INFORMATIONAL LEAFLET NO. 165

ASSESSMENT OF SOUTHEASTERN ALASKA HERRING STOCKS USING HYDROACOUSTICAL TECHNIQUES 1970-71

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August 1974

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INTRODUCTION

Since the start of the present research program in Southeastern Alaska in 1969, enumeration of the herring stocks has been one of the primary objectives.

Traditionally, the magnitude of pelagic fish populations such as herring have been estimated either directly by tag and recovery programs or indirectly from catch-per-unit of effort data. Both methods involve substantial effort, cost and voluminous data. Early in the program enumeration using acoustical techniques offered a promising alternative of accomplishing the same objectives at a much lower cost.

Research on acoustic techniques for resource assessment has been conducted at the University of Washington since March 1968. As a result of this research several types of automatic signal acquisition and processing systems have been developed.

In 1971, the Fisheries Research Institute at the University of Washington was contracted to acquire and assemble for the program a suitable hydroacoustic data acquisition system, develop the appropriate data analysis procedure and analyze the data collected. The major emphasis during the first year was to be on equipment development (Moberly and Thorne, 1971). The emphasis during the second year was on survey design and to make improvements on the original system (Moberly and Thorne, 1972).

MATERIAL AND METHODS

Equipment

The basic data acquisition system acquired was a Ross 200A Fineline 1/ with a frequency of 100 kHZ and a 6 degree circular transducer. The frequency and amplitude of the video signal was converted by an interface amplifier unit to an audio signal which was acceptable to a tape recorder unit. An oscilloscope was used to monitor echo levels and for data analysis (Figure 1).

Before the start of the 1971-72 field season, a calibration oscillator circuit was designed and installed in the system. This circuit allows a single rapid check of the receiver gain. The calibration oscillator consists of a timer circuit and an oscillator circuit, (Moberly and Thorne, 1972). Prior to each survey the circuit is activated. The timer circuit disables the transmitter and allows the oscillator to run for approximately 60 seconds. The oscillator inserts a signal of known amplitude at the transducer terminals of the receiver. This signal is amplified by the receiver and recorded on magnetic tape, thus giving a permanent reference to the receiver performance.

Also added to the system was a voltage control panel and frequency meter. This allows the operator to monitor and adjust the input voltage if necessary.

SURVEY AREA AND TECHNIQUES

The survey area in 1970-71 consisted of waters south of Petersburg (Figure 2). Table 1 lists the individual areas. In 1971-72 the area was expanded to include Sitka and Berners Bay north of Juneau (Figure 2). Table 2 lists the areas surveyed during the 1971-72 field season.

Between areas of known herring concentrations a random searching technique was used in 1970-71. This was time consuming and was not done in 1971-72, thus allowing more time to be spent on known herring concentrations. In some areas considerable time was spent locating the herring and setting up the transect.

1/ Use of a trade name does not imply endorsement by the Alaska Department of Fish and Game.

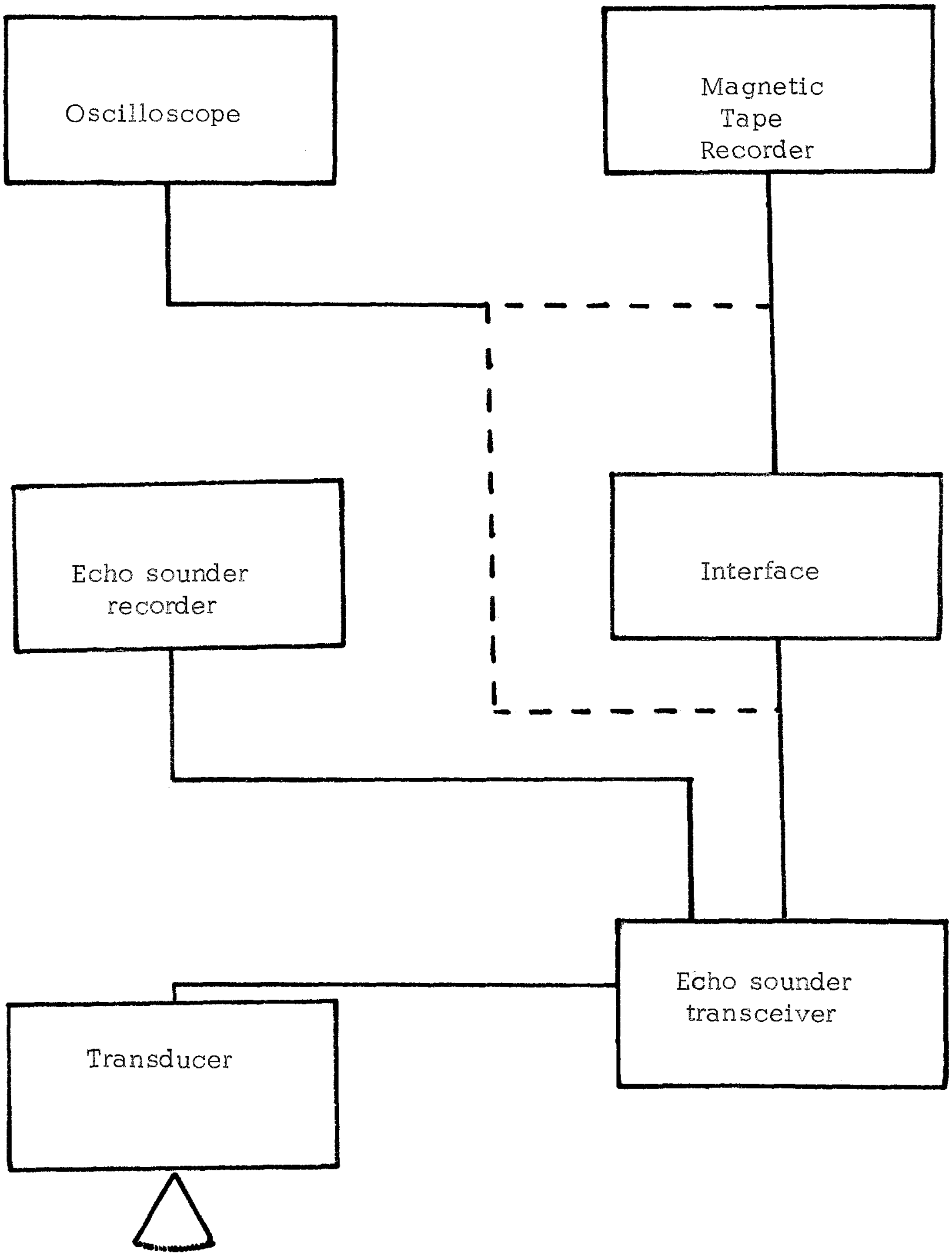

Figure 1. Acoustic data-acquisition system.

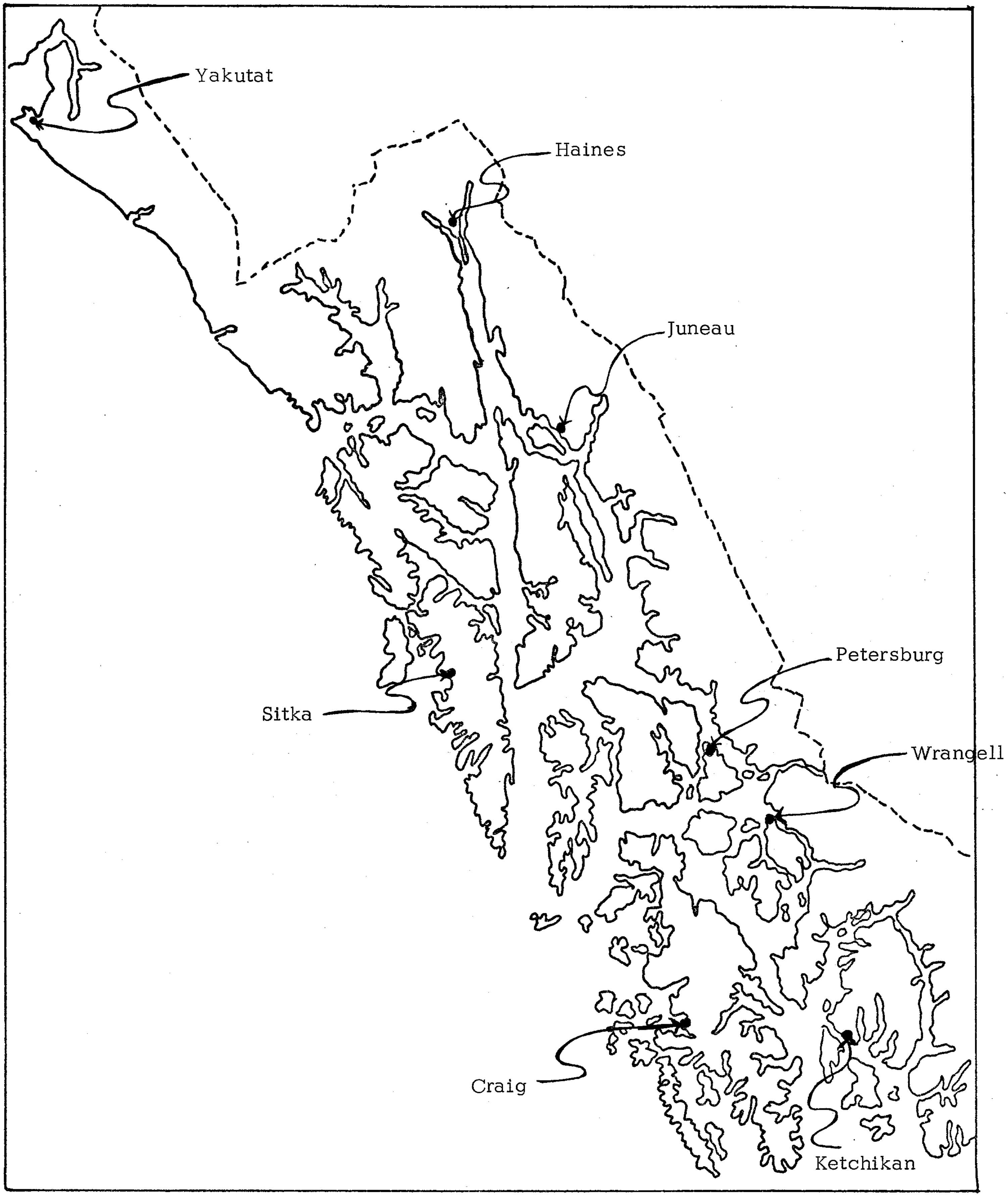

Figure 2. Southeastern Alaska survey area showing major cities.

Table 1. 1970-71 surveys of Southeastern Alaska herring stocks using acoustical equipment, with the signals stored on magnetic tape.

Area - Dates	Schools Number	Depth Fathoms	Duration over school in seconds	Signal amplitude	Signal width m sec
Carroll Inlet					
2-4-71	Several testing equipment				
Shaken Strait					
2-5-71	1	26	3.0	0.4	3.0
	2	25	7.0	0.8	8.0
	3	29	5.0	0.6	2.5
	4	25	2.5	0.3	6.0
El Capitan Passage					
2-5-71	1	56	5.0	0.7	5.0
	2	58	45.0	2.7	12.0
	3	59	5.0	0.7	3.0
Meares Passage					
2-20-71	No herring schools encountered during taping.				
Sukkwan Straits					
2-12-71	1	32	75.0	1.7	6.0
	2	135	15.0	2.6	6.0
Klakas Inlet					
2-12-71	1	25	4.0	1.0	5.0
	2	100	7.5	3.6	8.0
Carroll Inlet					
2-15-71	1	90	210.0	4.5	56.0
	2	80	9.0	4.3	28.0
George Inlet					
2-14-71	No herring schools encountered during taping.				
Port Johnson					
2-16-71	No herring schools encountered during taping.				
Dora Bay 2-16-71	No significant herring concentrations encountered during taping run.				

(Continued)

Table 1. 1970-71 surveys of Southeastern Alaska herring stocks using acoustical equipment, with the signals stored on magnetic tape (cont.).

Area - Dates	Schools Number	Depth Fathoms	Duration over school in seconds	Signal amplitude	Signal width m sec
Moira Sound, West Arm					
2-16-71	1	65	9.5	1.2	28.0
Moira Sound, Dickman Bay					
2-16-71	No significant herring schools encountered.				
Moira Sound, North Arm					
2-16-71	1	50	3.5	0.8	2.5
	2	50	6.0	1.5	2.5
	3	50	3.5	0.8	4.0
	4	50	3.0	1.5	7.0
	5	50	3.5	1.5	1.5
Cholmondeley Sound					
2-17-71	No significant herring schools encountered.				
Kasaan Bay, Skowl Arm					
2-18-71	No significant findings.				
Kasaan Bay, Twelve Mile Arm					
2-18-71	1	55	8.0	1.7	2.5
	2	30	6.5	2.2	12.0
	3	35	3.5	1.5	5.5
	4	30	2.0	0.8	4.0
	5	23	3.0	0.5	4.0
	6	21	3.0	0.7	5.5
	7	25	1.5	0.5	3.0
	8	26	6.5	1.0	3.0
	9	25	4.0	1.0	3.0
	10	32	6.0	2.2	13.0
	11 - 35 all similar in characteristics.				
		8	3.5	0.3	8.0
Wrangell Narrows					
2-19-71	1	7	5.0	2.2	8.0
	2	9	10.5	2.6	6.5
	3	9	3.5	1.8	5.5
	4	13	10.0	1.6	5.5
	5	14	10.0	1.6	5.5
	6	14	50.0	2.8	15.0
	7	16	15.0	1.3	4.0
	8	17	10.0	1.7	8.0

(Continued)

Table 1. 1970-71 surveys of Southeastern Alaska herring stocks using acoustical equipment, with the signals stored on magnetic tape (cont.).

Area - Dates	Schools Number	Depth Fathoms	Duration over school in seconds	Signal amplitude	Signal width m sec
	9	10	10.0	3.7	13.0
	10	14	7.5	0.2	8.0
	11	12	12.5	0.4	11.0
Wrangell Narrows					
2-20-71	1	14	9.5	1.1	20.0
	2	15	105.0	1.6	8.0
	3	25	6.0	0.5	8.0
	4	22	10.0	1.2	7.0
	5	22	40.0	1.6	7.0
Eastern Passage					
2-20-71	No herring schools encountered during taping.				
Blake Channel					
2-20-71	No herring schools encountered during taping.				
Bradfield Canal					
2-20-71	No herring schools encountered during taping.				

Table 2. 1971 analysis summary of Southeastern Alaska herring stocks using acoustical equipment, with the signals stored on magnetic tape.

Location	Date	Time	Volume ($10^6 m^3$)	Density (lbs/m^3)	Biomass (10^6 lb)	Comments
Ward Cove	1-20	Night	12.0	0.02	0.24	Scattered
Peninsula Pt.	1-20	Night	42.0	0.008	0.32	Scattered
Surprise Pt.	1-21	Night		-No apparent herring - layer of very small targets.		
Naket	1-21	Night		-Layer of small targets, probably not fish - scattered fish target 0.5-2 x 10^6 fish.		
Naket	1-22	Day		-Targets on bottom, tape saturated, species unknown.		
Surprise Pt.	1-22	Day		-Few fish on bottom.		
Deer Island	1-28	Night	8.2	3.2	26.2	
Sunny Bay	1-28	Night	4.1	4.7	19.9	
Sunny Bay	1-29	a.m.		-Fish on bottom.		
Sunny Bay	1-29	Night	3.0	2.6	10.2	
Zimovia Straits	1-30	Day		-Fish targets not believed to be herring.		
Anita Bay	1-30	Day		-Schools near bottom, tape saturated.		
Scow Bay-Wrangell	1-31	Night	17.9	1.8	32.2	Herring and some smelt.
Narrows	2-1	Night	12.3	1.6	19.5	Herring and some smelt.
Thomas Bay	2-3	Day		-Small dense target layer at 100m, scattered deep individual targets, medium size fish, $1/100m^3$ density - 7.6 x 10^6 fish total.		

(Continued)

Table 2. 1971 analysis summary of Southeastern Alaska herring stocks using acoustical equipment, with the signals stored on magnetic tape (cont.).

Location	Date	Time	Volume ($10^6 m^3$)	Density (lbs/m^3)	Biomass (10^6 lb)	Comments
Katlian Bay	2-7	Day	23.7	0.61	14.4	
Katlian Bay	2-7	Night	39.1	0.21	8.2	
Nakwasina	2-11	Night		-Scattered deep individual targets.		
Auke Bay	2-21	Dusk		-Fish on bottom, tape saturated.		
Auke Bay	2-21	Night	56.8	0.20	11.3	
Portland-Coglan-Spahn Islands	2-21	Night	30.6	0.18	5.4	
Pt. Louisa-Portland	2-23	Night	44.6	0.56	24.9	
Deer Island-Sunny Bay	3-17	Dawn	4.9	0.92	4.5	

Once a concentration of herring is located, a larger transect area is selected which contains the herring school. Some preliminary transects are run and the best combination of instrument settings selected. The most satisfactory combination of pulse length and sounder gain for most of the herring school densities encountered was a pulse length of 0.6 m sec., sounder gain 5.0, and a -12 dB interface attenuation.

Just prior to the recorded run the calibration oscillator was activated. After the signal of known amplitude has been recorded the survey was run in a zig-zag pattern covering the area randomly and at a constant speed. The amount of time spent in the transect area was determined by the operator.

The results indicated that several transects across a school are necessary because of the variability encountered. The results also indicated that the major variability in the population estimate came from the estimate of school size rather than from fish density.

During the 1970-71 field season most of the transects were conducted during the day. In 1971-72 most were conducted at night. During the daytime the herring are usually at or very near the bottom, and usually the signal would reach saturation and thus could not be measured.

DATA ANALYSIS

Survey Techniques

The objective of the analysis was to estimate the total number of herring in each sample area from the volume and density of the schools. In each region schools of fish believed to be herring were designated on the echogram. The corresponding echo signals from the magnetic tapes were analyzed by oscilloscope and the following parameters measured; average voltage amplitude, depth, average width (where width is defined as the lower depth of school minus upper depth) and duration within the sounding beam. Amplitudes were adjusted for depth to correct for two way sound absorption. The volumes of the schools were determined by the formula:

$$V = w \frac{t}{T A}$$

where w = width of school
t = time over school
T = time in transect area
A = area of transect in m^2

This value is not the volume occupied by the individual school, but rather the volume extrapolated by straight proportion over the area of the surveyed region. Volumes measured by this technique are over estimates of the real volumes occupied by schools, since the estimate assumes that the school occupies the entire cross-sectional area of the sounder beam. The error is accordingly greater the smaller the area of the school in proportion to the area of the beam. The density of the schools are correspondingly under estimated by this assumption, but the total number of fish is unbiased.

The relationship between density and amplitude was determined from measurements of the amplitudes of individual fish targets, the cross-sectional area of the sounder beam and the pulse length. Data collected from Carroll Inlet on January 18 and 20 and March 5, 1972 was also analyzed with a digital squared-voltage integrator (Moose, Thorne, and Nelson, 1971) for comparison with measurements obtained using the oscilloscope. The density of the fish in a school in number per cubic meter is:

$$D_s = \frac{A^2}{(a)} \frac{1}{(V)}$$

where A = the average amplitude, adjusted for length

a = the average amplitude of the individual fish at a reference depth

V = the pulse resolution volume in m^3 at the reference point

where V = t' C

t' = the pulse length in meters

C = the cross-sectional area of the sounder beam in m^2

Collection of Biological Data

Biological sampling in conjunction with the acoustical surveys was not accomplished during 1970-71. However, a sample was collected from the commercial fishery in Carroll Inlet. During 1971-72 sampling again was not done in conjunction with the acoustical surveys. Samples were collected from the commercial fishery in Ward Cove - Peninsula Point, Deer Island, Scow Bay - Wrangell Narrows, Katlian Bay, Auke Bay, and Carroll Inlet. Samples were collected at point of delivery except some samples were collected from the fishermen on the fishing grounds in Carroll Inlet. A separate report on the biological phase of the research program was prepared in 1970-71 (Moberly, 1973) and in 1971-72 (Moberly, 1974). Reference should be made to these reports for detailed analysis.

RESULTS

Echo Strength Measurement

Measurement of amplitude of individual herring targets were made from data collected from Carroll Inlet at night, January 17, 1972. A total of 100 observations were made with a storage oscilloscope and the mean echo strength was calculated according to the technique of Craig and Forbes (1970). The distribution of observed echo strength is shown in Figure 3, in decibel units relative to the largest observed target. The mean echo strength referenced to sounder gain 5, interface attenuation -12dB, and 100 m depth was 0.1 Vp.

Survey Results 1970-72

During the 1970-71 field season acoustical surveys were conducted from February 4 to February 20, 1971. The survey areas are listed in Table 1 which also gives the number of schools and corresponding depth, width and duration within the sounder beam and average adjusted amplitude. Volumes, densities and the total number of fish are presented in Table 3.

During the 1971-72 field season surveys were expanded. Combined school dimensions, average density, and total biomass estimates from various series in Carroll Inlet are given in Table 4. Population estimates based on the several daytime surveys were similar, ranging from 12.6 million pounds to 16.2 million pounds. However, population estimates based on nighttime surveys were lower and much more variable, ranging from 0.1 million pounds to 6.2 million pounds. The difference between day and night was similarly reflected in the analysis with the digital squared-voltage integrator. The corresponding estimate with the two systems (oscilloscope and integrator) for the January 18 and 20 and March 5, 1972 series are shown in Table 5.

Data from schools in other locations is given in Table 2. Major concentrations of fish were located at Deer Island south of Wrangell, Scow Bay (Wrangell Narrows) south of Petersburg, Katlian Bay near Sitka, and Auke Bay near Juneau. The Auke Bay stock was the largest with an estimated 41.6 million pounds in the Auke Bay vicinity.

Biological Data 1970-71

Collection of biological data was accomplished on several populations in Southeast Alaska during 1970-71 (Moberly, 1973). Unfortunately, only one of these populations, Carroll Inlet, was assessed acoustically. Samples were

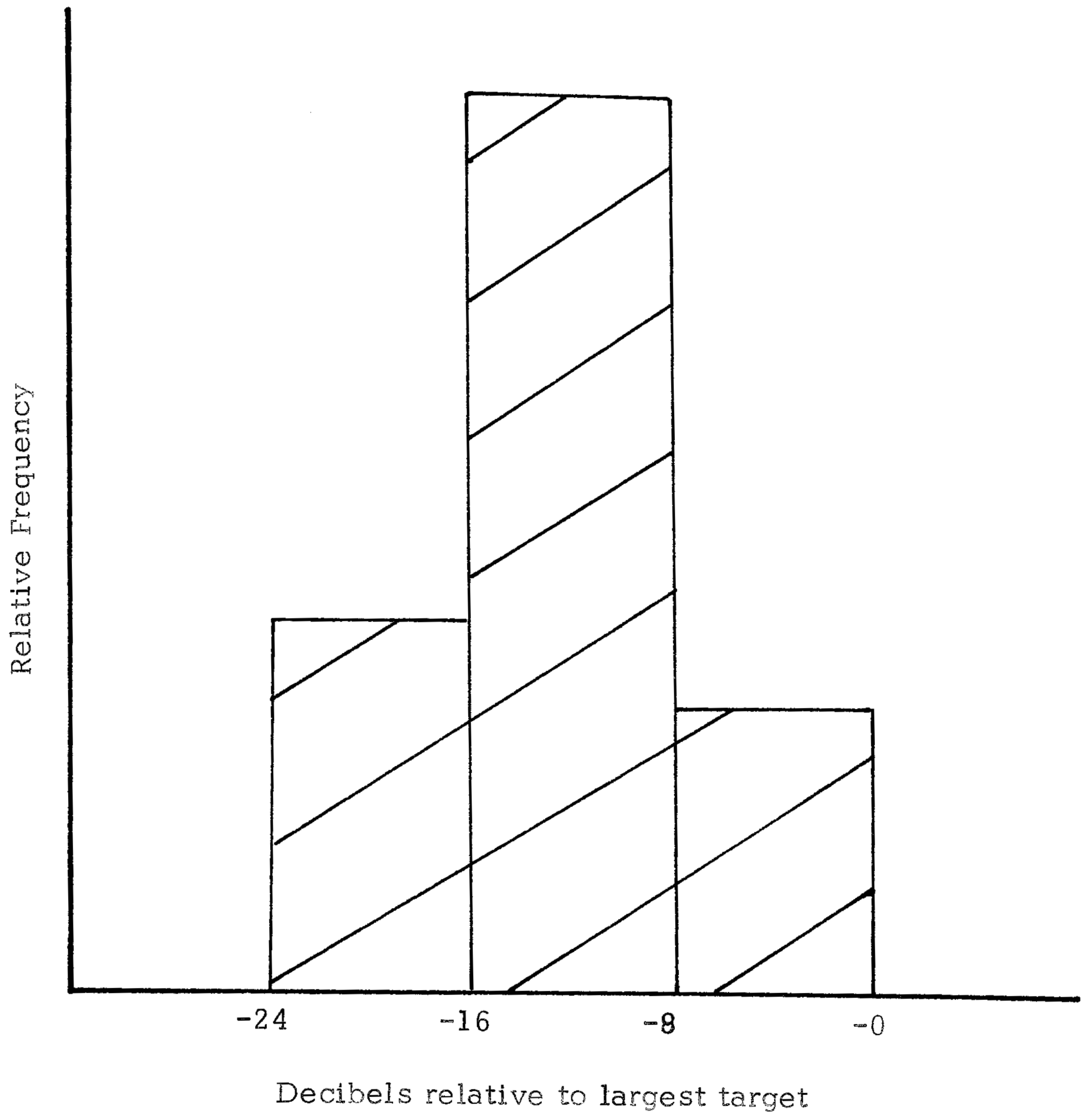

Figure 3. Distribution of observed individual fish echo strengths.

Table 3. Volumes and densities of herring schools and estimated total number of herring in each of the areas surveyed, 1970-71.

Area - Dates	Schools numbers	Volume ($10^3 m^3$)	Density (Fish m^3)	Total (10^3 fish)	Total fish in area 10^3
Shaken Strait	1	17	0.07	1	
	2	107	0.3	32	
	3	24	0.19	5	
	4	29	0.03	1	39
El Capitan Passage	1	115	0.22	25	
	2	2,490	3.4	8,466	
	3	69	0.24	17	8,508
Sukkwan Straits	1	1,538	1.3	1,999	
	2	308	3.1	955	2,954
Klakas Inlet	1	76	0.42	32	
	2	229	6.0	1,374	1,406
Carroll Inlet 2-15-71	1	17,267	9.4	162,310	
	2	3,700	8.6	31,820	194,130
Moira Sound 2-16-71	W-1	1,384	1.0	1,384	
	N-1	15	0.27	4	
	2	26	1.0	26	
	3	23	0.27	6	
	4	33	1.0	33	
	5	8	1.0	8	1,461
Twelve Mile Arm (Kasaan Bay) 2-18-71	1	33	1.3	43	
	2	121	2.2	266	
	3	29	1.0	29	
	4	12	0330	4	
	5	19	0.11	2	
	6	25	0.22	6	
	7	6	0.11	1	
	8	27	0.46	12	
	9	17	0.46	8	
	10	124	2.2	273	
	11-35	10	0.05	13	655

(Continued)

Table 3. Volumes and densities of herring schools and estimated total number of herring in each of the areas surveyed, 1970-71 (cont.).

Area - Dates	Schools numbers	Volume ($10^3 m^3$)	Density (Fish m^3)	Total (10^3 fish)	Total fish in area 10^3
Wrangell Narrows 2-19-71	1	82	2.2	180	
	2	144	3.1	446	
	3	38	1.5	57	
	4	110	1.2	132	
	5	110	1.2	132	
	6	1,511	3.6	5,440	
	7	124	0.78	97	
	8	165	0.78	129	
	9	275	6.3	1,733	
	10	124	0.02	3	
	11	264	0.06	16	8,364
Wrangell Narrows 2-20-71	1	478	0.56	268	
	2	1,763	1.2	2,116	
	3	121	0.11	13	
	4	168	0.67	113	
	5	671	1.2	805	3,314

Table 4. Carroll Inlet data analysis summary of intensive surveys during 1971-72.

Time	Date	Average depth (m)	Width (m)	Surface area ($10^6 m^2$)	Volume ($10^6 m^3$)	Density (fish/ m^3)	Density (lb/ m^3)	Biomass (10^6 lbs)	Transects across school
Day	1-16	100	21.5	0.315	6.8	7.9	1.98	13.5	3
Day	1-16	100	17.5	0.394	6.9	8.9	2.23	15.4	6
Day	1-18	100	16.5	0.254	4.2	15.4	3.85	16.2	3
Day	1-18	100	26.5	0.203	5.4	9.3	2.33	12.6	2
Day	1-18	115	19.8	0.273	5.2	10.5	2.63	13.7	6
Dusk	1-18	70	35.6	0.337	12.0	4.9	1.23	14.8	4
Dusk	1-20	60	52.5	0.181	9.5	3.6	0.90	8.6	1
Night	1-16	50	35.0	1.514	41.2	0.60	0.15	6.2	5
Night	1-17	45	55.0	0.700	39.7	0.04	0.01	0.4	2
Night	1-17	45	50.0	0.643	29.9	0.012	0.003	0.1	3
Night	1-18	55	45.3	0.247	11.2	1.0	0.25	2.8	2
Night	1-20	45	40.4	0.473	19.1	0.81	0.20	3.8	2
Night	3-5		29.1	0.430	12.5	0.60	0.15	1.9	5

Table 5. Comparison of population estimates in Carroll Inlet, January 18 and 20, and March 5, 1972, obtained with oscilloscope and digital integrator.

Time	Date	Biomass estimate (10^6 lbs)	
		Oscilloscope	Digital Integrator
Day	1-18	16.2	20.2
Day	1-18	12.6	15.0
Day	1-18	13.7	13.2
Dusk	1-18	14.8	13.6
Dusk	1-20	8.6	5.3
Night	1-18	2.8	1.3
Night	1-20	3.8	3.5
Night	3-5	1.9	2.2

collected from Carroll Inlet throughout the harvest period of November 5, 1970 to January 6, 1971. The harvest was 3.6 million pounds or nearly 14.4 million fish. This catch compares favorably with past catches from this population except during 1968-69 when severe cold weather hampered fishing.

The samples collected throughout the season were combined and the age and growth data is presented in the Department's Technical Data Report series (Moberly, 1973). Approximately 52% of the sample was from the 1967 year class. This year class was also dominant in several of the other stocks in southern Southeast Alaska.

There has been speculation that herring segregate on the wintering grounds. One group being age groups 0 through 3 (juveniles) and the other group 3 and older (adults). The age composition of the adult stock varies from one population to another, generally speaking however, most age 4 fish in Southeast Alaska are sexually mature.

Observations during the commercial fishery in 1970-71 indicated that occasionally the fishermen released a catch of herring if the size of the fish were judged to be too small for bait purposes. This would tend to support the theory that the fish are segregated. This practice would also bias the samples from the commercial catch toward the larger (older) fish. It should be easy to collect information to either accept or reject the segregation theory when sampling can be done from a Department vessel.

Biological Data 1971-72

Again samples were collected from several populations in Southeast Alaska (Moberly, 1973) and several of these stocks were also assessed acoustically. Areas from which biological data and acoustical data were both collected were Ward Cove - Peninsula Point, Deer Island, Scow Bay (Wrangell Narrows), Katlian Bay, Auke Bay, and Carroll Inlet.

The Carroll Inlet fish were the fastest growing for a given age and the Auke Bay fish the slowest. Considering weight for a given length, the Deer Island and Scow Bay fish were ahead of the Katlian Bay fish with Carroll Inlet and Auke Bay following.

Investigation further into the theory of segregation on the wintering grounds was not done. Plans for the 1972-73 field season include sampling from a Department vessel with trawl gear. This method of collection should increase the quality of the data as well as yield information on movements and segregation. For a detailed presentation of biological data reference should be made to special reports by Moberly, 1973 and 1974.

DISCUSSION

Determination of Density

Acoustical techniques of fishery resource assessment are based either on the counting of individual fish targets (Cushing, 1968, Craig and Forbes, 1970) or on measurement of the amplitude of fish targets. Counting techniques are generally used for low density populations, such as large cod, where nearly all fish can be resolved as individuals by the sonic system. Determination of fish density from amplitude measurements is based on the theoretical relationship:

$$D = k\ (A)^2$$

where D = the density

k = constant of proportionality

A = the voltage amplitude of the fish echo

The technique of estimating fish abundance is based on the assumption that reflected intensities of fish targets are additive, so that the number of fish in an echo can be determined by dividing the echo intensity of the target intensity of a single fish. This relationship has been confirmed in field studies by Truskanov and Scherbino (1966) and by Thorne (1970-71). The echo intensity is proportional to the squared-voltage amplitude and can be visually estimated from an oscilloscope or measured with an echo integrator.

The oscilloscope has been used to study well defined herring schools. Under these circumstances the echo amplitude can be readily estimated with the oscilloscope. This procedure can also be used in the field aboard ship allowing estimates to be made 'on the spot'. This then allows management of the fishery to be on a 'real time' basis.

Data collected from Carroll Inlet during 1971-72 was analyzed by both the oscilloscope and the digital integrator and showed good correspondence. This confirmed that the level of precision obtained with the oscilloscope was adequate, at least at the present level of survey effort.

The density estimates are based on measurements of individual fish echo strength. The results revealed a considerable variability in target strength. This variability has also been noticed in other studies of target strength and necessitates considerable effort to obtain large numbers of observations in order to accurately determine absolute density. A computer program for automatic measurement of target strength is being developed under the Sea Grant Marine Acoustics Program at the Fisheries Research Institute at the University of Washington in Seattle and hopefully will be available for use on future surveys.

Diel Differences in Distribution

The difference between daytime and nighttime estimates in Carroll Inlet in 1971-72 was probably related to changes in distribution and behavior. During the day the herring were tightly schooled at depths below 50 m and often were right on the bottom. The daytime densities were typically estimated at about 10 fish/m^3. As nighttime approached the school rose toward the surface, sometimes reaching upper depths of less than 20 m. Dispersion horizontally and vertically was apparent and the tide and degree of darkness seemed to influence this dispersion considerably (Tester, 1938). Often on bright moonlit nights the school exhibited behavior similar to that observed during the day. Estimated nighttime densities were as low as 12 fish/100m^3. The nighttime estimates in Carroll Inlet did not seem realistic. The mean of the night estimate in January 1972 was only 2.7 million pounds. On the night of March 5, 1972, after a removal of about 2 million pounds, the estimate was still 1.9 million pounds according to the oscilloscope analysis and 2.2 million pounds according to the integrator.

Samples from the fishery during this period did not show any change in the percent age composition and thus immigration into the population was not thought to be an influence on the two population estimates.

One possible explanation for the lower estimate at night may have been dispersion of the fish outside of the survey area. This possibility will be investigated during the 1972-73 surveys.

In most areas, surveys were conducted at night because the fish were on or very near the bottom during the day. Dark cloudy days being somewhat an exception. In areas where major stocks were present, such as Deer Island, Auke Bay and Katlian Bay, the fish remained in well defined schools at fairly high densities even at night. Deer Island, which was surveyed on a very bright moonlit night, showed little change in distribution between the day and night. The highest nighttime density encountered of 20 fish/m^3 (2.3 kg/m^3) was recorded on this survey.

Comparison of Results from 1970-71 to 1971-72

Considerably more data was collected during the 1971-72 surveys than in 1970-71. Only two areas were surveyed during both periods, Carroll Inlet and Scow Bay. Considerably more fish were found in Scow Bay (Wrangell Narrows) during 1971-72 than in the previous season. (Sampling from the commercial catch in 1971-72 indicated that approximately 20% of the sample was smelt.) The results between the two seasons were not comparable however, since the more recent survey was made at night and the 1970-71 survey was made during the day. The Carroll Inlet series in 1970-71 consisted of two transects during the day, giving density estimates of 9.4 and 8.6 fish/m^3. These also compared well with four or five daytime density estimates made during 1971-72. These estimates ranged from 7.9 to 10.5 fish/m^3. The school volume estimated from 1970-71 differed greatly, 34.5 X 10^6 m^3 and 7.4 X 10^6 m^3. The 1971-72 estimates of school volume ranged from 4.2 X 10^6 m^3 to 6.9 X 10^6 m^3, based on three of six transects each.

The results indicated that several transects across a school are necessary because of the variability encountered. The results also indicated that the major variability in the population estimate comes from the estimate of school size rather than fish density. This is extremely interesting from the viewpoint of survey strategy, since estimates of school volume can easily be calculated in the field. This then allows field personnel to decide on the basis of observed variability of school volume measurements whether sufficient survey effort has been expended in an area.

Species Identification

Species identification was based largely on composition of commercial catches. In several areas it was not possible to identify species. Scattered intermediate size fish targets of unknown species were almost universally present in protected areas with depths greater than 90 meters. Typical densities were estimated at about 1 fish/100 m^3. A population estimate of 7.6 million fish was made of these targets in Thomas Bay.

RECOMMENDATIONS AND CONCLUSIONS

The major objective of the 1970-71 study was to develop a data acquisition system adequate for herring population assessment. With the addition of the calibration oscillator and the input voltage control panel during 1971-72, this objective has been accomplished. The system performed well and without breakdown during 1971-72.

Emphasis during the 1971-72 field season was on survey design with some exploratory work. The survey effort was greatly expanded during during 1971-72 primarily due to more vessel time being available. Population estimates made from the survey data was used as a basis for determining harvest levels, realizing of course, that variability was high at this time.

Carroll Inlet was the only area where sufficient data was collected to fix the population magnitude adequately for management purposes. In the Deer Island area three nighttime surveys were run, but the results were variable and most other areas, including the large population in the Auke Bay area, had only a single survey.

The amount of data considered usable for comparison between areas does not reflect the effort put into data collection. Considerable experimentation on gain setting, survey procedure, exploratory activities, continual maintenance problems with the vessel, and adverse weather conditions were some of the problems encountered. In comparing data between areas, usually one survey was all that could be used since the remaining surveys conducted were made at different settings either at day or night. Some further experimentation is necessary on the daytime v.s. nighttime variability but most of the procedures are now established so that several duplicate independent surveys can be made on each stock of herring. This probably will not involve an increase in vessel time because of budget limitations. Sampling for target identity and biological data is also anticipated during the 1972-73 season.

Priority of vessel time should be allocated to the major stocks and/or those with established fisheries. Very little time should be allocated for exploratory work unless accompanied by an increase in vessel time. Decisions on whether sufficient effort has been expended on an area can be made on the basis of the variability observed during the surveys.

Estimates are presently based on theoretical relationships and individual fish echo strength measurements without alternate techniques for confirmation. Extensive acoustic assessment programs are being conducted in other areas, particularly herring studies in Puget Sound. Data from these programs will assist in refining the absolute estimates in Southeast Alaska. Development of sampling capabilities will be a major benefit for species composition data and confirmation of echo targets. It may also be possible to check the acoustical data by surveying a stock before and after an intensive short term fishery. Although the fishing effort may have an effect of scattering the fish, a comparison between catch and the population estimates from the acoustical surveys before and after the fishery removal may provide a check on the accuracy of the acoustical surveys.

While the acoustic techniques theoretically provide estimates of absolute population size, the principal need at this stage is for a relative index of population magnitude for annual comparison. Most fisheries are managed by relative rather than absolute indices. The major emphasis on future surveys must be to expend the necessary survey effort to obtain sufficiently precise estimates for year to year comparisons. Acoustic assessment techniques have the tremendous advantage that they can be used to obtain estimates immediately prior to the fishery. Major changes in stock sizes can then be determined in advance and management of the fishery effort made on this basis. Management of the stock can become increasingly more accurate and precise as more data is obtained on annual fluctuations of acoustically estimated stock sizes in relationship to fishing removal.

ACKNOWLEDGMENTS

The authors wish to express thanks for help received in various ways from several colleagues; especially the efforts of the electronic engineer Bob Mattie and the crew of the vessel KITTIWAKE. Thanks is also extended to G.L. Finger and J.C. McMullen for their constructive criticism and to Sharon Peterson and June Grant for their assistance in preparing the manuscript.

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