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ACOUSTIC ASSESSMENT OF HERRING STOCKS IN SOUTHEASTERN ALASKA

By

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INTRODUCTION

Acoustic techniques developed under the University of Washington Sea Grant Marine Acoustics Program have been applied to the assessment of herring stocks in Southeastern Alaska since 1971 by the Fisheries Research Institute under contract with the Alaska Department of Fish and Game (ADF&G). The development of the acoustic system for ADF&G and its initial applications are described in earlier contract reports (Thorne, 1971, 1972), and the results of surveys during the third contract year in this report.

EQUIPMENT

The basic data acquisition system is described in the 1971 contract report. Additions to the system are described in the 1972 contract report. The general data acquisition system is also described in Thorne, Nunnallee, and Green, 1972.

SURVEY TECHNIQUE

After routine maintenance in Seattle, the data acquisition system was transported to Ketchikan and reinstalled aboard the M. V. *Kittiwake*. Stocks were surveyed by ADF&G personnel at various locations in Southeastern Alaska between November 15, 1972 and March 16, 1973. The survey procedure consisted of zigzag transects over various areas with echo sounder and tape recorder operating, both day and night. Several replications were made in various areas, particularly Carroll Inlet. A total of 50 hr of acoustic data was collected on magnetic tape.

DATA ANALYSIS

Basic data analysis procedures are described in the 1971 contract report. Densities of herring in various schools were determined from visual estimation of the amplitudes of echoes from an oscilloscope (CRT). The volume occupied by schools was obtained from school dimensions measured from either the CRT or the echogram. The relationship between amplitude and density of herring was determined by target strength measurements in 1972. Several of the series of runs were independently analyzed by different individuals for evaluation of the variability associated with the amplitude estimates obtained with the CRT. In addition, a number of series were analyzed with the digital echo integration system, (DDAPS), described in Moose, Ehrenberg, and Green (1971) and Thorne (in press). The DDAPS precisely measures the squared echo amplitude.

RESULTS

The results of analysis of the ten runs conducted in Carroll Inlet in December 1972 and the five runs made in February 1973 are given in Table 1. Population estimates from the survey in February were greater than in December, indicating recruitment to the area in the interval between the two series; but the biomass in February 1973 was still less than the biomass in previous years. Comparison of the results of the February series, 1973 with those of the series in 1971 and 1972 processed by CRT with the same processor is made in Table 2. The 1971 series was a very limited survey, consisting of only two runs across the school, and the result may be an overestimate; nevertheless, a decreasing population over the three years is clearly indicated.

Seven of the runs during December 1972 were analyzed by DDAPS and by two CRT processors. One processor consistently overestimated amplitude by about 40%; the result was an overestimation of density by a factor of two. The second processor overestimated daytime densities but not the night time densities. Population estimates from night series were lower than those from day series even when analyzed by DDAPS, indicating movement outside the survey boundaries at night.

The results of surveys in other locations are given in Table 3. Twelve surveys were made in the vicinity of Deer Island between November 15, 1972 and February 13, 1973. Populations were much less than those encountered in this location during the previous year. Extreme difficulties were encountered in CRT processing because of irregularity of schools. During afternoon fish were very near or on the bottom, and at night in shallow water near the bottom. The highest estimate (7.32 million lbs) was obtained by DDAPS processing of the data from irregular schools at mid-depth in early morning.

The results of surveys in Katlian Bay on November 18-21, 1972 were comparable to the results obtained in the previous year, but few herring were encountered in the area in surveys one week later.

The largest population was encountered in Bocas de Finas, December 2-3, 1972; it is estimated from the four surveys to have been between 15.6 and 36.4 million lbs.

A further comparison of the CRT and DDAPS processing was made on the Auke Bay surveys March 13 and 16, 1973, and illustrated the problems associated with the CRT technique although mean estimates from the three series for the two processes were similar (3.58 million lbs on the CRT, 3.32 million lbs on DDAPS). The CRT technique consistently resulted in overestimates of density during the daytime survey on March 13, when schools were near bottom (Fig. 1). In contrast, during the March 16 survey, when the fish were off bottom and slightly dispersed but still in well-defined schools, there was slight underestimation by the CRT technique (Fig. 2). During the second run on March 13, conducted about dusk, fish distribution ranged from high-density, well-defined schools at the beginning of the survey to large, irregular, dispersed schools near the end; and the former were overestimated whereas the latter were considerably underestimated (Fig. 3). As a consequence, the

Table 1. Summary of data from Carroll Inlet surveys

Date	Run	Time	Volume ($10^6 m^3$)	Density (lbs/m^3)	Biomass (10^6 lbs)	Processor	Comments
12/13/72	1	1400-1414	1.33	2.35	3.1	RT-CRT	Single school crossing
	1	1400-1414	1.10	1.63	1.8	JD-CRT	
	1	1400-1414	-	-	1.4	DDAPS	
	2	1419-1442	0.57	2.28	1.3	RT-CRT	Single school crossing
	2	1419-1442	0.54	2.00	1.1	JD-CRT	
	2	1419-1442	-	-	0.63	DDAPS	
	3	1445-1508	0.36	2.70	0.97	RT-CRT	Single school crossing
	3	1445-1508	0.33	1.50	0.50	JD-CRT	
	3	1445-1508	-	-	0.30	DDAPS	
	5	1731-1807	2.80	0.24	0.68	RT-CRT	One crossing; school rising along bottom and dispersing
	5	1731-1807	2.80	0.16	0.45	JD-CRT	
	5	1731-1807	-	-	0.41	DDAPS	
	6	1818-1840	6.10	0.22	1.32	RT-CRT	Two crossings; shoreward bias
	6	1818-1840	7.30	0.12	0.85	JD-CRT	
	6	1818-1840	-	-	0.82	DDAPS	
	7	1847-1918	2.29	0.19	0.44	RT-CRT	School breaking up
	7	1847-1918	2.15	0.12	0.25	JD-CRT	
	7	1847-1918	0	0	0.25	DDAPS	
12/14/72	9	2139-2221	2.15	0.24	0.52	RT-CRT	Two schools; shoreward bias
	9	2139-2221	2.53	0.12	0.32	JD-CRT	
	9	2139-2221	0	0	0.33	DDAPS	
	10	2243-2259	1.75	0.019	0.033	TC-CRT	Spit Point school only; dispersed and in shallow water
	11	2304-2326	0.66	0.027	0.018	TC-CRT	
	12	2333-2402	1.94	0.124	0.241	TC-CRT	
2/1/73	1	1508-1545	0.94	1.04	0.98	TC-CRT	On bottom
	2	1553-1616	2.6	1.7	4.5	TC	Near bottom
	2	1553-1616	3.2	2.6	8.4	RT	Near bottom
	3	1620-1633	2.7	2.6	7.2	RT	Near bottom
	4	1639-1715	4.3	2.4	10.3	RT	Coming off bottom
	5	1749-1808	6.0	0.63	3.8	RT	Off bottom, dispersing

Table 2. Estimates of density, volume, and total abundance of herring schools in Carroll Inlet from various transect series during winter 1971-1973

Series			Density, fish/m^3	Volume, $10^6 m^3$	Population, 10^6 fish
Date	Time	Run			
2/15/71	Day	1	9.4	34.5	324
		2	8.6	7.4	64
	mean		9.0	21.0	194
1/16-1/20/72	Day	1	7.9	6.8	54
		2	8.9	6.9	61
		3	15.4	4.2	65
		4	9.3	5.4	50
		5	10.5	5.2	55
	Night	1	0.6	41.2	25
		2	0.04	39.7	1.6
		3	0.012	299	3.6
		4	1.0	11.2	11
		5	0.8	19.1	16
	Dusk	1	4.9	12.0	59
		2	3.6	9.5	34
	Day mean		10.4	5.7	57
Relative error of daytime observations (percent)			28.3	20.0	10.3
	Nighttime mean		0.5	82.0	11.4
Relative error or nighttime observations (percent)			91.5	148	82.3
2/1/73	Night		2.5	6.0	15
	Day	1	10.4	3.2	33
		2	10.4	2.7	28
		3	9.6	4.3	41
	Daytime mean		10.1	3.4	34
Relative error of daytime observations (percent)			4.6	24.1	18.3

Table 3. Summary of data from surveys other than in Carroll Inlet

Location	Date	Run	Time	Volume ($10^6 m^3$)	Density (lbs/m^3)	Biomass (10^6 lbs)	Processor	Comments
Deer Island	11/15/72	1	Night					Short pulse - not analyzed
		2	Night	3.75	0.15	0.57	RT	Shallow water
		3	Night	8.21	0.32	2.63	RT	Shallow water
		4		4.95	0.31	1.56	RT	Shallow water
	11/16/72	1	Early	-	-	-		No herring
		2	morning	-	-	7.32	DDAPS	Irregular schools
	12/5/72	1	Night	4.07	0.15	0.61	RT	Shallow; single crossing
	1/30/73	1	Day	-	0	0	RT	Schools saturating and on bottom
		2	Night	11.08	0.10	1.14	RT	Near bottom, shallow, dispersed
		3	Night	-	-	0.38	DDAPS	
	2/13/73	1	Night	4.29	0.47	2.03	TC	Close to beach; dispersed irregular schools
		2	Night	3.55	0.09	0.33	TC	
Anita Bay	11/16/72	1	Day	-	-	0.36	DDAPS	Fish near bottom
Skowl Bay	11/16/72	1	Night	-	-	0.14	RT	Fish near bottom
	2/28/73	1	Night	-	-	0.13	DDAPS	
		2	Night	-	-	0.03	DDAPS	
Katlan Bay	11/18-21/72	1	Day	7.76	1.4	11.0	RT	
		2	Day	8.12	2.5	20.0	RT	
		3	Day	7.56	0.9	6.8	RT	
		4	Day	9.14	1.2	11.2	RT	
		5	Day	-	-	-		Not analyzed - no echogram
	11/27/72	1	Night	0.41	0.49	0.19	TC	Irregular schools; very few encountered
	11/28/72	1	Day	1.66	0.70	1.17	TC	Near bottom; much less school volume than in earlier surveys

Table 3. Summary of data from surveys other than in Carroll Inlet - Continued

Location	Date	Run	Time	Volume ($10^6 m^3$)	Density (lbs/m^3)	Biomass (10^6 lbs)	Processor	Comments
Bocas de Finas	12/2-3/72 1	1	Day	21.71	0.72	15.6	JD	
		2	Day	30.84	1.18	36.4	JD	
		3	Day	29.88	1.12	33.57	JD	
		4	Day	34.06	0.69	23.40	JD	
Lisianski Inlet	1/20/73	1	Day	0.59	0.63	0.37	RT	
		2	Day	0.66	0.73	0.48	TL	
		3	Day	0.21	0.52	0.11	TL	
Ward Cove	2/3/73	1	Day	-	-	-		Fish hard on bottom
	2/7/73	1	Night	-	-	0.05	DDAPS	Fish very dispersed
Auke Bay	3/13/73	1	1637-1810	2.87	2.06	5.90	TC-CRT	High density, near bottom
		1	1637-1810	-	-	2.62	DDAPS	
		2	1842-1959	7.75	0.17	1.33	TC-CRT	Off bottom; dispersing
		2	1842-1959	-	-	3.26	DDAPS	
	3/16/73	1	1917-2019	9.92	0.35	3.51	TC-CRT	
		1	1917-2019	-	-	4.08	DDAPS	

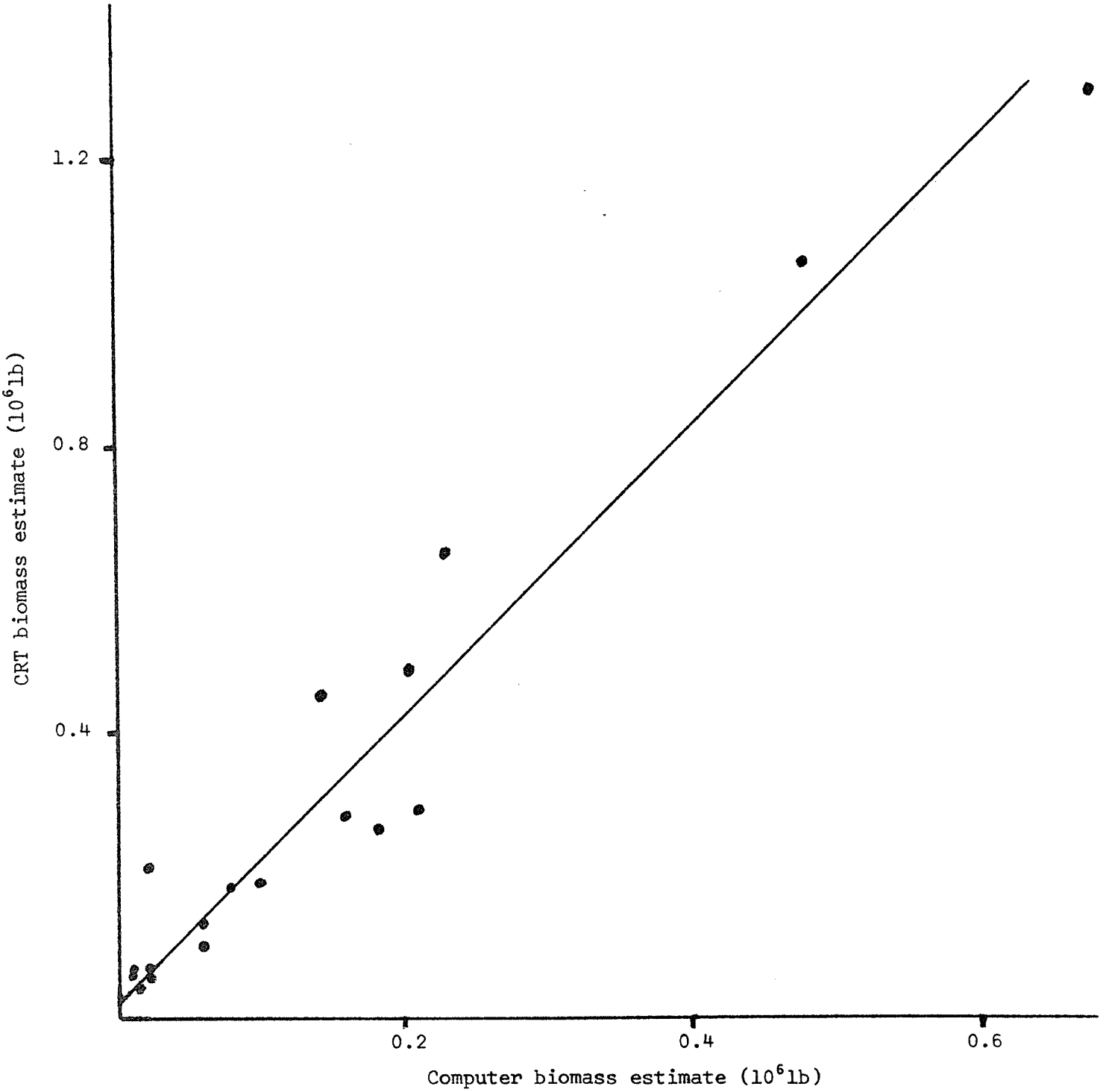

Fig. 1. Comparison of biomass estimates from CRT and DDAPS for various schools encountered during the first survey of Auke Bay on March 13, 1973.

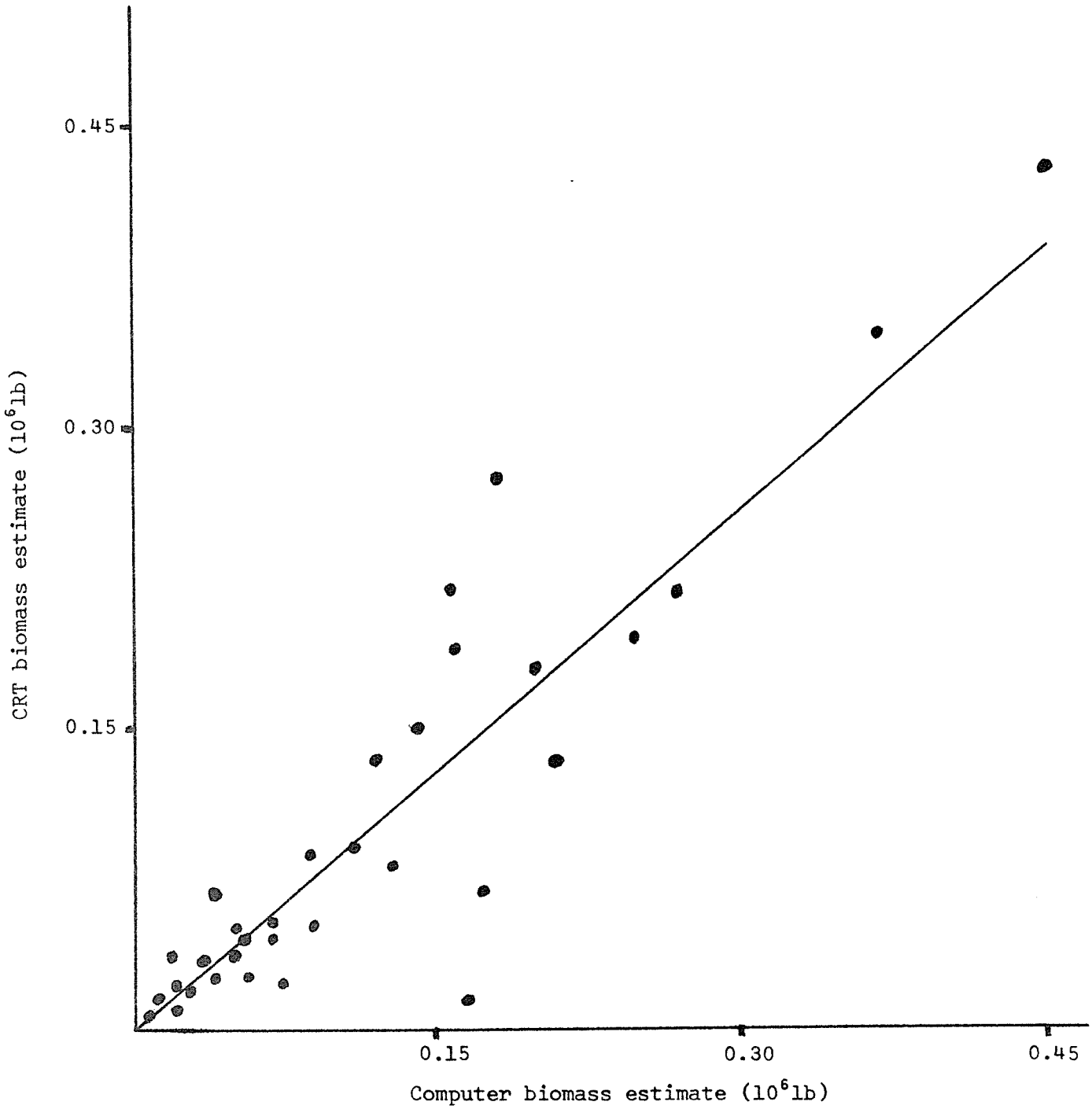

Fig. 2. Comparison of biomass estimates from CRT and DDAPS for various schools encountered during survey of Auke Bay on March 16, 1973.

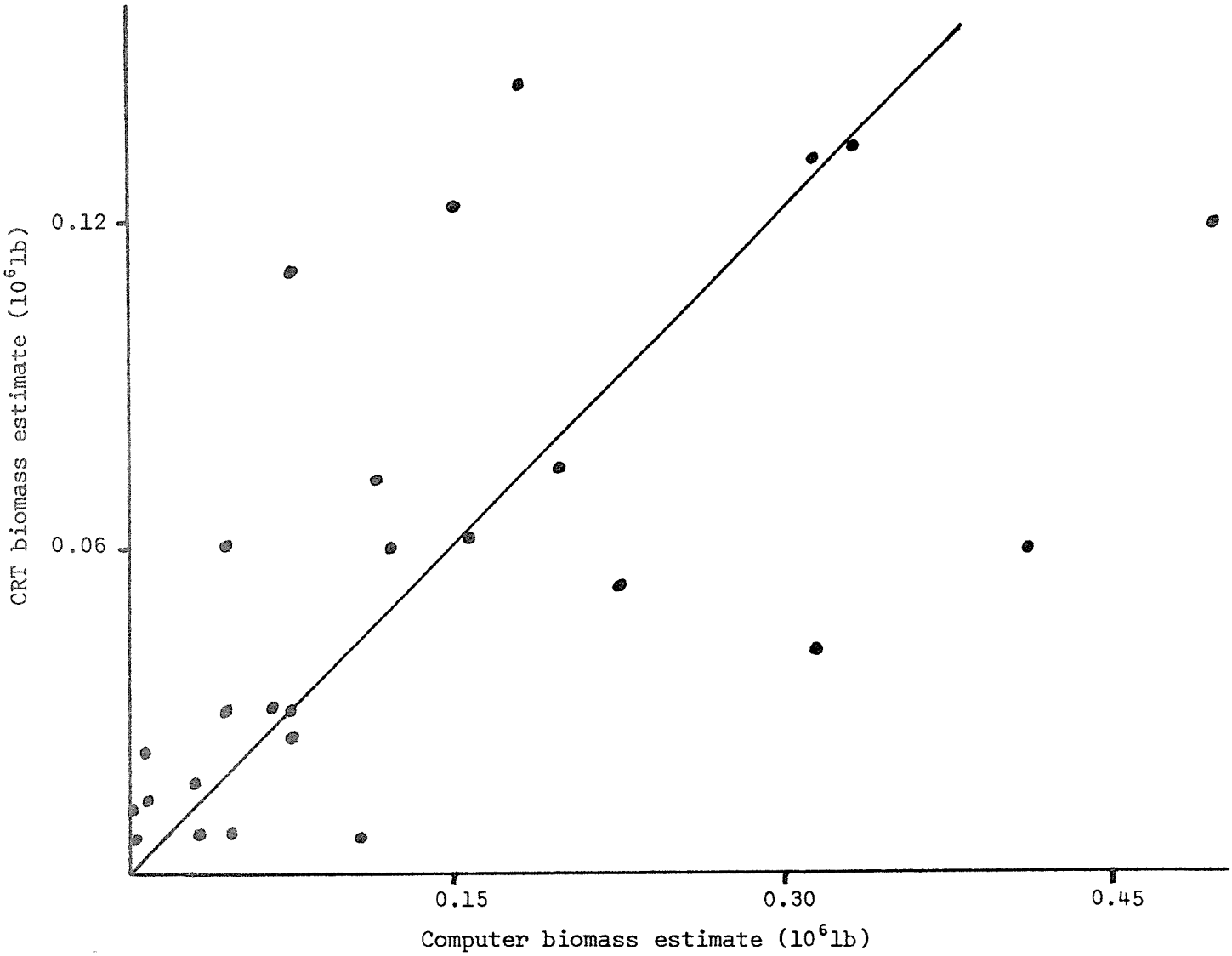

Fig. 3. Comparison of biomass estimates from CRT and DDAPS for various schools encountered during the second survey of Auke Bay on March 13, 1973.

population was underestimated and data on individual schools were poorly correlated between the two methods.

DISCUSSION

One of the potential advantages of the use of acoustic stock assessment techniques is procurement of timely estimates by management. However, historical survey data can provide valuable additional information, particularly when only relative estimates are obtained. When absolute estimates are obtained, historical data can provide the insight needed for accurate decisions to be made, especially if mortality rates may not be well defined. During the past year acoustic estimates were obtained for the third year in Carroll Inlet and for the second year in many other locations so that several annual estimates can be compared. In such comparisons consideration must be taken of variance components from survey and analysis procedures; consequently, the CRT technique for measuring echo amplitude as well as the effects of diel changes in distribution were critically examined. The CRT was initially applied to acoustic assessment of herring stocks in Alaska because of its speed and convenience combined with an indication of the distribution of herring in large, well-defined schools. Comparison of the results of the CRT technique with the more precise measurements of squared amplitude obtained through the DDAPS indicates a fairly consistent 25-50% overestimation of echo amplitude from daytime schools and thus an overestimation of density by about a factor of two. The consistency of the technique does lead to the procurement of a valuable relative index. For example, estimated mean density in Carroll Inlet during daytime in all three years was nearly constant, ranging from 9.0 to 10.4 fish/m^3, but school volume decreased considerably. Extreme difficulties were encountered with the CRT technique under night conditions, when fish were not distributed in regular, well-defined schools. Estimates of echo amplitude among the three CRT operators ranged from a fairly consistent 40% overestimation to a 70% underestimation, and the difficulties were clearly related to the degree of dispersion and irregularity. These results, particularly the lack of consistency, suggest that the CRT is not adequate for analysis of data from night surveys.

Diel variability is apparent in the estimates in addition to that derived from the processing technique. A strong shoreward bias is noticeable in many of the night surveys, particularly in Carroll Inlet and Deer Island. It seems likely that fish are concentrated near shore at night, outside the limits of the surveys, and that subsequent estimates are much too low. Unfortunately fish are frequently on or very near the bottom during most of the day. At Deer Island optimal survey time may be early morning, during reorganization of the fish into schools and before complete downward migration. The irregularity of schools during this time necessitates use of an integrator rather than the CRT.

Acoustic assessment may not be possible in some areas because of nonpelagic distribution. An example is Ward Cove, where fish are definitely on the bottom during day and are probably near shore at night.

Acoustic estimates in 1973 are based on target strength measurements in 1972. The relationship is tentative; it provides a good relative index, but more detailed measurements must be made before it can be confidently assumed to provide absolute estimates. Target strength studies on herring in Southeastern Alaska as well as Puget Sound have been delayed, but should be completed by the end of 1974.

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