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Herring Spawning Bed Survey in Fishermans Bank, P.E.I. - Fall 1986

by

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Abstract

Herring spawning bed surveys were carried out in Fisherman's Bank, P.E.I. in August/September 1986. A single spawning bed was found in depths between 15 and 20 meters. The spawning bed covered an area of 1.1 km^2. Average number of deposited eggs was estimated at 3.8 X 10^6 ± .8 X 10^6 eggs/m^2. Hatching occurred after 7 days at temperature ranging from 14.0 to 16.3°C. Predation was mainly by mackerel (Scomber scombrus) and winter flounder (Pseudopleuronectes americanus). The use of the underwater video camera enabled the observation of herring spawning behaviour and for the first time recording cannibalism on herring egg deposition.

The herring spawning biomass in Fishermans Bank was estimated at 27,110 ± 5,600 mt. Based on herring catch of 7,000 mt taken from this fishery during the spawning season, the exploitation rate is estimated as 20.5%.

Resumé

Des relevés de frayères de hareng ont été effectués sur le banc Fisherman's (I.P.E.) en août et septembre 1986. Une seule frayère a été découverte par des profondeurs comprises entre 15 et 20 mètres; elle était d'une étendue de 1,1 km^2. On a estimé à 3,8 x 10^6 ± 0,8 x 10^6 oeufs/m^2 le nombre moyen d'oeufs déposés. L'éclosion s'est produite après 7 jours à des températures variant de 14,0 à 16,3°C. Les principaux prédateurs étaient le maquereau (Scomber scombrus) et la plie rouge (Pseudopleuronectes americanus). L'utilisation d'une camera vidéo sous-marine a permis d'observer le comportement du hareng pendant le frai et, pour la première fois, d'enregistrer du cannibalisme lors du dépôt des oeufs de hareng.

On a estimé à 27 110 ± 5 600 tm la biomasse de hareng sur le banc Fisherman's pendant le frai. D'après des captures de 7 000 tm par la pêche à cette espèce pendant la saison du frai, on estime le taux d'exploitation à 20,5%.

Introduction

Scuba-diving survey of herring spawning beds in Fisherman's Bank southwest P.E.I. was initiated in the fall of 1985 to collect information on egg density and provide an independent estimate of the spawning biomass. This location was chosen because it supports a major fall herring fishery in the southern Gulf of St. Lawrence. The bank is relatively shallow (10-25 m deep), extending for an area approximately 6 km^2, and ideally situated close to Murray Harbour, P.E.I. About 100 fishing boats using herring drift-nets are engaged in this fishery.

In the present report, the results of the herring spawning bed survey in fall 1986 are presented. As in previous surveys, the purpose was to collect information on spawning conditions, locate the spawning beds, estimate the density of egg deposition and the spawning stock biomass. In this year's survey an underwater video camera system was used along with Scuba-diving in locating the spawning beds.

Materials and Methods

Search Area and Procedure

The search area for herring spawning beds was restricted to Fisherman's Bank (N 46 01 00; W 62 16 00 Figure 1). Based on previous surveys in the fall of 1985, spawning beds were found only in this area. Locating the spawning beds was carried out by spot dives and underwater video camera. Two camera systems were used: An EDO Western Camera with a low-light tube and Cosmicar 10 mm wide-angle lens, equipped with flood light, monitor and time-lapse video recorder. Toward the end of the survey, problems with the camera were encountered, and another system was used. This system comprised a SONY b/w video camera with a custom made casing. The camera has a standard Vidicon tube with a 16 mm lens and a monitor.

A LORAN C (Sci-Tex Model 787C Dual Automatic Receiver) was used for locating the stations. A search and sampling grid was made, with station intervals of 200 m. At each station the camera was lowered over the side of the vessel, then the vessel was left drifting while the bottom was viewed on the monitor.

Two vessels were used for the survey. The first was a chartered lobster fishing boat (13 m) from Murray Harbour, P.E.I. The second vessel was the RV Navicula (20 m) on loan from Bedford Institute of Oceanography.

Physical Data Collection

Surface and bottom temperatures were recorded regularly. Temperature and salinity at selected stations were taken by a portable CTD. Bottom depth and type were reported at each station.

Quadrat Sample Collection and Analysis

Quadrat samples were taken in a manner similar to previous surveys (Messieh 1986). At each station the diver collected a quadrat sample (0.25 m^2) of the herring deposit, using an airlift operated by compressed air from the divers tank. In case of heavy egg deposition, the airlift was not used, and the samples were cut out of the egg sheet within the quadrat. In stations where a thick carpet of egg mass was found, a $\frac{1}{4}$ quadrat sample (1/16 m^2) was taken.

Samples were collected in bags and preserved in 4% formalin for laboratory examination. Counting of eggs was estimated from dried samples. Eggs were thoroughly cleaned from gravel and then placed in an oven (60°C) to dry for about 16 h to a constant weight. Subsamples of about 1000 eggs were weighed, accurately counted, and estimates of total number of eggs per quadrat were made. Egg density deposition was expressed as number of eggs per m^2.

Another method of estimating egg density was tested during this year's survey. This method depends on the observed relationship between spawn mat thickness and number of eggs in a quadrat, as tested by linear regression analysis.

Results

The search for herring spawn began on August 27, 1986 by spot dives, but no spawn was found. On August 31 and September 1 a complete coverage of the bank was made by sampling 74 stations using the underwater video camera. Again, no spawn was found, but schools of herring were observed on the monitor. On September 2, schools of herring were seen on the monitor and recorded on the video tape. Also a large milt patch (about 400 m diameter) was seen in the morning at 10 a.m.

On September 3, due to strong winds, we were not able to go to sea. On September 4, a large heavy spawn was located by the video camera. Thirty stations were sampled by the camera to delineate the spawning bed. Another milt patch was located about $\frac{1}{2}$ mile southwest of the bank on 18 m depth. The underwater camera survey of the spawning bed was completed on September 5. Records of spawning herring on video tape showed their spawning behaviour. Survey of the rest of the bank area did not reveal any other spawn.

Sampling of the spawning beds by scuba-divers extended over 4 days (September 6-9) and involved 29 stations. On September 18, a second survey of the bank was carried out but no other spawn was found, and the original spawning bed was almost gone. Incubation period was estimated from egg developmental stage as 7 days. Incubation period in relation to temperature is shown in Figure 2. Temperature ranged between 14.0 and 16.3°C at surface, and 14.0 - 15.8°C at bottom (Figure 3).

The single spawning bed found was estimated to have an area of 1.1 km^2 (Figure 4). Average number of eggs/m^2 was estimated at 3,800 ± 790 (Table 1). Deposited eggs were found at 15 - 20 m depth. The visibility was good (5 - 6 m) with currents occasionally swift at the surface. The predominant substrate was bedrock and cobble. The algae cover was negligible, composed mainly of filamentous red algae *Polysiphonia* and unidentified corraline algae. Predation on herring eggs was mainly by winter flounder (*Pseudopleuronectes americanus*) cunner (*Tautogolabrus adspersus*) and mackerel (*Scomber scombrus*).

Biological data relevant to calculation of spawning biomass are presented in Table 1. Spawning biomass expressed as wet weight of fish was estimated at 27,110 ± 5,600 mt which is 1,420 mt less than that in 1985. Catch of herring from Fishermans Bank was 7,000 mt which represent an exploitation rate of 20.5%.

Regression of number of eggs per unit area on thickness of egg deposition mat (Table 2; Figure 5) showed good correlation. Observations on thickness of egg deposition taken at 12 stations are presented in Appendix I. With the omission of one observation as an outlier, the correlation coefficient was R = 0.84. In future surveys, the thickness of egg deposition could provide a reliable index for spawning intensity.

Results of tests for equality of variances (Appendix II) showed that the variances produced from two different sample sizes ($\frac{1}{4}$ m^2 and 1/16 m^2) are not significantly different.

Discussion

This is the second year's survey of herring spawning bed on Fishermans Bank. The single spawning bed found in this survey was much larger than any of the four spawning beds found in fall 1985. The area of this spawning bed was 1.1 km^2 compared to 1.8 km^2 for the four spawning beds combined. Egg deposition was relatively thick exceeding 5 cm in thickness in some areas. Average thickness of a mat of 2 cm (20 layers of eggs) resulted in very high mortalities (95% in samples taken on September 9) due to poor water circulation and lack of oxygenation. These conditions, however, did not result in egg deterioration and mass mortalities similar to those observed in fall 1985 (Messieh 1986). Conditions resulting in this heavy egg deposition in a restricted area are still under investigation.

The use of the underwater video camera system in this survey enabled us to observe and record the spawning behaviour of herring. The observation of a milt patch on the bank prior to the deposition of eggs led to the conclusion that the female herring spawners did not release their eggs until the milt was released. Watching the schools of herring on the video monitor confirmed this conclusion. If this is the case, segregation by sex during spawning appears to be a part of herring spawning behaviour. Examination of some samples from commercial catch collected near the spawning bed, showed dominance of one sex or the other, thus agreeing with this observation. For the first time in spawning bed surveys we observed herring spawning during daytime. By interviewing local fishermen, they agreed that this is the first year to note this phenomenon.

Mackerel predation on herring eggs was again confirmed this year. Moreover, cannibalism of herring on their own eggs was observed. Recording this phenomenon on video tape provided direct evidence for cannibalism.

Estimate of spawning biomass of 27,110 mt showed a small reduction from the 1985 biomass (28,530 mt). Commercial catch landed in Murray Harbour, P.E.I., mostly fished on Fishermans Bank was about 7,000 mt. This represents an exploitation rate of about 20.5% which is higher than the exploitation rate of last year (13.6%). However, it is close to the rate (20%) recommended by CAFSAC for Atlantic herring.

References

Jean, Y. 1956. A study of spring and fall spawning herring (Clupea harengus) at Grande-Rivière, Bay of Chaleur, Quebec. Department of Fisheries, Quebec. Contribution 49, 76 p.

Messieh, S. 1986. Herring spawning bed survey in Fisherman's Bank, P.E.I. in fall 1985. CAFSAC Res. Doc. 86/78, 16 p.

Messieh, S., R. Pottle, P. MacPherson, and T. Hurlbut 1985. Spawning and exploitation of Atlantic herring (Clupea harengus) at Escuminac in the southwestern Gulf of St. Lawrence, spring 1985. J. Northw. Atl. Fish. Sci. Vol. 6: 125-133.

Table 1. Biological data relevant to calculation of spawning biomass.

Age (yr)	Catch Numbers at Age	Mean Weight (g)	Mean Fecundity (000)
<3	234	180	-
3	1852	195	80
4	22950	230	95
5	6532	295	120
6	11608	350	130
7	2971	385	150
8	1561	395	180
>8	601	420	200

Area of Bed	1,100,000 m^2
Estimated total egg deposition	4.18×10^{12}
Proportion lost by fish predation	0.30
Initial egg deposition	5.43×10^{12}
Weighted average fecundity	113,425
Number of spawning female	4.79×10^{7}
Total males and females	9.58×10^{7}
Weighted average weight	283 g
Estimated spawning biomass	27,110 mt
Catch of spawning fish	7,000 mt
Exploitation rate	20.5%

Table 2. Comparison between estimates of egg mat thickness and egg counts.

DATE	SAMP.#	THICKNESS(cm)	EGGS/M^2(X10^6)
06/9/86	1	5.1	15.5
06/9/86	2	4.2	12.1
06/9/86	3	1.9	7.9
06/9/86	4	1.2	9.1
06/9/86	5	0.2	1.5
08/9/86	2	3.1	11.3
08/9/86	3	2.0	7.6
08/9/86	4	1.8	8.7
08/9/86	5	1.9	6.5
08/9/86	7	1.9	6.4
09/9/86	1	2.0	2.4
09/9/86	2	4.0	2.2

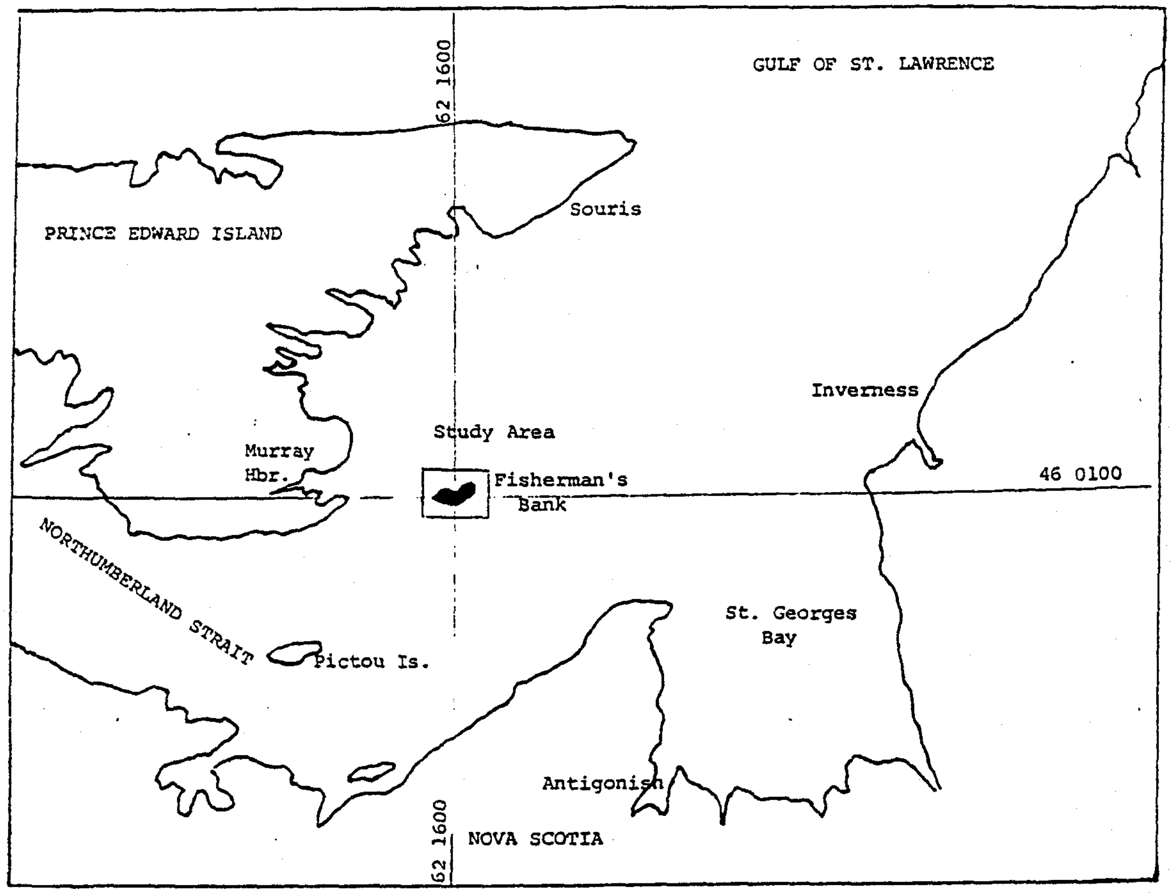
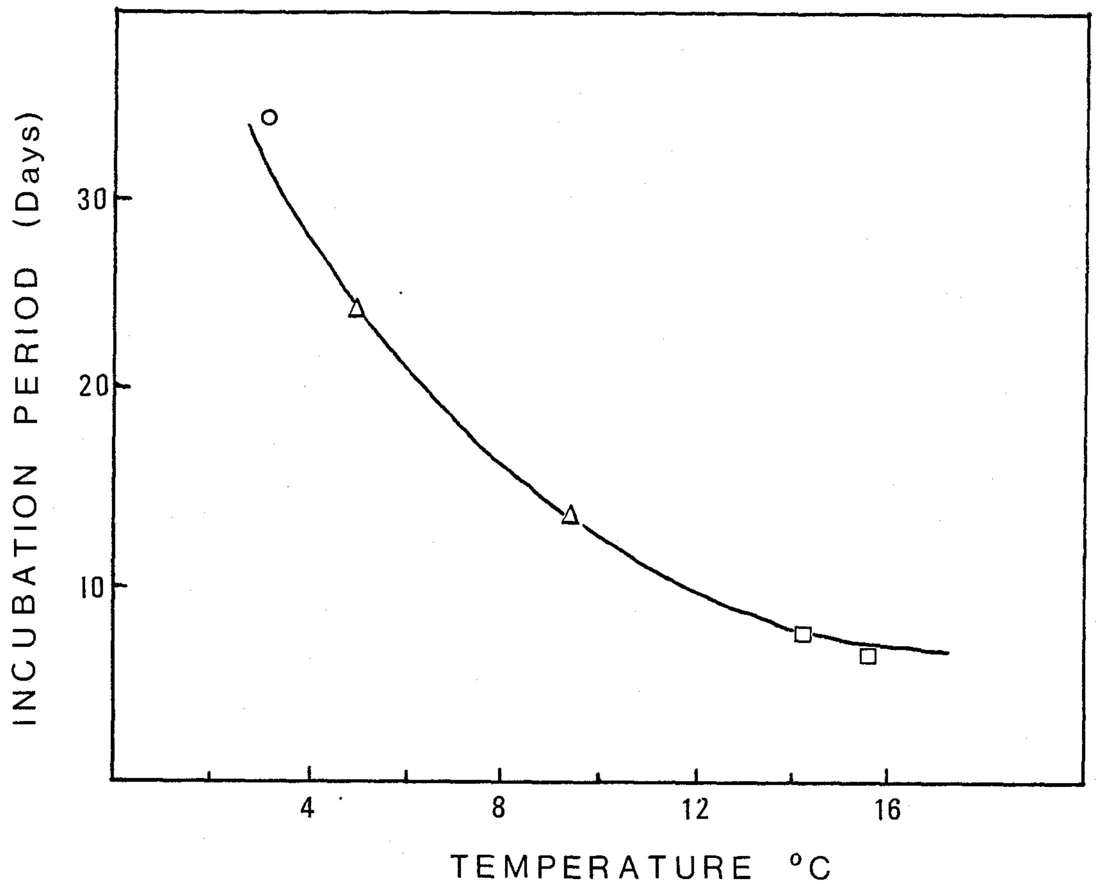


Figure 1. Map of the southern Gulf of St. Lawrence showing the herring spawning bed survey area of Fisherman's Bank



Δ - Escuminac, Spring (Messieh, 1985)

□ - Fishermans Bank, Autumn (Messieh et al, 1986)

o - Bay of Chaleur, Spring (Jean, 1956)

Figure 2. Relationahip between temperature and incubation period of Atlantic herring in the Gulf of St. Lawrence and other areas.

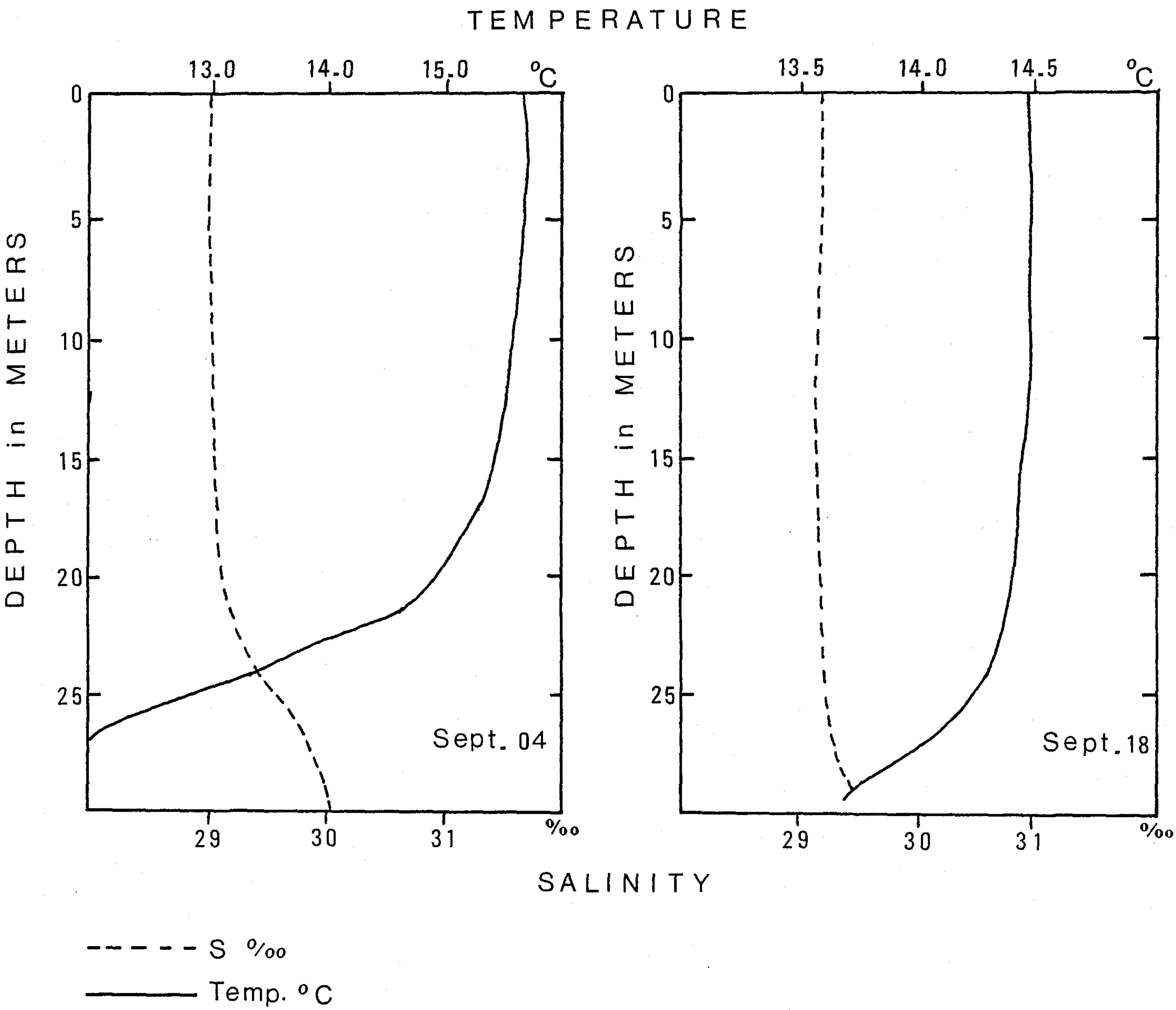


Figure 3. Temperature and salinity profiles near the survey area of Fishermans Bank, September, 1986.

FISHERMAN'S BANK 1986

Herring Egg Density

contours in millions of eggs per sq/m.

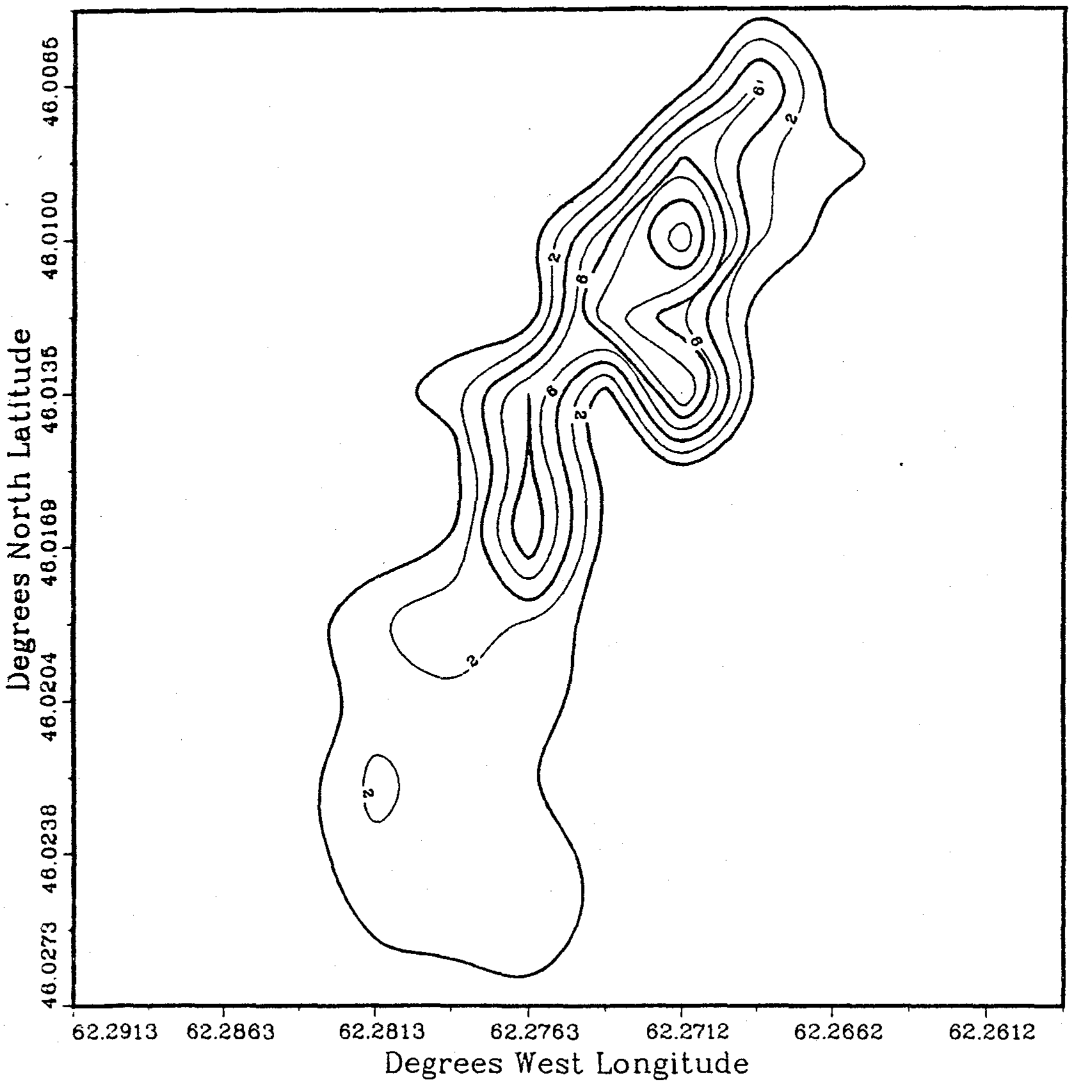
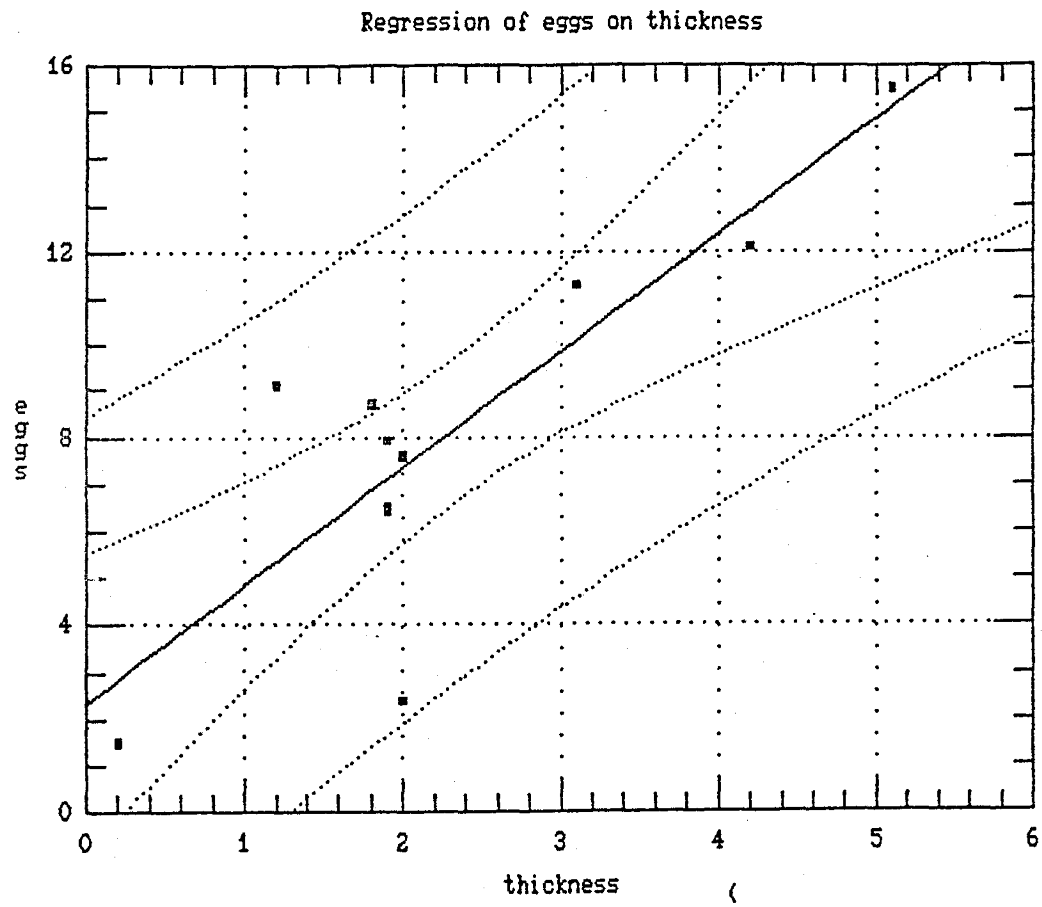


Figure 4: Area and egg density of herring spawning bed on Fishermans Bank, fall 1986.



Regression Analysis - Linear model: Y = a+bX

Dependent variable: eggs			Independent variable: thickness	
Parameter	Estimate	Standard Error	T Value	Prob. Level
Intercept	2.33473	1.40721	1.65913	0.131464
Slope	2.50269	0.532531	4.6996	1.1208E-3

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	Prob. Level
Model	116.62513	1	116.62513	22.08625	.00112
Error	47.523957	9	5.280440		
Total (Corr.)	164.14909	10			

Correlation Coefficient = 0.842902 R-squared = 71.05 percent
Stnd. Error of Est. = 2.29792

Figure 5: Relationship between herring egg deposition expressed in number per unit area and thickness of spawning mat.

APPENDIX I

THICKNESS OF EGG MAT DEPOSITION (cm)

DATE	06/9/86	06/9/86	06/9/86	06/9/86	06/9/86	06/9/86
Samp.#	1	2	3	4	5	2
1	5.6	3.8	0.6	1.6		2.2
2	3.2	2.8	0.5	3.0	1-3	4.0
3	3.2	5.5	4.0	0.0	layers	4.1
4	5.2	2.8	1.0	0.0		2.5
5	5.5	3.2	2.7	3.0		2.1
6	5.2	7.5	1.0	0.0		2.2
7	5.6	7.0	1.1	3.0		4.2
8	5.0	0.5	1.5	0.0		3.4
9	6.5	2.0	2.0	0.0		2.0
10	6.2	6.8	5.0	1.2		3.8
mean	5.1	4.2	1.9	1.2	0.2	3.1
S	1.1	2.4	1.5	1.4	-	0.9
S.E.	0.3	0.8	0.5	0.4	-	0.3

DATE	08/9/86	08/9/86	08/9/86	08/9/86	09/9/86	09/9/86
Samp.#	3	4	5	7	1	2
1	1.1	1.0	1.5	1.2	3.5	3.0
2	0.6	1.3	2.1	3.0	1.5	3.5
3	2.2	4.0	3.0	4.5	3.8	1.8
4	3.0	1.6	1.5	2.3	0.5	3.0
5	2.0	1.6	1.6	1.2	0.7	2.0
6	3.9	2.1	0.9	1.0	2.5	6.0
7	1.8	2.0	3.0	1.7	0.7	2.7
8	2.0	1.6	1.5	1.3	1.8	3.0
9	2.0	1.7	1.5	1.2	1.4	5.5
10	0.9	1.0	2.0	1.3	3.8	10.0
mean	2.0	1.8	1.9	1.9	2.0	4.0
S	1.0	0.9	0.7	1.1	1.3	2.5
S.E.	0.3	0.3	0.2	0.3	0.4	0.8

Appendix II

Tests for the equality of variances

Two tests were used to examine whether two different sample sizes (1/4 m^2 quadrat or 1/16 m^2 quadrat) produced similar variances. Both tests are based on the assumption that 1) the samples are independent and random, and 2) the population from which the samples were drawn are normally distributed.

Test 1: Test for equality of two variances

$S_1^2 / S_2^2 = 1.13$; (F value = 3.18)

The null hypothesis is not rejected hence the variances are not significantly different

Test 2: Bartlett Test

If S_1^2 and S_2^2 denote the sample variances, and df_1 and df_2 denote the degrees of freedom. Then the weighted arithmetic average of the variances, using the associated degrees of freedom as weights, is the mean square error:

$$MSE = \frac{1}{df_T} \left(\sum_{i=1}^{r} df_i \, S_i^2 \right)$$

Where: $$df_T = \sum_{i=1}^{r} df_i$$

Similarly, the weighted geometric average of the S_i^2, denoted by GMSE is:

$$GMSE = \left[(S_i^2)^{df_2} \; (S_i^2)^{df_2} \right]^{1/df_T}$$

The relation between the two averages for any given set of S_i^2 values is:

$$GMSE \leq MSE$$

Therefore if the ratio between the two averages is close to 1, it is evident that the population variances are equal.

GMSE = 783.10; MSE = 784.59

Therefore, the two sample variances are considered equal.