.3%	98.7%	99.5%
% Fish > 4 inches	N/A	14%	73%	28%	38%	44%	29%
Cisco population estimate (>4")	N/A	166,000	2.31 mil	743,000	1.6 mil	1.48 mil	2.67 mil
Age 0 cisco estimate (4-7")	N/A	115,000*	713,000*	164,000	463,000	968,000	1.98 mil
Adult cisco estimate (>7")	N/A	N/A	1.6 mil	586,000	1.1 mil	489,000	690,000
Pelagic[1] Estimate (cisco > 4")	N/A	35,000	535,000	138,000	101,000	542,000	1.10 mil

[1] **Pelagic Estimate = fish counted between 21 and 46 meters of depth.**

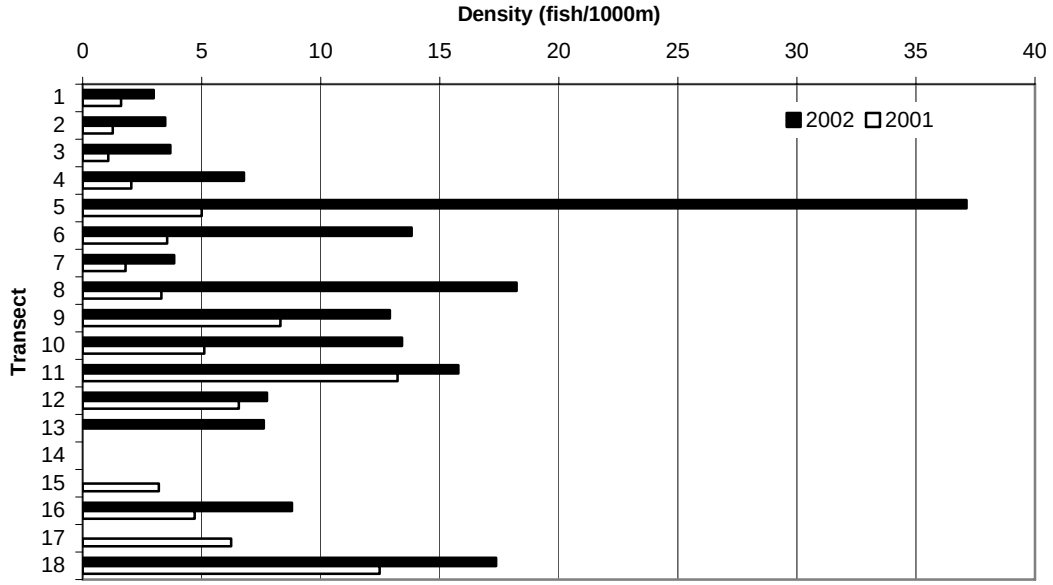

Figure __. Acoustic target (all targets) density estimates (fish/1000m^3) by transect in Tiber Reservoir – September 2001 and 2002. Some transects were excluded due to problems with volumetric expansion, tree interference or loss of bottom tracking.

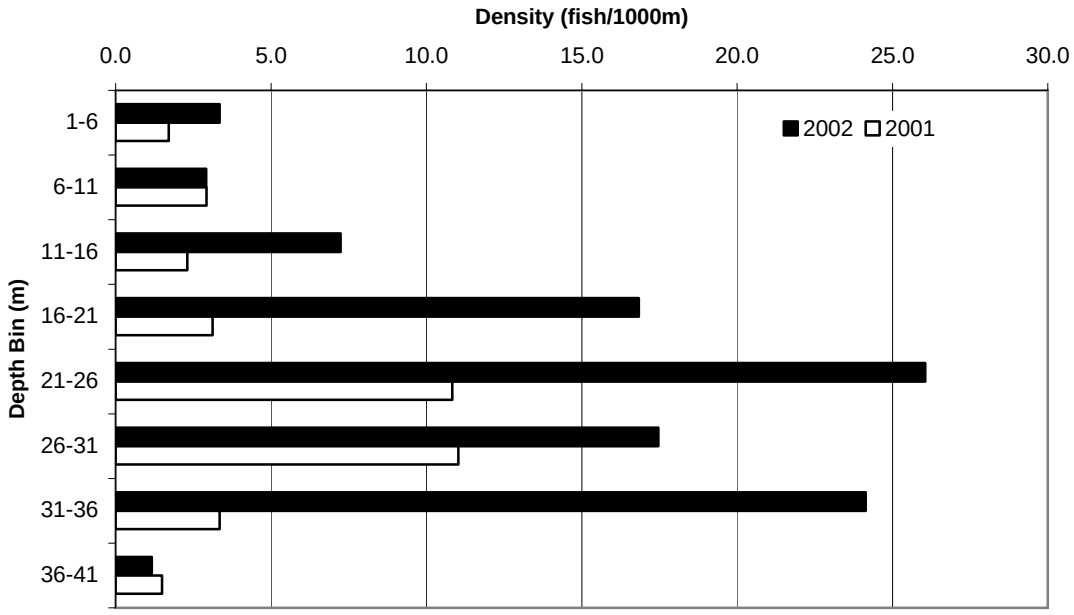

Figure __. Acoustic target (all targets) densities (fish/1,000m^3) by depth across all transects in Tiber Reservoir - September 2001 and 2002.

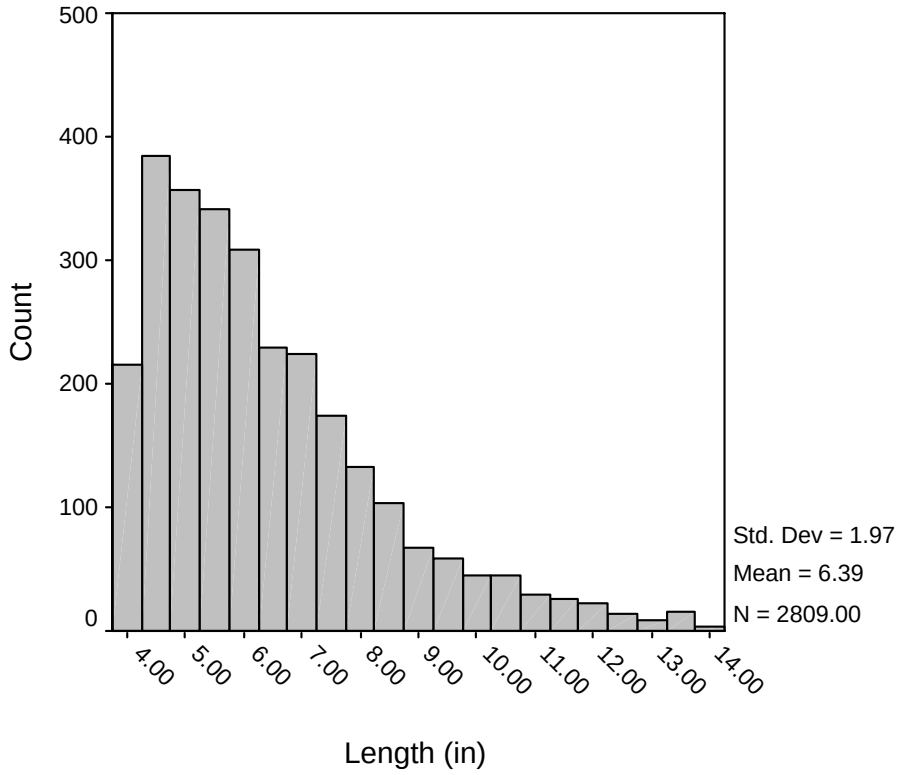

Figure __. Length frequency of acoustic targets between four and fourteen inches across all transects in Tiber Reservoir, September 2001.

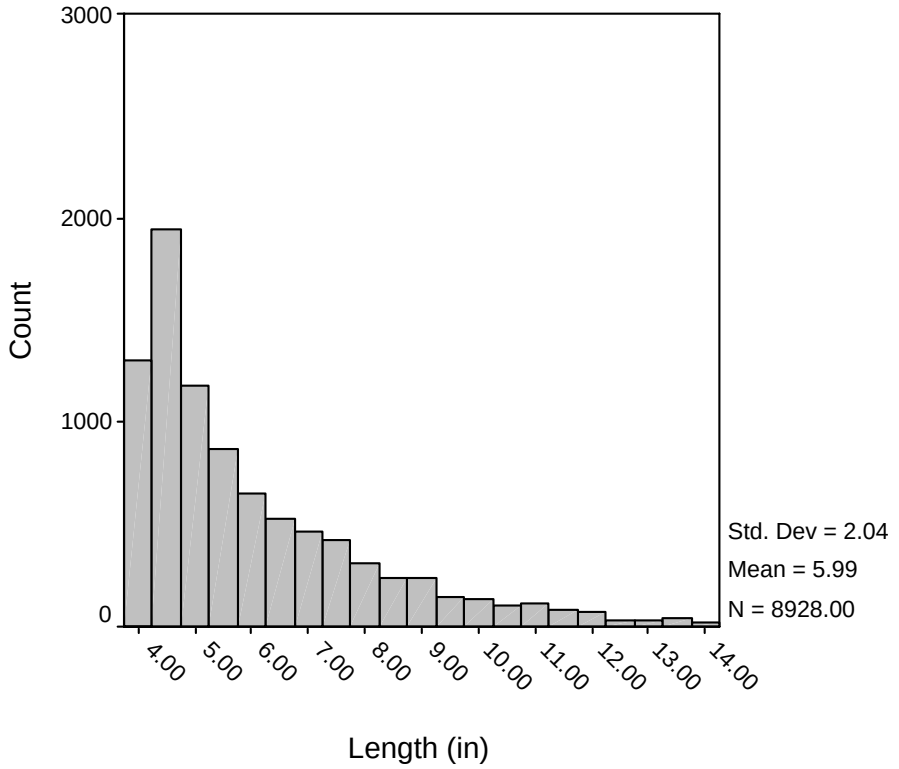

Figure __. Length frequency of acoustic targets between four and fourteen inches across all transects in Tiber Reservoir, September 2002.

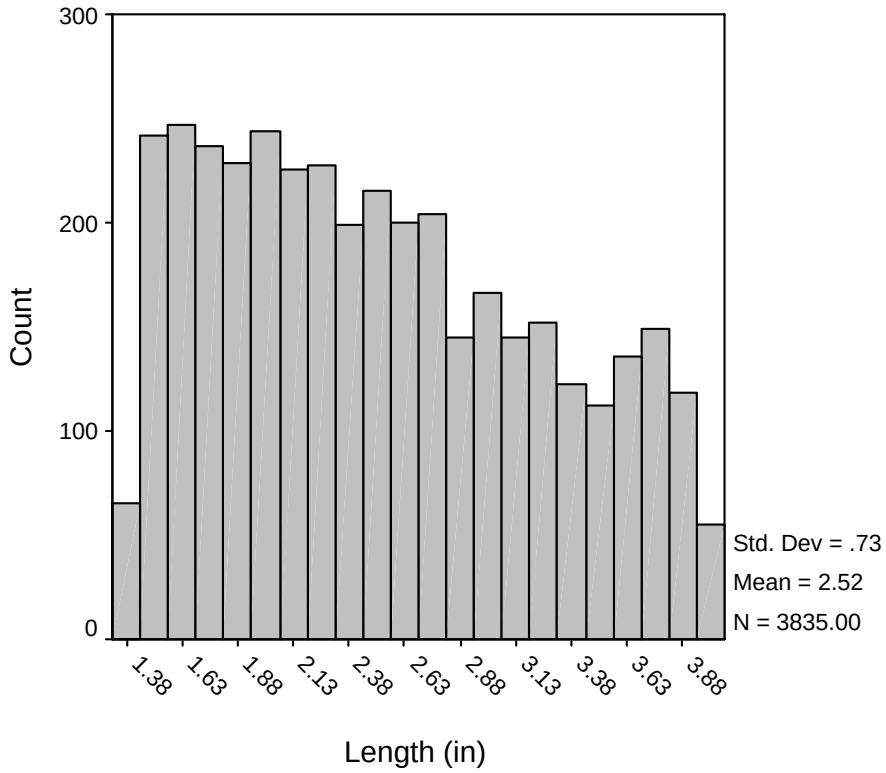

Figure __. Length frequency of acoustic targets less than four inches across all transects in Tiber Reservoir, September 2001.

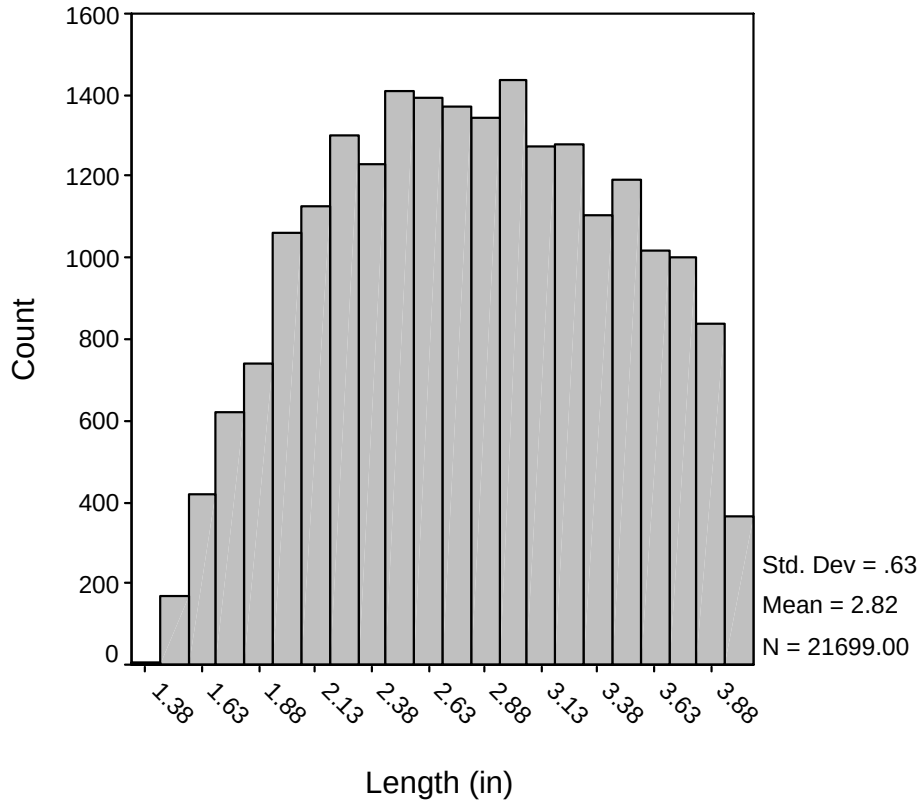

Figure __. Length frequency of acoustic targets less than four inches across all transects in Tiber Reservoir, September 2002.

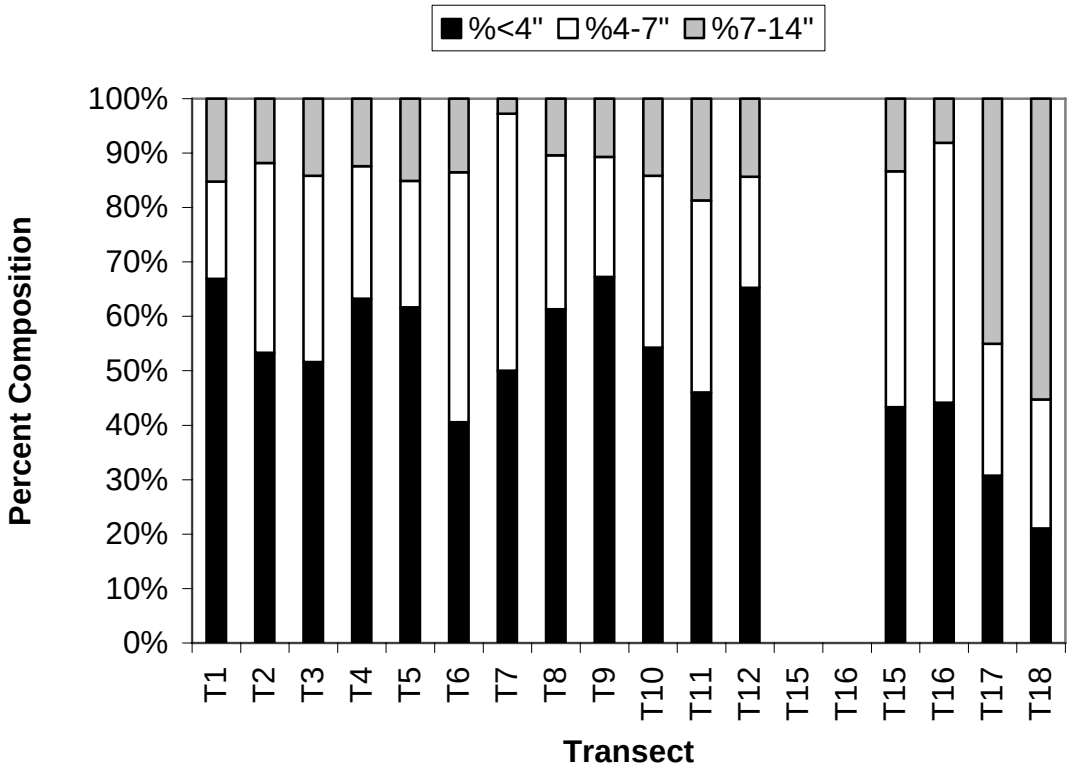

Figure ___. Percent composition by size of acoustic targets across transects in Tiber Reservoir, 2001. Some transects were excluded due to problems with volumetric expansion, tree interference or loss of bottom tracking.

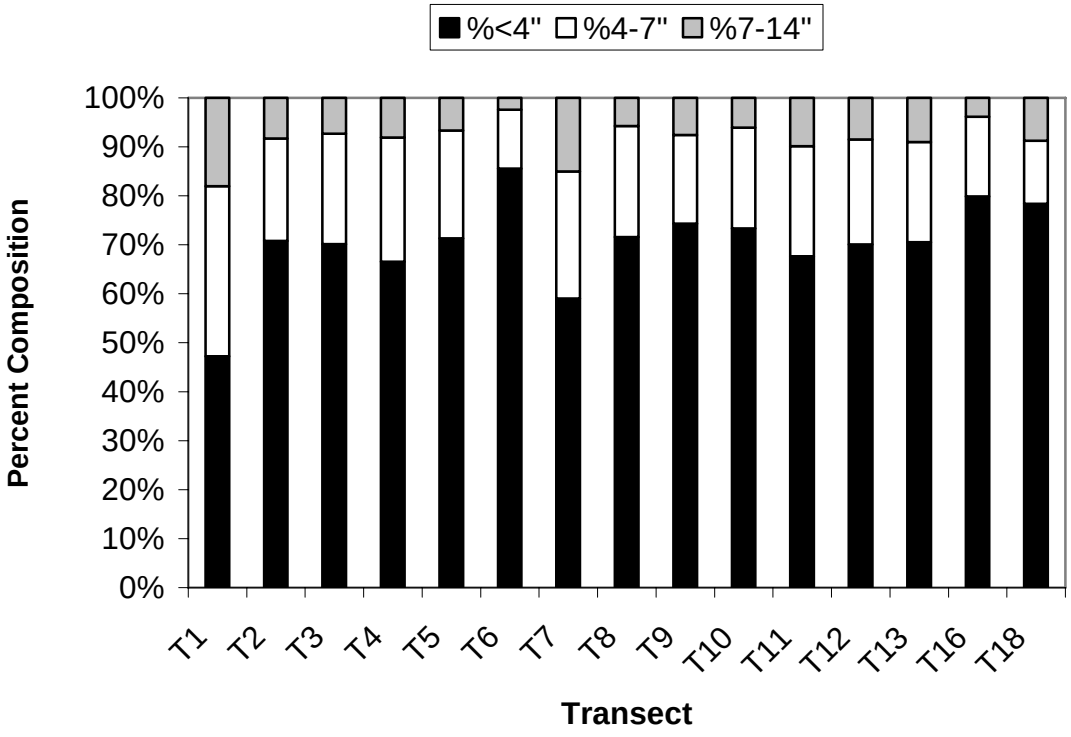

Figure ___. Percent composition by size of acoustic targets across transects in Tiber Reservoir, 2002. Some transects were excluded due to problems with volumetric expansion, tree interference or loss of bottom tracking.

Appendix I. Tiber Reservoir hydroacoustic fish population estimates for 1996 through 2002. Estimates include targets of all size.

Year 2002	Depth (m)	Mean Density (fish/m^3)	Lake Volume (m^3)	Number of Fish	% Of Total
	1-6	3.34E-03	366,003,934	1,223,826	13.23%
	6-11	2.91E-03	249,823,622	727,075	7.86%
	11-16	7.24E-03	166,093,975	1,203,007	13.00%
	16-21	1.68E-02	134,992,595	2,272,816	24.56%
	21-26	2.61E-02	91,193,879	2,376,188	25.68%
	26-31	1.75E-02	52,379,130	915,097	9.89%
	31-36	2.41E-02	21,933,892	529,413	5.72%
	36-41	1.17E-03	4,618,895	5,391	0.06%
	Total Fish (all sizes)			**9,252,813**	
	Total Fish Below Thermocline (all sizes)			**3,826,088**	
	Fish Per Acre			**544**	

Year 2001	Depth (m)	Mean Density (fish/m^3)	Lake Volume (m^3)	Number of Fish	% Of Total
	1-6	1.71E-03	247,581,392	423,231	12.4
	6-11	2.93E-03	189,120,615	553,892	16.3
	11-16	2.30E-03	147,095,456	338,891	10.0
	16-21	3.12E-03	108,812,280	339,993	10.0
	21-26	1.08E-02	83,346,075	903,168	26.5
	26-31	1.10E-02	70,293,535	775,649	22.8
	31-36	3.35E-03	15,416,872	51,625	1.5
	36-41	1.50E-03	12,333,497	18,450	0.5
	41-46	1.71E-03	3,083,374	0	0.0
	Total Fish (all sizes)			**3,404,897**	
	Total Fish Below Thermocline (all sizes)			**1,748,891**	
	Fish Per Acre			**200**	

Year 2000	Depth (m)	Mean Density (fish/m^3)	Lake Volume (m^3)	Number of Fish	% Of Total
	1-6	4.70E-03	259,103,346	1,216,761	28.6
	6-11	5.58E-03	198,852,978	1,109,977	26.1
	11-16	3.83E-03	152,413,660	583,710	13.7
	16-21	5.29E-03	116,875,921	618,159	14.5
	21-26	3.75E-03	85,710,406	321,445	7.6
	26-31	2.46E-03	34,131,721	83,988	2.0
	31-36	1.75E-03	61,583,619	107,857	2.5
	36-41	2.76E-03	13,651,948	37,620	0.9
	41-46	4.79E-02	3,663,049	175,616	4.1
	Total Fish (all sizes)			**4,255,133**	
	Total Fish Below Thermocline (all sizes)			**726,526**	
	Fish Per Acre			**250**	

Year 1999	Depth (m)	Mean Density (fish/m^3)	Lake Volume (m^3)	Number of Fish	% Of Total
	1-6	1.52E-03	366,003,934	555,929	20.7
	6-11	1.85E-03	249,823,622	461,426	17.2
	11-16	2.96E-03	166,093,975	490,847	18.3
	16-21	2.93E-03	134,992,595	395,051	14.7
	21-26	3.80E-03	91,193,879	346,109	12.9
	26-31	4.46E-03	52,379,130	233,730	8.7
	31-36	7.22E-03	21,933,892	158,458	5.9
	36-41	9.12E-03	4,618,895	42,132	1.6
	41-46	2.32E-02	46,867	1,089	0.0
	Total Fish (all sizes)			**2,684,783**	
	Total Fish Below Thermocline (all sizes)			**781,518**	
	Fish Per Acre			**158**	

Year 1998	Depth (m)	Mean Density (fish/m^3)	Lake Volume (m^3)	Number of Fish	% Of Total
	1-6	2.45E-03	366,003,934	895,858	28.1
	6-11	1.55E-03	249,823,622	386,827	12.1
	11-16	2.25E-03	166,093,975	373,405	11.7
	16-21	4.89E-03	134,992,595	659,829	20.7
	21-26	7.14E-03	91,193,879	651,180	20.4
	26-31	3.54E-03	52,379,129	185,675	5.8
	31-36	1.23E-03	21,933,891	26,979	0.8
	36-41	1.05E-03	4,618,894	4,855	0.2
	41-46				
	Total Fish (all sizes)			**3,184,608**	
	Total Fish Below Thermocline (all sizes)			**868,689**	
	Fish Per Acre			**187**	

Year 1997	Depth (m)	Mean Density (fish/m^3)	Lake Volume (m^3)	Number of Fish	% Of Total
	1-6	6.30e-04	308,815,904	195,789	16.1
	6-11	9.60e-04	251,431,202	241,757	19.9
	11-16	1.53e-03	180,916,740	276,937	22.8
	16-21	1.23e-03	148,833,974	182,391	15.0
	21-26	2.00e-03	105,883,370	211,749	17.4
	26-31	1.01e-03	77,226,188	77,878	6.4
	31-36	3.60e-04	56,787,446	20,371	1.7
	36-41	2.60e-04	29,032,318	7,604	0.6
	41-46	6.70e-05	10,709,886	716	0.1
	Total Fish (all sizes)			**1,215,192**	
	Total Fish Below Thermocline (all sizes)			**318,318**	
	Fish Per Acre			**71**	

Year 1996	Depth (m)	Mean Density (fish/m^3)	Lake Volume (m^3)	Number of Fish	% Of Total
	1-6	1.96e-03	281,164,432	552,434	37.3
	6-11	1.96e-03	228,196,216	447,005	30.2
	11-16	1.57e-03	164,356,460	258,106	17.4
	16-21	9.70e-04	135,292,058	130,592	8.8
	21-26	5.80e-04	94,347,938	54,980	3.7
	26-31	3.30e-04	68,599,294	22,365	1.5
	31-36	1.80e-04	46,825,364	8,519	0.6
	36-41	2.30e-04	21,079,188	4,788	0.3
	41-46	1.40e-04	6,817,850	970	0.1
	Total Fish (all sizes)			**1,479,846**	
	Total Fish Below Thermocline (all sizes)			**91,710**	
	Fish Per Acre			**105**	

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