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BC hydro

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Hydroacoustic Surveys of Williston Reservoir (June, September, and October, 1988)

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The Peace/Williston Fish & Wildlife Compensation Program is a cooperative venture of BC Hydro and the provincial fish and wildlife management agencies, supported by funding from BC Hydro. The Program was established to enhance and protect fish and wildlife resources affected by the construction of the W.A.C. Bennett and Peace Canyon dams on the Peace River, and the subsequent creation of the Williston and Dinosaur Reservoirs.

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EXECUTIVE SUMMARY

HYDROACOUSTIC SURVEYS OF WILLISTON RESERVOIR (JUNE, SEPTEMBER AND OCTOBER 1988)

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Three hydroacoustic surveys were conducted on Williston Lake on behalf of B.C. Hydro and the B.C. Provincial Ministry of Environment during the periods June 24-July 5, September 1-7 and October 23-November 5, 1988. A draft report was supplied to B.C. Hydro after data analysis in November 1989.

Williston Lake is located in northeastern British Columbia, Canada and was formed by the creation of the W.A.C. Bennett Dam. It has been 23 years since completion of the dam and 18 years since it has reached full pool. In accordance with preimpoundment mandate, a program of environmental compensation is to be undertaken to enhance fish populations in the Williston Lake watershed.

Prior to undertaking enhancement measures, a program of limnological investigations was undertaken in an effort to understand the biology of the maturing system. A baseline hydroacoustic survey of the pelagic zone of the lake was undertaken to better understand the fish distribution and abundance as an integral part of these investigations. Attempts were made to coordinate the hydroacoustic data collection with planned gill net sampling in various locations within the lake during the three sample periods. The objectives of the hydroacoustic sampling were to document the numbers of fish, acoustic fish sizes, and densities of fish for each transect within each survey period and to provide B.C. Hydro with a summary report of the results.

There were 69 transects established on Williston Lake to provide a sample of the pelagic fish population within the lake. The transects were oriented roughly perpendicular to the long axis of the lake and situated at intervals of approximately 5 km. The transects were sampled using a BioSonics dual beam hydroacoustic data acquisition system during hours of darkness in order to afford the highest probability of individual fish detection. Unscheduled diurnal sampling indicated that the pelagic fish are sometimes associated with the submerged trees in the lake during day and emerge into the open water at night.

Data analysis was accomplished using a BioSonics Model

that the extrapolation of the population to the entire lake is very rough since the extensive shallows and varying sample areas were not taken into account for this exercise.

A number of recommendations were developed based on this initial baseline hydroacoustic study of Williston Lake.

1. The optimum time for hydroacoustic surveys of Williston Lake appear to be in September when the nights are longer and the fish are utilizing the pelagic region.

2. Future acoustic surveys should be scheduled between the last quarter and the first quarter of the new moon to assure maximum darkness during the sampling period.

3. Transects would be much easier to located at night if they were marked with lights or large reflectors.

4. The survey vessel should be equipped for night work and have trawl capability to adequately sample the smaller fish found in the pelagic region of the lake.

5. The survey design should include a detailed investigation of the populations inhabiting the large inlets and bays of the lake. This would best be undertaken from a smaller boat with a pole mounted transducer in both down-looking and side-looking mode.

6. Fish behavior and gill net effectiveness would be easily monitored by a fixed location hydroacoustic system deployed in conjunction with a gill net sampling site. Gill nets did not appear to be as effective in the pelagic region of the lake as they were near shore.

7. Fixed location hydroacoustic systems may be used in the future to monitor the effectiveness of enhancement structures and utilization of bays and inlets during compensation efforts.

8. Mobile hydroacoustic systems may be used to monitor increased utilization of the pelagic region of the lake after enhancement if properly deployed with conjunctive net sampling (both gill net and trawl).

281 Echo Signal Processor (ESP) and Biosonics TS post processing software. Analysis provided information on acoustic fish sizes and volume densities of fish. The surface area of Williston Lake, determined by optical scanning of topographical maps, was used in the calculation of the overall fish population.

The results of the three surveys are summarized in tabular and graphic format in five appendices including population summary tables, target strength vs. depth tables, target strength vs. depth histograms, three dimensional plots of numbers of fish vs. target strength and depth, and the echograms collected during each survey.

The average target strength (acoustic fish size) for each of the three surveys was -44.16 dB (S.D. 6.02 dB) for June, -44.41 dB (S.D. 5.52 dB) for September, and -46.59 dB (S.D. 6.03 dB) for October. A comparison of the acoustically estimated size distribution and the actual sampled size distribution from gill nets proved revealing of the bias associated with the gill net sampling technique. The acoustic data indicated the presence of small fish in the pelagic zone that the gill nets were incapable of capturing. Similar comparisons with trawl samples taken of small fish (juvenile sockeye) in other lakes showed good correlation to acoustic estimates of fish size.

Fish populations were generated for the portion of the lake sampled during each survey as well as extrapolated populations for the entire lake. In July, 51% (35 of 69 transects) of the lake was sampled yielding a population of 2.485E+06 fish. The highest densities in the pelagic region were encountered at transect 49 in the Peace Reach. The extrapolated estimate for the entire lake was 4.899E+06 fish.

In September, 55% (38 of 69 transects) were sampled producing an estimate of 6.182E+06 fish. During this survey, the highest density of fish was encountered at the junction of the three reaches at transect 47. The extrapolated estimate was 1.123E+07 fish.

In October, despite deteriorating weather conditions, 72% (50 of 69 transects) of the lake was sampled. Only 1.030E+05 fish were counted for this survey, a significant drop from the former survey. The largest densities of fish were found at transect 44 in the Peace Reach. The extrapolated population for October was 7.106E+06 fish.

Fluctuations in population from July through October may be attributed to movement to and from the pelagic region of the lake for various reasons. Since the pelagic region of the lake was not adequately sampled with net gear, it is difficult to establish which species may have contributed to the variability in population estimates. It should be noted

INTRODUCTION

This report represents the culmination of hydroacoustic studies conducted on behalf of B.C. Hydro (hereinafter referred to as Hydro) and the B.C. Provincial Ministry of Environment (hereinafter referred to as MOE) under Hydro professional services contract purchase order #843 978. Funding was provided through the Williston Compensation Program. The purpose of the contract was to provide services in conducting hydroacoustic surveys of fish populations in Williston Reservoir (hereinafter referred to as Williston Lake), to supply and use hydroacoustic equipment, and to provide summary data of the results of the surveys.

Description of the Survey Area

Williston Lake is located in northeastern British Columbia (Figure 1). The lake was formed by completion of the W.A.C. Bennett Dam located on the Peace River drainage approximately 26 km upstream from the town of Hudson Hope. In 1972, the lake reached maximum pondage at 672 m above sea level, resulting in Williston Lake being the largest body of water in British Columbia (Barrett, et al, 1985). The meristics of the system are impressive with a total surface area of 156,968 hectares and a total volume of 6.436E+10 cubic meters at the 665 m lake level above sea level.

Impoundment of a lake or river system can cause considerable environmental changes which in turn affect the resident and migratory fish populations (Odum 1971). Studies performed by Swedish and Soviet scientists (Nilsson 1958, Grimas 1961, Lindstrom 1962 and Frey 1967) all indicate a pattern of change that occurs in new lakes formed by impoundment. Initial rapid increases in population were noted at all trophic levels. This occurs for the first few years after which significant declines in population were noted. Additionally, as one might expect, those species most adaptive to the lacustrine environment became dominant as the others declined.

It has been 22 years since completion of the dam and 17 years since the reservoir first reached full pool, thus the system should be relatively stable at this time. According to pre-impoundment mandate, a program of environmental compensation is to be undertaken to enhance fish populations in the Williston Lake watershed. Part of the task involves understanding the biology of the maturing system,

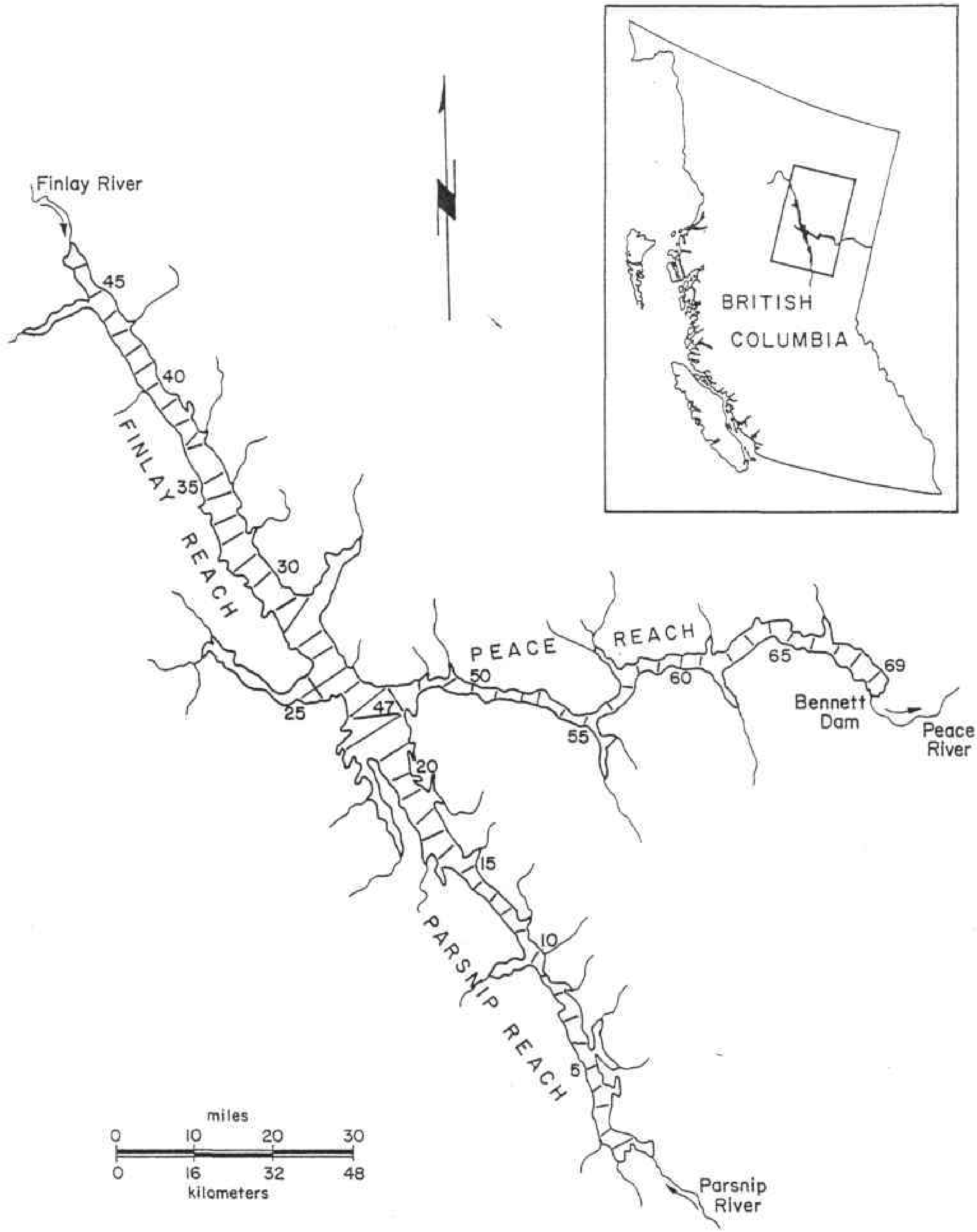

Figure 1. Location of Williston Lake and acoustic transects used in 1988.

particularly with regard to the vast lacustrine environment created by the impoundment of the Finlay, Parsnip, and Peace drainages. The objective of this portion of the study was to provide Hydro biologists with information on fish populations and distribution of fishes inhabiting the pelagic portion of the lake.

Project Objectives

This report represents the dual-beam hydroacoustic surveys completed on Williston Lake during June 24 - July 5, 1988, September 1 - 7, 1988 and October 23 - November 5, 1988. The specific objectives of these surveys were to:

1. Estimate the number of targets on each transect,

2. Estimate the acoustic fish sizes for each transect,

3. Estimate fish densities for each transect,

4. Provide a summary report of the above information.

The application of hydroacoustics to fulfill such objectives has been successfully undertaken and documented over the last two decades (Shotton and Bazigos 1984, Dickie et al. 1983, Thome 1983, Traynor and Ehrenberg 1979). Recent and major advances in digital electronic and microcomputer technology coupled with their common and reasonably inexpensive availability has resulted in hydroacoustics becoming even more important, reliable, economical, accurate and rapid (Johanneson and Mitson 1984, Forbes and Nakken 1972). Hydroacoustics has consequently provided a new and accessible opportunity to efficiently evaluate and manage fish stocks.

METHODS AND MATERIALS

Data Collection

Williston Lake is divided naturally into three distinct regions defined by the respective drainages forming the lake basin; the Parsnip Reach to the south, the Finlay Reach to the north, and the Peace Reach to the east (Figure 1). In total, 69 transects were established approximately 5 km apart in the three reaches (1-22, 23-46, and 47-69, respectively) and oriented roughly perpendicular to the lake shore and spanning nearly the entire width of the lake in most cases. Exceptions to this were transects in the Finlay and Parsnip reaches that exhibited extensive shallows with standing trees. It was virtually impossible to navigate these waters during hours of darkness without risking loss of equipment. For this reason, transecting in the shallow regions was confined to the main channel. Two additional transects were added during the program (transects 23A and 25A). Transects were navigated using compass and visual bearing. It is recommended that future hydroacoustic programs include time to adequately mark transects for ease of location and repeatability during hours of darkness. The field log for each of the surveys is presented in Tables 1-3.

Each of the transects was sampled using dual-beam hydroacoustic equipment during hours of darkness. All of the hydroacoustic surveys were conducted at night because previous work, particularly on juvenile sockeye salmon had demonstrated that they generally feed in midwater during hours of darkness and are best distributed for acoustic detection at this time. During the day, the fish are grouped closer to the bottom and are harder to detect with the acoustic gear (Burczynski and Johnson 1985). This phenomena was verified on two occasions during the course of the survey activity on Williston Lake during the 1988 sampling season. During the November survey, it was necessary to survey a portion of the lake during daylight hours due to snow conditions which made night navigation impossible (refer to field log data for transects affected).

The boat RPM was held constant for each vessel used to produce a speed of approximately 2-3 m/sec. The transducer was towed alongside the boat at a depth of one to two meters and oriented looking straight down.

Gillnet sampling was conducted by Hydro staff in conjunction with the hydroacoustic sampling, however, the effort was largely concentrated in the littoral region of the lake. The pelagic sets that were made were typically

Table 1. Field log for Williston Lake survey of June 24 - July 5, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
24/6/88	1	21	300	4352	2229	2310	Gr= +6dB, 40 log R PW 0.4ms, chart thresh. 0.05 v, 3000 rpm course: 245 deg.
	1	22	4352	1:2352	0006	0047	choppy from mid-lake to east shore course: 27 deg.
25/6/88	1	46	1:2353	1:4300	2340	0000	hit log mid transect twilight course: 30 deg
	2	45	300	1712	0019	0034	still twilight course: 207 deg.
	2	44	1714	5531	0107	0156	Ingenika log dump to S. Point, S. Point to Ingenika Pt. to E. shore course: 28 deg.
	2	43	5531	1:1902	0221	0245	Mark A point on chart hit another log! course: 214 deg.
26/6/88	2	36a	1:1902	1:3441	2137	2152	transecting in Davis Bay recorded random transects
	3	36b	345	4115	2202	2248	transect across lake start in Davis Bay course: 225 deg.
	3	40	4117	1:0740	2359	0026	course: 41 deg.
	3	36c	1:0740	1:4200	0158	0233	repeat after dark course: 223 deg.
27/6/88	4	32	305	5205	2317	0007	many large targets course: 210 deg.
	4	28	5205	1:5243	0217	0329	*Gr= 0dB cut off at 0233 restart at 0241

Table 1. (cont'd.) Field log for Williston Lake survey of June 24 - July 5, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
29/6/88	5	3	300	1615	1158	1213	new boat, rpm start =1400 changed to 1200, Gr = 0dB west to east
30/6/88	5	5	1615	2834	0124	0136	21 min from 3 to 4 at 2300 rpm, trans. 1200rpm east to west
	5	9	2834	3531	0304	0309	east to west
	5	10	3531	5110	0338	0354	choppy in mid transect also boat interferences west to east
1/7/88	5	20	5116	1:3100	0100	0141	very rough & windy east to west
	6	18	303	3525	0230	0302	rpm = 1350 west to east
	6	16	3525	1:0716	0342	0414	full moon, big wind clear sky east to west
	6	25a	1:0716	1:4529	2311	2350	tr. across Omineca Inlet South to north
2/7/88	7	25b	300	14154	0010	0150	clear sky, twilight Windy in main channel course: 30 deg.
	8	47	300	4444	2329	0012	raining south to north
3/7/88	8	48	4444	5845	0058	0112	still raining north to south
	8	49	5918	1:1641	0135	0154	wind & rain west to east
	8	50	1:1641	1:2506	0215	0225	wind from E. & rain south to north

Table 1. (cont'd.) Field log for Williston Lake survey of June 24 - July 5, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
	8	51	1:2506	1:4005	0249	0304	wind & rain south to north
	8	52	1:4005	1:5002	0328	0339	south to north
	9	53	302	1910	0357	0414	north to south
	9	69	1910	5211	2336	0010	calm, partly cloudy course: 40 deg.
4/7/88	9	68	5211	1:2834	0050	0126	course: 0 deg.
	9	66	1:2834	1:5802	0210	0240	light chop course: 340 deg.
4/7/88	10	64	310	2746	0329	0354	moderate chop course: 340 deg.
	10	62	2746	4933	2237	2259	calm, clear, cool course: 120 deg.
	10	60	4933	1:0402	2336	2350	light breeze course: 320 deg.
5/7/88	10	58	1:0402	1:1818	0034	0048	calm course: 310 deg.
	10	56	1:1818	1:3623	0123	0141	calm course: 120 deg.
	10	55	1:3623	1:4727	0224	0236	windy course: 325 deg.
	11	54	300	1334	0313	0324	calm course: 350 deg.

Table 2. Field log for Williston Lake survey of September 1 - 7, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
1/9/88	1	48	304	2230	1049	1109	Gr= 0dB, 40 log R PW 0.4ms, 1050 rpm course: 320 deg.
	1	49	2230	3841	1129	1146	Gr= 0dB, power low, turned off O-scope, lights bright half moon, light breez course: 30 deg.
2/9/88	1	50	3842	5017	1211	1223	Gr= 0dB, choppy from west course: 355 deg.
	1	51	5017	1:0905	1244	0104	Gr= 0dB, course: 10 deg.
	1	52	1:0905	1:1930	0135	0145	Gr= 0dB, course: 346 deg.
	1	53	1:1930	1:4127	0207	0230	Gr= 0dB, course: 160 deg.
	1	54	1:4127	1:5147	0250	0301	Gr= 0dB, choppy course: 0 deg.
	2	55	304	1921	0338	0355	Gr= 0dB, course: 355 deg.
	2	56	1931	3257	0425	0439	Gr= 0dB, 150m offshore start due to forest in water course: 300 deg.
	2	69	3258	1:1116	2102	2140	Gr= 0dB, 1100 rpm course: 40 deg.
	2	68	1:1117	1:4800	2238	2316	Gr= 0dB, course: 0 deg.
3/9/88	3	67	300	3638	0013	0047	course: 180 deg.
	3	65	3638	1:0255	1032	0150	Gr= 0dB, course: 0 deg.
	3	63	1:0255	1:3515	0245	318	Gr= 0dB, course: 310 deg.
	3	61	1:3515	2:0215	0347	0415	Gr= 0dB, course: 160 deg.
	4	60	720	2053	0453	0507	Gr= 0dB, course: 320 deg.
	4	58	2053	3826	0525	0543	Gr= 0dB, course: 130 deg.

Table 2. (cont'd.) Field log for Williston Lake survey of September 1 - 7, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
3/9/88	5	21	153	1:1308	2208	2321	Gr= 0dB, waves 3 ft., course: 210 deg.
	5	19	1:1313	1:5145	0000	0039	Gr= 0dB, calm course: 205 deg.
4/9/88	6	18	151	5158	0113	0203	Gr= 0dB, course: 210 deg.
	6	17	5202	1:2326	0225	302	Gr= 0dB, course: 35 deg.
	6	47rep2	1:2326	end	0355	0422	Gr= 0dB, 4 ft. waves wind at 25 mph course: 320 deg.
	7	36	150	4553	2115	2200	Gr= 0dB, course: 225 deg.
	7	39	4555	1:1005	2257	2322	Gr= 0dB, course: 236 deg.
5/9/88	7	40	1:1008	1:3432	0000	0024	Gr= 0dB, course: 41 deg.
	7	41	1:3434	end	0053	0122	Gr= 0dB, course: 205 deg.
	8	43	151	3123	0207	0237	Gr= 0dB, course: 214 deg.
	8	37	3116	4954	0325	0345	Gr= 0dB, course: 215 deg.
	8	32	5100	1:1442	1839	1902	Gr= 0dB, daytime transect course: 30 deg.
	8	30	1:1442	1:4121	1930	2002	Gr= 0dB, dusk course: 16 deg.
	9	25	151	1:2326	2117	2239	Gr= 0dB, night course: 208 deg.
6/9/88	10	47rep2	130	3429	0022	0055	Gr= 0dB, wind course: 320 deg.
	10	23repl	3432	1:4515	0056	0207	Gr= 0dB, wind course: 210 deg.

Table 2. (cont'd.) Field log for Williston Lake survey of September 1 - 7, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
	11	23rep2	000	5045	0212	0308	Gr= 0dB, course: 30 deg.
	11	16	5129	1:2725	2058	2133	Gr= 0dB, course: 217 deg.
	11	15	1:2728	1:4600	2255	2314	Gr= 0dB, course: 218 deg.
	12	14	150	2215	2332	2353	Gr= 0dB, course:192 deg.
7/9/88	12	13	2222	3920	0030	0047	Gr= 0dB, course 206 deg.
	12	12	3914	4517	0149	0155	Gr= 0dB, course: 222 deg.
	12	10	4518	1:0420	0340	0358	Gr= 0dB, course: 182 deg.

Table 3. Field log for Williston Lake survey of October 23 - November 5, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
23/10/88	1	48	355	1926	2022	2037	Gr=+6dB, 40 log R, PW= 0.4ms moderate chop from west, 1100 course: 330 deg.
	1	49	1929	3535	2055	2111	Gr= +6dB, light chop course: 30 deg.
	1	50	3539	4548	2130	2140	Gr= +6dB, choppy course: 330 deg.
	1	51	4550	1:0215	2158	2214	Gr= +6dB, moderate chop course: 330 deg.
	1	52	1:0218	1:1328	2239	2250	Gr= +6dB, course: 180 deg.
	1	53	1:1332	1:3116	2307	2325	Gr= +6dB, course: 170 deg.
24/10/88	1	54	1:3119	1:3807	0003	0010	Gr= +6dB, course: 355 deg.
	1	55	1:3810	1:5019	0057	0109	Gr= +6dB, course: 340 deg.
	2	56	306	1447	0151	0204	Gr= +6dB, moderate chop course: 120 deg.
	2	57	1451	3151	0228	0246	Gr= +6dB, course: 110 deg.
	2	58	3154	4537	0300	0315	Gr= +6dB, course: 320 deg.
	2	59	4540	1:0357	0353	0411	Gr= +6dB, choppy course: 330 deg.
	2	60	1:0510	1:1815	2033	2046	Gr= +6dB, course: 320 deg.
	2	61	1:1819	1:3751	2101	2121	Gr= +6dB, light chop course: 340
	2	62	1:3755	2:0159	2135	2159	Gr= +6dB, course: 165 deg.
	3	63	308	3402	2232	2303	Gr= +6dB, course: 265 deg.
25/10/88	3	69	3405	1:1119	0906	0943	Gr= +6dB, daytime transects** course: 30 deg.

Table 3. (cont'd.) Field log for Williston Lake survey of Oct. 23 - Nov. 5, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
25/10/88	3	67	1:1122	1:3811	1006	1033	Gr= +6dB, light chop, day tra course: 200 deg.
	3	65	1:3811	2:0023	1052	1114	Gr=+6dB, course: 345 deg.
	4	64	304	2523	1141	1204	Gr= +6dB, course: 180 deg.
27/10/88	5	47	310	4500	2145	2228	Gr= +6dB, course: 300 deg.
	5	23	4503	1:5917	2228	2345	Gr= +6dB, moderate chop course: 205 deg.
	6	22	0	1:0342	2349	0052	Gr= +6dB, choppy course: 80 deg.
28/10/88	6	21	1:0345	1:5305	0119	0208	Gr= +6dB, course: 210 deg.
	7	20	304	2852	0255	0322	Gr= +6dB, course: 230 deg.
	7	19	2855	5654	0341	0410	Gr= +6dB, course: 205 deg.
31/10/88	8	3	300	2724	1754	1819	Gr= +6dB, 40 log R, PW= 0.4ms PR= chart on 80m, 1000 rpm course: 140 deg.
	8	4	2727	4346	1847	1904	Gr= +6dB, calm, light rain course: 200 deg.
	8	5	4349	1:0129	1934	1952	Gr= +6dB, course: 200 deg.
	8	6	1:0132	1:1520	2025	2039	Gr= +6dB, course: 180 deg.
1/11/88	8	8	1:1625	1:3812	1739	1800	Gr= +6dB, course: 60 deg.
	8	10	1:3815	1:5230	1844	1858	Gr= +6dB, course: 0 deg.
	9	11	300	647	1919	1923	Gr= +6dB, course: 220 deg.
	9	12	650	1440	1948	1955	Gr= +6dB, course: 220 deg.

Table 3. (cont'd.) Field log for Williston Lake survey of Oct. 23 - Nov. 5, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
1/11/88	9	13	1443	2546	2022	2033	Gr= +6dB, course: 230 deg.
	9	14	2549	4643	2054	2116	Gr= +6dB, course: 190 deg.
	9	15	4646	1:1640	2151	2220	Gr= +6dB, course: 40 deg.
	9	16	1:1643	1:5956	2245	2329	Gr= +6dB, course: 220 deg.
	10	17	201	1:0029	2358	0056	Gr= +6dB, course 30 deg.
2/11/88	10	18	1:0032	1:5252	0124	0217	Gr= +6dB, course: 180 deg.
	11	25	200	end	0530	0732	Gr= +6dB, course: 30 deg. moderate waves, 3 ft.
	12	26	100	4021	0754	0833	Gr= +6dB, course: 210 deg. Day transecting***
	12	30	4024	1:1847	0940	1018	Gr= +6dB, course: 20 deg. calm , light chop
	12-13	32	1:1850	1356	1052	1151	Gr= +6dB, course: 220 deg.
	13	36	1600	1:0532	1524	1613	Gr= +6dB, course: 220 deg.
	13	44repl	1:0532	1:5851	1826	1919	Gr= +6dB, course: 40 deg. transect to south of position on chart, mark on echogram = Ingenika Pt., waves 3 ft, sampling aborted!
4/11/88	14	43repl	200	3806	0758	0835	Gr= +6dB, day transects*** 2.5 ft. waves, rpm= 1150 PR= 2/sec, chart -80m course: 215 deg.
	14	44rep2	3809	1:3556	0906	1004	Gr= +6dB, mark #1 -bay ent -rance, mark #2 -Ingenika Pt. day transect*** course: 40 deg.
	15	40repl	202	3649	1652	1728	Gr= +6dB, dusk***, calm, range 80m course: 35 deg.

Table 3. (cont'd.) Field log for Williston Lake survey of Oct. 23 - Nov. 5, 1988.

Date	Tape Number	Transect Number	Counter start	Counter stop	Time start	Time stop	Comments
4/11/88	15	40rep2	3652	1:1257	1729	1803	Gr= +6db, paper speed 1, Dusk-night transition*** course: 200 deg.
	15	40rep3	1:1300	1:4628	1804	5200	Gr= +6dB, night*** course: 35 deg.
	16	43rep2	202	4418	2033	2106	Gr= +6dB, mark -mouth of Chowika Bay course: 200 deg.
	16	38	4418	1:2103	2207	2245	Gr= +6dB, abort due to wind course: 35 deg.
5/11/88	17	37	200	2941	0428	0457	Gr= +6db, course: 220 deg.
	17	34	2944	1:0420	0544	1820	Gr= +6dB, course: 25 deg.
	17	33	1:0424	1:3246	0656	0724	Gr= +6dB, day transect course: 25 deg.

unsuccessful in capturing significant numbers of fish. The gillnet samples will ultimately be used by Hydro to estimate the biomass of fish in Williston Lake.

Dual-Beam Hydroacoustic System

The Biosonics dual-beam hydroacoustic system was used for acoustic sampling and was deployed from three different boats during the course of the study. First, due to unavailability of the scheduled jet boat to be provided by the Ministry of Fisheries, a rental jet boat was used which was not adequately setup to function at night. The second boat used was the scheduled jet boat which functioned adequately, but was out of service for the second survey due to mechanical failure. Its main drawback was its relatively slow speed while traveling between transects. The third boat was the Canadian Biosonics boat which was most suited to working the deep water due to its high speed but it was unsuited to working in the shallow regions of the Finlay Reach and southern most Parsnip Reach at night because of the propeller driven outdrive configuration.

The Biosonics hydroacoustic equipment consisted of a 420-kHz dual-beam transducer (6 and 15 degrees) installed in a dynamic towed body (Endeco V-fin), a Model 105 dual channel echo sounder, a Model 281 Echo Signal Processor (ESP), a Model 115 chart recorder, an oscilloscope, an IBM compatible microcomputer, a Model 171 recorder interface and a Sony digital audio tape (DAT) cassette recorder (see Appendix A). The entire system was powered by 115 VAC provided by a Honda gasoline generator. A block diagram and flow chart of the hydroacoustic system is presented in Figure 2.

A dual-beam rather than a single-beam technique was used because it permitted the fish's acoustic target strength to be determined in situ (Burczynski and Dawson 1984, Ehrenberg 1974, 1972). Using this technique, echo returns on two different transducer elements with different beam widths are compared. The beam pattern factor is conveniently eliminated from the measurement, and the output signal is then proportional to the fish acoustic response. Since these measurements are not reliant on net catches or other assumed representative data, they are pertinent to the actual acoustic data being collected. This eliminates the bias associated with net selectivity and fisherman efficiencies. It should be noted, however, that although acoustics is non-selective in nature, user set criteria can represent bias, e.g. setting a high acceptance threshold will discriminate against small fish and setting gains too high can give poor results on large fish if their signals

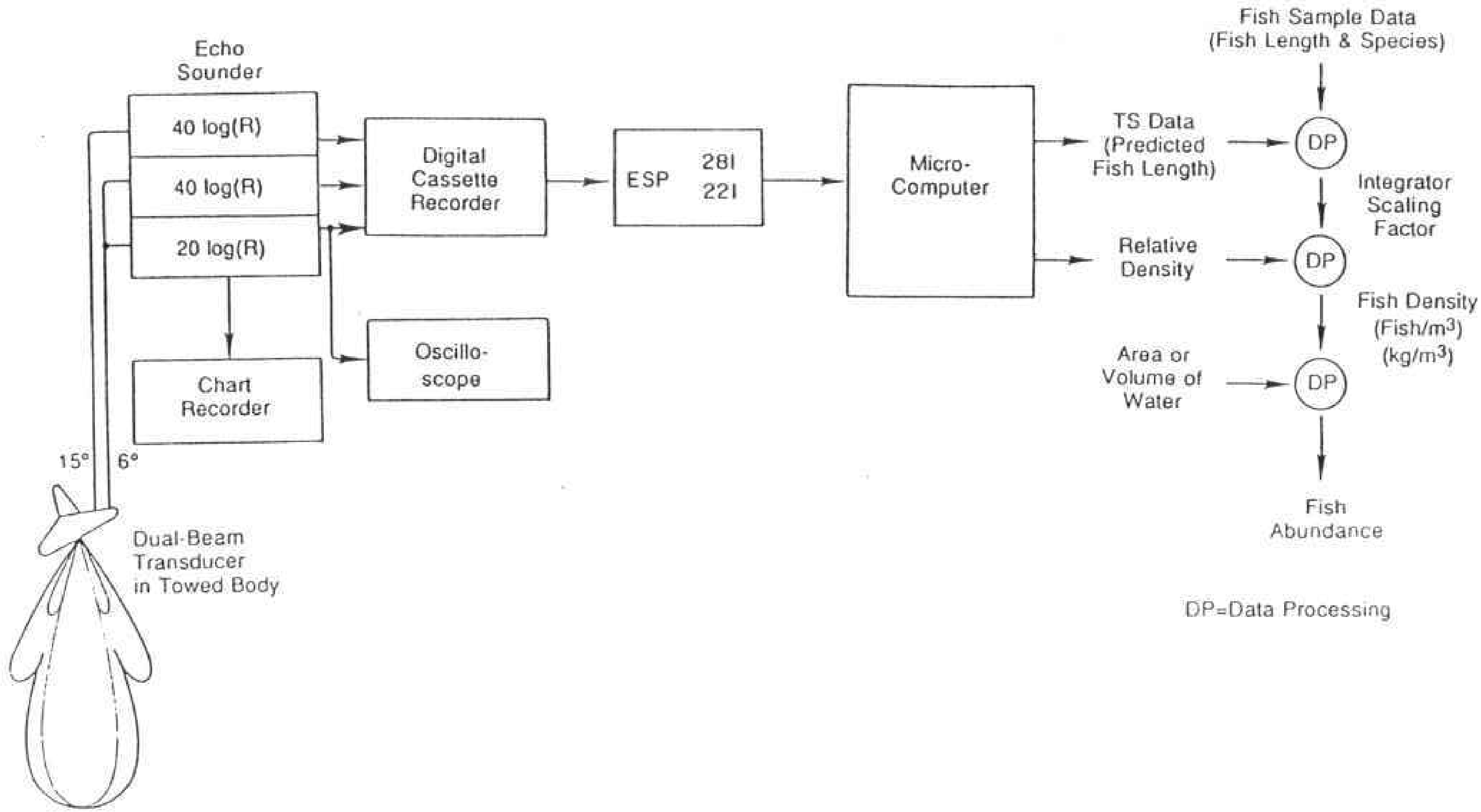

Figure 2. Block diagram of Dual Beam hydroacoustic system.

saturate the system. If experienced operators are conducting the survey, they will be aware of these potential problem areas and minimize their effects resulting in relatively unbiased information for the biologist.

During data collection in the field, the echo sounder was set to collect 40 log R data which was stored on DAT tapes in digitized format. For dual-beam data collection, echoes were received on both the 6 and 15 degree transducer elements and stored on separate channels on the tape with the synchronization signal multiplexed with the narrow beam channel data.

Data Processing and Analysis

During dual-beam data processing, the data was played back from the DAT tape and standardized with a calibration signal recorded in the field so that the data reproduced in the laboratory was identical to the signals produced by the echo sounder in the field. The dual-beam processor (Model 281 ESP) provided information on the reflective power of individual fish according to Ehrenberg (1984a-b, 1974), Traynor and Ehrenberg (1979). The reflecting power of an individual fish can be expressed as the fish's backscattering cross section or its decibel equivalent, "target strength". Target strength information permits fish sizes and their range to be approximated, as well as allowing the accuracy of the survey to be assessed.

The target strengths for individual fish were determined by the dual-beam processor and post-processing software (Biosonics[1] TS program) according to the method described by Ehrenberg (1984a-b)(Appendix B). The criteria of amplitude and duration of echo were applied for classification of single fish and other targets. If the amplitude of the echo was between specified minimum and maximum thresholds, and its duration was more than 80% but not exceeding 110% of transmitted pulse length, it was classified as a single fish return and included in the statistics. The maximum threshold was adjusted to 6 dB below the measured bottom echo, and the minimum threshold was set up 6 dB above the background noise. The maximum half angle for processing targets was set at 5 degrees due to the sparseness of targets in this survey. The optimum threshold would have been closer to 3 degrees according to Traynor and Ehrenberg (1979), however, the sample volume would have been substantially reduced at that threshold. The processing parameters are listed in Appendix A.

The post-processing software was used to calculate the mean values of target strength, backscattering cross section and density of individual fish according to the classification criteria. The mean acoustic fish size and range of sizes were also calculated (Love 1977).

The accepted target data generated by the post-processing software was subsequently loaded into a general purpose spreadsheet for final computation of transect populations. The TS program computed an estimate of sampled volume based on a complete water column defined by the selected depth strata. In Williston Lake, the variability in depth of bottom and extensive shallows made this estimate unrealistic. The sample volume estimates were therefore adjusted according to the length of each depth stratum at the stratum midpoint. The resulting densities better reflect the true fish densities according to the actual sampled volume. The current version of the TS program now reads the depth information from the ESP files and automatically adjusts the density estimates.

Additionally, the sampled volume for an individual pulse of sound was adjusted to reflect the average size of the fish encountered on a particular transect. These estimates of sample volume better reflect the true "effective" sample volume than assuming a 5 degree (half angle) beam angle. The "effective" volume half angles are listed at the top of each computational worksheet.

Finally, the number of fish per cubic meter was computed and converted to fish per square meter surface area. The number of fish per square meter surface area was multiplied by the number of square meters for each transect stratum to arrive at a final estimate of the number of fish for that area. The stratum estimates were summed to arrive at a count for each transect area.

RESULTS AND DISCUSSION

Target Strength Results

The target strengths estimated from the dual-beam hydroacoustic technique are tabulated in depthwise frequency tables for each transect in Appendices B1-B3 for the three surveys, respectively. The results are also graphically represented in Appendices C1-C3 and D1-D3. Appendices C1-C3 show depthwise and summary histograms for each transect which illustrate the stratified nature of the targets. Appendices D1-D3 provide three-dimensional perspective to the data for each transect.

Target Strength Distributions

Table 4 lists the acoustic target strength results for the three surveys. The results were reasonably consistent throughout the year with only minor changes noted in the data, particularly in October. The average target strength for June was -44.16 dB with a standard deviation of 6.02 dB. The minimum and maximum target strengths for June were, respectively, -68.06 dB and -18.34 dB. The average target strength for September was -44.41 dB with a standard deviation of 5.52 dB and minimum and maximums of -61.39 dB and -28.64 dB, respectively. And finally, the average target strength for October was -46.59 dB with a standard deviation of 6.03 dB and minimum and maximum of -67.52 dB and -25.51 dB, respectively. The target strengths for the October survey appeared to be slightly lower than those for the previous surveys. The reason for this is unknown. It should be noted, however, that this phenomena occurred in all three reaches with the majority of the samples coming from the Parsnip Reach. The acoustic size distributions are illustrated in Figures 3-5 for each of the three surveys. Some possible explanations for this are that smaller fish were recruited into the pelagic zone later in the year, that the fish had changed their average orientation in the water column resulting in lower echo returns, or that the larger fish in the population were no longer available to the system, e.g. near shore during spawning activity.

Table 4. Average Backscattering Cross-section and Target Strength Summary for Williston Lake Hydroacoustic Survey, 1988

DATE	REACH	# FOR STATS	SIGMA dB	STD DEV	TS dB	STD. DEV. dB	MINIMUM TS	MAXIMUM TS
June	Finlay	399	8.2880E-05	1.5930E-04	-44.82	6.19	-68.06	-18.34
	Parsnip	284	1.4400E-04	5.2040E-03	-44.46	6.14	-67.77	-27.62
	Peace	459	8.7210E-05	1.1430E-04	-43.68	5.57	-60.03	-30.38
Williston Lake		1142	9.9800E-05	5.0790E-04	-44.16	6.02	-68.06	-18.34
Sept	Finlay	1140	7.6300E-05	1.0600E-04	-44.44	5.76	-61.30	-29.78
	Parsnip	389	6.4440E-05	9.6410E-05	-44.82	5.34	-61.21	-29.59
	Peace	1085	7.3510E-05	1.1050E-04	-44.22	5.32	-61.39	-28.64
Williston Lake		2614	7.3380E-05	1.0660E-04	-44.41	5.52	-61.39	-28.64
Oct	Finlay	935	7.0550E-05	1.2130E-04	-45.86	6.91	-67.33	-25.56
	Parsnip	2435	4.4490E-05	1.0170E-04	-46.86	5.67	-67.52	-31.45
	Peace	527	4.7200E-05	1.1110E-04	-46.58	5.7	-65.72	-25.51
Williston Lake		3916	5.1270E-05	1.0920E-04	-46.59	6.03	-67.52	-25.51

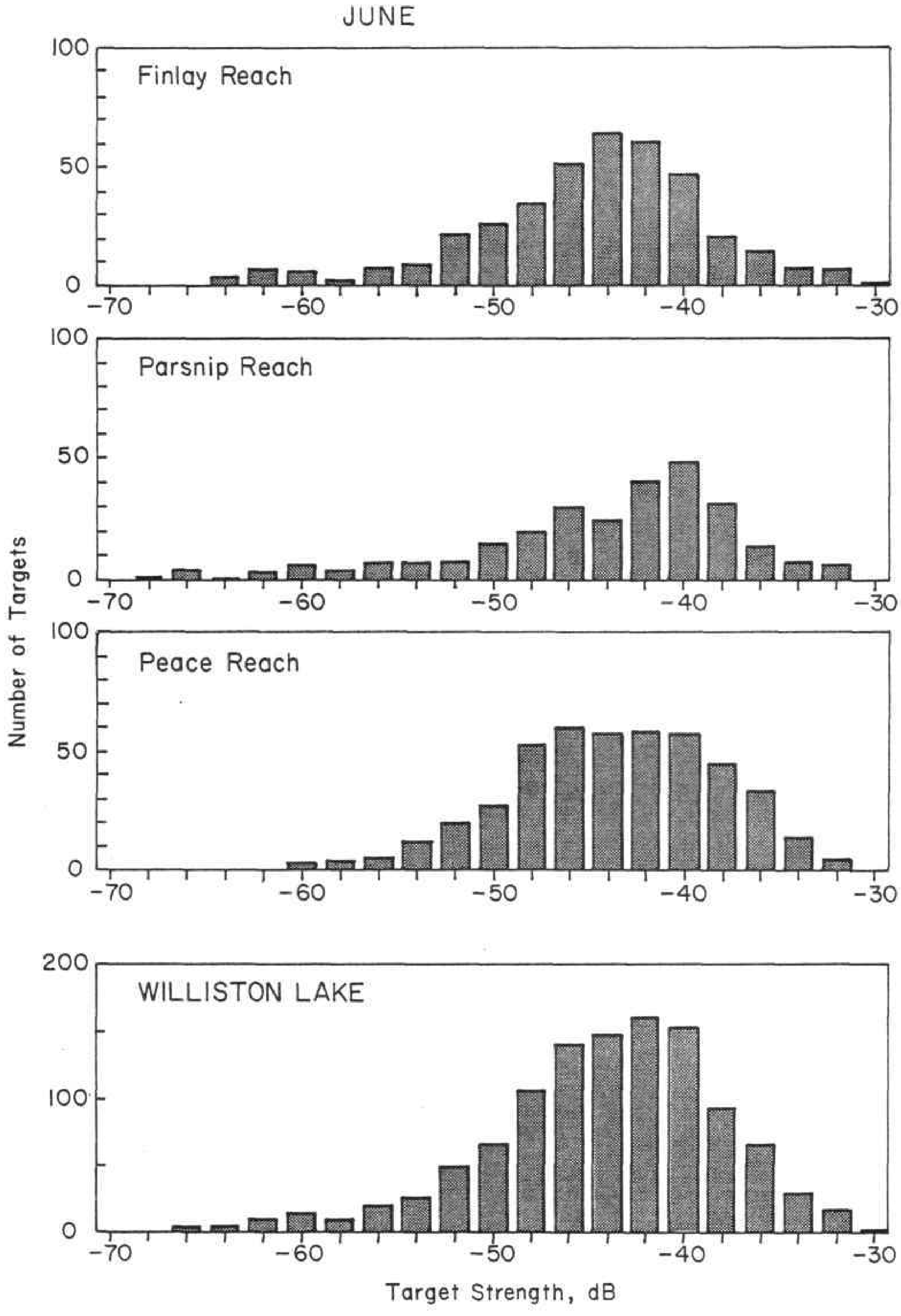

Figure 3. Acoustic size distribution for June 1988.

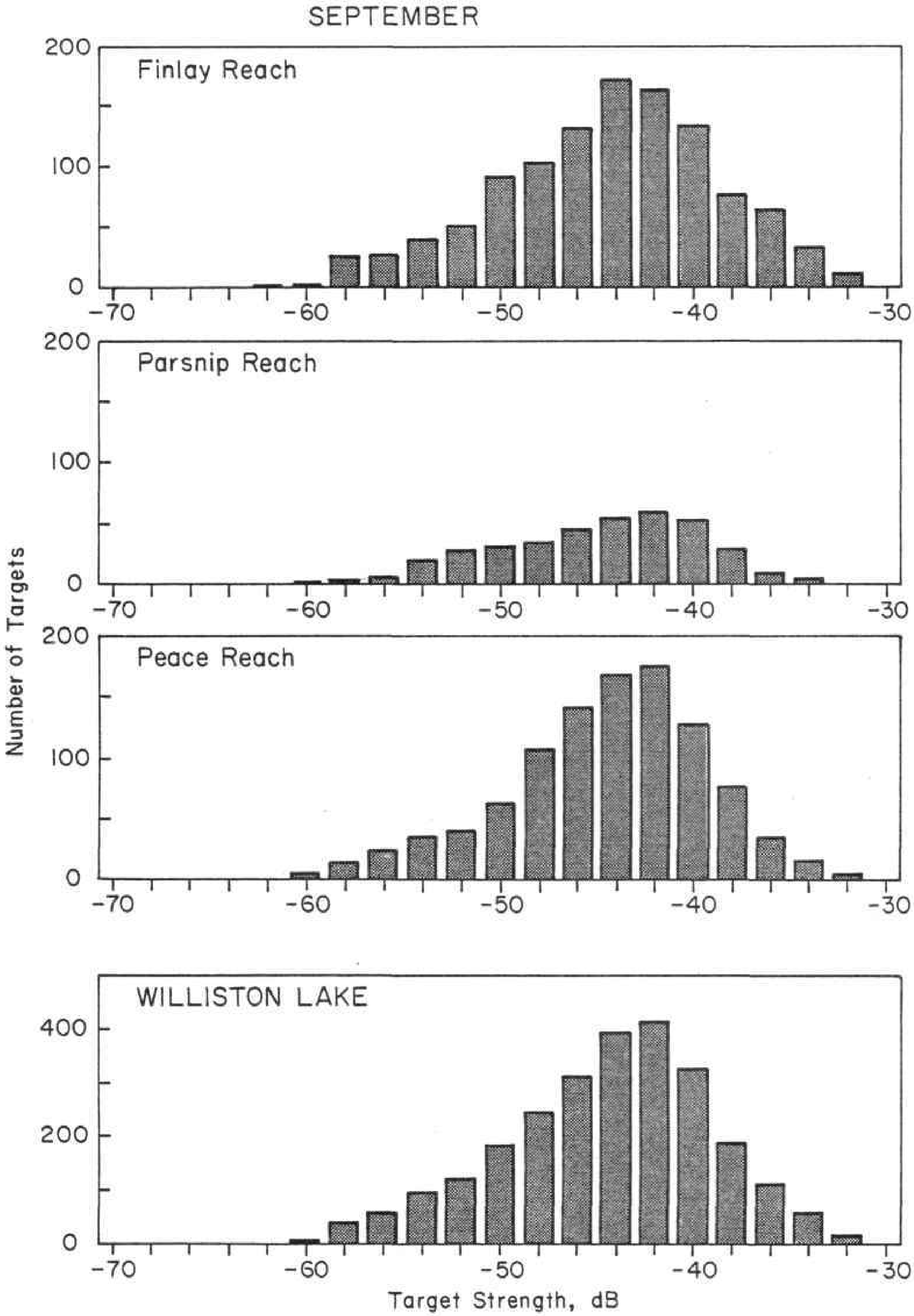

Figure 4. Acoustic size distribution for September 1988.

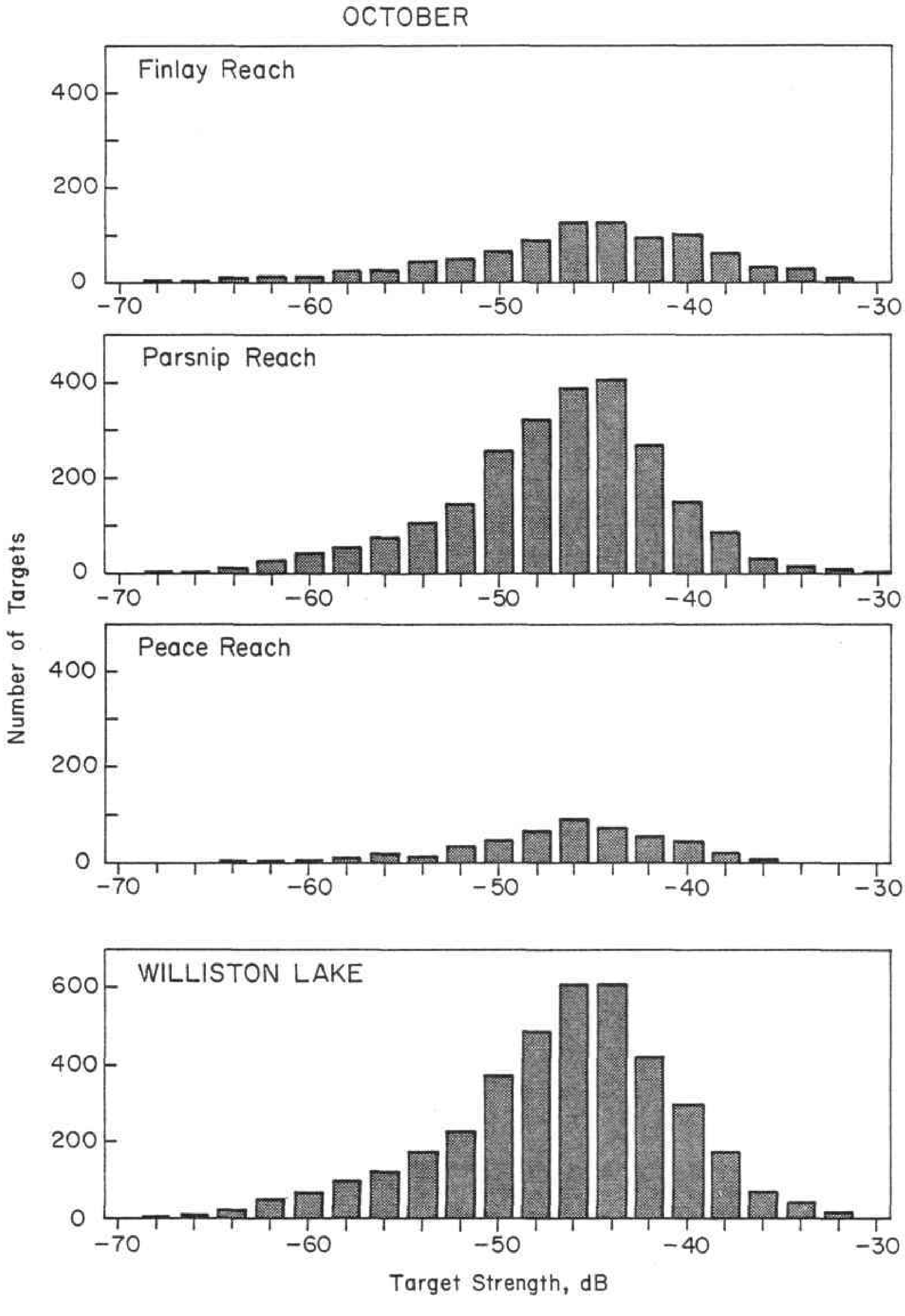

Figure 5. Acoustic size distribution for October 1988.

Target Strength vs Fish Length

The target strength data indicated that there was a substantial spread in fish sizes throughout Williston Lake during all three sample periods. Net sampling during the same periods was mostly limited to the larger fish, suggesting bias in the sampling gear (gill nets) as one might expect. It should be noted that the spread of the acoustic data is partially due to the characteristics of a non-uniform fish backscattering directivity pattern as noted in Burczynski and Johnson (1986). This results in a wide range of potential acoustic returns from a given fish depending on its orientation in the acoustic beam relative to the position of the transducer. The degree of this bias is not known, but, in examining the three surveys it is apparent that it is somewhat consistent. The largest source of bias arises from the physical sampling gear, particularly with respect to smaller fish.

Table 5 summarizes the average equivalent target strengths of fish converted from fish lengths taken in the gill net samples. The average equivalent target strength of sacrificed fish data supplied by MOE and Hydro was approximately -39 dB for all survey periods and all species sacrificed. The minimum size fish captured was 20 mm (-60.26 dB) and the maximum size fish was 850 mm (-30.30 dB). The average target strength from fish lengths proved to be larger than the average target strength determined from the dual beam acoustic data indicating that perhaps the nets were not capable of capturing the smaller fish in the lake. The one small fish captured (20 mm) appeared to be an isolated incident but did substantiate the presence of the smaller fish. Figure 6 shows the distribution of all net caught fish sizes converted to target strengths according to Love's (1977) equation in relation to acoustically estimated target strengths. Figure 7 compares the pelagic net samples converted to target strengths to the acoustically estimated target strengths. The net sampling bias is apparent according to this data.

Density Estimates and Population

The density and population estimates for each of the three surveys are tabulated in Appendices E1-E3. The population distribution is illustrated in Figure 8 for each of the three surveys and the population estimates for each transect are summarized in Table 6.

Table 5. Length and Equivalent Target Strength of Fish from Net surveys of Williston Lake, 1988 (Love, 1977).

DATE	REACH	NUMBER n	MEAN LENGTH mm	STD. DEV.	TS dB	STD. DEV.	MINIMUM LENGTH	MAXIMUM LENGTH	MINIMUM TS	MAXIMUM TS
June	Finley	462	298.63	89.02	-38.95	2.10	136	850	-44.94	-30.30
	Parsnip	272	364.32	91.67	-39.48	2.62	20	795	-60.26	-30.83
	Peace	403	273.91	79.60	-39.76	2.19	158	702	-43.74	-31.82
Williston Lake		1137	305.58	86.32	-39.36	2.26	20	850	-60.26	-30.30
Sept	Finley		no fish samples taken							
	Parsnip	82	268.88	80.64	-39.97	2.40	160	497	-43.64	-34.58
	Peace	406	268.82	63.14	-39.73	1.98	103	470	-47.16	-35.03
Williston Lake		488	268.83	66.08	-39.77	2.05	103	497	-47.16	-34.58
Oct	Finley	468	286.53	83.98	-39.47	1.63	125	750	-45.61	-33.92
	Parsnip	646	251.04	82.19	-40.41	2.31	152	840	-44.05	-30.39
	Peace	414	287.02	60.17	-39.19	1.64	157	630	-43.79	-35.03
Williston Lake		1528	271.66	76.77	-39.79	1.92	125	840	-45.61	-30.39

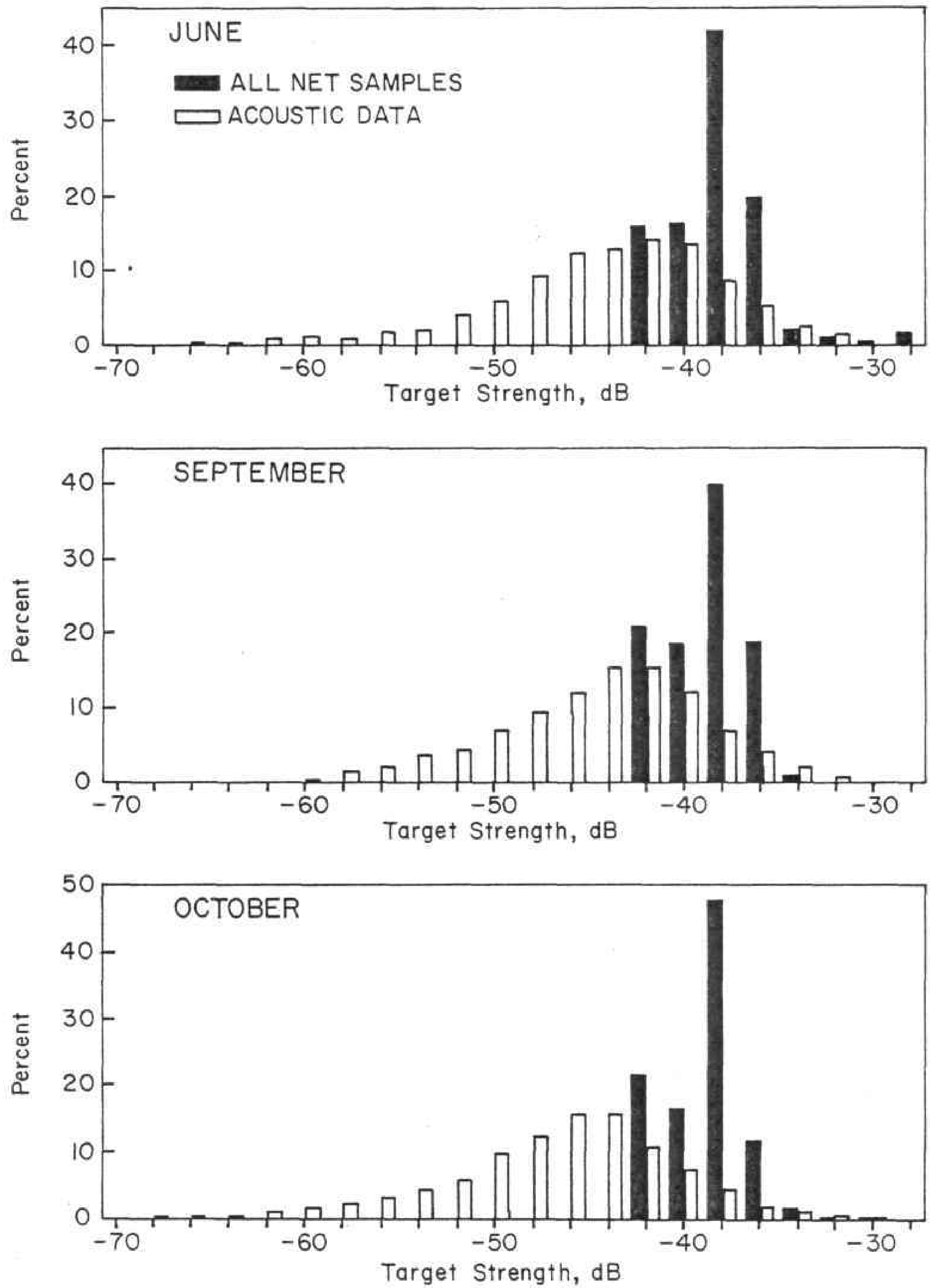

Figure 6. Comparison of fish size distributions from acoustic and all net samples.

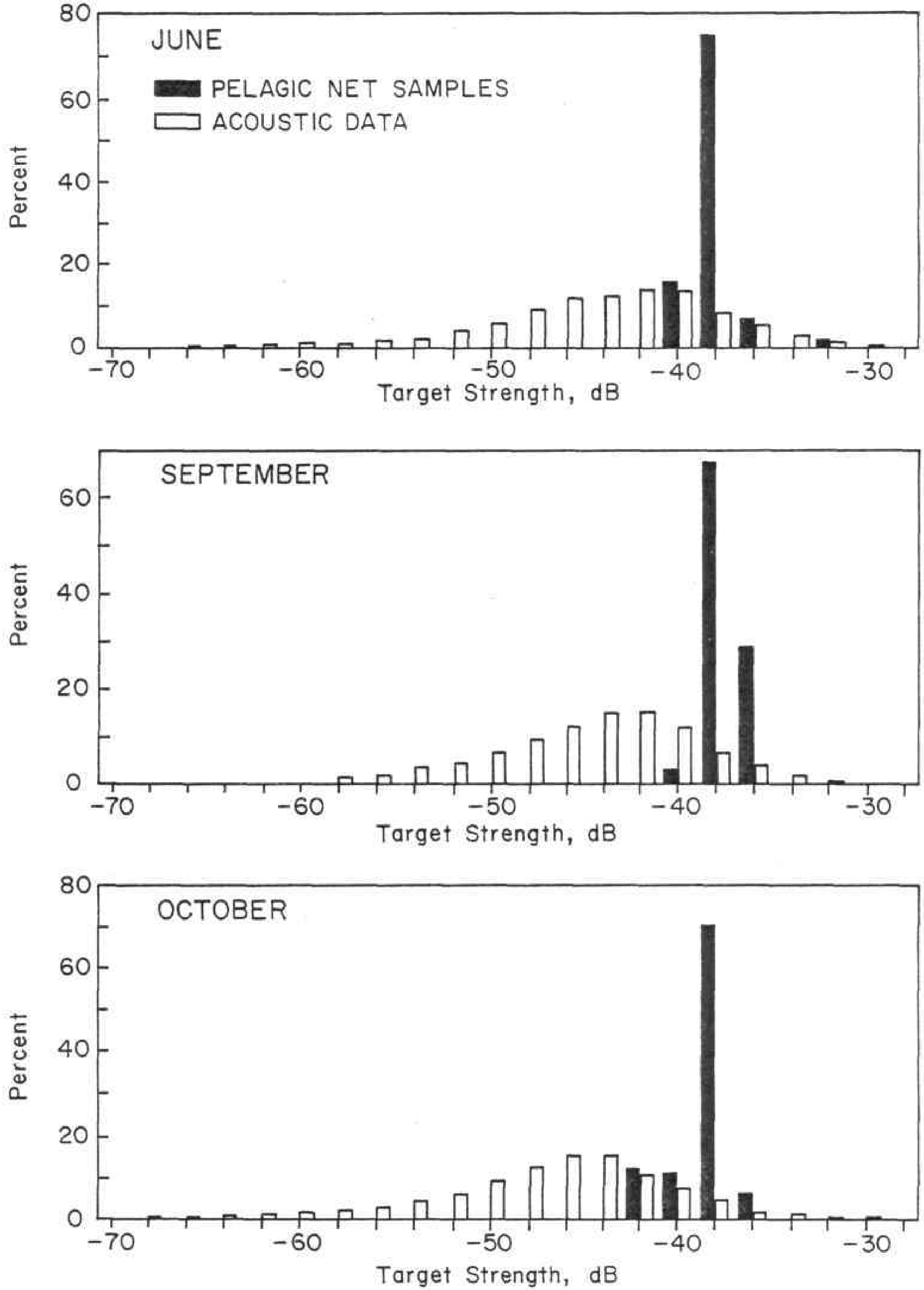

Figure 7. Comparison of fish size distributions from acoustic and pelagic net samples.

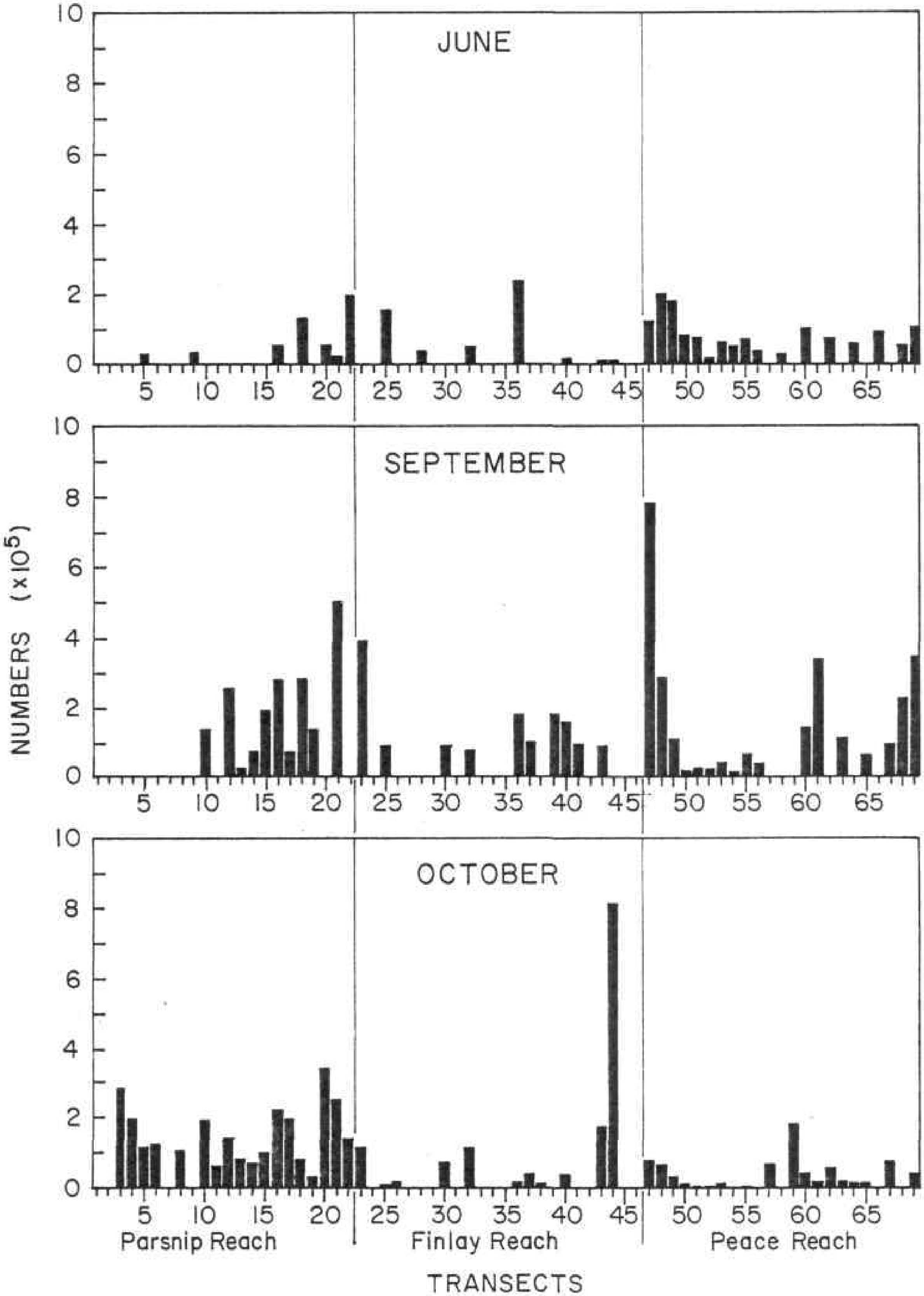

Figure 8. Fish population distribution for the June, September, and October surveys in 1988.

Table 6. Williston Lake fish populations for June, September, and October 1988 by transect.

Transect	June	Sept	Oct	Transect	June	Sept	Oct
1				35			
2				36	239458	179920	18075
3	0		287026	37		101152	46827
4			202645	38			13917
5	29870		119303	39		178631	
6			128344	40	19834	154012	41930
7				41		96911	
8			109807	42			
9	34615			43	8163	89230	182218
10	4992	137244	197298	44	12951		818843
11			66303	45	0		
12		254940	147459	46	0		
13		30647	88045	47	124786	780791	88107
14		75710	71739	48	197743	284223	73610
15		190244	105118	49	179612	107875	39408
16	58055	281622	229066	50	83931	21744	13286
17		74300	200837	51	76171	25673	10202
18	134553	284356	86139	52	15595	24238	10855
19		137151	37897	53	62858	45079	14326
20	57322		342384	54	51496	12863	5749
21	24374	507175	254876	55	71336	70371	6402
22	199103		148585	56	37999	46772	0
23		394035	122099	57			75669
24				58	29809	0	9132
25	160863	89862	13947	59			186041
26			23462	60	104464	141994	45842
27				61		339932	19930
28	39045			62	74268		60959
29				63		114684	25893
30		89217	79549	64	61054		20148
31				65		66075	17302
32	53938	78865	122038	66	86208		
33				67		98395	79429
34				68	52374	228422	
				69	98198	347662	41457

	June	Sept	Oct
NUMBER	35	38	50
% SAMPLED	51%	55%	72%
TOTAL	2.4850E+06	6.1820E+06	5.1495E+06
AVERAGE	7.1001E+04	1.6268E+05	1.0299E+05
STD. DEV.	6.1638E+04	1.5431E+05	1.3018E+05
VARIANCE	3.7992E+09	2.3813E+10	1.6946E+10
t(n-1)	2.0320E+00	2.0270E+00	2.0120E+00
95% CL	2.1171E+04	5.0742E+04	3.7041E+04
% CL	29.82%	31.19%	35.97%
ADJUSTED	4.8991E+06	1.1225E+07	7.1063E+06

The July survey was the least sampled of the three surveys, largely due to logistic challenges with the scheduled boats. During the subsequent two surveys, a subset of the total transect pattern was sampled at the discretion of the field supervisor. Thirty five of the sixty nine transects (51%) were sampled with a total population of 2.485E+06 fish estimated. The unweighted mean number of fish per transect was estimated at 7.100E+04 fish with 95% confidence limits on the mean of 2.117E+04 fish. Stratum fish densities ranged from 0 fish/cu. meter to 1.6691E-03 fish/cu meter. The highest density of fish was encountered on transect 49 (1.6378E-02 fish/cu. meter).

In September, the stratum densities ranged from 0 fish/cu. meter to 3.4731E-03 fish/cu. meter with the highest density found on transect 47. Thirty eight of the sixty nine transects (55%) were completed with continued problems with the boat and a decision to down scale the sampling effort by the field supervisor. A total of 6.182E+06 fish were estimated on the sampled transects. The unweighted mean number of fish per transect was estimated at 1.627E+05 fish with 95% confidence limits of 5.074E+04 fish. Larger numbers of targets were detected in all regions of the lake than in the previous survey.

In October, the number of transects sampled was highest with 50 of the 69 transects competed (72%). This resulted in a population of 5.150E+06 fish. The unweighted mean number of fish per transect was estimated at 1.030E+05 with 95% confidence limits of 3.701E+04 fish. Stratum densities ranged from 0 fish/cu. meter to 2.1319E-03 fish/cu. meter in October with the highest density found on transect 44.

Figure 9 illustrates the results of the extrapolation of the mean number of fish per transect area over the total number of transect areas on the lake. This is a rough estimate of total abundance since the extensive shallows and varying sample areas are not taken into consideration. It does, however, show the relative magnitude of the differences between the respective surveys.

Much of the variation in numbers over the three survey periods may have been related to the degree of light during the survey period. The early survey was run under conditions of almost continuous light conditions while the later surveys were run during hours of darkness. Trial transects during the October survey run during day, dusk and night indicated a substantial vertical response to the light conditions. It should be noted that only the night transects were used for population estimation. This would not account for the lower estimate in October, however, since this survey was conducted under maximum darkness conditions. There is insufficient data to suggest why the October population was lower than the September survey.

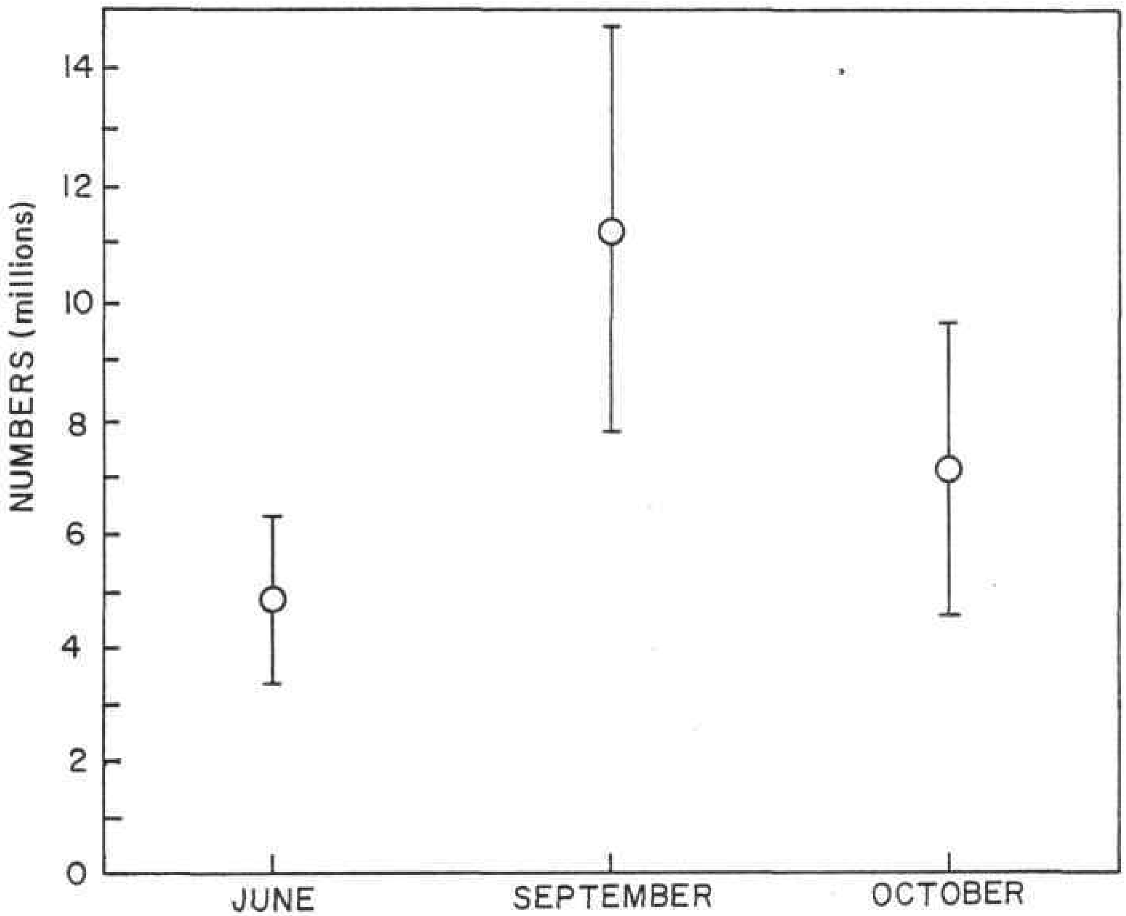

Figure 9. Unweighted extrapolated fish populations, with 95% confidence limits of the mean, for June, September, and October, 1988.

According to the acoustic data collected in 1988, it appears as though the best time for acoustic estimation of the pelagic fish population in Williston Lake is during the month of September and during hours of darkness, preferably between the last quarter of moon and the first quarter of moon to assure maximum possible darkness. Surveys should be conducted using a dedicated boat equipped with a midwater trawl to adequately sample the pelagic water column for smaller fish. Supplementary pelagic gillnet sampling would also be desirable to capture the larger fish. Since this data was collected, considerable improvements have been made to the Echo Signal Processor allowing it to accurately track bottom as well as tracking individual fish. The latter technique may be of value in evaluating the movement of littoral populations of fish in the many bays and inlets on Williston Lake.

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