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The effect of freezer storage on herring length and maturity stage determination

by

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ABSTRACT

It is known from preceeding studies that freezing of herring results in a reduced length. In April 1981 and June 1985, herring samples were collected from ports in the southern Gulf of St. Lawrence. To arrive at conversion factors, fish were measured and the maturity stage determined in fresh condition, then frozen for a period of time, thawed and re-examined. The linear regression equation of the relationship between frozen-thawed fish length and fresh fish length was found to have a slope of 1.01 and an intercept of 2.28 mm. Results of maturity stage determinations indicate substantial changes in the stage assignment between fresh and frozen observation.

RÉSUMÉ

Des études antérieures ont montré que la congélation du hareng entraîne une diminution de la longueur des poissons. En avril 1981 et en juin 1985 on a recueilli des échantillons de hareng dans des ports du sud du golfe du Saint-Laurent. On a mesuré, et déterminé le stade de maturité, des poissons à l'état frais et après les avoir soumis à une période de congélation puis décongelé afin d'arriver à des facteurs de conversion. La droite de régression décrivant la relation entre la longueur des poissons congelés-décongelés et la longueur des poissons frais présente une pente de 1,01 et une ordonnée à l'origine de 2,28 mm. Les résultats des déterminations du stade de maturité indiquent des modifications substantielles des stades de maturité attribués aux poissons frais et aux poissons congelés.

INTRODUCTION

Accurate measurement of fish length and determination of gonad development are essential parameters used for both stock assessment and other biological studies. Observation of some parameters is not practical in the field and it is usual to collect and freeze samples for subsequent examination in the laboratory. Hodder et al. (1972) reported on a reduction in length for herring measured in a fresh condition and after freezer storage. Such shrinkage could cause the greatest complications in cases where a two-phase sampling design is employed where length frequency data taken from fresh fish are partitioned into age groups using an age-length key derived from frozen samples. Freezing could also have some effect on assignment of maturity stage, since the criteria for each stage is based on observation of fish in a fresh condition.

This report summarizes results of two independent studies completed by the Scotia-Fundy and Gulf Regions for herring in the southern Gulf of St. Lawrence (NAFO Division 4T).

MATERIALS AND METHODS

Samples from commercial catches were collected in 1981 and 1985 at various landing sites in the Gulf of St. Lawrence. Scotia-Fundy samples were taken in April from the fixed gear fishery in NAFO Unit Area 4Tf in 1981. This fishery is based on the inshore movement of herring ready to spawn and, historically, catches have been dominated by pre-spawning, spawning and post-spawning fish. Three random samples were taken, consisting of two samples of 100 fish from two catches and one sample of 62 from a third catch. Both of the dupblicate samples were frozen and one of the pair examined after 4 wk and the other after 8 mo. The sample of 62 fresh fish was examined to determine maturity stage and length, and then each fish was tagged with a T-bar tag for subsequent identification after freezing. Individual fish were stored in closed plastic bags and the duplicate samples stored in waxed cardboard boxes. It was assumed there was no difference between the two containers, although the plastic bags are more air tight and could diminish the effect of shrinkage and dessication during storage.

Gulf Region samples were collected in 1985 from landings in Tignish, P.E.I. (June 14), Petit Cap, N.B. (June 18), Ballantynes Cove, N.S. (June 19), Cape Tormentine, N.B. (June 21) and Cap Pele, N.B. (June 21). The fish were measured to the nearest millimeter and three to five fish from each 5-mm length group were kept and stored individually in bags. Individual fish weights were also recorded and one or two fish from each length interval were examined to determine maturity stage and the gonads replaced in the body cavity prior to freezing. Two of the five samples were examined after 7 d freezer storage and the remaining three samples after 32 d storage.

In both studies, fish length was determined to the nearest mm and defined as the total length from the tip of the jaw to the maximum extent of the caudal fin. Weight was determined to the nearest gram using an electronic balance. Gonad development was assigned to one of the eight stages described by Parrish and Saville (1965). Stage VI describes spawning fish and, by definition, gonads in this condition "run freely by slight external pressure." In the Scotia-Fundy study, fish which did not meet this requirement but which had obviously released some gonad material prior to or during capture were, by convention, assigned to stage V to conform to standard sampling protocol. In the Gulf Region study, these fish were assigned to stage VI.

Fish were stored at approximately -10°C. Thawing of the samples for later examination was accomplished by placing the samples in cool water for 1-2 h or until completely thawed.

Comparison of percent maturity stage composition between fresh, short-term freezing and long-term freezing was made to assess changes attributed to the effect of storage. Regression analyses of fresh length and length after storage were completed and linear equations fit.

RESULTS

In the Scotia-Fundy study, only the sample of 62 fish had length measurements for fresh and frozen individual fish. Lengths ranged between 300 and 380 mm with a mean length of 340.2 mm in the fresh condition and a reduction to 335.2 mm after 7 mo freezer storage, indicating an average net loss of 5.0 mm over the storage period. Similar results were observed in the Gulf Region study with an average net loss of 4.7 mm after 7 d and 5.8 mm after 32 d. Fish lengths ranged between 260 and 385 mm. The relationships between length of fresh fish and length after storage were as follows:

Fresh length = 1.69 + 1.01 (frozen length) after 7 d (Gulf)

Fresh length = 6.61 + 1.0 (frozen length) after 32 d (Gulf)

Fresh length = 14.3 + 0.97 (frozen length) after 7 mo (Scotia-Fundy)

with correlation coefficients of 0.99 for each regression equation. Regression analysis was also used to determine if there was a relationship between the reduction in length and the fresh length. However, low correlation coefficients indicate that the above conversion equations can be applied over the observed length range. Comparison of fresh and frozen lengths for the three samples are given in Tables 1-3 and regression plots are shown in Fig. 1-4.

Comparison of maturity stage composition between fresh and stored samples indicates substantial changes after freezing. In the Gulf study, there was a tendency for stage IV and V fish in fresh condition to be assessed as stage VI after 7 d storage while after 32 d many stage IV fish were considered to be stage III. Results are summarized in Table 4.

In contrast, the Scotia-Fundy study appeared to indicate a substantial reduction in the number of stage VI fish after storage. In the paired samples, the percent stage VI changed from about 50% to 0% and the mean stage from 5.32 and 5.82 to 4.89 and 4.88 for the two replicates. Similar results were observed in the third sample of 62 fish in which the occurrence of stage VI changed from 79% to 0% after 7 mo storage. Of the 49 fish assessed to be stage VI in the fresh condition, 58% were assigned to stage IV, 46% to stage V and 6% to stage VII after storage. Results of this comparison are shown in Tables 5 and 6.

CONCLUSIONS

Reduction in fish length due to freezer storage appears to be significant and should be taken into consideration during analysis of sampling data. Most herring samples are frozen for a period of 1 mo or more prior to examination and a conversion to fresh length should be applied. This is particularly important in the case of two-phase sampling designs in which a length frequency based on fresh length measurements is partitioned with an age-length key derived from frozen samples. Although the effect of

freezing appears to be related to duration of storage in the Gulf Region study, the best conversion factor may be derived from the regression of fresh length on length after various periods of storage. This was completed for the three data sets used in this study and the resultant conversion equation is the most appropriate for use on frozen samples:

$$\text{Fresh length} = 2.28 + 1.01\ (\text{frozen length}).$$

Changes in maturity stage assignment due to freezer storage are more difficult to assess. The effect appears to be most evident for stage VI, although one study indicates an increase in percent composition of this stage and the other a decrease. Several factors may account for this change. Freezer storage may cause the gonads to shrink and close the vent making it difficult to determine a free running condition. Alternatively, freezing may rupture tissue and induce release of gonad material. Stress-induced spawning during capture may result in premature release and the visual appearance of frozen and then thawed gonads may not conform to the currently used descriptive scale.

The impact of apparent changes in maturity stage may not have substantial implications for assignment to spawning group. In general, the changes are not sufficient to alter the expected maturity stage composition of a sample in relation to time of year and spawning season. The one exception is the change from stage VI to stage III in the Gulf Region study, but this is based on a small sample (20) and may not be indicative of the overall trend.

It is recommended that a scale based on the visual appearance of thawed gonads be developed to assist in assignment of maturity stage.

ACKNOWLEDGMENTS

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Table 1. Comparison of herring lengths before and after freezer storage (7 mo) for Scotia-Fundy samples.

Length group (mm)	Frequency	Average fresh length (mm)	Average thawed length (mm)	Difference (mm)
300	4	301.8	295.8	6.0
305	4	306.5	302.0	4.5
310	5	312.0	305.4	6.6
315	2	318.5	313.5	5.0
320	7	321.7	316.4	5.3
325	3	328.7	323.3	5.4
330	4	333.0	326.5	6.5
335	4	338.0	334.8	3.2
340	-	-	-	-
345	1	346.0	342.0	4.0
350	7	352.3	347.4	4.9
355	3	355.0	352.3	2.7
360	4	362.3	356.3	6.0
365	6	366.8	362.3	4.5
370	3	372.3	369.3	3.0
375	3	377.0	374.0	3.0
380	2	382.0	374.0	8.0
Mean	62	340.2	335.2	5.0

Table 2. Comparison of herring lengths before and after freezer storage (7 d) for Gulf samples.

Length group (mm)	Frequency	Average fresh length (mm)	Average thawed length (mm)	Difference (mm)
260	1	258	254.0	4
265	1	263	257.0	6
270	2	270.5	266.5	4
275	3	274.3	270.7	3.6
280	6	279.5	273.8	5.7
285	6	284.7	279.5	5.2
290	7	290.0	286.1	3.9
295	7	294.9	290.7	4.2
300	9	300.2	297.0	3.2
305	8	304.5	301.0	3.5
310	8	310.5	306.0	4.5
315	7	316.3	312.4	3.9
320	8	320.0	316.6	3.4
325	8	326	323.3	2.7
330	9	329.4	324	5.4
335	9	335.7	330	5.7
340	7	339.7	334.7	5
345	7	344.0	337.0	7
350	5	349.4	342.8	6.6
355	3	355.3	349.0	6.3
360	2	359.5	354	5.5
365	4	364.3	359.5	4.8
370	2	368.5	356	12.5
375	0			
380	2	378.5	373	5.5
385	1	383	378	5
Mean	132			

Table 3. Comparison of herring lengths before and after freezer storage (32 d) for Gulf samples.

Length group (mm)	Frequency	Average fresh length (mm)	Average thawed length (mm)	Difference (mm)
275	4	275.0	271.3	3.7
280	1	282	276	6.0
285	6	285.5	282.0	3.5
290	5	290.8	285.0	5.8
295	6	294.3	287.0	7.3
300	8	300.4	295.4	5.0
305	10	305.6	301.2	4.4
310	9	310.6	306.4	4.2
315	12	315.7	310.0	5.7
320	14	320.2	314.2	6.0
325	15	324.7	319.1	5.6
330	16	330.5	324.9	5.6
335	15	334.7	328.2	6.5
340	15	340.6	334.7	5.9
345	13	345.0	339.2	5.8
350	14	350.1	342.7	7.4
355	9	355.0	348.7	6.3
360	8	359.3	352.1	7.2
365	4	375.5	362.3	3.2
370	0			
375	1	373.0	364.0	9.0
Mean	185			

Table 4. Changes in maturity stage determinations before and after freezer storage for Gulf Region samples (a) 7 d, (b) 32 d.

(a) Stage	Fresh		Thawed	
	Number	Percent	Number	Percent
III	2	4.9	0	0
IV	7	17.0	3	7.3
V	10	24.4	0	0
VI	22	53.7	37	90.2
VIII	0	0	1	2.4
(b)				
III	2	9.1	8	36.4
IV	20	86.4	13	59.1
V	1	4.5	0	0
VI	0	0	1	4.5

Table 5. Comparison of maturity stage composition for replicate samples after short- and long-term freezer storage for Scotia-Fundy samples.

Date collected	20 April		23 April		25 April	
Date sampled	May	Dec	May	Dec	May	Dec
Stage III	1	-	1	-	-	-
IV	11	11	2	25	1	28
V	43	89	28	69	11	31
VI	45	-	54	-	50	-
VII	-	-	13	5	-	3
VIII	-	-	2	1	-	-
Total	100	100	100	100	62	62

Table 6. Change by maturity stage between fresh and thawed samples for Scotia-Fundy samples.

		Fresh stage						
		III	IV	V	VI	VII	VIII	Total
FROZEN STAGE	III	-	-	-	-	-	-	-
	IV	-	1	3	23	-	-	27
	V	-	-	9	23	-	-	32
	VI	-	-	-	-	-	-	-
	VII	-	-	-	3	-	-	3
	VIII	-	-	-	-	-	-	-
	Total	-	1	12	49	-	-	62

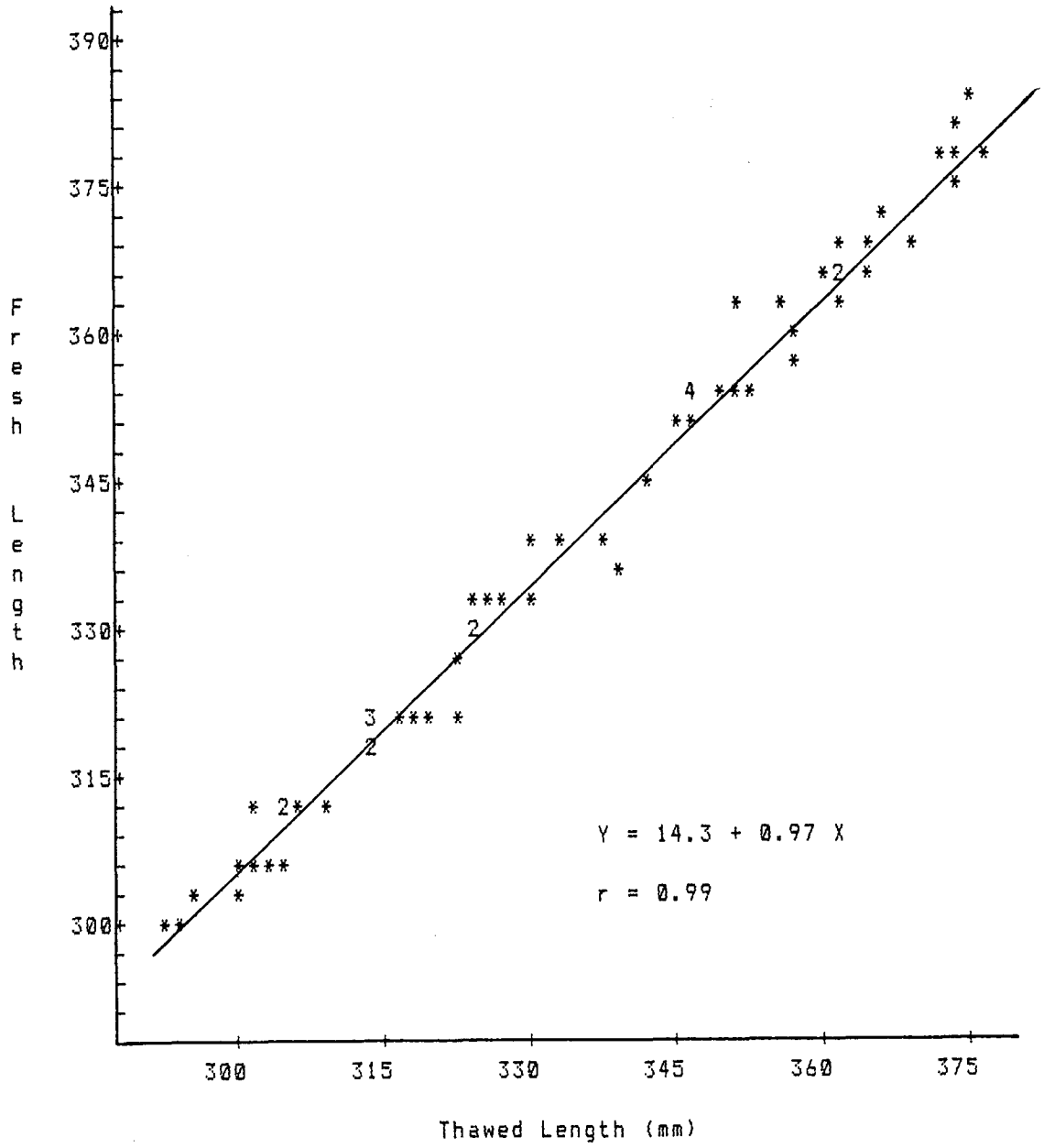

Figure 1. Regression of fresh length on thawed length for herring after seven months storage for Scotia-Fundy samples.

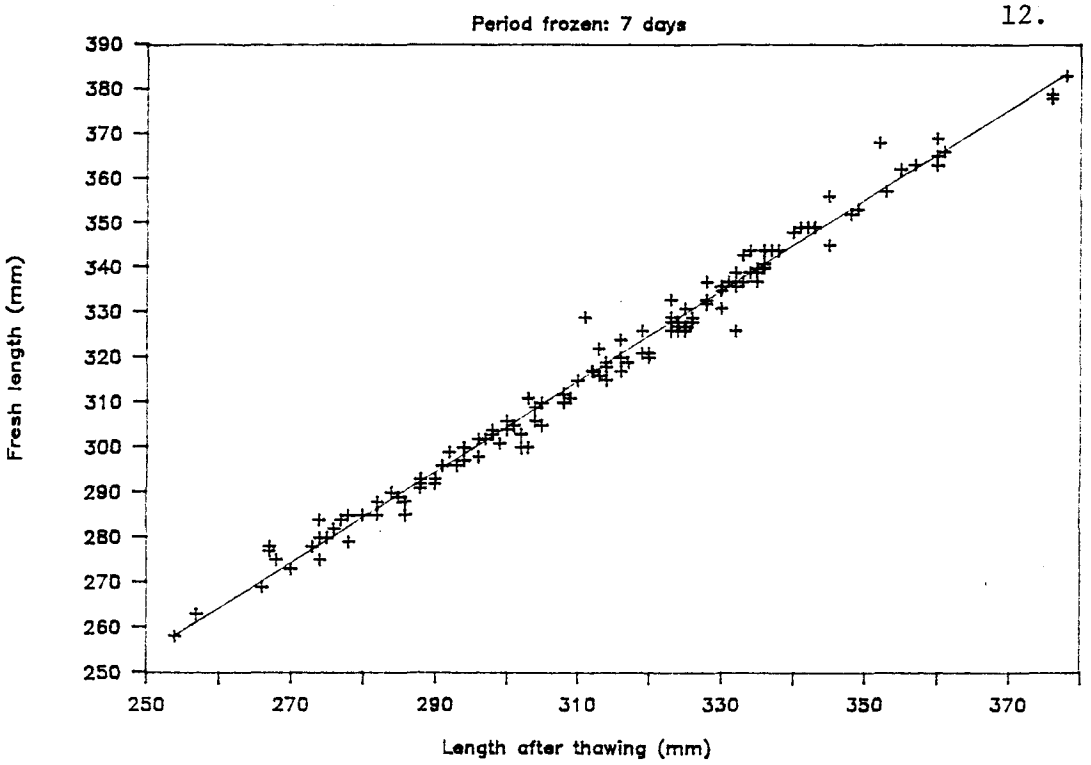

Figure 2. Relationship between fresh herring length and frozen-thawed herring length after 7 days for the Gulf study (r = 0.99, n = 185).

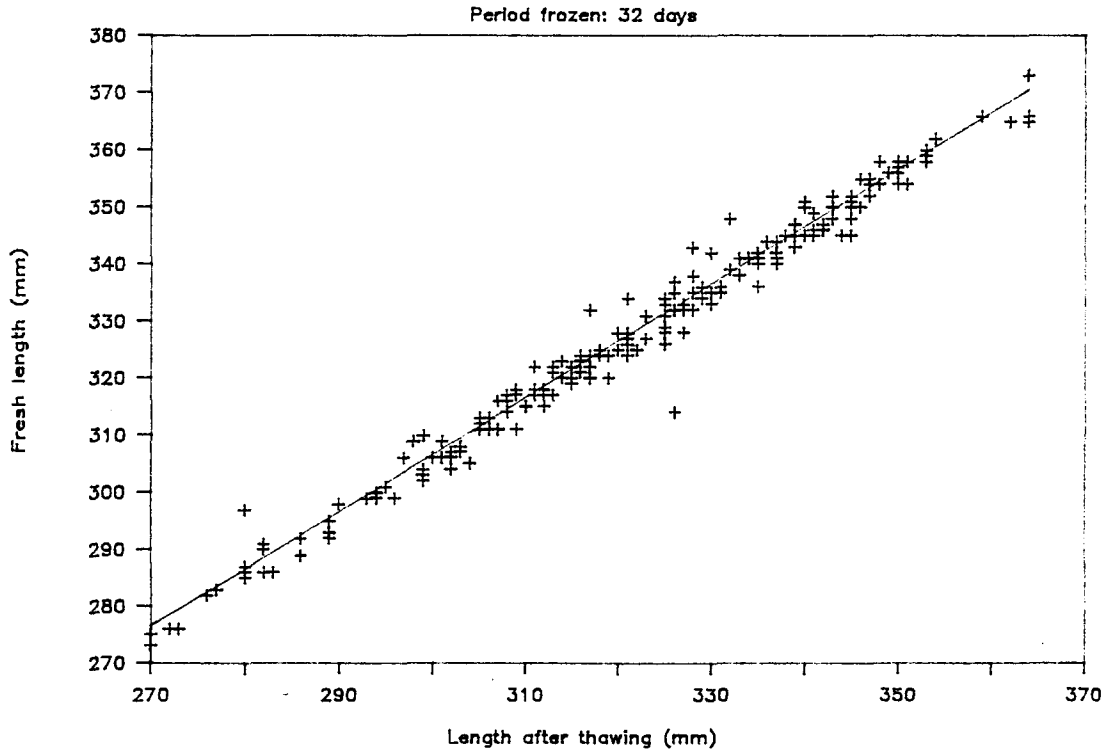

Figure 3. Relationship between fresh herring length and frozen-thawed herring length after 32 days for the Gulf study (r = 0.99, n = 132).

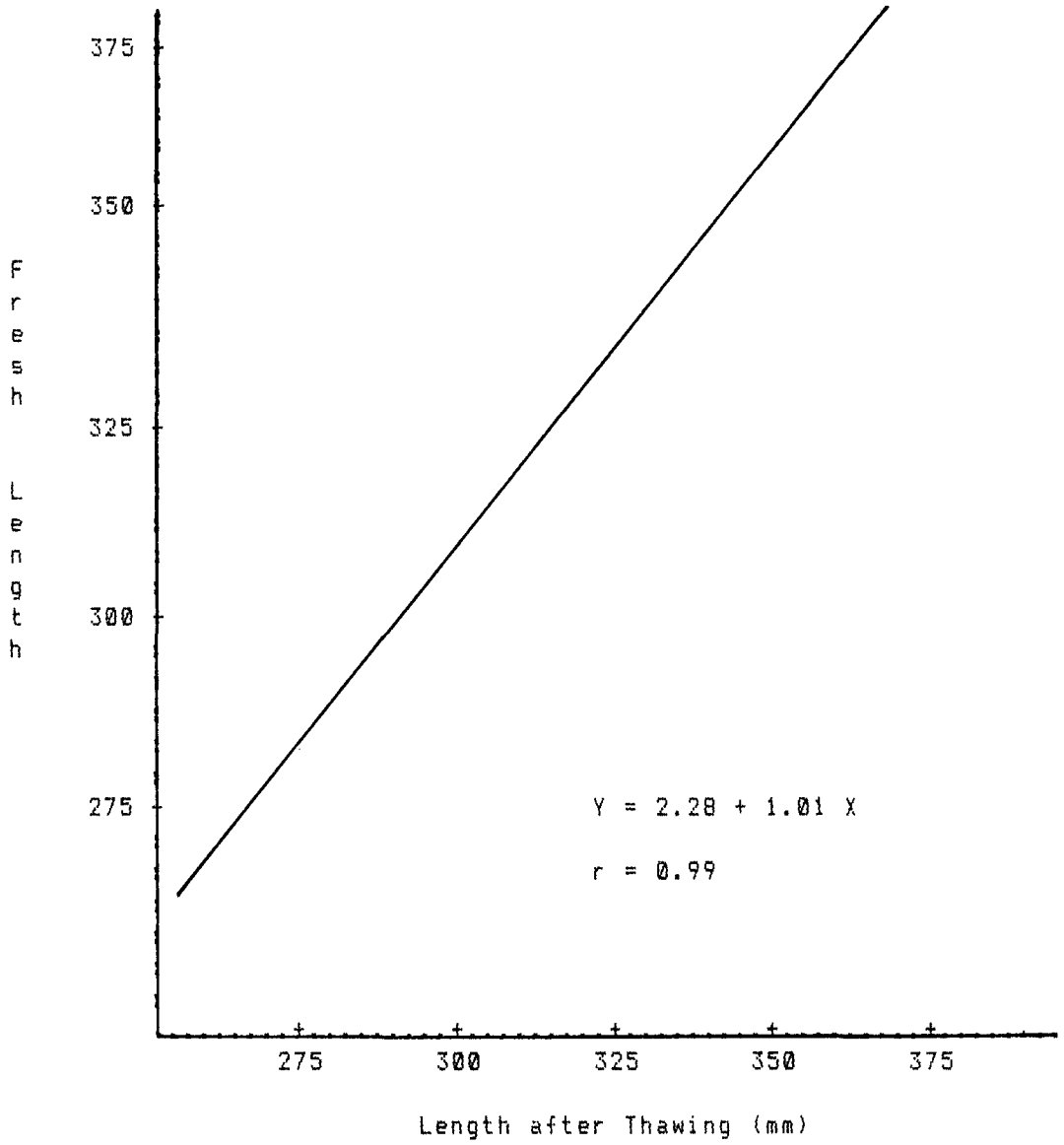

Figure 4. Regression of length after thawing on fresh length of herring for Gulf and Scotia-Fundy Region samples combined.