SOME OBSERVATIONS OF JUVENILE HERRING AT THE FRASER RIVER ESTUARY, B.C.

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INTRODUCTION

This paper is a preliminary summary of observations on juvenile herring taken on Sturgeon and Roberts banks, Fraser River estuary, during beach seine sampling over the period March 1979 to July 1981. Previous data on juvenile herring in the Strait of Georgia are scarce. The only other reports are those of Hourston (1957), who dealt mainly with qualitative estimates of abundance, and Barraclough (1967) who reported larvae from a late spawning population at Boundary Bay and/or Point Roberts. The former location is reported to support a spawning population of 2501 to 5000 t/yr (Hourston and Humphreys 1978).

METHODS

Beach seine surveys at low tide were conducted on Roberts and Sturgeon banks over the period March to July 1979, and subsequently regular samples at fewer locations were obtained every 2 to 3 weeks, March 1980 to July 1981. The studies were primarily directed toward a comparative study of how juvenile salmonids used the low tide refuges on the Banks.

Fish were caught using a beach seine 14.7 m in length, with wings 4.0 m (1 cm stretched mesh), bunt 4.9 m (3 mm mesh), and depth 3.5 m. The seine was fitted with about 10 gillnet-type floats and a leadline. Station locations are as reported in a previous publication (Greer et al. 1980): Roberts Bank - Stations 26, 28, 33, 37, and 45; Sturgeon Bank - Station 14, 93, 96, and 156.

Fish were preserved in 10% buffered formalin. Measurements of length and weight were made on fish after a preservation period of not more than 7 months.

Abuandance and seasonality

Detailed interpretations of the abundance and seasonality of herring catches in 1980 and 1981 are not yet available. However, some data are available from previous studies. Goodman (1975) found herring in inshore table seine sets on Roberts and Sturgeon banks over the period May to September 1973. Herring were first reported in mid-May from Sturgeon Bank but were not found on Roberts Bank until late June. Herring catches in beach seines in 1979 (Greer et al. 1980) showed a catch per unit effort of 25.3 from Sturgeon Bank compared to 53.4 on Roberts Bank. These data are from catches made from March to July.

RESULTS

Length frequency data

Sturgeon Bank

Herring taken on Sturgeon Bank in late June and early July 1980 ranged from 25 to 59 mm, with modal peaks at about 30 and 50 mm (Fig. 1). In late July this pattern persisted, with a few larger herring appearing. By mid-August and September, a definite bimodal or multi-modal pattern was evident, with several examples of fish >100 mm. In 1981, juvenile herring with length range 25 to 45 mm were also observed (Fig. 2) but few fish were taken after June.

Roberts Bank

The majority of juvenile herring taken on Roberts Bank were all over 40 mm in length in all samples from both 1980 and 1981. In late June to early July 1980, there was a poorly-defined peak in abundance at approximately 70 mm (Fig. 3). In late July to early August this peak was also present with a few fish in the 35 to 40 mm size. This was the case in early June 1981 also (Fig. 4).

Length-weight relationships

Analyses of length-weight relationships are only partially complete for 1980 data. They should be considered tentative results as the groupings of data used in the results are currently being revised. The length-weight relationships computed for the various locations and dates are as follows:

Location, Date (1980)		Length-Weight Regression Equation[1,2]
Sturgeon Bank (Stn. 156)	May 7 to July 9	$\log_e wt = -4.203 + (2.903 \cdot \log_e Len)$
" "	July 9 to 30	$\log_e wt = -8.654 + (3.990 \cdot \log_e Len)$
" "	July 30 to Sept 4	$\log_e wt = -7.834 + (3.776 \cdot \log_e Len)$
Sturgeon Bank (Stn. 96)	June 12	$\log_e wt = -5.573 + (3.205 \cdot \log_e Len)$
" "	June 12 to 27	$\log_e wt = -6.440 + (3.426 \cdot \log_e Len)$
" "	June 27 to Aug 12	$\log_e wt = -6.670 + (3.480 \cdot \log_e Len)$
Roberts Bank (Stn. 26, 33,37,45)	June 13 to 20	$\log_e wt = -5.750 + (3.260 \cdot \log_e Len)$
" "	June 28 to July 10	$\log_e wt = -5.031 + (3.029 \cdot \log_e Len)$
" "	July 10	$\log_e wt = -0.1295 + (1.849 \cdot \log_e Len)$
" "	July 10 to July 28	$\log_e wt = -2.566 + (1.189 \cdot \log_e Len)$
" "	July 28 to Sept 24	$\log_e wt = -4.967 + (3.034 \cdot \log_e Len)$

[1] Equations based on sample size of 50 fish.
[2] Weight in mg, length in mm.

Diet studies

Juvenile herring (45 to 55 mm) from Roberts Bank (Stn. 26 of 1979 survey) were examined for stomach contents, and results from 20 fish are given in Table 1. As shown, decapod larvae, harpacticoid copepods, calanoid copepods, gammarid amphipods, and cirriped larvae were among the most common items in the diet. These invertebrates use the eel grass beds as habitats.

DISCUSSION

Because of the dearth of data on juvenile herring elsewhere in the Strait of Georgia, there are few data to compare results with. The only comprehensive data from B.C. waters are from Hourston (1959), who worked in Barkley Sound. Hourston (1959) documented the fact that juvenile herring were strongly oriented toward the shoreline. Using data on herring abundance, temperature, salinity, food supply estimated by zooplankton tows, and the physical appearance of habitats, he concluded that the shelter afforded by the nearshore environment was the most important feature for determining juvenile abundance. However, nearshore-intertidal food resources were not evaluated, and may have been important as the fish probably were not using the "offshore" zooplankton sampled.

In 1979, juvenile herring were about twice as abundant on Roberts Bank compared to Sturgeon Bank, and this difference may be related to salinities and food supply. Although data are not completely interpreted, it is clear that juvenile herring on Roberts Bank are using water with surface salinities >20‰. On Sturgeon Bank, which is much closer to the direct discharge of the Fraser River, salinities were usually <20‰ and frequently ranged down to 0‰ during freshet. Hourston (1959) found that in Barkley Sound average salinities ranged from 17.23 to 29.3‰ where juvenile herring were consistently abundant. Roberts Bank habitats are characterized by eel grass, with ample microcrustaceans available as food. Sturgeon Bank stations were characterized by sand, with available crustacean food being advected from offshore.

The hatching location of juvenile herring found on the Banks is yet to be determined directly. Infrequent and light spawning is reported on Roberts Bank (Fisheries Officers' observations) but not until May, well past the usual period elsewhere in the Straits (March). There must be considerable year to year variation in spawning time in the southern Strait of Georgia, as Cardwell and Koons (1981) reported that the "Point Roberts to mid Birch Bay" (adjacent to Roberts Bank, but in the U.S.) herring spawn from February to June. According to the age-length relationship presented by Hourston (1957) for the Strait of Georgia, the juveniles (modal peak about 70 mm) reported on Roberts Bank in June were about 4 months old and could have come from stocks almost anywhere in the southern Straits. The smaller herring (20 to 40 mm), which were actually more abundant on Sturgeon Bank, would be about 1 to 2 months old and could have come from a late spawning on Roberts Bank, Point Roberts, or Boundary Bay. Barraclough (1967) concluded that the juvenile herring (20 to 25 mm) obtained in July off Sturgeon and Roberts banks in plankton tows were from a late spawning population.

The length-weight relationships obtained in our study were comparable to those presented by Hourston (1957) for herring elsewhere in the Strait of Georgia. The length-weight relationship in 1956 yielded an exponent of 2.76 compared to 3.11 in 1955. These inter-year differences were as marked as the intra-seasonal differences from our data from Roberts Bank, where the coefficient ranged from 1.189 to 3.260. The unusually low coefficients calculated from July 1980 data require further investigations. These low values decreased the mean coefficient from Roberts Bank fish to 2.461 compared to 3.463 on Sturgeon Bank.

ACKNOWLEDGMENTS

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Table 1. Herring gut contents (n = 20).

Item	Roberts Bank Intercauseway, 11 June 1979 Percent Number	Percent Frequency
Natantia zoea larvae	37.5	90
Brachyuran zoea larvae	0.1	15
Harpacticoid copepods	32.1	100
Small Calanoid copepods	28.3	75
Scaphocalunus sp.	<0.1	5
Metridia longa	0.1	15
Eurytemora sp.	0.6	35
Acartia sp.	<0.1	5
Anisogammarus pugettensis	0.1	10
Pontogeneia rostrata	<0.1	5
Ischyrocerus anguipes	<0.1	5
Unknown Gammarid	0.5	40
Hyperid amphipod	<0.1	5
Bryozoan larvae	0.3	20
Cirriped cypris and nauplii	0.2	35
Oikopleura	<0.2	10
Tanaidacea	<0.1	5

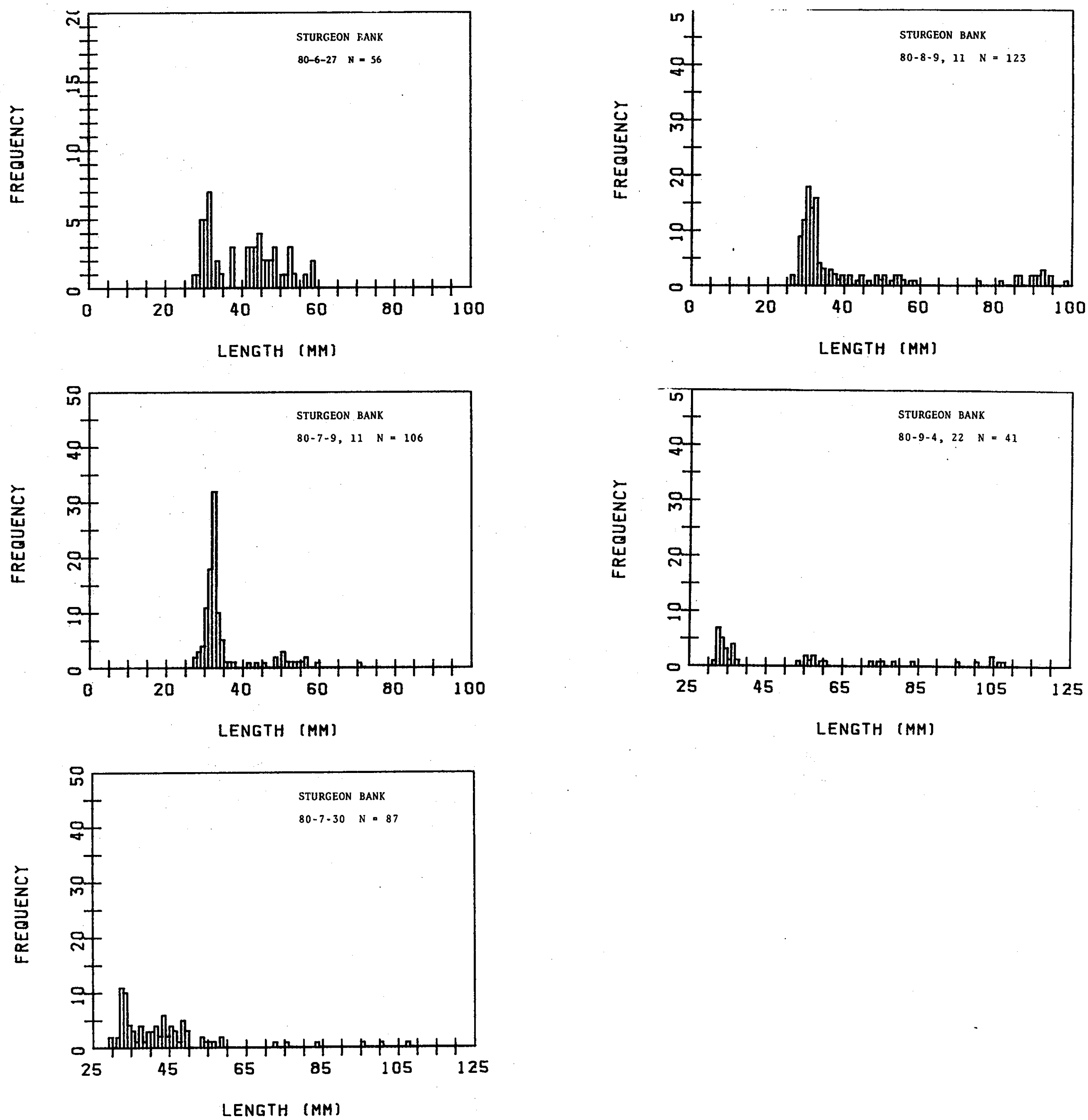


Fig. 1. Length frequency data for juvenile herring taken by beach seine on Sturgeon Bank, Fraser River estuary in 1980.

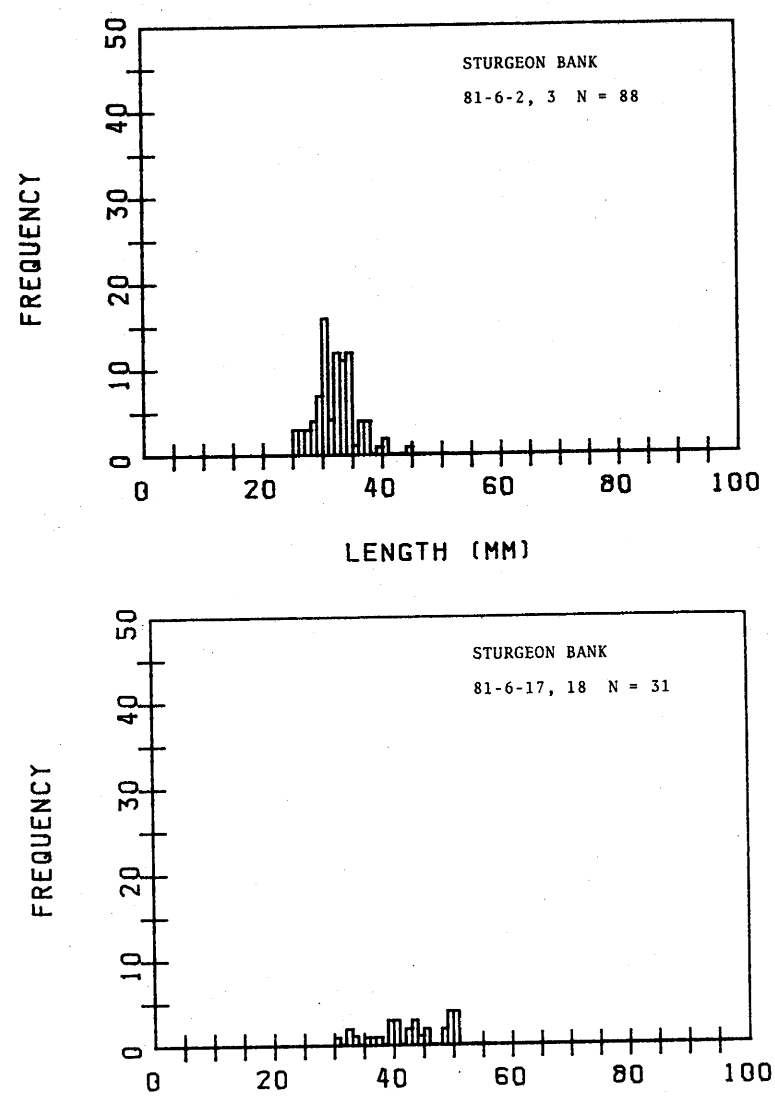


Fig. 2. Length frequency data for juvenile herring taken by beach seine on Sturgeon Bank, Fraser River estuary, in 1981.

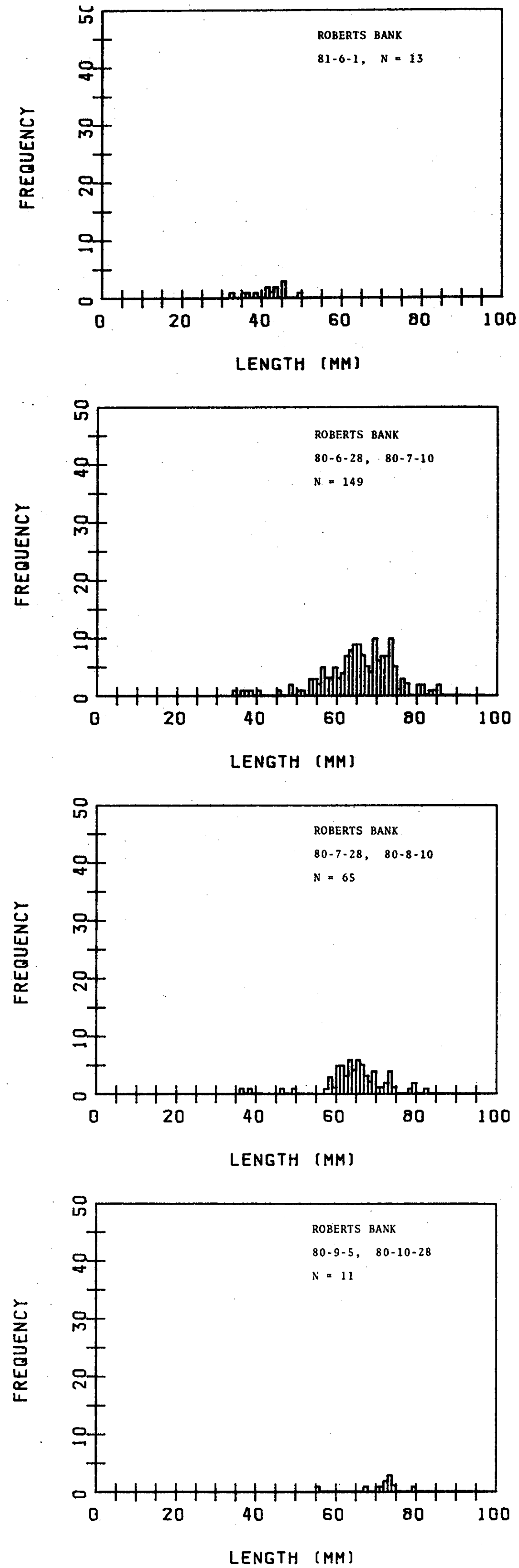
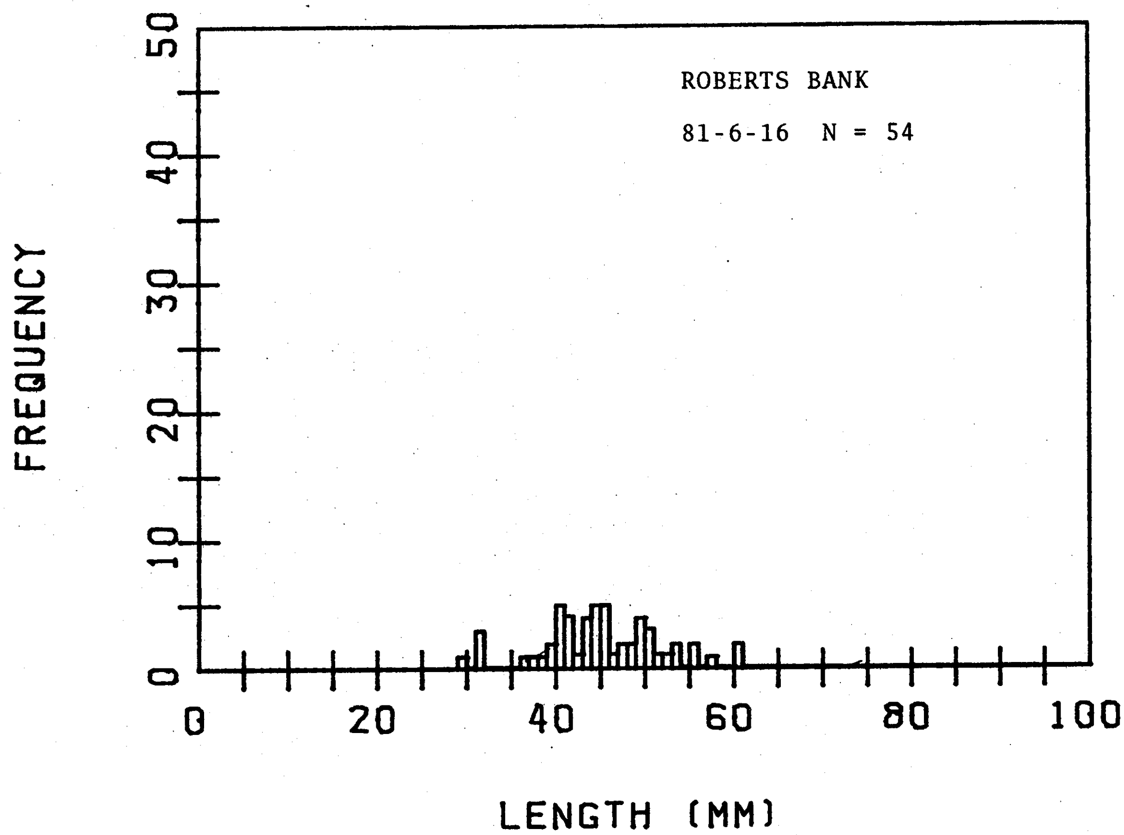


Fig. 3. Length frequency data for juvenile herring taken by beach seine on southern Roberts Bank, Fraser River estuary, in 1980.



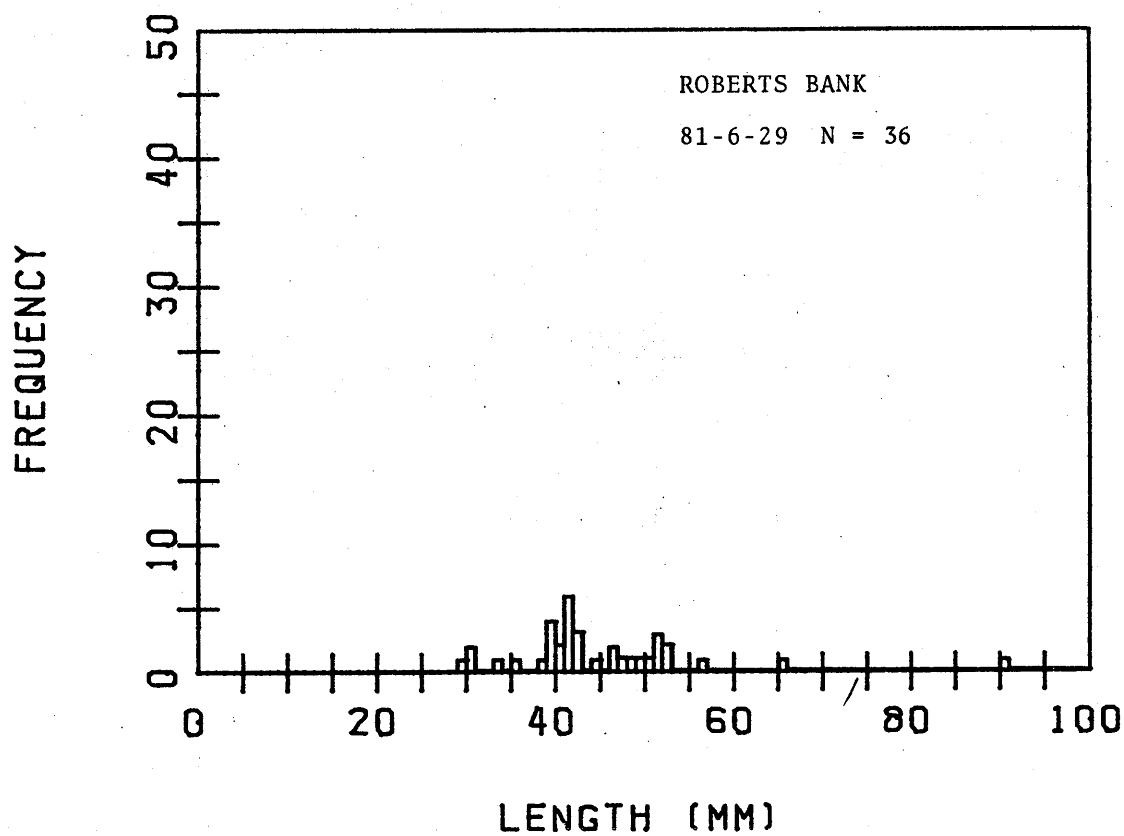


Fig. 4. Length frequency data for juvenile herring taken by beach seine on southern Roberts Bank, Fraser River estuary, in 1981.

BIOMASS ESTIMATES OF PACIFIC HERRING, *Clupea harengus pallasi*, IN CALIFORNIA FROM THE 1980-81 SPAWNING GROUND SURVEYS

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INTRODUCTION

In 1973, the California Department of Fish and Game began estimating the annual spawning biomass of Pacific herring (*Clupea harengus pallasi*) in Tomales and San Francisco bays (Spratt 1981). Both bays are relatively small in area and are well suited for intensive spawning ground surveys. Tomales Bay estimates have fluctuated normally around a mean of 6,000 tons. The San Francisco Bay estimates began to increase in 1978, due to improvements in sampling techniques and in 1979-80 the spawning biomass was estimated to be nearly 53,000 t (Spratt 1981).

This report includes spawning biomass estimates for Tomales Bay and San Francisco Bay during the 1980-81 spawning season. These data are the basis of the herring roe fishery management plan.

DESCRIPTION OF STUDY AREA

Tomales Bay

Tomales Bay lies in Marin County, a short distance north of San Francisco. It is 20 km (12.5 mi) long and averages more than 1.5 km (0.9 mi) wide. Hardwick (1973) mapped the distribution and abundance of marina flora in Tomales Bay and found that eel grass *Zostera marina*, comprised 75% by weight of all vegetation in the bay. The distribution of eel grass in Tomales Bay has changed slightly each year (Spratt 1981) and the present distribution was determined during March of 1981. Other species of marine flora are utilized as spawning substrate in Tomales Bay, but eel grass is the only spawning substrate included in my surveys.

San Francisco

The regular survey area in San Francisco Bay includes all shoreline and shallow subtidal areas to a depth of 4.6 m (15 ft) bounded by the Golden Gate Bridge, Richmond Bridge, and the Oakland Bridge. While most spawns are subtidal in San Francisco Bay, there is also considerable intertidal spawning activity. Intertidal spawns in San Francisco Bay literally cover all available substrate in the area, including: bare rocks, sand, pier pilings, and marina flora. The two major subtidal spawning areas are Richardson Bay and the east bay between Richmond and Oakland. They consist of sparse beds of *Gracilaria* spp. interspersed with *Ulva* sp. and some eel grass. The only areas consistently not utilized for spawning are broad mud flats with no vegetation.

METHODS

Tomales Bay sampling techniques

This season, spawning ground surveys were conducted from December 1, 1980 to March 20, 1981. Spawn sampling techniques have remained relatively unchanged since 1973 (Spratt 1981). Every eel grass bed was sampled daily from a 4.6 m (15 ft) boat by towing a vegetation sampler through the bed.

The distribution of eel grass changes yearly, new beds are discovered, old ones disappear, and the area of some beds change significantly.

Every year in March after spawning has nearly stopped, the area of all eel grass beds is remeasured and this new data is used to calculate all of the season's spawns. Previous estimates of eel grass density ranging from 0.5-4.0 kg/m^2 (Spratt 1981) were applied this season to each bed by subjective on site inspections.

San Francisco Bay sampling techniques

Techniques used in San Francisco Bay to estimate spawning biomass have evolved over the years. Before 1978, sampling biomass estimates for San Francisco Bay were determined by sampling intertidal (shoreline) spawns only. In January of 1979, a major subtidal spawn was located in Richardson Bay, and the following season, seven subtidal spawns were located which accounted for 79% of the season's spawning activity (Spratt 1981). In order to compute biomass from subtidal spawns, it is necessary to determine the weight (kg/m^2) of vegetation present in the spawning area. In the fall of 1979, Department divers collected quantitative samples of vegetation from Richardson Bay. This vegetation survey was expanded in the fall of 1980 to include Belvedere Cove, Tiburon, Kiel Cove, and the east bay between Richmond and Oakland. The boundaries of known vegetation beds were determined by dragging a vegetation sampler through them. Sampling stations were selected randomly by placing a grid over the beds, and numbering points where grid lines intersected. In the east bay 15 stations were selected and in the Richardson Bay area 20 stations were selected. Divers removed all vegetation from three 1/4 m^2 quadrats at each station. The vegetation was damp dried and weighed to the nearest gram immediately after collection. When a subtidal spawn occurs, the vegetation sampler is used to collect samples and determine spawning area (m^2). The number of eggs/kg of vegetation are determined using techniques developed in the 1979-80 season (Spratt 1981). The estimate of egg deposition is the product of number of eggs/kg vegetation, kg vegetation/m^2, and spawn area (m^2).

Biomass Computation

The techniques used to estimate total number of eggs deposited during a season differs between Tomales and San Francisco bays. However, conversion from numbers of eggs spawned to tons of adults is identical for both bays.