TARGET STRENGTH MEASUREMENTS OF ADULT SALMON IN THE YENTNA RIVER, ALASKA

By: Kenneth E. Tarbox

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Regional Information Report[1] No. 2S91-3

Alaska Department of Fish and Game
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333 Raspberry Road
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[1]Contribution 91-3 from the Soldotna Area office. The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature.

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INTRODUCTION

In 1988, the Alaska Department of Fish and Game (ADF&G), Commercial Fisheries Division, Upper Cook Inlet (UCI) research staff prepared a five year research plan for the UCI area (Tarbox et al 1988). The plan recognized that the geographical size of UCI (Figure 1) and the biological complexity of the area combined to create unlimited opportunities for research. However, limited resources required a prioritization of effort. In the field of hydroacoustics, the staff noted that the precision and accuracy of the Bendix Corp. side scanning sonar adult salmon counters needed additional documentation of calibration parameters and counting threshold assumptions.

A series of unrelated events have since raised many of the same concerns regarding the accuracy of the Bendix counter. In 1987 and 1989, major oil spill events in UCI resulted in reduced commercial salmon fishing time. Litigation occurred between the fishing and oil industries and the state and an estimate of the number of salmon surplus to spawning needs which were not harvested became an important issue in those cases.

Suomala (1990) in a critical review of the Bendix counters indicated that "no tests of the minimum and in situ operational echo signal to noise parameters are documented" and " the source and variance of the assigned value of -38dB//4 m diameter sphere for typical sockeye salmon is not documented". While these statements are incorrect (Skvorc, ADF&G, Anchorage, personal communication, has measured target strengths of Kenai River sockeye salmon (*Onchorhynchus nerka*), and Ransom et al. 1986 has presented target strength information on salmon in the Susitna River) the need for additional site specific data regarding the target strength of species monitored remained. Therefore, in 1990 the UCI staff implemented a preliminary target strength investigation for adult salmon migrating in the Yentna River, Alaska. The primary purpose of this study was to assess whether the Bendix side scan sonar counter counting threshold was set low enough to enumerate all salmon species.

METHODS

A hydroacoustic investigation of adult sockeye salmon was conducted on the Yentna River, Alaska (Figure 1) on 31 July 1990. The sampling location was approximately 5 km above the confluence with the Susitna River at the existing Bendix Corp. side scanning south bank sonar site. The specific site was approximately 200 m downstream of the existing Bendix counter.

The hydroacoustic equipment used for data acquisition consisted of a BioSonics Inc. Model 105 echo sounder with dual beam receivers, a 420 Khz 6/15° degree dual beam transducer mounted on a nearshore tripod (within 2 m of shore), a Model 171 tape recorder interface, a Sony model SL-HF400 video cassette recorder, a digital audio processor, and an oscilloscope. The selected pulse width was 0.4 milliseconds (ms) and the pulse repetition rate was 5 pulses/second. Various gain and threshold settings were used in data collection and processing (Tables 1 - 4). Data sets have been referenced by tape number (1-4). The system was calibrated by Biosonics, Inc. following the surveys.

Dual beam data recorded on video cassette tape were processed using a Biosonics Inc. Model 181 dual beam processor (King and Tarbox 1988). A returning pulse was accepted as a single target if the pulse width was within approximately 20% of the transmitted pulse width at -6dB and -18dB. The maximum half angle selected was 4°. Since the signal to noise ratio decreased from shore, a counting threshold of -43.0 dB was used for the full counting range (10 m). In an effort to examine threshold effects tape 4 was re-examined (referred to as tape 4a) with the counting threshold reduced to -55.0 dB and the counting range limited to approximately 7 m.

Data generated by the dual beam processor were transferred to microcomputer data files for analysis using a Biosonics, Inc. software program (TS112 version 1.116). Computation of mean target strengths and backscattering cross sections were made from individual echoes and printed out in 1 m range intervals (beginning 1 m offshore of the transducer). Chi-square analysis was performed to test for differences in target strength distribution between tapes.

A fish wheel was operated approximately 1 km downstream of the counting site. The fishwheel was located approximately 4 m from shore. Basket dimensions were 1.6 x 1.6 m. All sockeye and pink salmon collected were counted and measured to the nearest mm (mid-eye to fork of tail). Length frequency plots were made for each species. When the fishwheel was operated for less than 24 hrs, the catch was expanded to reflect the catch for 24 hrs of operation.

RESULTS

Target strength data from all tapes were similar with means ranging from -32.0 to -32.4 dB (Tables 4 - 7). A pattern of larger targets offshore was evident in all data sets. Nearshore mean target strengths ranged from -35.0 to -33.7 dB. In contrast, 10 m mean target strengths ranged from -32.0 to -31.1 dB (Tables 4 - 7). Analysis of tape 4a indicated that target strength was even smaller targets nearshore with a mean at -38.2 dB (Table 8, Figure 2).

The distribution of targets was also similar for tapes 1 - 4 (Figure 3). A chi-square analysis indicated that no significant difference in target distribution existed among tapes (chi-square = 50.676, p = .05, df = 39).

The adjusted fish wheel catch for 31 July 1990 indicated that pink salmon were the predominate species (2647 fish, 76.6%), followed by sockeye salmon (562 fish, 16.3%), coho salmon (*O. kisutch*, 144 fish, 4.1%), and chum salmon (*O. keta*, 103 fish, 3.0%). Plots of length frequency indicated that there was a considerable overlap in size between small sockeye and pink salmon as well as between chum and large sockeye salmon (Figure 4). Lengths were not measured for coho salmon.

DISCUSSION

Mean target strengths collected for tapes 1 - 4 were within 3 dB of those reported by Ransom et al. (1986). They noted that the overall grand mean target strength for Susitna River salmon was -35.4 dB with individual sample period means ranging from -36.9 to -33.2 dB. Smaller targets were associated with periods during which numbers of pink salmon were increasing. The mean target strength from tape 4a (-34.8 Db) was even closer to that collected by Ransom et al. (1986).

While the salmon species composition was not known from shore, the increasing target strengths suggested that smaller fish (i.e pink salmon and age 1.2 sockeye salmon) traveled closer to shore with larger salmon (i.e. age 1.3 sockeye, coho, and chum salmon) further offshore. Tarbox (1986) suggested a similar pattern from gill net catches in the mainstem Susitna River. He noted that "smaller fish in an environment as demanding as the Susitna River probably migrate nearshore to avoid higher offshore current velocities".

As noted, the primary purpose of this study was to assess whether the Bendix side scan sonar counter counting threshold (when operated at design specifications) included most targets in the multi-species counting environment of the Susitna River. Results indicated that a portion of targets (up to 25% from tape 4a; Figure 2) would be below the Bendix counting threshold. Therefore, the Bendix Corp. side scanning system, when operated at design specification, probably undercounts pink salmon and smaller sockeye salmon in the Yentna River.

However, a number of other counter operational characteristics combine to reduce absolute counting error. The counter has been adjusted based on the results of visual monitoring of targets on an oscilloscope. This has allowed the operator to estimate the level of under-counting and to adjust the counter to over-count targets above threshold. The operator also has the flexibility to effectively reduce the counting threshold by increasing the transmit power.

In conclusion, operators of the Bendix system in multi-species systems (especially those with a high percentage of pink salmon) or in systems which have predominately small sockeye salmon should be aware of the potential for counting threshold limitations. The Bendix system counting logic and threshold settings should be re-evaluated and adjusted in these situations.

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Table 1. Calibration and processing parameters used in collection and analysis of Yentna River, Alaska, 1990 hydroacoustic data (Tape 1 and 2).

Sounder	Receiving sensitivity (dB/uPa@1m)	Channel 1	40 log R =	-166.00 dB
			20 log R =	-144.40 dB
		Channel 2	40 log R =	-166.70 dB
			20 log R =	-144.50 dB
	Source level (dB/uPa@1m)			217.30dB
	TVG Crossover			13.0 m
	Receiver gain			-6 dB
Transducer	Beam width	Narrow		6 degree
		Wide		15 degree
	Wide beam dropoff	"A" coefficient		1.614 dB
		"B" coefficient		0.500 dB
	Beam pattern factor	Average squared value	Narrow	.0009146
Dual beam processor	Correction multiplier	Narrow beam		1.000 (0dB)
		Wide beam		1.084 (dB)
	Threshold	Narrow beam		1200 mV (-43.7 dB)
		Wide beam		1200 mV (-43.0 dB)
		Bottom		8000 mV (-27.3 dB)
	Maximum half angle			4°
	Pulse width criteria	-18 dB	Maximum	.8801 mS
		-6 dB	Minimum	.2668 mS
		-6 dB	Maximum	.5336 mS
	Bottom window			1.0 meters
	Start depth			1.0 meters

Table 2. Calibration and processing parameters used in collection and analysis of Yentna River, Alaska, 1990 hydroacoustic data (Tape 3 and 4).

Sounder	Receiving sensitivity (dB/uPa@1m)	Channel 1	40 log R =	-166.00 dB
			20 log R =	-144.40 dB
		Channel 2	40 log R =	-166.70 dB
			20 log R =	-144.50 dB
	Source level (dB/uPa@1m)			217.30dB
	TVG Crossover			13.0 m
	Receiver gain			-12 dB
Transducer	Beam width	Narrow		6 degree
		Wide		15 degree
	Wide beam dropoff	"A" coefficient		1.614 dB
		"B" coefficient		0.500 dB
	Beam pattern factor	Average squared value	Narrow	.0009146
Dual beam processor	Correction multiplier	Narrow beam		1.000 (0dB)
		Wide beam		1.084 (dB)
	Threshold	Narrow beam		600 mV (-43.7 dB)
		Wide beam		600 mV (-43.0 dB)
		Bottom		5000 mV (-25.4 dB)
	Maximum half angle			4°
	Pulse width criteria	-18 dB	Maximum	.9478 mS
		-6 dB	Minimum	.2668 mS
		-6 dB	Maximum	.5336 mS
	Bottom window			1.0 meters
	Start depth			1.0 meters

Table 3. Calibration and processing parameters used in collection and analysis of Yentna River, Alaska, 1990 hydroacoustic data (Tape 4A).

Sounder	Receiving sensitivity (dB/uPa@1m)	Channel 1	40 log R =	-166.00 dB
			20 log R =	-144.40 dB
		Channel 2	40 log R =	-166.70 dB
			20 log R =	-144.50 dB
	Source level (dB/uPa@1m)			217.30dB
	TVG Crossover			13.0 m
	Receiver gain			-6 dB
Transducer	Beam width	Narrow		6 degree
		Wide		15 degree
	Wide beam dropoff	"A" coefficient		1.614 dB
		"B" coefficient		0.500 dB
	Beam pattern factor	Average squared value	Narrow	.0009146
Dual beam processor	Correction multiplier	Narrow beam		1.000 (0dB)
		Wide beam		1.084 (dB)
	Threshold	Narrow beam		300 mV (-55.8 dB)
		Wide beam		300 mV (-55.0 dB)
		Bottom		5000 mV (-25.4 dB)
	Maximum half angle			4°
	Pulse width criteria	-18 dB	Maximum	.9478 mS
		-6 dB	Minimum	.2668 mS
		-6 dB	Maximum	.5336 mS
	Bottom window			1.0 meters
	Start depth			1.0 meters

Table 4. Average backscattering cross section (sigma) and target strength data by range strata for Tape 1, Yentna River, Alaska, 1990.

Range Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strength Mean (dB)	Target Strength Standard Deviation (dB)
1.0 - 2.0	100	.6085E-03	.6688E-03	-34.56	4.77
2.0 - 3.0	177	.6505E-03	.1039E-02	-34.57	4.62
3.0 - 4.0	185	.9785E-03	.1217E-02	-32.74	4.91
4.0 - 5.0	297	.1139E-02	.1318E-02	-31.65	4.57
5.0 - 6.0	200	.9191E-03	.9783E-03	-32.39	4.29
6.0 - 7.0	226	.1272E-02	.1517E-02	-31.30	4.64
7.0 - 8.0	227	.1464E-02	.1582E-02	-30.34	4.31
8.0 - 9.0	182	.1343E-02	.1524E-02	-31.29	5.02
9.0 - 10.0	99	.1237E-02	.1487E-02	-31.45	4.61
Total	1696	.1105E-02	.1345E-02	-32.05	4.80

[a] Target strength determined from dual beam data collected in situ.

Table 5. Average backscattering cross section (sigma) and target strength data by range strata for Tape 2, Yentna River, Alaska, 1990.

Range Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strength Mean (dB)	Target Strength Standard Deviation (dB)
1.0 - 2.0	152	.6171E-03	.8320E-03	-34.67	4.56
2.0 - 3.0	247	.8179E-03	.1125E-02	-33.44	4.81
3.0 - 4.0	196	.8902E-03	.1607E-02	-33.44	4.77
4.0 - 5.0	381	.1033E-02	.1323E-02	-32.35	4.72
5.0 - 6.0	246	.9397E-03	.9785E-03	-32.11	4.08
6.0 - 7.0	320	.1180E-02	.1334E-02	-31.66	4.73
7.0 - 8.0	289	.1446E-02	.1826E-02	-30.77	4.57
8.0 - 9.0	225	.1166E-02	.1191E-02	-31.45	4.54
9.0 - 10.0	162	.1347E-02	.1600E-02	-31.05	4.63
Total	2223	.1071E-02	.1376E-02	-32.20	4.74

[a] Target strength determined from dual beam data collected in situ.

Table 6. Average backscattering cross section (sigma) and target strength data by range strata for Tape 3, Yentna River, Alaska, 1990.

Range Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strength Mean (dB)	Target Strength Standard Deviation (dB)
1.0 - 2.0	103	.5871E-03	.6396E-03	-34.38	4.30
2.0 - 3.0	179	.7906E-03	.1229E-02	-33.73	4.67
3.0 - 4.0	214	.1063E-03	.1573E-02	-32.37	4.71
4.0 - 5.0	314	.1106E-02	.1391E-02	-32.02	4.72
5.0 - 6.0	245	.9472E-03	.1013E-02	-32.27	4.35
6.0 - 7.0	363	.1267E-02	.1740E-02	-31.52	4.63
7.0 - 8.0	395	.1164E-02	.1380E-02	-31.51	4.38
8.0 - 9.0	359	.1271E-02	.2165E-02	-31.17	4.23
9.0 - 10.0	146	.9936E-03	.1200E-02	-31.99	4.16
Total	2324	.1093E-02	.1541E-02	-32.01	4.55

[a] Target strength determined from dual beam data collected in situ.

Table 7. Average backscattering cross section (sigma) and target strength data by range strata for Tape 4, Yentna River, Alaska, 1990.

Range Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strength Mean (dB)	Target Strength Standard Deviation (dB)
1.0 - 2.0	69	.4733E-03	.5042E-03	-35.01	3.96
2.0 - 3.0	57	.4880E-03	.5248E-03	-35.04	4.19
3.0 - 4.0	89	.7263E-03	.7433E-03	-33.52	4.44
4.0 - 5.0	103	.9076E-03	.1144E-02	-33.02	4.81
5.0 - 6.0	136	.1079E-02	.1590E-02	-32.14	4.53
6.0 - 7.0	216	.1212E-02	.1419E-02	-31.64	4.78
7.0 - 8.0	132	.1433E-02	.1499E-02	-30.68	4.62
8.0 - 9.0	156	.1153E-02	.1535E-02	-31.98	4.87
9.0 - 10.0	71	.1104E-02	.1279E-02	-31.63	4.16
Total	1030	.1043E-02	.1338E-02	-32.35	4.74

[a] Target strength determined from dual beam data collected in situ.

Table 8. Average backscattering cross section (sigma) and target strength data by range strata for Tape 4a, Yentna River, Alaska, 1990.

Range Stratum (m)	Number of Targets	Sigma Mean	Sigma Standard Deviation	Target[a] Strength Mean (dB)	Target Strength Standard Deviation (dB)
1.0 - 2.0	169	.2844E-03	.3846E-03	-38.15	4.85
2.0 - 3.0	164	.3263E-03	.4865E-03	-37.73	4.95
3.0 - 4.0	139	.7982E-03	.1485E-03	-34.78	5.64
4.0 - 5.0	167	.8995E-03	.1208E-02	-33.57	5.48
5.0 - 6.0	201	.9567E-03	.1276E-02	-33.03	5.12
6.0 - 7.0	186	.1125E-02	.1266E-02	-32.11	5.26
Total	1026	.7449E-03	.1142E-02	-34.78	5.69

[a] Target strength determined from dual beam data collected in situ.

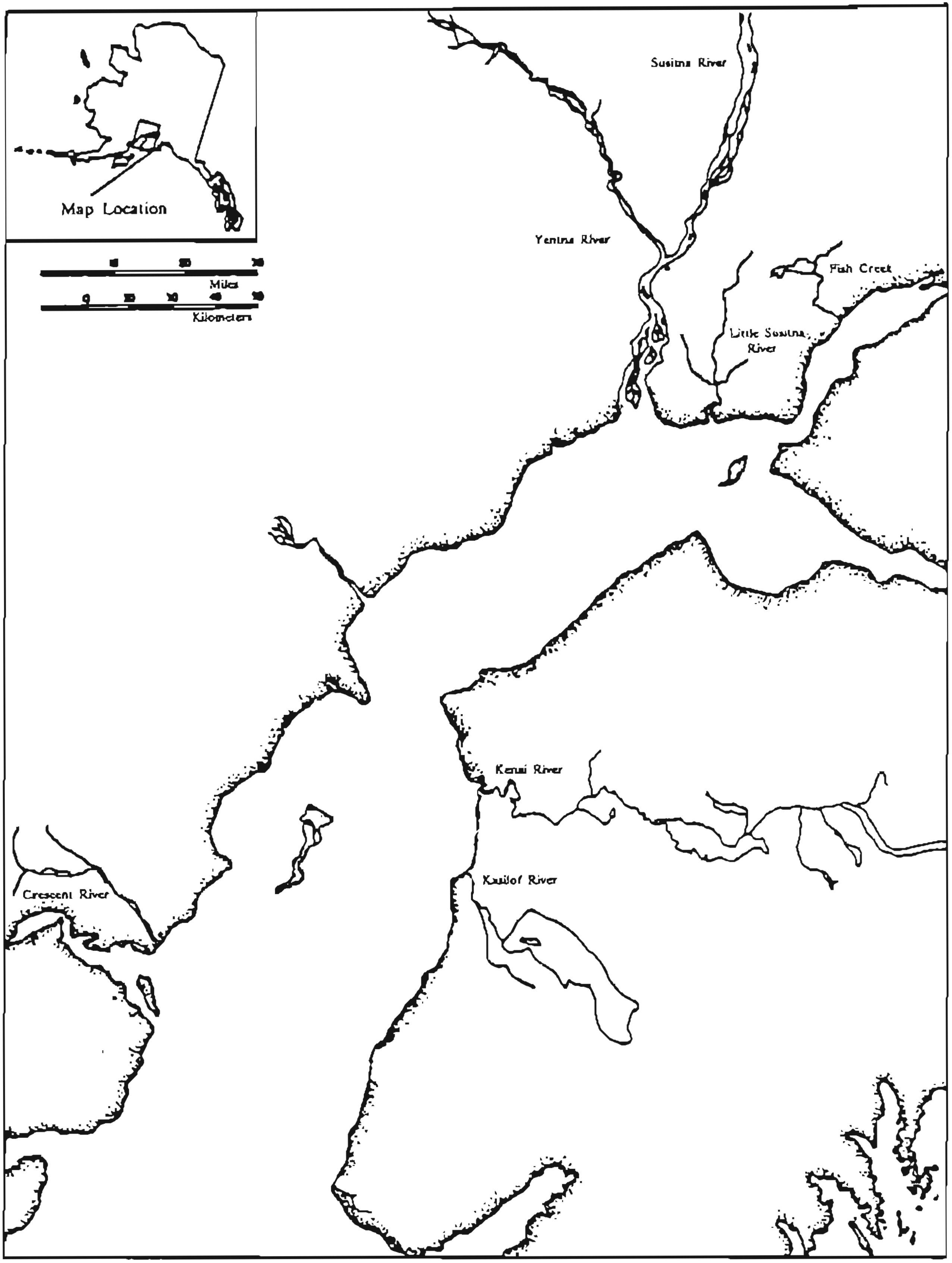

Figure 1. The Upper Cook Inlet area showing the locations of the major sockeye salmon spawning drainages.

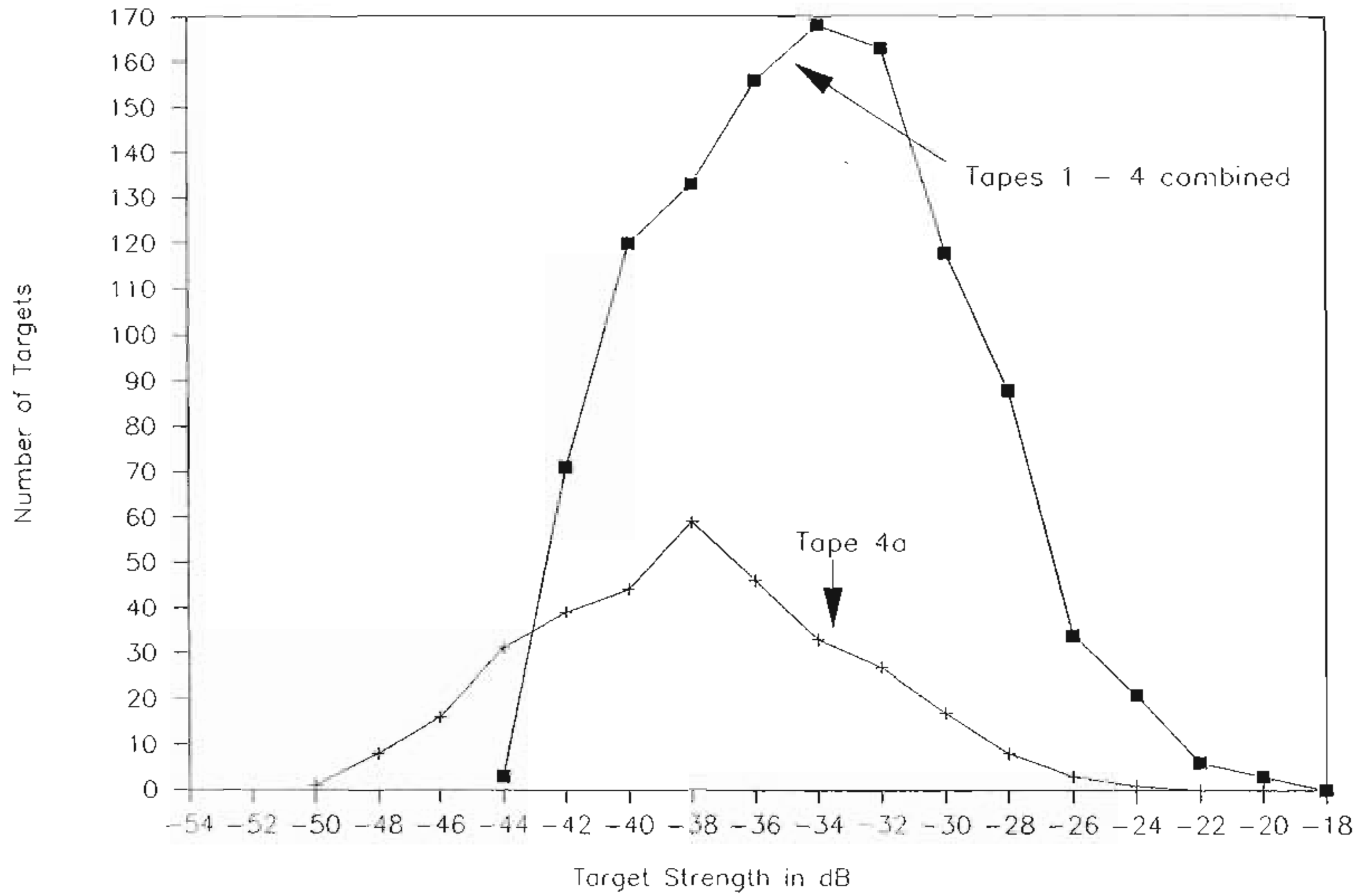

Figure 2. Target strength of salmon measured between one and three meters from the transducer in the Yentna River, Alaska (31 July, 1990)

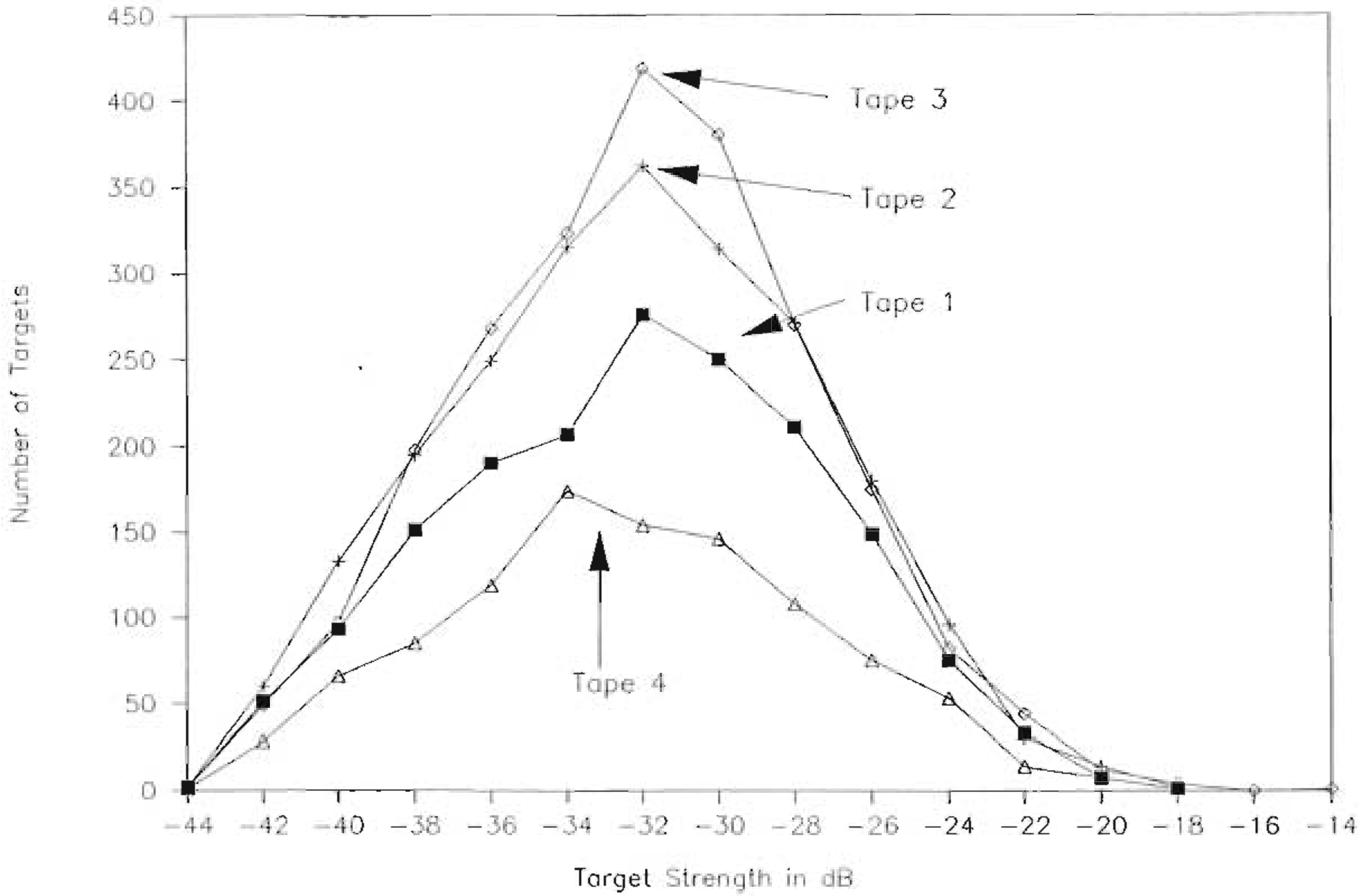

Figure 3. Target strength of salmon measured between one and ten meters from the transducer in the Yentna River, Alaska (31 July 1990).

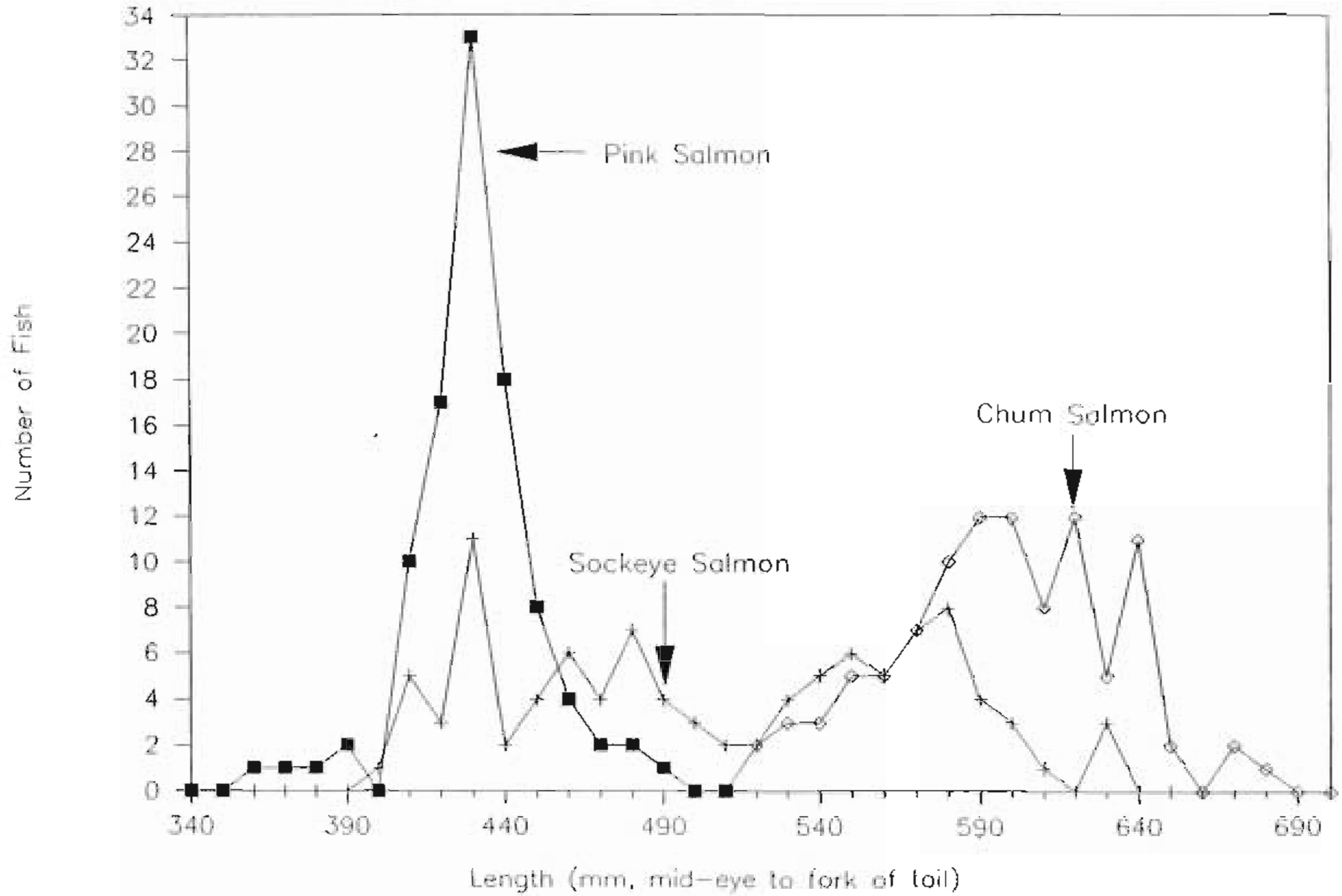

Figure 4. Length frequency of salmon collected in the Yentna River, Alaska on 31 July and 1 August, 1990.