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Preliminary density estimates of snow crab *Chionoecetes opilio* by underwater television

by

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Les Documents de recherche sont publiés dans la langue officielle utilisée par les auteurs dans le manuscrit envoyé au secrétariat.

Summary

An underwater TV camera is towed on a sledge in order to estimate the densities of snow crab *Chionoecetes opilio* on the fishing grounds. The camera is mounted in front of a rake which digs into the sediment. Semi-buried animals flounce over the transversal bar of the rake. They can then be counted either immediately while watching a T.V. monitor on deck, or later on, from video recordings. The distribution of crab on the sea floor is slightly patchy ($\bar{x} = 13 \cdot 10^3 \pm 2 \cdot 10^3$) individuals/Km^2; the dispersion index $I = S^2/\bar{x} = 1.41$ is significantly > 1 at the 5% level). This spacial distribution is bimodal and is not satisfactorily modelled by a negative binomial. No rhythm could be detected within the spacial series of observations. About 40% of crab were semi-buried. The percentage of semi-buried individuals appears inversely correlated with size, 78% of semi-buried individuals had a carapace width smaller than 10 cm.

Resumé

Une caméra de télévision sous-marine remorquée sur un traineau permet d'évaluer les densités de crabes des neiges, Chionoecetes opilio sur les fonds de pêche. La caméra est montée en avant d'un rateau qui racle le sédiment. La faune semi endogée passe par dessus la barre du rateau. Les comptages de crabes s'effectuent soit en temps réel sur un moniteur de télévision située à la passerelle, soit en temps différé à partir d'enregistrements vidéo. La distribution des crabes sur le fond est de type agroupé ($\bar{x} = 13 \cdot 10^3 \pm 2 \cdot 10^3$ individus/Km^2; l'indice de dispersion $I = S^2/\bar{x} = 1.41$ est significativement $>$ 1 au seuil de 5%). Cette distribution est bimodale et s'ajuste mal à la binomiale négative. Il n'a pas été décelé de composante cyclique dans la série spatiale des échantillons. Près de 40% des crabes paraissent semi endogés. Le pourcentage d'individus endogés varie en fonction inverse de la taille, 78% des individus endogés avaient une largeur de carapace inférieure à 10 cm.

Introduction

The snow crab Chionoecetes opilio is widely harvested in the Gulf of St Lawrence; little is known however about its growth, its density on the fishing grounds and its geographic distribution. The fishery is only operated through trapping and great fluctuations in catchability as a function of seasons, sex, age and size are to be expected. Female snow crab , for instance, are not usually caught in the traps in the same place as the males, a fact which is also known for other species of crab such as Geryon quinquedens.

The primary concern for regulating the fishery has so far been to assess how many crab were taken over the fishing season, and to tentatively evaluate from there whether the stocks were in a stable condition or were declining as the fishery progressively developed its fishing power and expanded over wider grounds.

This approach is particularly difficult since the information on basic biological parameters such as growth and natural mortality is still insufficient. Standard virtual population analysis approach is not possible because the age classes cannot so far be distinguished in the catch. Jones (1983) variation of cohort analysis based on sizes is not possible because growth is not sufficiently known. If a terminal molt were shown to exist and if most of the size range in the catch pertained to the group of individuals in terminal molt, Jones (1983) approach would not apply. All virtual population types of approach require one of three conditions" (a) that the abundance on the grounds and the natural mortality be known in order to estimate the fishing mortalities, (b) that the mortalities be known to estimate the abundance, (c) that some simple minded assumption be made about mortalities such as natural mortalities and fishing mortalities independent from age. Otherwise an infinite number of solutions exist since there are more unknown parameters than observations.

The Leslie method used for assessing abundance of snow crab is somehow a simplification of virtual population analysis, in which the underlying assumptions are that there is no natural mortality, growth or recruitment to the fishery over the fishing season and that the fishery is not expanding its fishing grounds or becoming more efficient through the fishing season. All these assumptions may turn out to be doubtful, because: 1) the fishing season is also the season of maximum biological activity in the Gulf of St Lawrence, the period at which most species grow, reproduce and die as summer surface water temperatures raise and food chains work with high turnover rates; 2) fishermen are likely to move their traps when they have poor catching power therefore expanding fishing grounds and eventually increasing their efficiency.

Direct estimates of abundance analogous to those obtained on pelagic fish by echosounding would possibly be the most reliable tool. Traps cannot be used easily for estimating densities because their efficiency varies greatly as a function of the physiological state of the individuals. Trawling could be attempted but it may be fairly destructive. Further, snow crab are caught on soft mud bottoms where heavily chained trawls required for catching benthic semi-buried animals would be difficult to operate. Attempts have been made to count crab on the bottom using underwater photographic cameras set on a towed unmanned submersible, i.e. the BRUTIV operated by St Andrews DFO laboratory (Elner, 1982). The reported densities were quite low.

We attempted to develop a slightly different approach in which the towed vehicle is a rake which carries an underwater television with continuous recording of the sea floor activity along the area covered. We report hereon the first results of our trials.

Material and Methods

Technology:

A black and white CM8 television camera manufactured by Subsea Systems is mounted on a modified sea scallop 2 m wide rake dredge (Fig. 1) of the type used in northern Brittany (France). The camera faces backwards at the rake. All benthic animals and rocks, including those buried in the sediment to a depth of 10 cm tumble over or swim over the toothed drag bar. They are counted, identified and frequently measured by reference to a black and white scale painted on the bar. The T.V. system is operated from the surface through a television cable. The 120 volts power required by the TV and the light is provided either by the towing ship or by a portable generator. The TV signal is recorded on a 1/2" video system on which it is possible to manually input information such as geographic position of the ship and depth. An internal clock displays time on the screen at recording when required. It is possible to activate the video recording in slow motion and to make stops on an image for better interpretation of the data displayed.

This set up is very similar to the one used for estimating abundance of sea scallops on fishing grounds in Brittany. It was first designed by Albert Merrien (1980). It had previously been shown to be efficient for counting the Majid crab *Maia squinado*. *Chionoecetes opilio* is also thought to be a member of the Majid family.

In our experiment the TV rake was towed by the 76 feet "Shamook", a research vessel from St John's Newfoundland. It could be operated however from a much smaller ship (42 ft) should the surveys be more coastal (scallop stocks).

Data acquisition

The experiment took place in "Baie des Chaleurs" during the month of October 1983. The location (Fig. 2) is not known as a commercial fishing ground for snow crabs and is rather marginal to the true fishery (densities are likely to be lower than on a true fishing ground). However the location was selected for its accessibility and shallow depth (Fig. 3) which would have allowed a salvage operation of the towed camera in case of wrecking.

The rake was towed for 4 hours 25 minutes over a distance of 9.65 nautical miles. The track included two sharp turns in order to check for stability of the device (Fig. 1 & 2).

The counts were made at the lab over 0.25 km units of towing estimated by interpolation from time and geographic positions displayed on the video screen. The width of the viewing area along the drag bar was 1.3m. The crabs and rocks were counted, the presence/absence of brittle stars was also recorded.

Data processing

A principal components analysis was run on the data using as variables the presence/absence of brittle stars, the number of rocks, the number of crabs, the sample number along the track and the speed. This analysis was used for obtaining preliminary information on the correlations between these variables and possible sources of bias in the abundance estimates.

A simple non statistical method was used for detecting possible periodicities in the counts along the tracks (such periodicities may cause severe problems for estimating the abundance along transects). In this simple procedure, the counts are sorted out along the track by steps (periods) increasing from 2 to N/2, where N is the number of counts. Within each of these subsets of counts corresponding to a step size, we calculate the variance of the counts. At each step size coinciding with a consistent period or its multiple, a trough value may be expected in the diagram of variances v.s. step size.

The distribution of counts per sample was tested for its dispersion characteristics, using a variance to mean ratio. The departure of this ratio from 1 (random non patchy or Poisson type distribution) was tested by chisquare. A negative binomial function was fitted by maximum likelihood procedure to the observed distribution. The mean density and variance estimates for counts per sample were converted to estimates per standard square Km using formulae based on mathematical expectation theory:

$E(ax) = a\,E(x)$ and $\sigma^2_{ax} = a^2 \sigma^2_x$. Confidence limits were calculated for the estimate of the mean using the central limit theorem approximation since the number of samples was greater than 30.

All computations and graphs were made on the HP 9845B computer of the "Centre de recherche en biologie marine" connected to an HP 9872C plotter and a 9895A dual flexible disc drive. All programs used were custom made.

Results

The distribution of crab counts along the track is provided in Figure 3. The position of the samples along the track is provided in Figure 2. The data on sample number, tow number, crab counts, rock counts, presence/absence of brittle stars and speeds is presented in Table 1.

The graphics output of the principal component analysis is provided in Figure 4. There is no strong correlation between number of rocks and number of crab . This is also shown in Figure 5. The correlation between speed and number of crab is positive and very weak , showing that within the present range speed is not a major source of bias. There is a strong inverse correlation between speed and number of brittle stars, brittle stars being small are possibly less readily seen at high speeds. There is an inverse correlation between speed and number of rocks possibly showing that the rake skips over the rocks at higher speeds.

The mean number of counts per sample is 4.18 with a variance of counts of 5.93. The dispersion index is 1.41, which is significantly greater than 1 ($.01 < p < .025$ for chi2 = 75.06 and 53 degrees of freedom). Within this sample scale, the distribution of crab is therefore moderately but significantly patchy. The graphic representation of Figure 6 does not allow detection of any well defined periodicity within our data of crab counts along the track.

The binomial distribution of our data on crab counts could be acceptable since the dispersion index is significantly larger than 1. A special procedure would then be required for setting asymmetric confidence limits on the mean for any set of samples smaller than 30 (Conan et al. 1980). However the parameter of the binomial distribution fitted by maximum likelihood $K = 10.74$ and the arithmetic mean $\bar{x} = 4.18$ do not provide a good fit of the calculated to the observed distribution (Fig. 7). A significant departure from goodness of fit is detected by chi 2 (Chi 2 = 10.20, with 4 degrees of freedom, $0.025 < p < 0.05$). The actual distribution of counts in Figure 7 appears to be bimodal.

The mean density estimate for $250 \times 1.3 = 325$ m^2 is 4.18 and the variance of the mean is $S^2_{\bar{x}} = 5.93/54 = 0.11$. For $10^6 m^2$ the estimate of the mean $\bar{x}' = 12860$ and the estimate of the variance of the mean $S^2_{\bar{x}'} = 0.11 \quad (10^6/325)^2 = 1.04 \; 10^6$.

Since the number of samples $N = 54$ is greater than 30 we can use the central limit theorem and set symmetric confidence limits for the mean based on a normal distribution around the observed mean with variance $\sigma^2_{\bar{x}} = \sigma^2/N$. Therefore per square km the average number of counts is expected to be:

$$\bar{x}' = 12860 \pm (10^3 \sqrt{1.04})\ 1.96 = 2\ 10^3$$

In Table 2 estimates are provided for number of crab appearing to be walking above the sediment (mud) and buried in the sediment. Thirty seven percent of the crab appear to have been buried in the mud. Most of these were small crab , possibly mostly females: 79% of crab buried in the mud were smaller than 10 cm width.

Discussion

The method here described for direct estimation of snow crab appears to be quite promising. The use of a rake and underwater TV rather than still photographic frames and a vehicle towed above the grounds revealed that a substantial amount of crab may be buried in the sediment. This burying behavior is likely to vary as a function of hour of day and season, it may be related to rhythms of activity and catchability in traps.

The distribution of crab appears to be slightly patchy at the scale studied. However the variance of counts remains relatively small and allows quite precise estimates even with a rather small number of samples. The observed bimodal distribution of counts may possibly be explained by the fact that the track crossed two different areas with modal densities at 3 and 6 per unit respectively, or that the population of individuals sampled was heterogeneous (possibly males and females appearing with uncorrelated densities).

Further technical improvements will allow us to automatically record physical parameters along the track and to measure more accurately the individuals as well as sex them. Further research is needed on rhythms of activity, on geographic location of males, females, small individuals and berried females, and on characteristics of patchiness of the distribution at different sample scales.

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Merrien, A. 1980. Utilisation de la télévision sous-marine pour l'inventaire et l'estimation directe des ressources en coquilles Saint-Jacques. Ex.: La Baie de Saint Brieue. ICES C.M. 1980/B: 22, 24 pp.

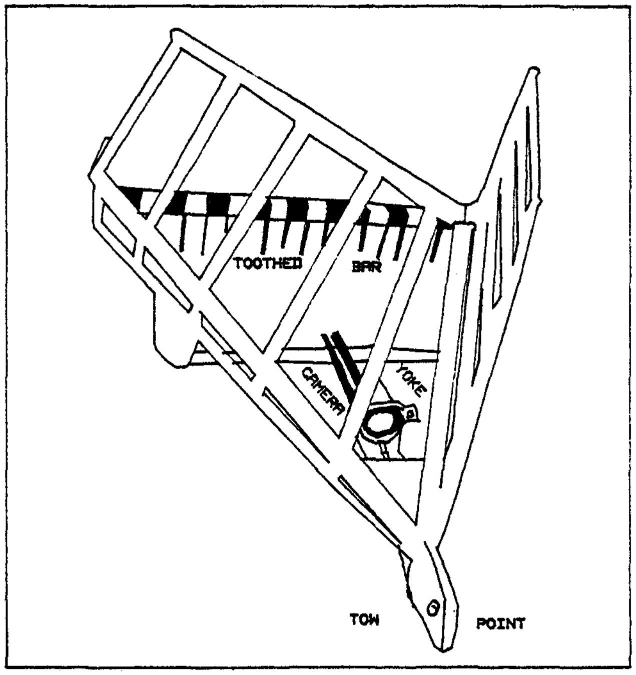
Table 1 - Summary of data collected during the survey.

Unit #	Tow #	# of crabs per unit	# of rocks per units	+ : presence of brittle stars	speed of tow in km/h
1	001	08	23	-	3.42
2	001	03	17	-	3.42
3	001	02	15	-	3.42
4	001	03	17	-	3.42
5	002	04	18	+	3.70
6	002	01	15	+	3.70
7	002	06	15	+	3.70
8	002	05	17	-	3.70
9	002	03	16	-	3.70
10	002	04	11	-	3.70
11	003	05	13	-	3.50
12	004	02	09	-	3.48
13	004	03	16	+	3.48
14	005	06	17	+	4.13
15	005	01	14	+	4.13
16	005	04	26	+	4.13
17	005	03	18	+	4.13
18	006	01	19	-	4.43
19	006	03	17	-	4.43
20	006	01	03	-	4.43
21	007	02	15	+	3.48
22	008	03	05	+	4.41
23	008	03	19	+	4.41
24	008	02	17	+	4.41
25	009	01	09	+	3.82
26	010	00	05	+	3.52
27	010	01	06	+	3.52
28	010	08	09	+	3.52
29	011	03	04	-	5.87
30	011	06	08	-	5.87
31	011	03	06	-	5.87
32	012	06	08	-	6.25
33	014	03	10	-	4.26
34	014	04	20	-	4.26
35	015	05	10	-	4.37
36	015	03	07	-	4.37
37	015	04	12	-	4.37
38	016	03	08	-	5.13
39	016	08	09	-	5.13
40	017	07	02	-	5.13
41	017	07	08	-	5.13
42	018	04	24	+	4.30
43	018	06	11	+	4.30
44	019	04	11	-	4.13
45	019	06	12	-	4.13
46	020	04	06	-	5.54
47	020	03	13	-	5.54
48	021	02	06	-	5.54
49	022	10	20	-	3.63
50	022	07	18	-	3.63
51	023	11	40	+	4.80
52	023	07	13	-	4.80
53	023	08	14	-	4.80
54	023	04	18	+	4.80

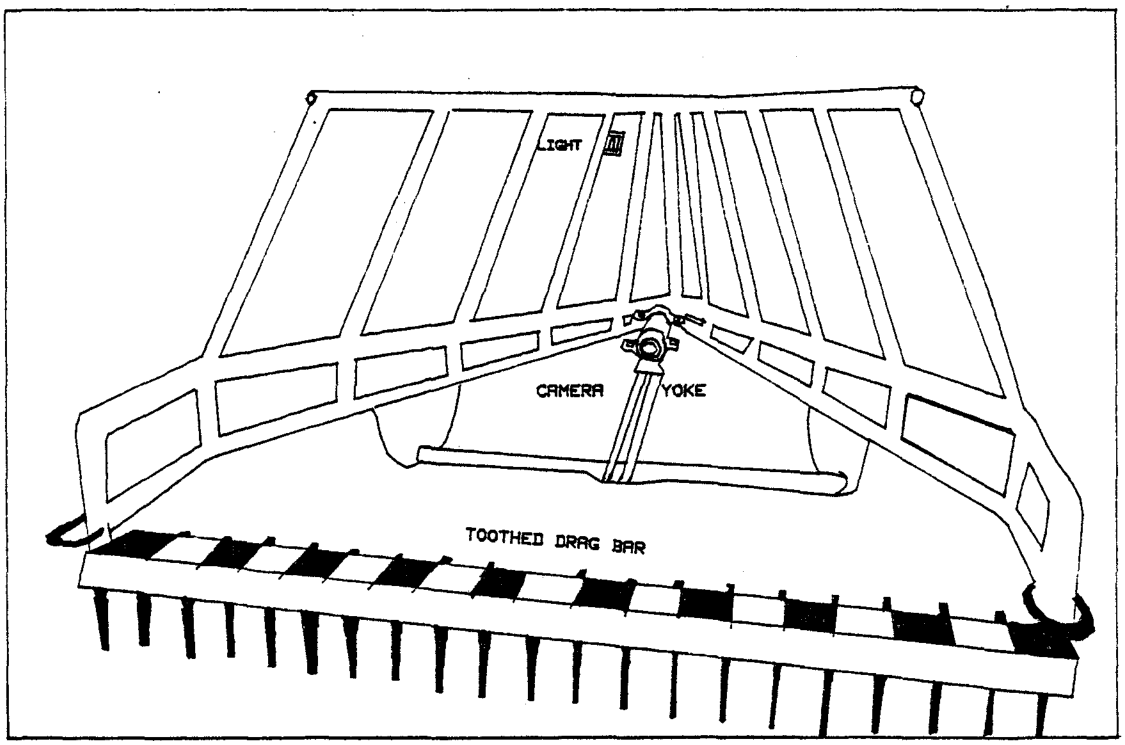
Table 2 - Burying behavior as a function of size

	Carapace width	Count	% among measured individuals	% among buried individuals
Not buried	> 10 cm	28	35.4%	54.9%
	< 10 cm	23	29.1%	45.1%
Buried	> 10 cm	6	7.6%	21.4%
	< 10 cm	22	27.9%	78.6%

Overall % of buried individuals: 36%



Front view



Rear view

Figure 1. Underwater sledge (a modified scallop drag) used for towing the underwater camera.

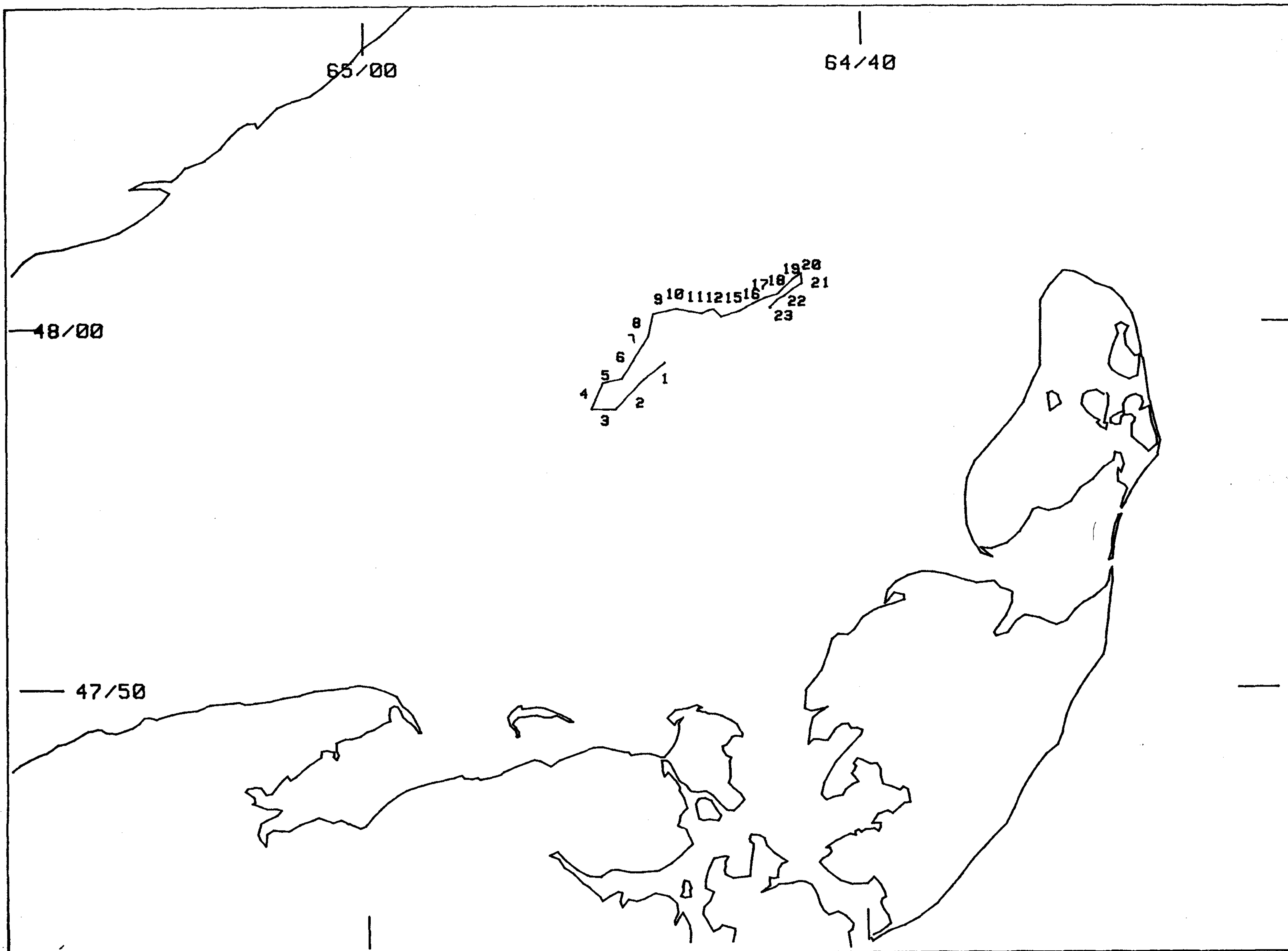


Figure 2 Geographic location of experiment. Numbers along two track represent geographic position of sample.

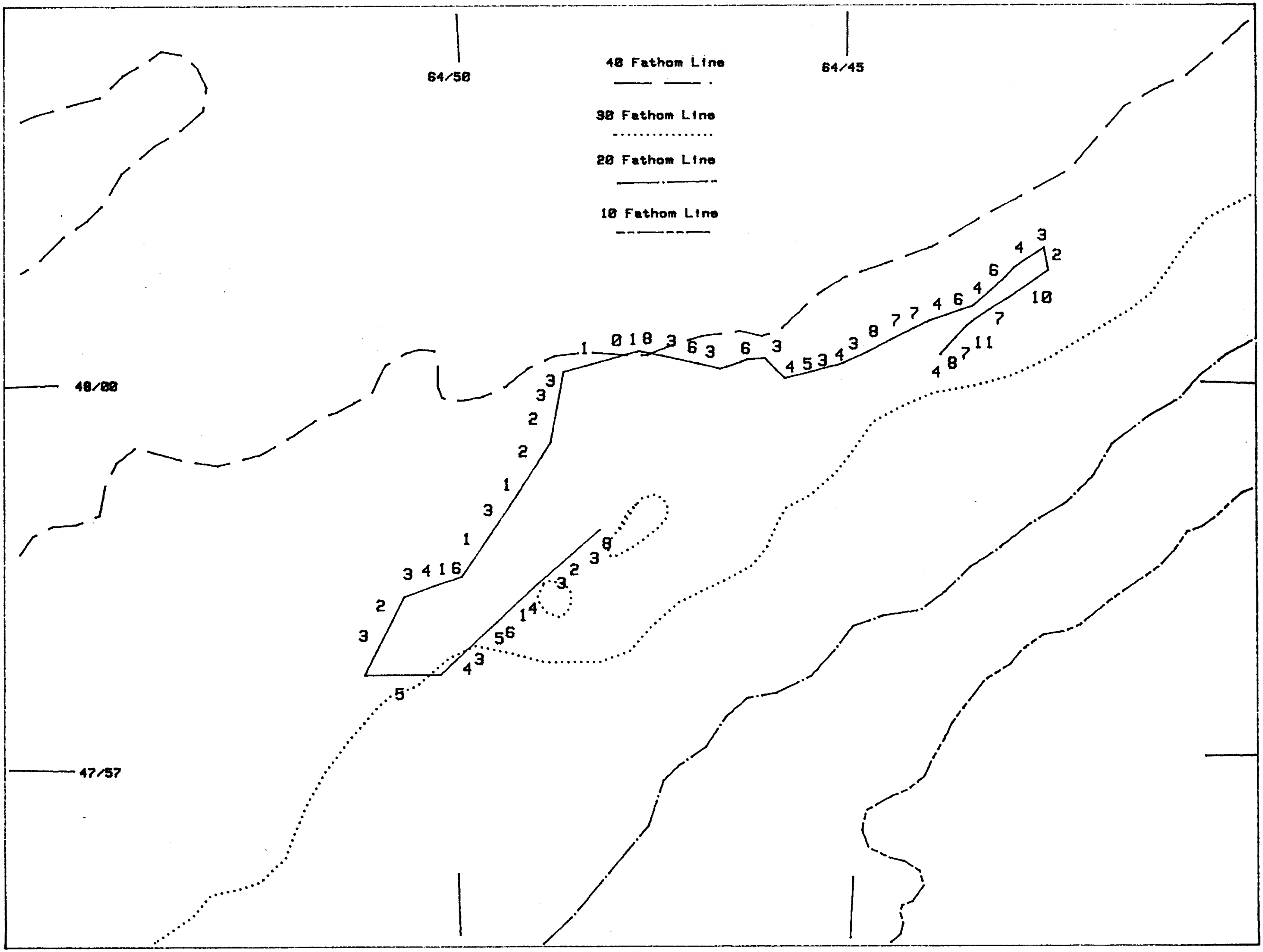


Figure 3 Geographic location of tow track. Numbers a long track represent crab counts in samples.

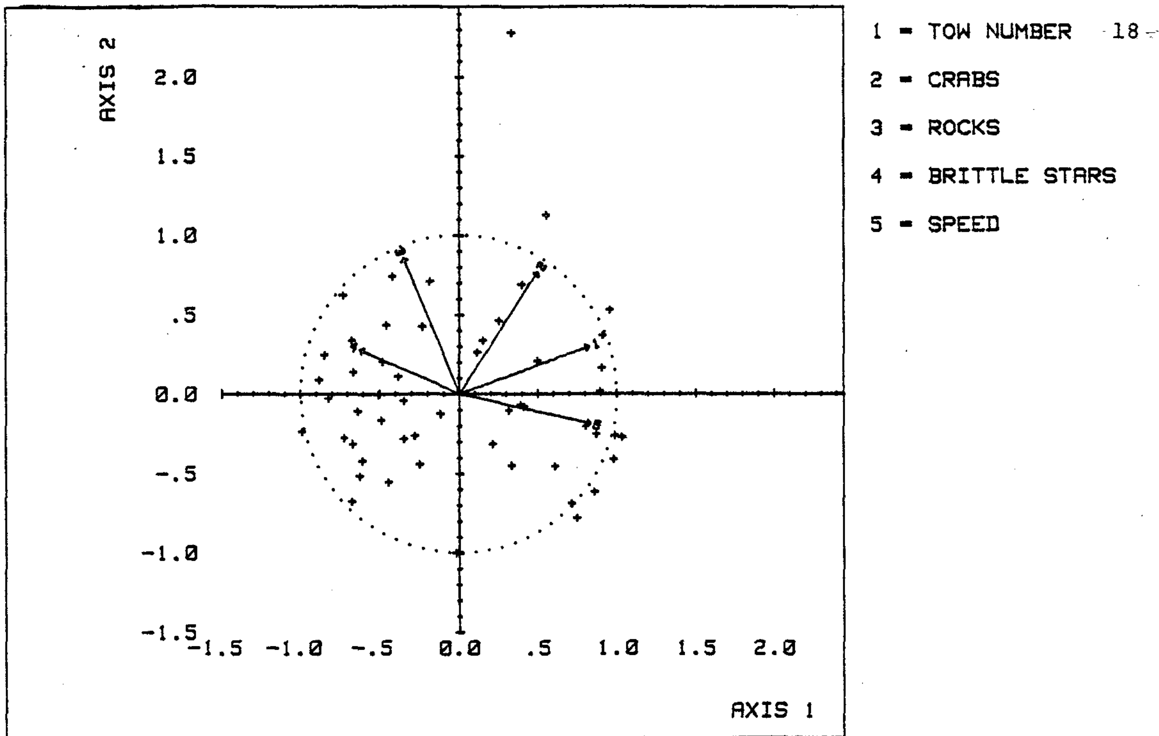


Figure 4 Principal component analysis.

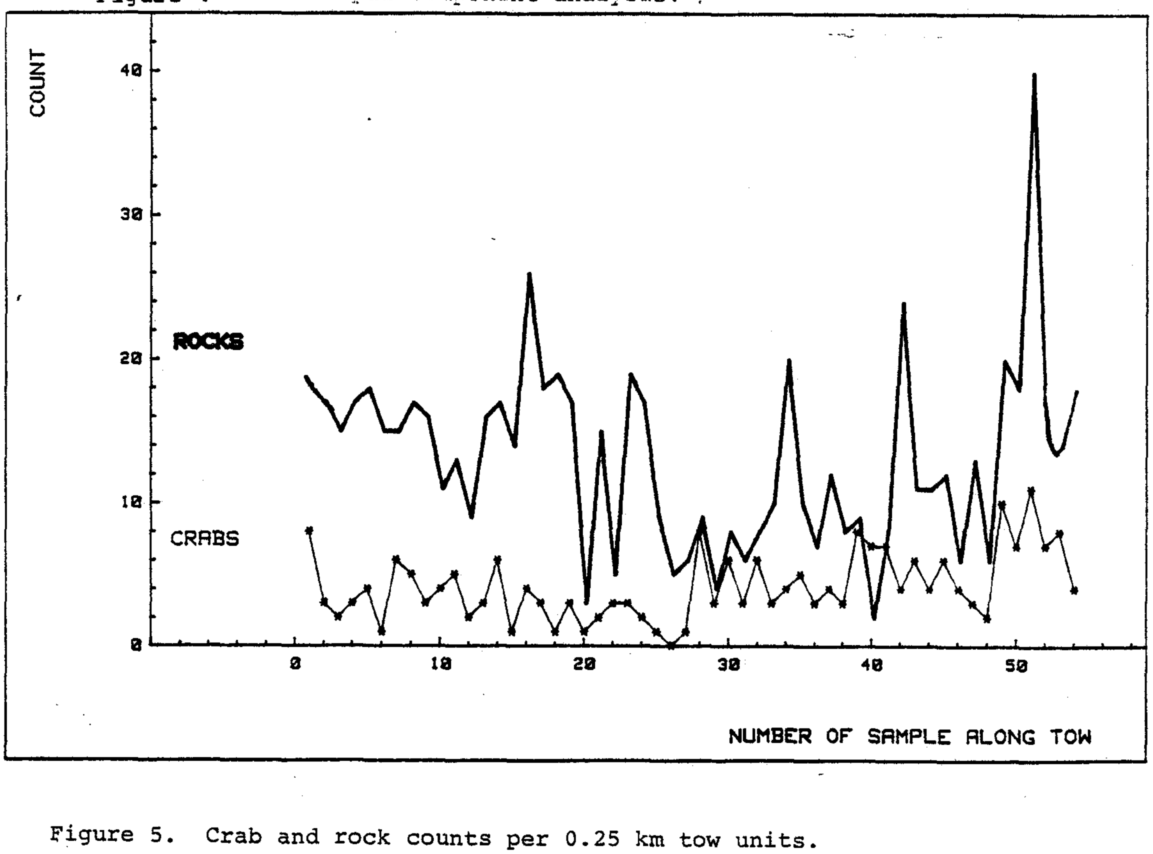


Figure 5. Crab and rock counts per 0.25 km tow units.

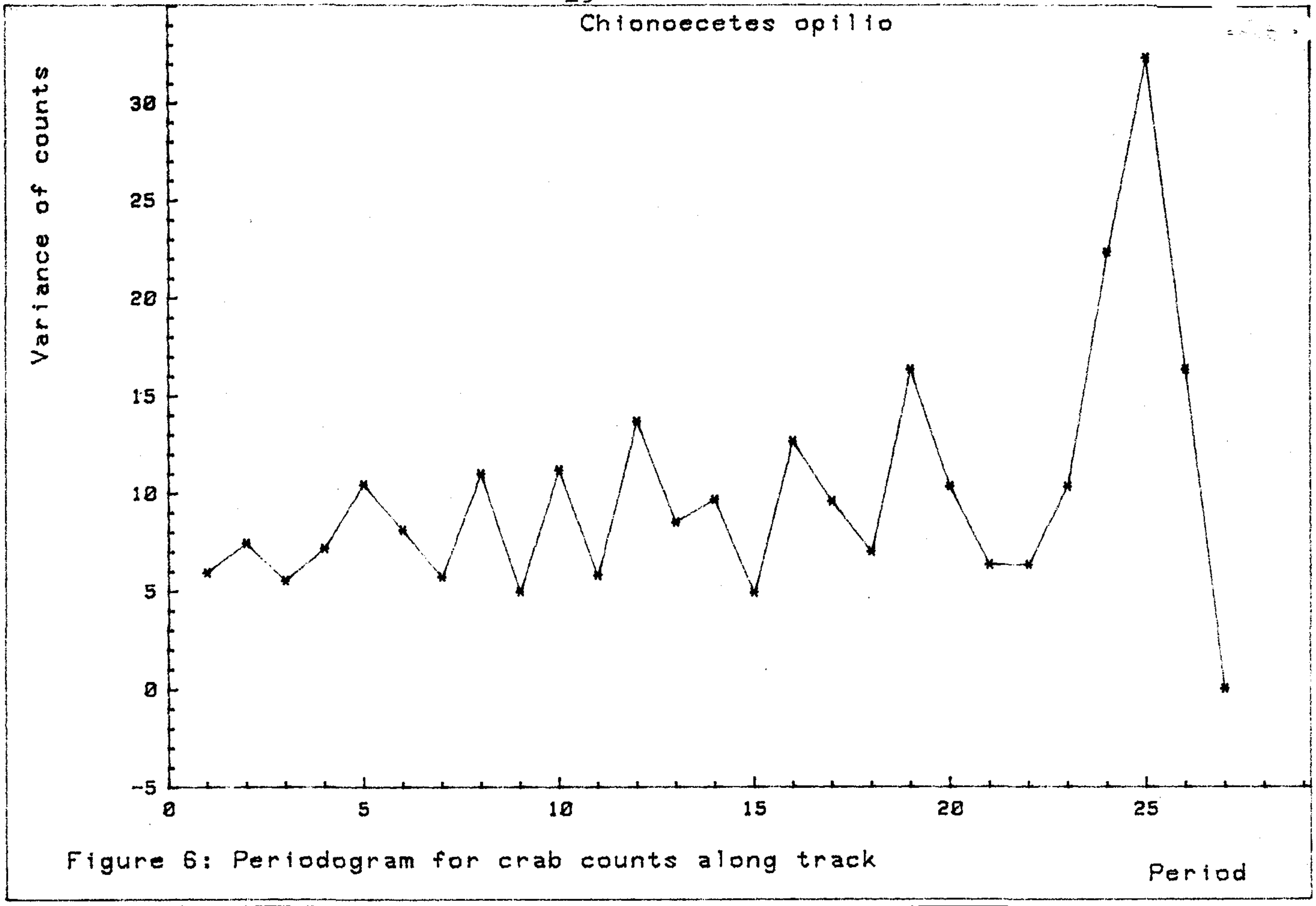


Figure 6: Periodogram for crab counts along track

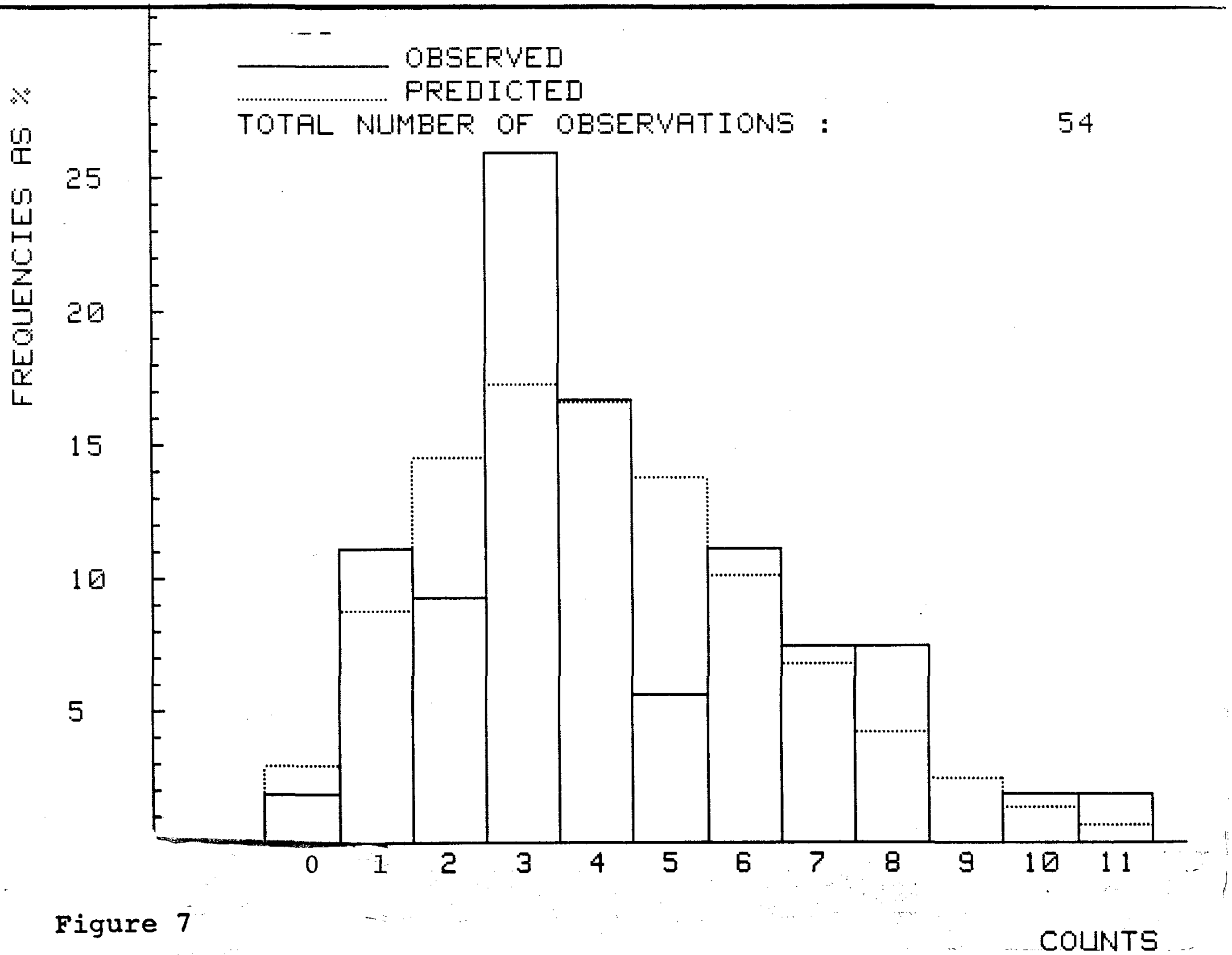


Figure 7