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Observations on the predation of cod and whiting on *Nephrops norvegicus* (L)
in the Outer Silver Pit during 1979.

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ABSTRACT.

This paper represents the first results of a two-year research programme on the predation by round fish on the Nephrops stock in the Outer Silver Pit. Significant correlations were found between the size of cod and whiting and the number and weight of the Nephrops in their stomach.

RESUME.

Cette contribution donne les résultats préliminaires d'une étude de deux ans sur la prédation de Nephrops par des poissons ronds dans le "Outer Silver Pit". Des corrélations significatives ont été observées entre la longueur du cabillaud et du merlan d'une part et le nombre et le poids de langoustines dans leurs estomacs d'autre part.

INTRODUCTION.

The Belgian fishery on Nephrops norvegicus (L) is mainly carried out in the Outer Silver Pit area as shown in figure 1. Since 1967 almost 100 % of the total Belgian Nephrops catch is taken from the North Sea, whereas formerly a considerable part was also taken from the Icelandic waters (Hovart and De Clerck, 1971).

The Belgian Nephrops catches for the period 1934-1979 are given in figure 2 showing high variations in the catches from year to year. The highest catch of about 575 tons was taken in 1978, followed by a drop to 300 tonnes in 1979. The lowest catch was recorded in 1958 (about 120 tons).

The exploitation pattern is typically seasonal. The highest catches are obtained from May till September. About 20 vessels (mean horse power of 270) are fishing for Nephrops in that period. The fishery is entirely carried out by otter-trawling.

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The aim of this study was to investigate the predation by fishes on the Nephrops stock in the area concerned in order to obtain more information about the trophodynamics of the main exploited fish stocks. This paper is dealing with quantitative data of stomach contents of cod (Gadus morhua L.) and whiting (Gadus merlangus (L.)) and represents the first results of a two-year research programme on this item.

MATERIAL AND METHODS.

The research was carried out on two commercial Nephrops vessels. The first trip was made on the "GUDRUN" Z 559 from 7-17 August 1979, the second one on the "ZEEMANSBLIK" Z 510 from 26 October-6 November 1979.

During these two cruises fresh stomach samples from cod (552) and whiting (223) were collected and preserved in formaldehyde 20 %. These stomach samples were taken ad random as well by day as by night. No sampling was carried out in cases where fresh or regurgitated food was found in the mouth or in the pharynx.

First, the total weight of the stomach was determined. The following step was the examination of the stomach contents. The number of Nephrops was counted per stomach and if possible length, weight and sex of each Nephrops. In cases where carapax length was not measurable biometric relations were used. The non-Nephrops content of the stomach was also determined and counted per species.

The cod and whiting samples were measured on board. The corresponding weights were calculated following the formulas for cod :

$$G = 0.0068 L^{3.10} \text{ (Daan 1974)}$$

and for whiting :

$$G = 0.006852 L^{3.07} \text{ (Redant, 1979).}$$

The length distribution in percentages of the sampled cod and whiting is given in tables 1, 3, 5 and 7.

RESULTS.

1. Cod

a. Qualitative results.

Stomachs from small cod mainly contained Polychaeta and small Crustacea as Crangon allmanni. This was found during the August as well as during the October-November survey. In larger cod however those species were replaced by Nephrops norvegicus, Coryster cassivelaunus, Macropipus holsatus, Aphrodite aculeata and fish species (tables 1 to 4).

The predation on Nephrops by cod was more pronounced during the summer survey. During this period 10 % of the small cod contained Nephrops whereas for larger cod this figure rose in some cases to 100 % (table 2). From the autumn samples it appeared that these values were generally lower (table 4). The results obtained by Kinnear and Livingstone (1979) were substantially lower in comparison with the August results of this study but somewhat higher than the autumn results given in table 4. Indeed the incidence frequency pointed out in the Scottish paper varied from 12 % for small cod to 50 % for large cod. However as empty stomachs were also used in these calculations a direct comparison is rather difficult.

The mean number of Nephrops per stomach and per length class of cod during August increased from 0.1 for small cod to a maximum of 2.8 for large cod (table 1). These figures ranged from 0.07 to 2.0 for the autumn observations (table 3). During August an individual maximum occurred in a 59 cm cod containing 12 Nephrops. Figures 3 and 4 show the relationship between the mean number of Nephrops per stomach and the corresponding length classes of cod. High correlation factors (0.97 and 0.8) indicated the growing predation of Nephrops with increasing length of the cod.

The carapax length of the Nephrops in the stomachs varied from 7 mm to 55 mm in August and from 7 to 36 mm in the autumn (table 5). The latter is comparable with the data of Kinnear and Livingstone (1979) giving a range from 8 to 30 mm. From table 5 it seemed that there is a relationship between the length of the prey and the length of the cod.

b. Quantitative results.

During the August survey the weight of Nephrops per stomach expressed in % varied from 3.75 for small cod up to 51.7 for large cod. In the autumn these values were between 2.79 and 11 %. The weight composition of the stomachs per cod length classes are given in figures 5 and 6. These figures clearly indicate the important predation on Nephrops on a weight basis.

A correlation was calculated between the weight of the Nephrops and the corresponding length class of the cod (figures 7 and 8). A high correlation factor of 0.97 occurred in the summer data emphasizing the increasing importance of larger cod on Nephrops. Also in the autumn data a correlation factor of 0.8 give support to the relevant predation.

2. Whiting.

a. Qualitative results.

The main food of whiting in the area consisted of fish species, Polychaeta and small Crustacea (tables 6 to 9). During August the predation of Nephrops was rather important. The mean number of whiting containing Nephrops in their stomach varied from 7,7 % for whiting smaller than 25 cm up to 100 % for whiting larger than 50 cm. (table 7).

The mean number of Nephrops per stomach rose from 0.08 in small whiting to 1.0 in whiting larger than 56 cm (table 6). Figure 9 shows the relationship between the mean number of Nephrops and the corresponding length classes of whiting. A correlation factor of 0.8 was found. Compared with the cod observations the amount of Nephrops in whiting stomachs was generally less important. Only one whiting of 41 cm length contained two Nephrops.

The carapax length of the Nephrops in the stomachs varied from 9 to 38 mm (table 5).

The predation of Nephrops by whiting during the autumn survey was rather negligible (table 8 and 9). Indeed only one whiting of 33 cm contained a Nephrops in this period.

b. Quantitative results.

The August results indicated that the weight of Nephrops per stomach was rather important. These values expressed as a percentage of the total stomach contents varied from 0.55 in small whiting up to 84.1 (figures 11 and 12). The relationship between the weight of the Nephrops and the corresponding length class of the whiting is given in figure 10. The correlation factor of 0.94 indicated the importance of whiting as predator during this period.

On a weight basis the autumn results were also negligible as was the case in section 2a.

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Table 1 - Mean number of species per stomach per length class of *Gadus morhua* during August 1979

Length classes	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90
Number of observations	39	147	68	20	37	21	13	11	16	17	15	6	3
<i>Nephrops norvegicus</i>	0.10	0.17	0.32	0.30	0.76	1.19	1.92	1.36	1.87	2.18	1.47	2.83	2.67
<i>Crangon allmanni</i>	4.38	0.73	0.21	0.15	0.03	0.52	0.08	-	0.13	-	0.07	0.50	-
<i>Epagurus bernhardus</i>	0.26	0.48	0.47	0.35	0.22	0.24	0.23	0.18	0.44	0.47	0.07	0.17	0.33
<i>Corystes cassivelaunus</i>	0.10	0.10	0.19	0.15	0.89	0.81	0.38	1.36	1.94	1.12	0.60	3.50	0.33
<i>Macropipus holsatus</i>	0.28	0.20	0.16	0.30	0.38	-	0.08	0.18	0.19	-	0.07	-	-
Crustacea sp.	-	0.01	-	-	-	-	-	0.09	0.06	0.12	0.07	0.17	-
Crustacea unidentified	1.67	0.58	0.88	0.30	0.24	0.19	0.38	0.45	0.06	0.12	0.20	0.17	-
Aphrodite acculeata	0.03	0.18	0.12	0.20	0.49	0.67	0.85	0.55	0.44	0.65	0.27	0.33	0.67
Polychaeta sp.	-	0.03	0.04	-	-	-	-	-	0.06	-	-	-	-
Mollusca sp.	0.05	0.10	0.10	-	0.05	0.05	-	-	0.13	0.06	-	-	-
Ophiotrex sp.	-	0.07	0.10	1.65	0.70	-	-	-	-	-	8.33	0.83	-
Pisces sp.	-	-	0.01	0.05	0.03	0.05	0.08	-	0.06	0.18	0.07	2.00	0.33
Pisces unidentified	0.05	0.07	0.16	0.20	0.19	0.24	0.54	0.09	0.06	0.24	0.33	-	-

Table 2 - Incidence frequency of stomach content per length class of *Gadus morhua* during August 1979

Length classes	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90
Number of observations	39	147	68	20	37	21	13	11	16	17	15	6	3
<i>Nephrops norvegicus</i>	10.3	15.0	26.5	30.0	43.2	66.7	69.2	54.5	68.8	82.4	60.0	100.0	33.3
<i>Crangon allmanni</i>	35.8	18.4	17.6	15.0	2.7	33.3	7.7	-	12.5	-	6.7	33.3	-
<i>Epagurus bernhardus</i>	25.6	42.9	45.6	30.0	21.6	23.8	23.1	18.2	43.8	42.9	6.7	16.7	33.3
<i>Corystes cassivelaunus</i>	10.3	7.5	11.8	15.0	29.7	23.8	23.1	45.5	37.5	65.3	20.0	83.3	33.3
<i>Macropipus holsatus</i>	7.7	10.2	10.3	20.0	16.2	-	7.7	9.1	12.5	-	6.7	-	-
Crustacea sp.	-	0.7	-	-	-	-	-	9.1	6.2	14.3	6.7	16.7	-
Crustacea unidentified	41.0	19.7	36.8	15.0	18.9	23.8	38.5	9.1	6.2	14.3	20.0	16.7	-
Aphrodite acculeata	2.6	17.0	11.8	25.0	32.4	23.8	61.5	45.5	43.8	35.7	20.0	33.3	66.7
Polychaeta sp.	-	2.0	4.4	-	-	-	-	-	6.2	-	-	-	-
Mollusca sp.	5.1	10.2	10.3	-	5.4	4.8	-	-	12.5	7.1	-	-	-
Ophiotrex sp.	-	2.0	4.4	15.0	8.1	-	-	-	-	-	13.3	16.7	-
Pisces sp.	-	-	1.5	5.0	2.7	4.8	7.7	-	6.2	21.4	6.7	50.1	33.3
Pisces unidentified	5.1	7.5	16.2	10.0	18.9	23.8	30.1	9.1	6.2	28.6	26.7	-	-

Table 3 - Mean number of species per stomach per length class of *Gadus morhua* during October - November 1979

Length classes	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90
Number of observations		28	45	24	9	11	10		2	3	1		
<i>Nephrops norvegicus</i>		0.07	0.18	0.17	0.56	0.09	0.60		0.50	0.33	2.00		
<i>Crangon allmanni</i>		0.79	0.47	0.29	-	0.09	0.40		-	-	1.00		
<i>Epagurus bernhardus</i>		0.21	0.27	0.33	0.11	-	0.10		0.50	-	-		
<i>Corystes cassivelaunus</i>		0.04	0.02	-	-	0.09	0.10		1.00	-	-		
<i>Macropipus holsatus</i>		0.36	0.58	0.29	0.56	0.55	1.00		5.00	-	5.00		
Crustacea sp.		-	-	-	-	-	-		-	-	-		
Crustacea unidentified		0.21	0.31	0.50	0.11	0.09	0.10		0.50	-	-		
Aphrodite acculeata		-	0.02	0.13	0.44	0.18	-		0.50	0.33	-		
Polychaeta sp.		-	-	0.04	-	-	-		-	-	-		
Mollusca sp.		0.04	-	-	-	-	0.20		-	-	-		
Ophiotrex sp.		-	-	-	-	-	-		-	-	-		
Pisces sp.		-	-	-	0.11	-	-		-	-	-		
Pisces unidentified		0.11	0.13	0.25	0.22	0.09	0.80		-	0.67	1.00		

Table 4 - Incidence frequency of stomach content per length class of *Gadus morhua* during October - November 1979

Length classes	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90
Number of observations		28	45	24	9	11	10		2	3	1		
<i>Nephrops norvegicus</i>		3.6	17.8	16.7	55.6	9.1	40.0		50.0	33.3	100.0		
<i>Crangon allmanni</i>		21.4	15.6	12.5	-	9.1	20.0		-	-	100.0		
<i>Epagurus bernhardus</i>		21.4	26.7	45.8	11.1	-	10.0		50.0	-	-		
<i>Corystes cassivelaunus</i>		3.6	-	-	-	9.1	10.0		50.0	-	-		
<i>Macropipus holsatus</i>		17.9	33.3	12.5	33.3	36.4	60.0		100.0	-	100.0		
Crustacea sp.		-	-	-	-	-	-		-	-	-		
Crustacea unidentified		17.9	24.4	25.0	11.1	9.1	10.0		50.0	-	-		
Aphrodite acculeata		-	2.2	12.5	22.2	18.2	-		50.0	33.3	-		
Polychaeta sp.		-	-	4.2	-	-	-		-	-	-		
Mollusca sp.		3.6	-	-	-	-	10.0		-	-	-		
Ophiotrex sp.		-	-	-	-	-	-		-	-	-		
Pisces sp.		-	-	-	11.1	-	-		-	-	-		
Pisces unidentified		10.7	13.3	16.7	22.2	9.1	40.0		-	66.7	100.0		

Table 5 - Carapax distribution of Nephrops in Gadus morhua and Gadus merlangus.
Gadus morhua - August 1979

Length-class	Carapax length-class	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36	37-39	40-42	43-45	46-48	55-57	Total
26-30		-	2	2													4
31-35		1	-	7	-	1	1	4	2	4	1	1	1	-	-	-	23
36-40		-	-	5	5	2	2	1	-	2	1	-	1	-	-	-	19
41-45		-	-	3	-	-	-	-	2	1	-	-	-	-	-	-	6
46-50		-	2	2	2	1	4	3	4	3	3	1	3	-	-	-	28
51-55		-	-	1	1	4	6	2	3	4	-	1	1	-	-	-	23
56-60		1	-	2	4	4	4	2	3	2	3	-	-	-	-	-	25
61-65		-	1	-	1	2	4	-	2	3	-	1	-	-	-	-	14
66-70		-	-	1	-	5	5	2	3	1	5	3	2	-	-	1	28
71-75		-	1	-	-	3	2	7	6	2	6	2	2	1	-	-	32
76-80		-	-	-	-	-	2	1	2	1	4	-	4	1	1	-	17
81-85		-	1	1	-	-	1	2	3	2	-	2	1	2	-	-	15
86-90		-	-	-	-	-	-	-	2	1	1	2	-	1	-	1	8
91-95		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
96-100		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
101-105		-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	2

Gadus morhua - October-November 1979

Length class	Carapax length-class	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36	Total
31-35		1	-	1	-	-	-	-	-	-	-	2
36-40		-	-	1	3	-	-	1	-	-	-	5
41-45		-	-	-	1	-	-	1	1	1	-	4
46-50		-	-	-	1	2	-	1	1	-	-	5
51-55		-	-	-	-	-	-	-	1	-	-	1
56-60		-	-	-	1	-	3	1	-	-	1	6
61-65		-	-	-	-	-	-	-	-	-	-	-
66-70		-	-	-	-	-	-	1	-	-	-	1
71-75		-	-	-	-	-	1	-	-	-	-	1
76-80		-	-	-	-	-	1	-	1	-	-	2

Gadus merlangus - August 1979

Length class	Carapax length-class	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36	37-39	Total
21-25		-	-	-	-	-	1	-	-	-	-	-	1
26-30		-	1	-	-	-	-	-	-	-	-	-	1
31-35		-	-	1	-	-	-	-	-	-	1	-	2
36-40		-	-	-	-	-	-	-	-	-	-	1	1
41-45		1	-	-	-	1	-	-	-	-	-	-	2
46-50		-	-	-	-	-	-	-	-	-	-	-	0
51-55		-	-	-	-	-	-	-	-	-	-	-	0
56-60		-	-	-	-	-	-	2	-	-	-	-	2

Table 6 - Mean number of species per stomach per length class of *Gadus merlangus* during August 1979.

Length classes	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
Number of observations	13	44	54	20	4	-	-	2
<i>Nephrops norvegicus</i>	0.08	0.02	0.04	0.10	0.75			1.00
<i>Crangon allmanni</i>	0.62	0.09	0.28	0.35	0.50			-
<i>Epagurus bernhardus</i>	-	0.05	0.09	-	-			-
<i>Corystes cassivelaunus</i>	-	-	0.04	-	-			-
<i>Macropipus holsatus</i>	0.15	-	0.18	-	-			-
Crustacea sp.	-	-	-	-	-			-
Crustacea unidentified	0.54	0.57	0.56	0.10	0.25			-
<i>Aphrodite acculeata</i>	-	-	0.02	-	-			-
Polychaeta sp.	0.46	0.64	2.20	1.10	-			-
Mollusca sp.	-	-	-	-	-			-
<i>Ophiotrex</i> sp.	-	-	-	0.05	-			-
Pisces sp.	-	-	-	-	-			-
Pisces unidentified	0.08	0.23	0.26	0.10	-			-

Table 7 - Incidence frequency of stomach content per length class of *Gadus merlangus* during August 1979.

Length classes	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
Number of observations	13	44	54	20	4	-	-	2
<i>Nephrops norvegicus</i>	7.7	2.3	3.7	10.0	50.0			100.0
<i>Crangon allmanni</i>	7.7	4.5	13.0	10.0	25.0			-
<i>Epagurus bernhardus</i>	15.4	-	9.3	-	-			-
<i>Corystes cassivelaunus</i>	-	-	1.9	-	-			-
<i>Macropipus holsatus</i>	7.7	-	7.4	-	-			-
Crustacea sp.	-	-	-	-	-			-
Crustacea unidentified	15.4	20.5	20.4	10.0	25.0			-
<i>Aphrodite acculeata</i>	-	-	1.9	-	-			-
Polychaeta sp.	15.4	18.2	25.9	10.0	-			-
Mollusca sp.	-	-	-	-	-			-
<i>Ophiotrex</i> sp.	-	-	-	5.0	-			-
Pisces sp.	7.7	-	-	-	-			-
Pisces unidentified	-	18.2	24.0	10.0	-			-

Table 8 - Mean number of species per stomach per length class of *Gadus merlangus* during October-November 1979.

Length classes	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
Number of observations	2	46	28	6	1	2		
<i>Nephrops norvegicus</i>	-	-	-	0.17	-	-		
<i>Crangon allmanni</i>	-	0.41	1.57	0.67	1.00	0.50		
<i>Epagurus bernhardus</i>	-	-	-	0.17	-	-		
<i>Corystes cassivelaunus</i>	-	-	-	-	-	-		
<i>Macropipus holsatus</i>	-	0.11	0.14	0.50	-	1.50		
Crustacea sp.	-	-	-	0.17	-	-		
Crustacea unidentified	-	0.65	0.57	0.17	1.00	0.50		
<i>Aphrodite acculeata</i>	-	-	-	-	-	-		
Polychaeta sp.	-	0.02	-	-	-	-		
Mollusca sp.	-	-	-	-	-	-		
<i>Ophiotrex</i> sp.	-	0.02	-	-	-	-		
Pisces sp.	-	-	-	-	-	-		
Pisces unidentified	-	0.24	0.18	-	1.00	-		

Table 9 - Incidence frequency of stomach content per length class of *Gadus merlangus* during October-November 1979.

Length classes	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
Number of observations	2	46	28	6	1	2		
<i>Nephrops norvegicus</i>	-	-	-	16.7	-	-		
<i>Crangon allmanni</i>	-	21.7	21.4	50.0	100.0	50.0		
<i>Epagurus bernhardus</i>	-	-	-	16.7	-	-		
<i>Corystes cassivelaunus</i>	-	-	-	-	-	-		
<i>Macropipus holsatus</i>	-	10.9	10.7	33.3	-	50.0		
Crustacea sp.	-	-	-	16.7	-	-		
Crustacea unidentified	-	30.4	32.1	16.7	100.0	50.0		
<i>Aphrodite acculeata</i>	-	-	-	-	-	-		
Polychaeta sp.	-	2.2	-	-	-	-		
Mollusca sp.	-	-	-	-	-	-		
<i>Ophiotrex</i> sp.	-	2.2	-	-	-	-		
Pisces sp.	-	-	-	-	-	-		
Pisces unidentified	-	21.7	17.9	-	-	-		

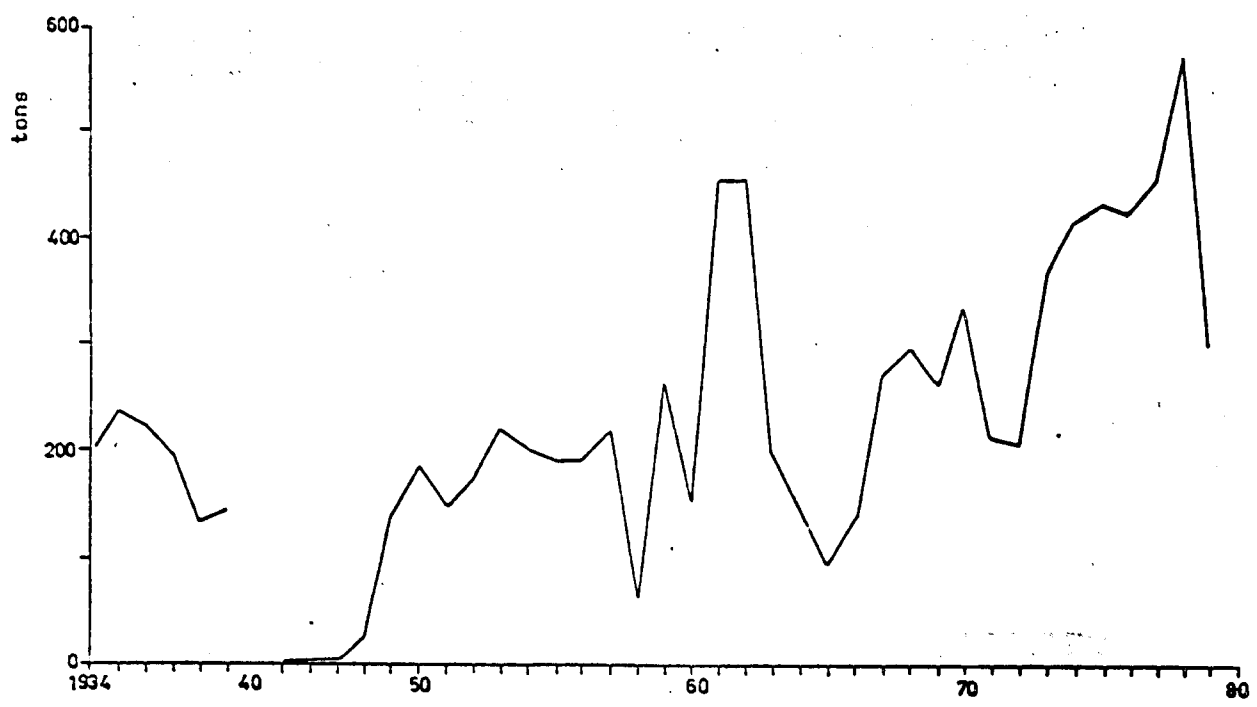
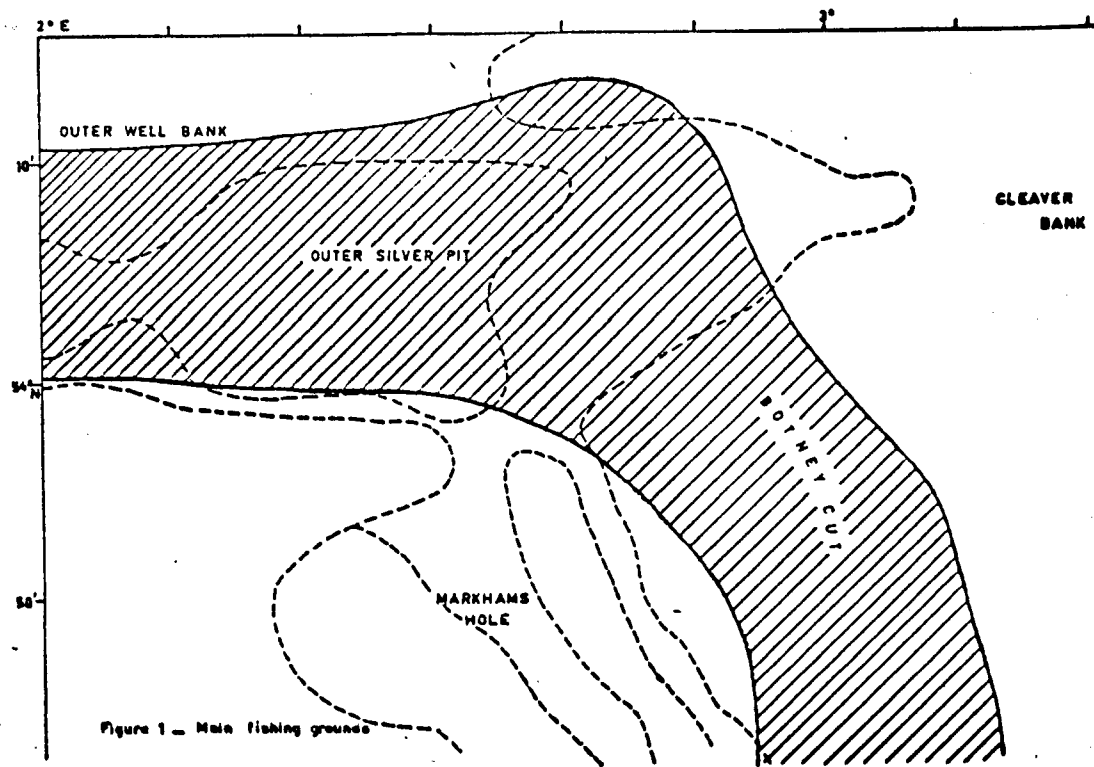


Figure 2.- Belgian catch of Nephrops in the North Sea

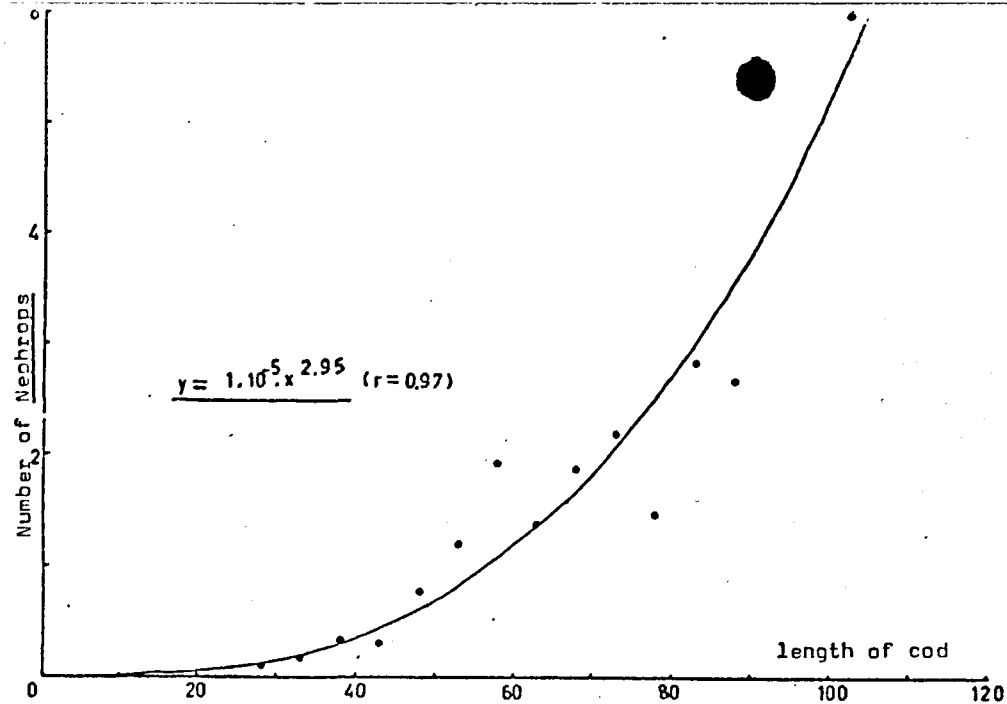


Figure 3.- Relation between the length of the cod and the number of Nephrops per stomach during August 1979.

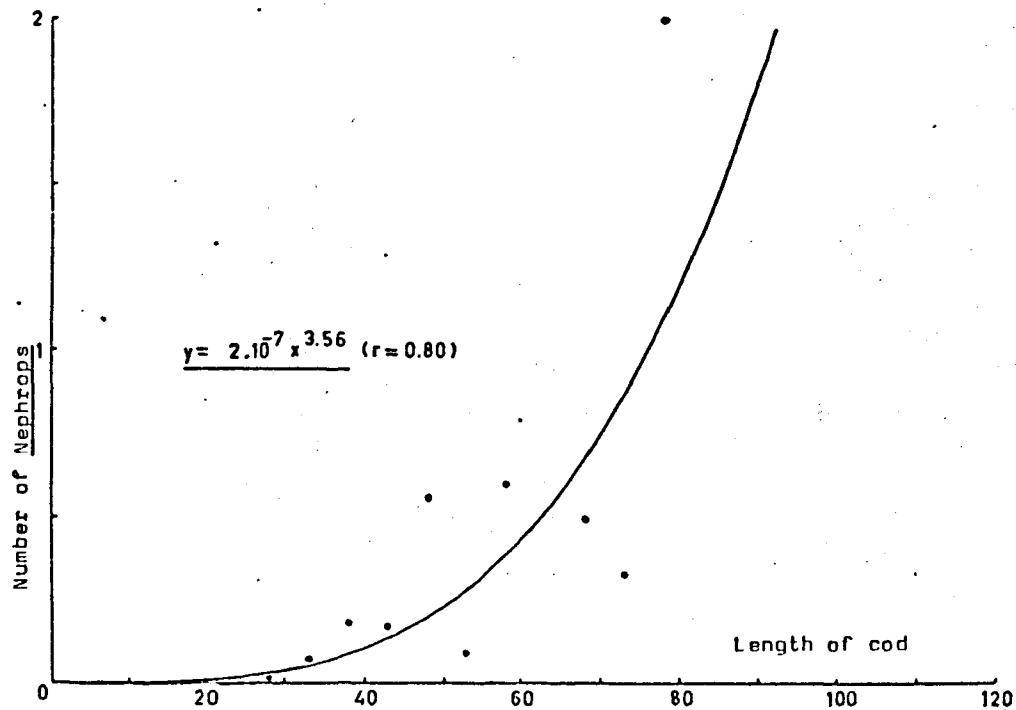


Figure 4.- Relation between the length of the cod and the numbers of Nephrops during Oct-Nov, 1979

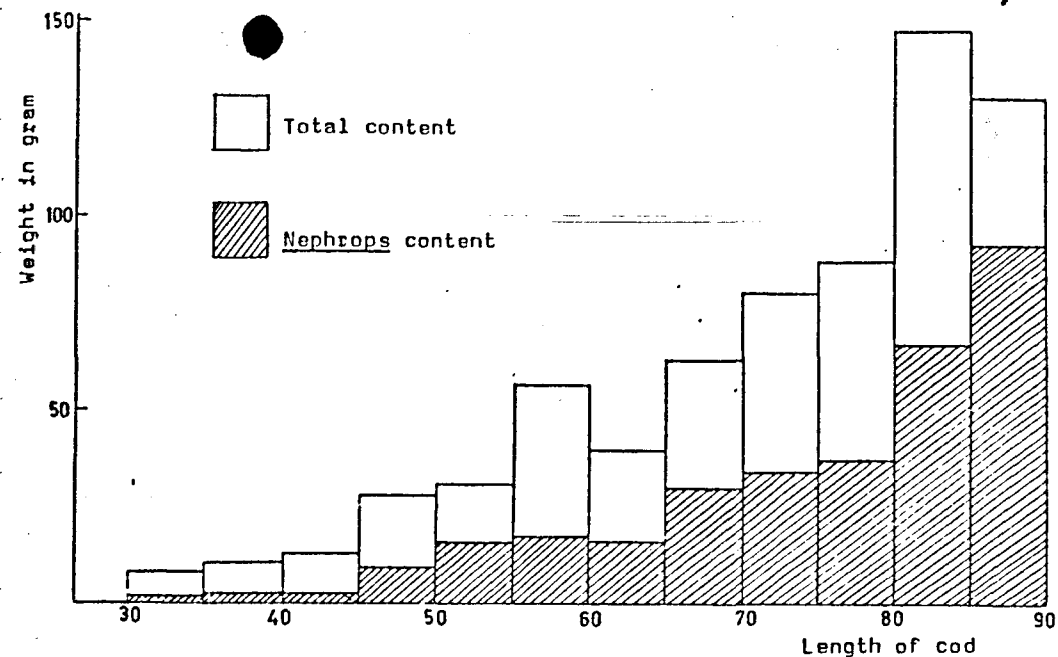


Figure 5.- Composition of the weight of the stomachs per length class of cod during August 1979.

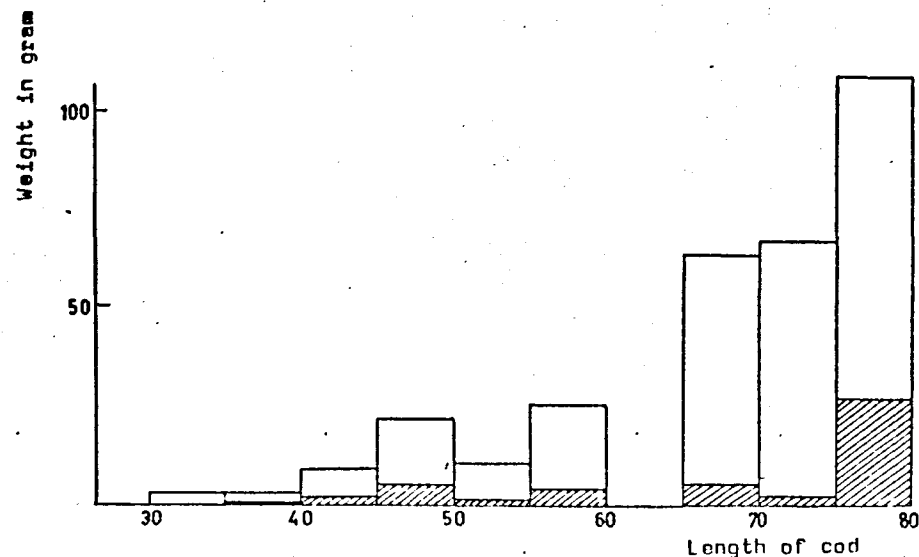


Figure 6.- Composition of the weight of the stomachs per length class of cod during Oct-Nov, 1979.

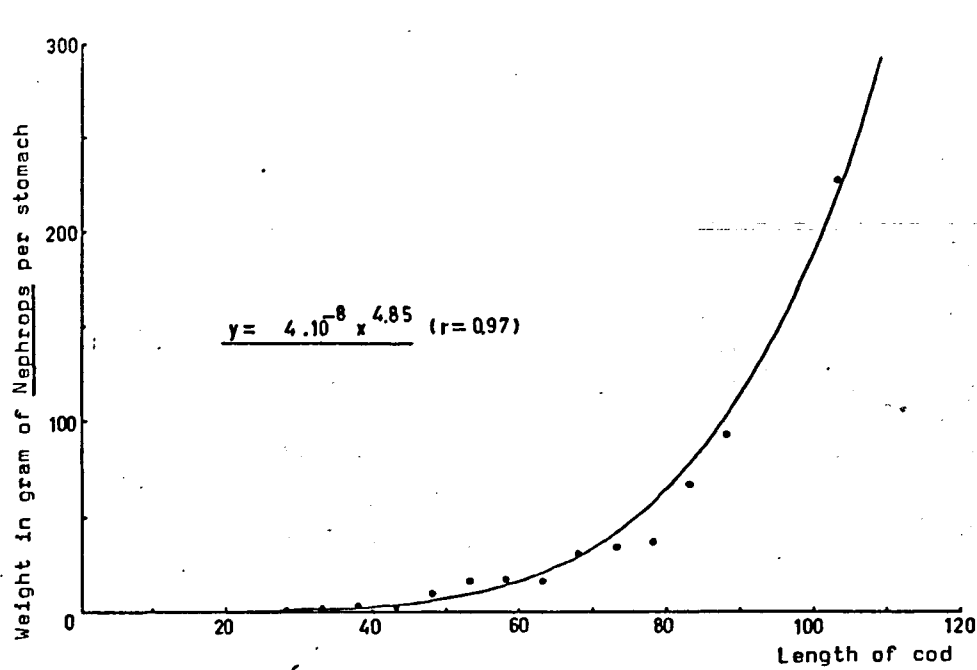


Figure 7.- Relation between mean weight of Nephrops per stomach and the length of cod during August 1979.

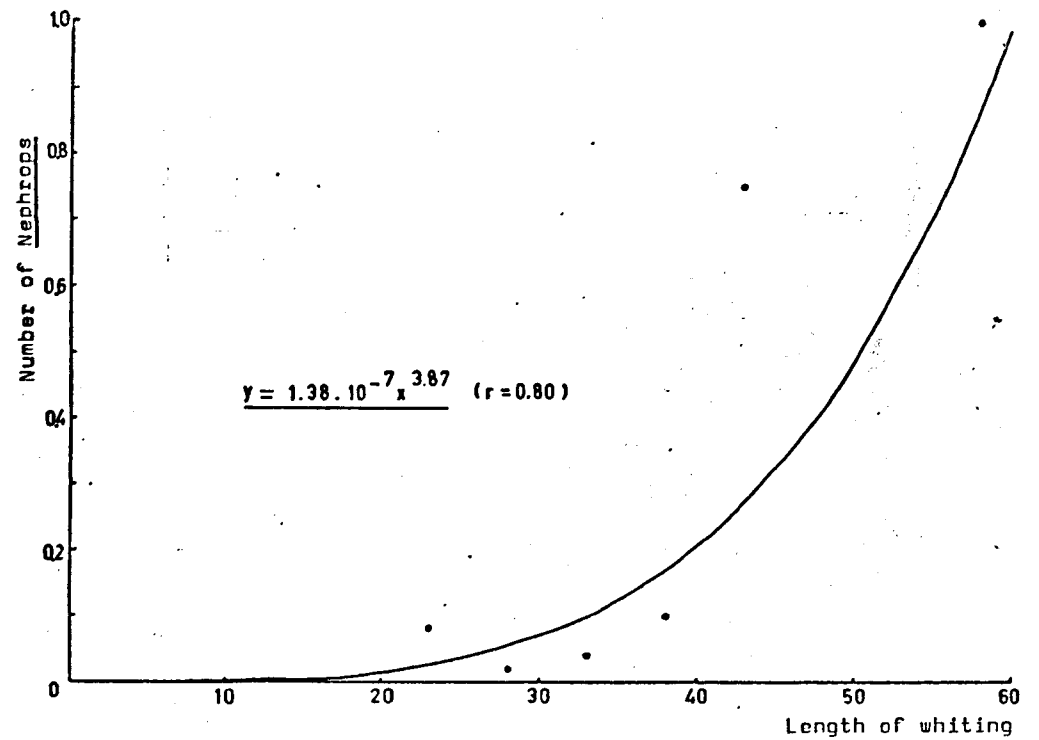


Figure 9.- Relation between the length of whiting and the number of Nephrops per stomach during August 1979.

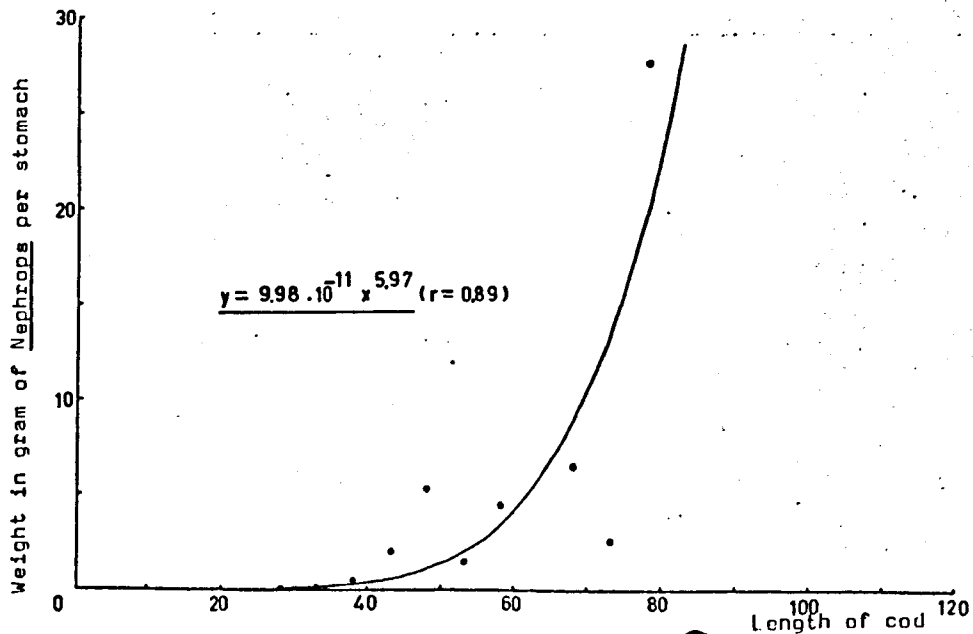


Figure 8.- Relation between mean weight of Nephrops per stomach and the length of cod during Oct.-Nov. 1979.

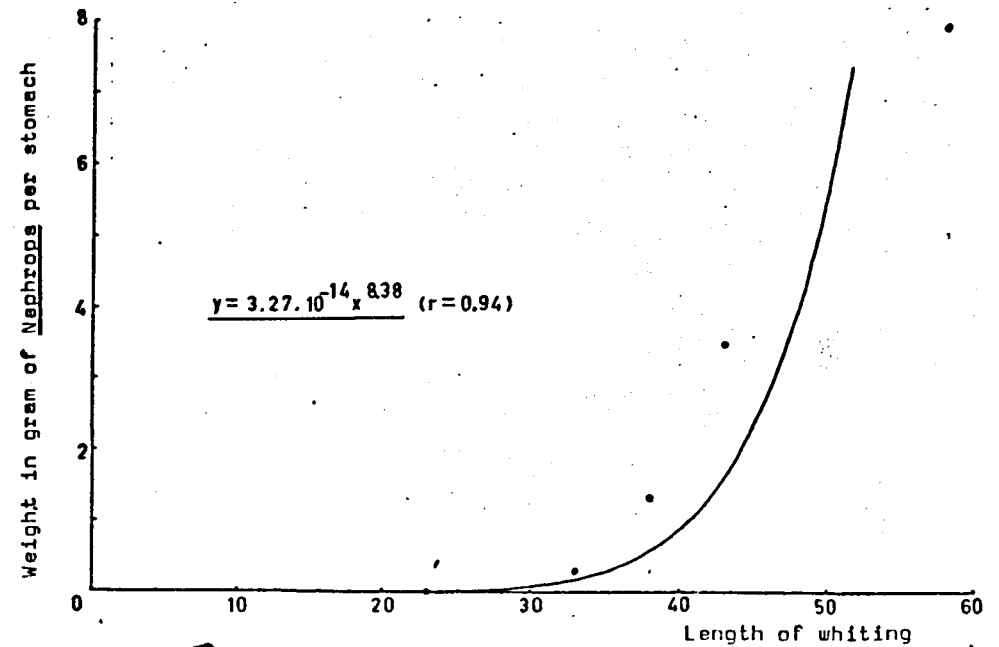


Figure 10.- Relation between mean weight of Nephrops per stomach and the length of whiting during August 1979.

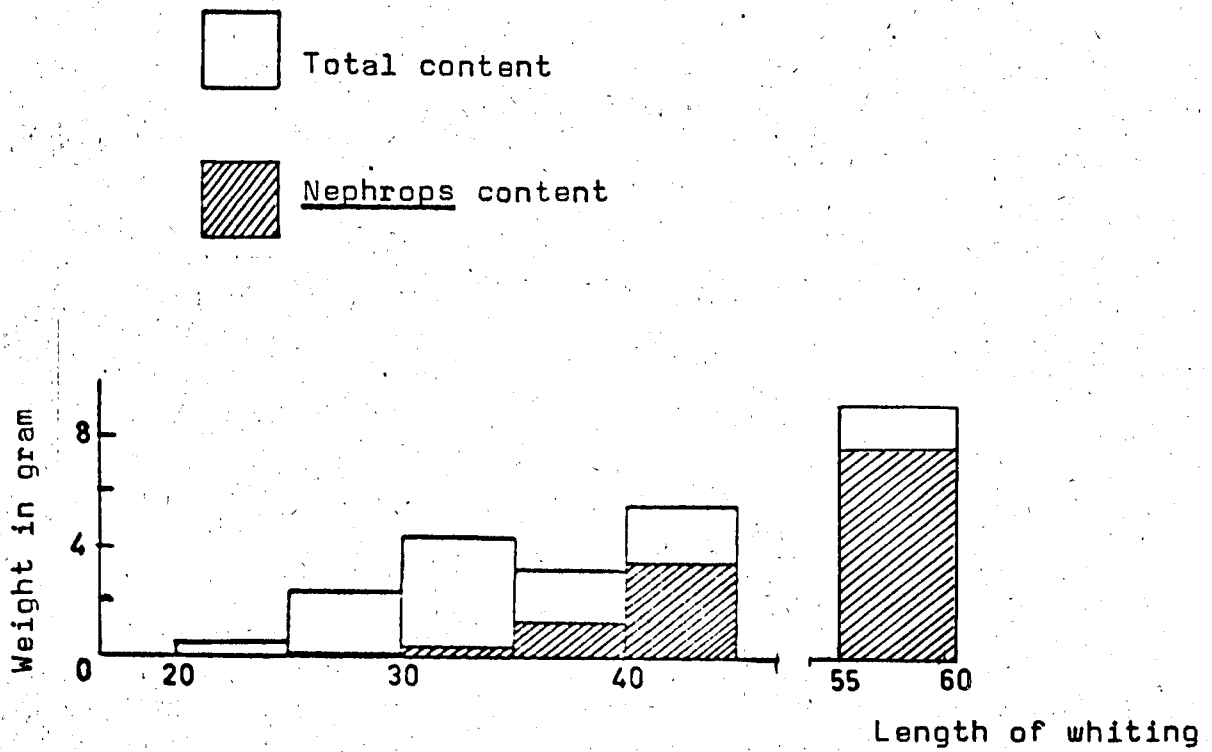


Figure 11.- Composition of the weight of the stomachs per length class of whiting during August 1979.

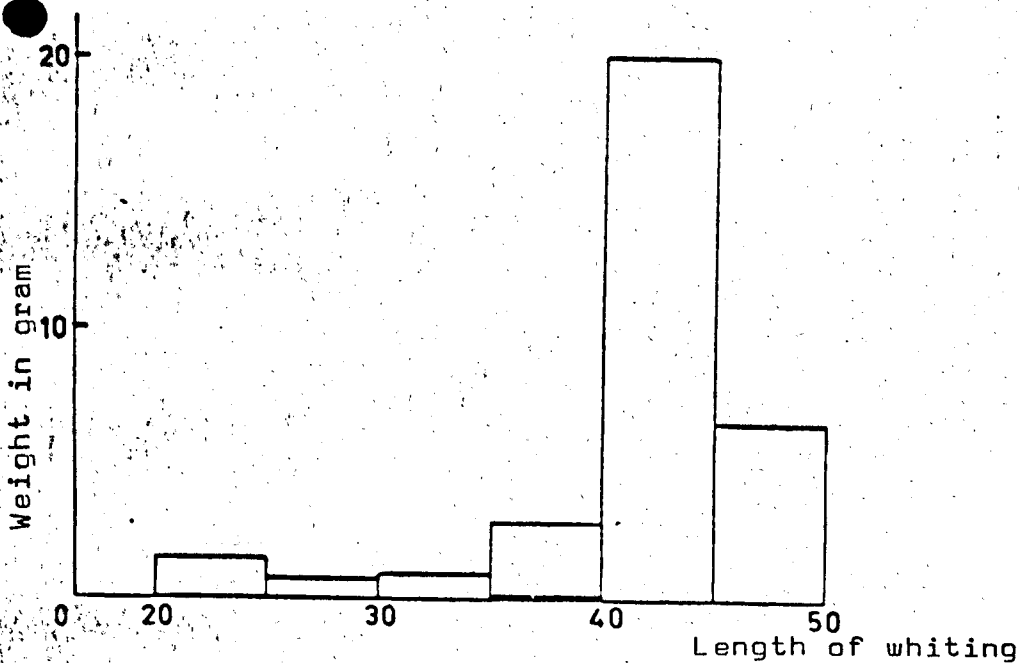


Figure 12.- Composition of the weight of the stomachs per length class of whiting during Oct. Nov. 1979.