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ACOUSTIC SURVEY OF HAKE  
IN PORT SUSAN AND VICINITY DURING 1973

by

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INTRODUCTION

Two acoustic surveys of the hake population in Port Susan and vicinity were conducted during 1972 as part of a cooperative program between the Washington Department of Fisheries and the University of Washington Sea Grant Marine Acoustics Program. The WDF contribution included funds provided through a contract with the Fisheries Research Institute. The results of the study are described in this report under the provisions of the contract.

MATERIALS AND METHODS

The first survey was conducted on March 5-7 aboard the NMFS research vessel *John N. Cobb* and included Possession Sound - Port Gardner as well as Port Susan (Fig. 1). The second series was conducted on April 10-11 aboard the WDF *Research I* and covered Port Susan, Port Gardner, Possession Sound, an area immediately south of Possession Sound, and the southern part of Saratoga Passage (Fig. 2).

Two echosounders were used simultaneously during the March cruise, a 38-KHz Simrad Scientific sounder and a Ross 200A Fineline, frequency 105 KHz. A second Ross 200A was used in April. All acoustic data were recorded on analog magnetic tape and later processed with the Digital Data Acquisition and Processing System (DDAPS). The output of the DDAPS was calibrated to fish density through net hauls with an assumption of 100% net efficiency, as in previous series (Thorne, Reeves, and Millikan, 1971; Moose, Thorne, and Nelson, 1971; Thorne, 1972; Thorne, in press).

RESULTS

Calibration

The relationships between fish density as determined from net catches and DDAPS integrated voltages from the Simrad EK 38 and Ross 200A sounders aboard the *John N. Cobb* were highly linear, as shown in Figs. 3 and 4. Linear correlation coefficients were 0.95 for the Simrad data and 0.91 for the Ross data. Relative errors of the linear slope (beta) coefficients were 7.9% for the Simrad data and 11.0% for the Ross data. The relationships were used to obtain density estimates from integrated voltages during transects in March. The Ross 200A sounder aboard WDF *Research I* was calibrated against the Simrad EK38 sounder aboard the *John N. Cobb* during a side-by-side inter-calibration transect; thus, density measurements obtained during the April series were based on the Simrad EK38 data-net haul relationship.

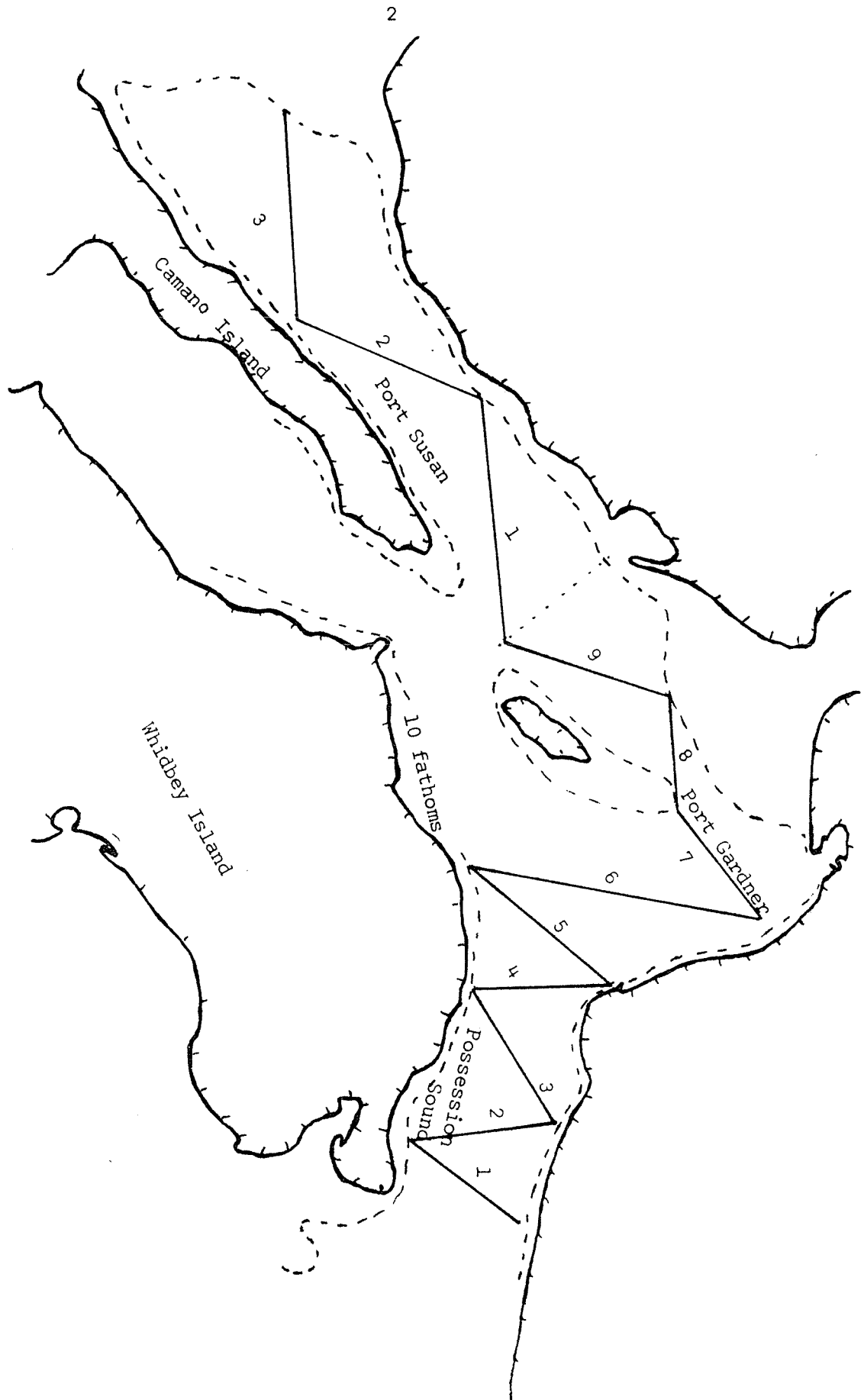


Fig. 1. Locations of transects in Port Susan, Port Gardner, and Possession Sound during March 1973 series.

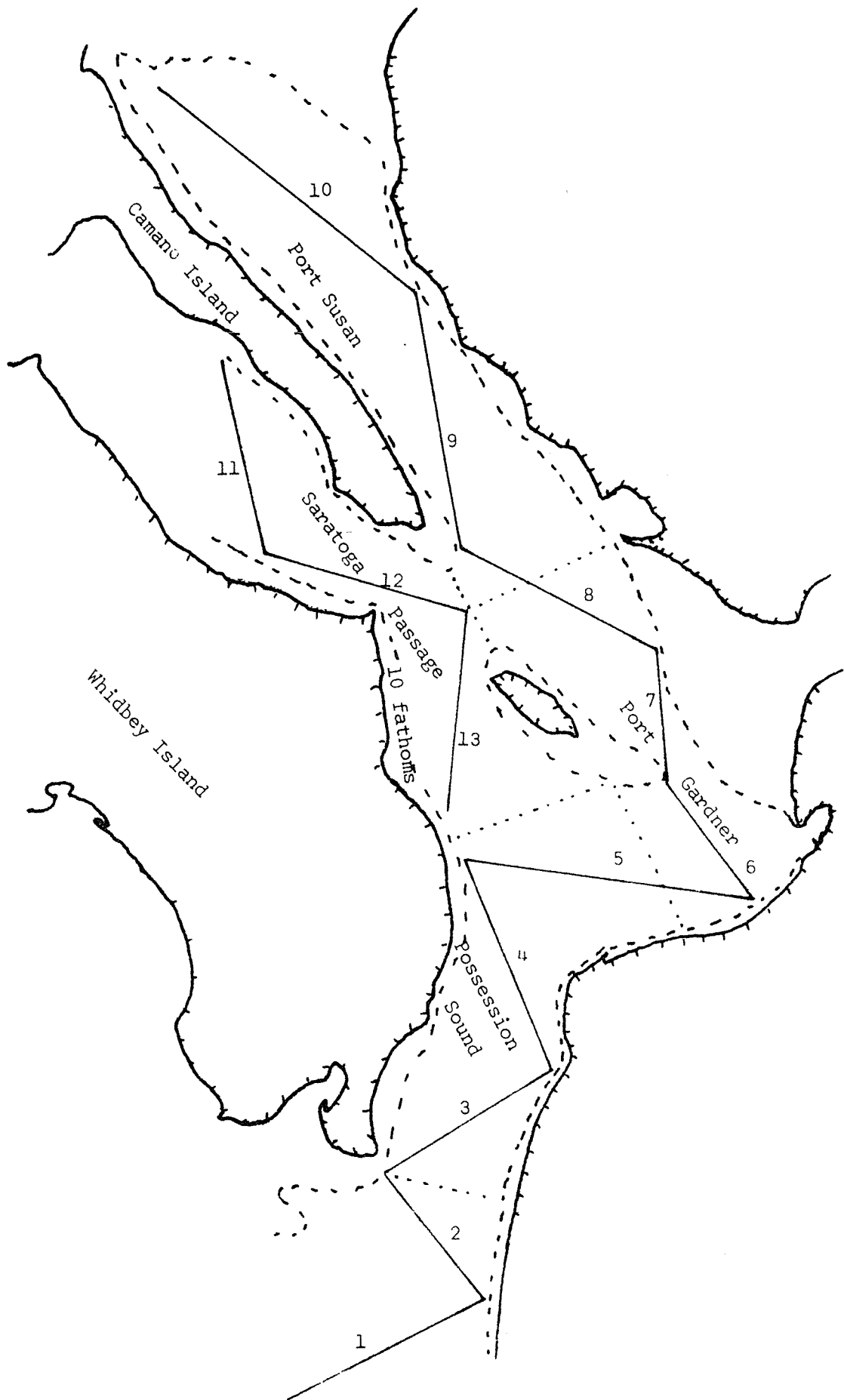


Fig. 2. Locations of transects during April 1973 series.

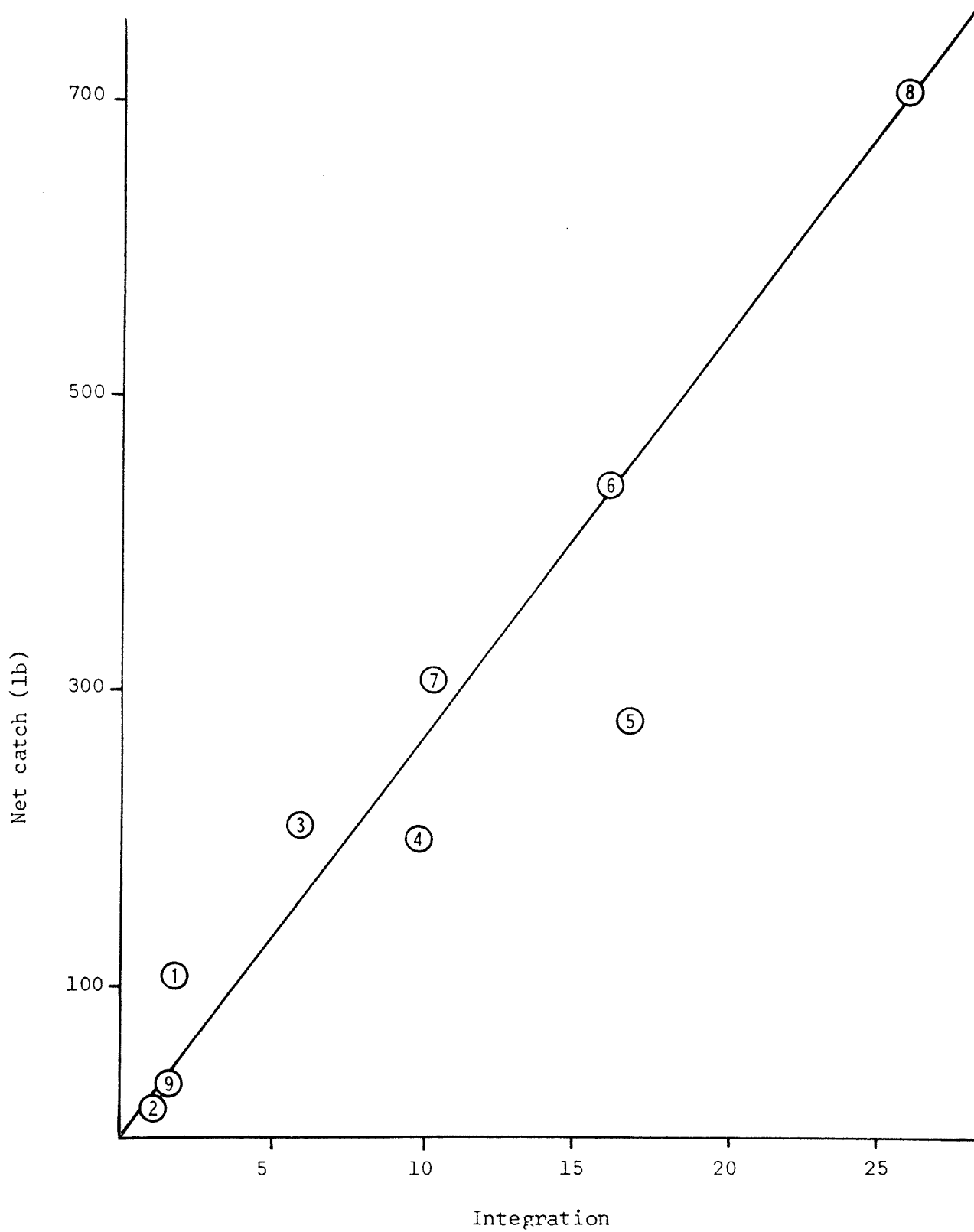


Fig. 3. Relation between net catches and DDAPS integrations of echo signals from Ross 200A sounder in 1973 series.

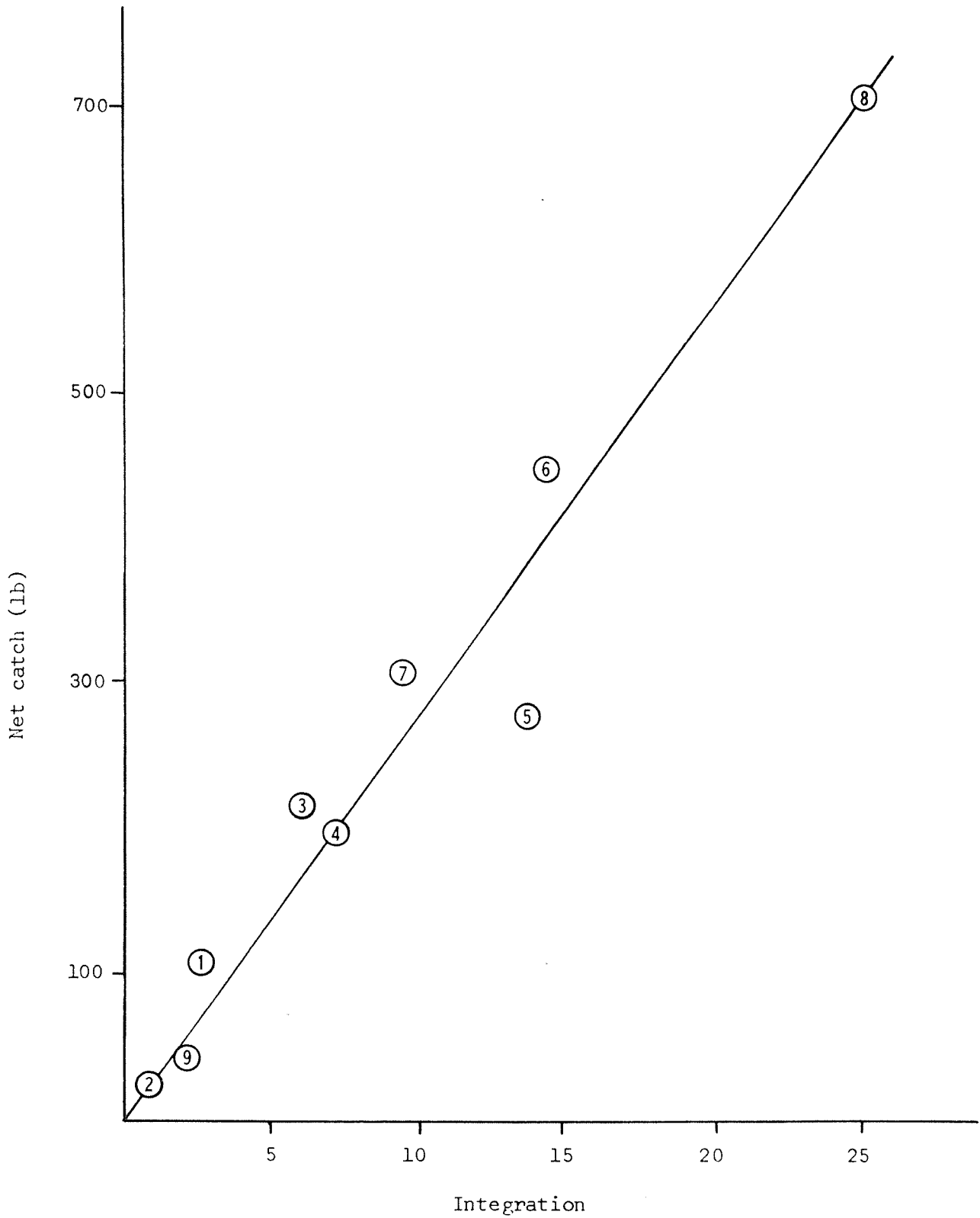


Fig. 4. Relation between net catches and DDAPS integrations of echo signals from Simrad EK-38 sounder in 1973 series.

### March Survey

Integrated voltages from each sounder were determined over 2-min intervals along transects and in 10-m depth intervals from 60 to 120 m. Then integrations were converted to density estimates by use of the appropriate calibration relationship. The densities observed in Port Susan were classified as either high or low, and weighted mean densities and variances were determined for each stratum, location, and sounder and for both sounders combined. Observations were weighted by volume as in previous studies (Thorne, in press). The population estimates for the strata were obtained by multiplying the weighted mean density by the volume of each stratum, and the total estimate determined by combining the results of the strata. The variances of population estimates were obtained from the relationship

$$\text{Var}N_T = V_1^2 \text{Var}D_1 + V_2^2 \text{Var}D_2 ,$$

where  $V_1$  is the volume of the low-density strata,

$D_1$  is the weighted mean low density,

$V_2$  is the volume of the high-density strata, and

$D_2$  is the weighted mean high density.

The variance does not include variability from the calibration relationship. The results of the March series are given in Table 1. The population estimate from the operation of both sounders for March was 7.63 million lbs for Port Susan and 7.04 million lbs for Possession Sound - Port Gardner.

### April Series

Population estimates for the April series were obtained in a similar fashion except that a single output was obtained for 60 m to 120 m for each 2-min section, and data were converted to density per unit surface area. Each output represented an equal surface area; thus, weighting was unnecessary. All data were grouped into three density strata and a variance was determined for the total population estimate by combining the variances for the strata. The population estimates for each area are given in Table 2. The estimated population in Port Susan was 7.3 million lbs, and that in Possession Sound - Port Gardner was 6.2 million lbs. The estimated population in all areas was 20.0 million lbs with a variance of  $0.68 \times 10^{12}$ .

## DISCUSSION

Annual surveys have been conducted in Port Susan since 1969; earlier studies are summarized in Thorne (1972). Surveys were expanded to Possession Sound - Port Gardner in 1972 and further expanded in April 1973 to include an area south of Possession Sound and part of Saratoga Passage. The 1973 estimates in Port Susan are the lowest of those obtained in the five-year study. The 1973 estimate for Possession Sound - Port Gardner is also

Table 1. Results of acoustic surveys in Port Susan and vicinity during March 1973

Location	Series	Population estimate ( $10^6$ lbs)	Variance ( $10^{12}$ )
Port Susan	Simrad	5.70	0.72
	Ross	9.49	1.32
	Combined	7.63	0.54
Possession Sound - Port Gardner	Simrad	7.75	0.93
	Ross	6.31	0.62
	Combined	7.04	0.39

Table 2. Estimated populations of hake in Port Susan and vicinity during April 1973

Location	Mean density (lbs/100m <sup>2</sup> )	Number of observations	Surface area (10 <sup>6</sup> m <sup>2</sup> )	Population estimate (10 <sup>6</sup> lbs)
South of Possession Sound	16.9	22	30	5.1
Possession Sound	13.0	28	40	5.2
Port Gardner	3.0	25	30	1.0
Port Susan	14.5	37	50	7.3
Southern Saratoga Passage	3.6	27	40	1.4

considerably less than the 1972 result. The results of the expanded surveys demonstrate that the hake stock is considerably more dispersed than has been originally believed. It is particularly interesting to note that the density per unit surface area was greatest in the area south of Possession Sound, in relatively open water. Part of the annual fluctuation observed in Port Susan is undoubtedly due to variation in distribution of the stock.

The precision of acoustic estimates was greatly improved with the development and application of the DDAPS in 1971. Since then, the relative errors of both calibration relationships and mean density estimates have been about 10% or less. The relative errors of estimated mean densities in 1969 and 1970 were also less than 10%, but the surveys required considerably greater effort; and the relative errors of calibration relationships in 1969 and 1970 were 25-30%. Thus part of the observed variability in annual population levels may be associated with lower calibration precision during the first two years.

Another index of abundance in Port Susan is provided by the net catches. The trawls for calibration range from 7 to 21 and provide an independent measure of abundance. The average net catches are compared with the average acoustic population estimates for the five years in Fig. 5. The correspondence is amazingly close when one considers the limited number of net hauls and indicates that the acoustic surveys provided an accurate measure of the abundance in Port Susan even during 1969 and 1970.

It is difficult to evaluate precisely the present status of the entire hake stock, since historical data are lacking over the larger area; however, the low levels in both Port Susan and Possession Sound - Port Gardner in 1973 indicate a reduced stock size. The stock should be examined carefully early in 1974.

#### LITERATURE CITED

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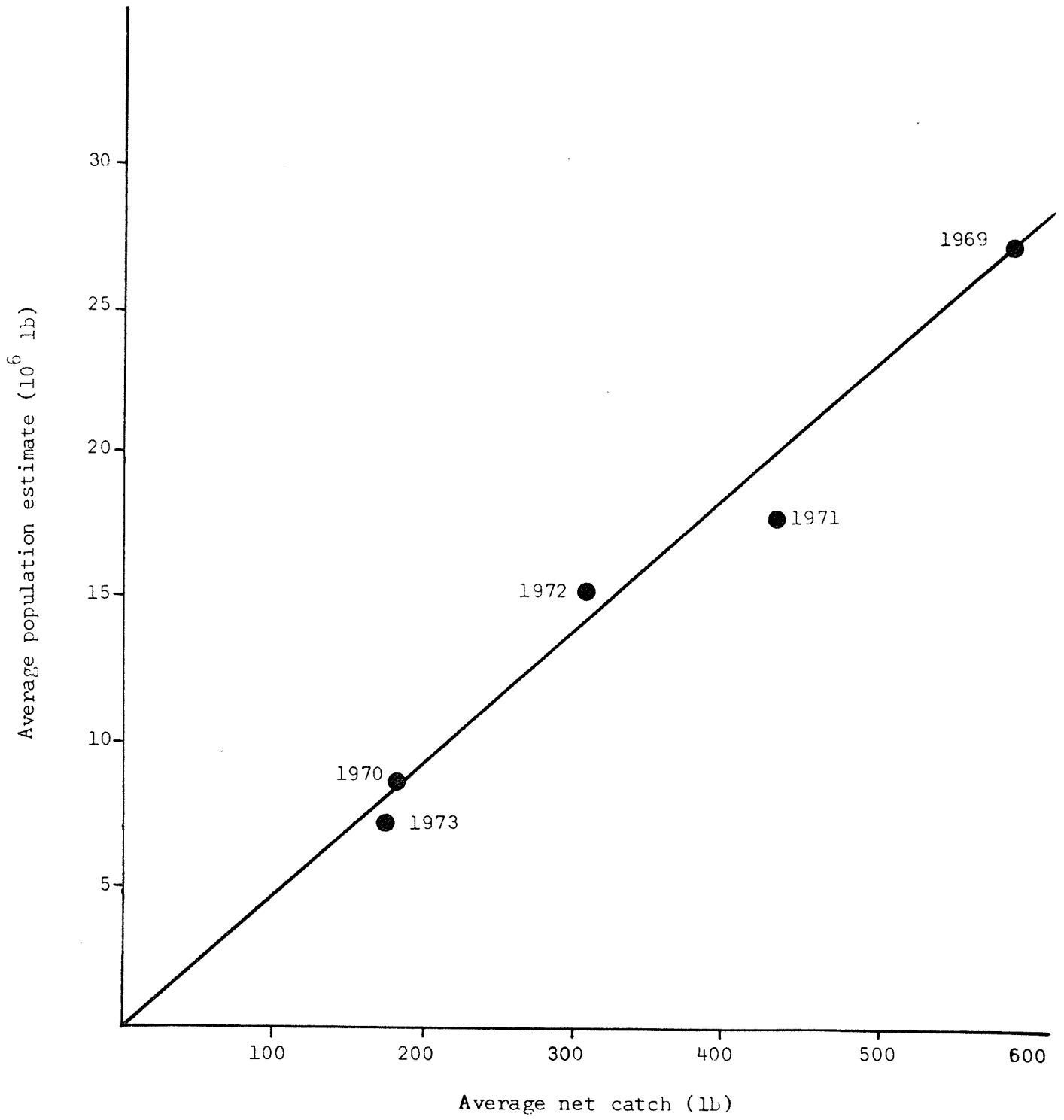


Fig. 5. Relation between population estimates from acoustic surveys and average net catches, 1969-1973.