NIOZ-RAPPORT 1995 - 8

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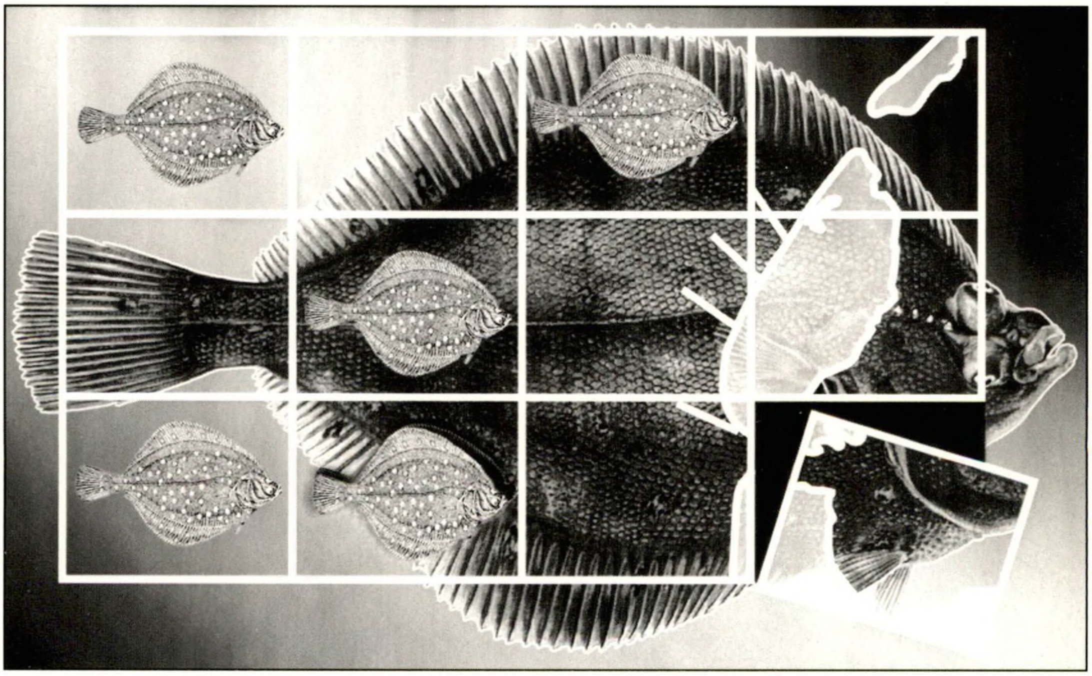

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SAMENVATTING

De groei en sterfte van 0-groep schol (*Pleuronectes platessa* L.) werd bestudeerd in het open kustgebied langs het eiland Texel van maart tot oktober 1992, en de resultaten zijn vergeleken met die van vergelijkbaar onderzoek in een belangrijk opgroeigebied, het Balgzand, een getijdegebied in de Waddenzee. De volgende hypotheses zijn getest: [1] De sterfte onder jonge schol is hoger in het open kustgebied dan in de Waddenzee door de aanwezigheid van grotere aantallen predatoren [2] De groei in het open kustgebied is lager dan in de Waddenzee door de aanwezigheid van sterkere interspecifieke competitie voor voedsel. Beide hypotheses werden verworpen. De sterfte in het kustgebied variëerde tussen 0.015 en 0.019 d^{-1}, vergelijkbaar met waarden gevonden op het Balgzand. Groei van 0-groep schol in het kustgebied is snel van 2.5 cm aan het einde van april tot 12.5 cm aan het einde van augustus. De waargenomen groei stemde overeen met de voorspellingen van een experimenteel bepaald model dat maximale groei in relatie tot water temperatuur beschrijft. Groei in het kustgebied lijkt alleen door de watertemperatuur bepaald te worden, en niet door andere factoren zoals voedselaanbod en competitie. De kustzone lijkt een belangrijk opgroeigebied voor jonge schol en van een zelfde kwaliteit als getijdeplaten in de Waddenzee, zoals het Balgzand te zijn.

SUMMARY

Growth and mortality of 0-group plaice (*Pleuronectes platessa* L.) was studied in the open coastal zone along the isle of Texel between March and October in 1992 and compared with estimates of estuarine nursery areas (Balgzand area, Wadden Sea), to test the following hypotheses: [I] Mortality of 0-group plaice in open coastal nursery areas is higher than in the estuarine Wadden Sea, due to the presence of higher numbers of predators. [II] Growth of 0-group plaice in open coastal nursery areas is lower than in the estuarine Wadden Sea, due to more severe interspecific competition for food. Both hypotheses could be falsified. Mortality rates in the coastal zone were between 0.015 and 0.019 d^{-1},which is similar to the mortality rates observed in the Wadden Sea. Growth of 0-group plaice appears to be high from about 2.5 cm at the end of April to about 12.5 cm at the end of August. A comparison of the observed growth with expected growth according to an experimentally established model, predicting maximal growth in relation to water temperature, revealed that growth of 0-group plaice in the coastal zone was maximal and only determined by prevailing water temperatures. The coastal zone appears to be an important nursery area for 0-group plaice, with a similar quality as the intertidal areas in the estuarine Wadden Sea.

1. INTRODUCTION

Plaice (*Pleuronectes platessa* L.) is a commercially important and well-studied flatfish species in the North Sea. Spawning occurs in offshore waters from about December until March, during which time the adults concentrate in specific areas, the main ones being the Southern Bight and the German Bight (HARDING *et al.*, 1978; VAN DER LAND, 1991). The planktonic eggs and larvae are transported to coastal waters by residual currents (TALBOT, 1976; 1978) and by successive selective tidal behaviour (RIJNSDORP *et al.*, 1985; BERGMAN *et al.*, 1989). Thereafter, metamorphosis takes places and the pelagic larvae settle at a length of 10-15 mm almost exclusively in estuaries and in shallow waters along the North Sea coast, so-called nursery areas (ZIJLSTRA *et al.*, 1982; VAN BEEK *et al.*, 1989).

Extensive research of the population dynamics of juvenile plaice in the estuarine Wadden Sea has revealed that growth and survival conditions are favourable for the major proportion of the population. (KUIPERS, 1977; ZIJLSTRA *et al.*, 1982; VAN DER VEER, 1986). The large food resources result in maximum possible growth at the prevailing water temperatures, and the relative scarcity of predators allows high survival rates (BERGMAN *et al.*, 1988; VAN DER VEER *et al.*, 1990, VAN DER VEER & WITTE, 1993). Open coastal waters are assumed to be less favourable (VAN DER VEER & BERGMAN, 1987; BERGMAN *et al.*, 1988). A higher abundance of predators - such as gadoids, turbot (*Scophthalmus maximus*), larger plaice and flounder (*Platichthys flesus*), shrimps (*Crangon crangon*) and swimming crab (*Macropipus holsatus*) - is expected to cause higher mortality rates (VAN DER VEER *et al.*, 1990). Moreover, because of these higher densities of other (predatory) species also the food availability may be lower due to interspecific competition, resulting in sub-optimal growth. Hardly any data exists for such coastal areas, except from some observation in British bays (EDWARDS & STEELE, 1968; Lockwood, 1974). DE VRIES (1974) sampled juvenile flatfish along the Dutch coast, and he compared the observed increase in mean length with growth of juvenile plaice in the Wadden Sea. His data suggested a higher growth rate in the open coastal zone. However, his data were not corrected for net efficiency and growth observations of 0-group were restricted to the period August to October.

The subject of this investigation was to estimate growth and mortality of juvenile plaice during their first year of life (0-group) in open coastal waters and to compare the results with data on growth and mortality in estuarine nursery areas in order to test the following hypotheses:

I. Mortality of 0-group plaice in open coastal nursery areas is higher than in the estuarine Wadden Sea, due to the presence of higher numbers of predators.
II. Growth of 0-group plaice in open coastal nursery areas is lower than in the estuarine Wadden Sea, due to more severe interspecific competition for food.

2. MATERIAL AND METHODS

Sampling was carried out at 4 stations in shallow coastal areas along the North Sea coast of Texel (The Netherlands) nearly every other week from March until October in 1992 (Fig. 1). At each station in principle two hauls were made parallel to the coastline at depths of 2, 4, 6, 8 and 10 m, and in addition two hauls were done perpendicular to the coastline from 2 to 10 m depth. All samples were taken with a 2-m beam trawl rigged with a fine meshed net (mesh size 5 x 5 mm) and one tickler chain, towed by RV 'Griend'. The size of area fished was registered by a meter wheel fitted at the frame of the beam.

All catches were sorted out on board and all 0-group plaice were measured to the nearest mm total length. In case of doubt, the age of plaice was checked by means of otolith reading. Catch numbers were corrected for net efficiency following KUIPERS (1975) and DAPPER (1978) and converted into abundance indices per 1000 m^{-2} (n.1000 m^{-2}). Growth rates were estimated from the observed increase in length. Daily instantaneous mortality rates ($Z;d^{-1}$) was calculated from the decrease in abundance according to

$$Z = -1 / t * \ln (N_t / N_0)$$

in which N_t and N_0 are the abundance indices at T = t and T = 0 and t is number of days. All statistical calculations (ANOVA) were run with SYSTAT (WILKINSON, 1989).

3. RESULTS

In spite of the good weather during the summer of 1992, the conditions were not optimal for sampling and all stations could not be sampled every week. In total 207 hauls were done between March 9th (Week 11) and October 20th (Week 43). Fig. 2 shows the sampling structure during the period. At each station hauls were taken every two weeks; however between August 20th and October 20th sampling was not possible at all.

3.1. ABUNDANCE

The sampling frequency was too irregular to permit an analysis for each station separately. ANOVA showed that neither sampling station nor depth significantly contributed to the mean abundance. Instead, the mean abundance for all stations was estimated per sampling period. Two estimates were calculated, one based on the hauls parallel to the coastline and one based on the hauls perpendicular to the coast.

Both estimates of the seasonal pattern in abundance resulted in roughly the same pattern (Fig. 3). The first 0-group plaice appeared in the catches at the beginning of May, followed by an increase in numbers to a maximum in the middle of June of about 250 to 500 ind.1000m^{-2}. Hereafter, numbers dropped to a density of about 100 ind.1000m^{-2} at the end of August. From September onwards numbers increased again due to immigration of individuals from the Wadden Sea.

The daily instantaneous mortality rate (Z;d^{-1}) was estimated from the period between peak density in June and immigration in September (Fig. 4). Based on the mean abundance of the hauls parallel to the coastline, numbers decreased over this period from about 500 to 130 ind.1000m^{-2} in about 75 days, which means a daily instantaneous mortality rate of about 0.019 d^{-1}. Based on the mean density of the hauls perpendicular to the coast, a slightly lower daily instantaneous mortality rate of 0.015 d^{-1} was found.

3.2. MEAN LENGTH

In total 7060 0-group plaice were measured. Never were the length-frequency distributions significantly different from normal distributions and therefore for each sampling station and period the mean length was estimated. Table 1 shows the size-frequency distributions, corrected for the different sampling periods for net efficiency. Mean length increased from about 2.5 cm at the end of April to about 12.5 cm at the end of August (Fig. 5). Both the estimate based on the hauls parallel to the coastline and those perpendicular to the coast showed the same seasonal pattern and similar absolute increases in mean length (Fig. 6). No difference was found between stations in the estimates based on parallel hauls (Fig. 5a), but significant differences between stations in mean length were observed in the estimates based on perpendicular hauls (Fig. 5b).

Due to these differences between stations, the increase in mean length of the 0-group plaice population was analysed by means of a general linear model. In the model, time period (in weeks), depth (steps of 2 m) and location (Station 1-4) were considered as categorical independent variables. Differences caused by time and location were explained as significant (P= < 0.001). However, no significant difference was found in depth (P= 0.802), supporting the conclusion that the two estimates based on parallel hauls and on perpendicular hauls are an estimate of the mean length at the station. Fig. 7 shows the less square means estimate of the mean length of 0-group plaice corrected for depth and station effects.

The mean length increase of the 0-group plaice population over the period from week 21 (May) to week 34 (August), in which the increase was almost linear was considered to represent growth. Observed growth was compared with predicted maximal growth according to an experimentally established growth model under excess of food (GLAZENBURG, 1983):

$$\Delta L = 1.3 * T + 1.7 \qquad (\text{mm.mo}^{-1})$$

in which ΔL is the predicted increase in length (mm.mo^{-1}), and T is the mean water temperature (°C) over the period of observation. Data on water temperature are presented in Fig. 8. Water temperature increased from about 9°C at the end of April to a maximum of 20°C at the end of July, followed by a steady decrease to temperatures of about 11°C at the end of the sampling period in October. No significant differences between stations were observed. Observed growth could only be compared with predicted maximal growth over the period of Week 24 (June 10th) to 34 (August 20th), because during this period no immigration or emigration of 0-group plaice will have occurred. Predicted maximal growth corresponded with observed growth suggesting maximal growth of the 0-group plaice population in the coastal zone at the prevailing water temperatures (Fig. 9).

4. DISCUSSION

4.1. SAMPLING STRATEGY

The sampling stations along the coastline of Texel are exposed to northerly and westerly winds. Although during the summer period wind stress is relatively low, even then sampling is often impossible due to wave action in the shallow beach zone. As a consequence sampling was irregular with respect to station and depth zones. The sampling programme consisted of two types of hauls, those parallel to the coastline at fixed depth and those perpendicular on the coast covering the whole depth range, to take account for possible depth-related distributions and size ranges. Fortunately, ANOVA showed that there was no significant effect of depth and station on the abundance estimate and also of depth on the estimate of mean length. Sampling station only had a significant impact on mean length and this had to be incorporated. Therefore only accurate estimates of mean length could be obtained by means of general linear model during the period of linear increase in summer.

The design of the sampling programme was based on the outline published by MILLER *et al.* (1992). However, accurate estimates of mortality and growth also depends on the efficiency of the sampling gear. The 2-m beam trawl used at this survey has been especially designed for this type of flatfish research by KUIPERS (1975, 1977). As part of his study on juvenile plaice in the Wadden Sea, Kuipers (1975) also tested the efficiency of the 2-m beam trawl in relation to fish size. Over a size range of 4 to 10 cm total length the net efficiency of the 2-m beam trawl is known to be high, between 70 and 100%. Therefore, all catches could be corrected for each size class and accurate estimates of abundance and size were obtained, which means that the size-frequency distributions are not biased by size-selective net efficiency.

4.2. ABUNDANCE

The seasonal pattern of abundance in the coastal zone corresponded well with those observed in the Wadden Sea. (KUIPERS, 1977; ZIJLSTRA *et al.*, 1982; VAN DER VEER, 1986). However, there appears to be a slight difference in timing. Larval immigration and settlement of 0-group plaice in the Wadden Sea starts in March and peak densities are observed in early May (ZIJLSTRA *et al.*, 1982; VAN DER VEER, 1986). In the coastal zone there appears to be a slight delay in larval settlement and hence peak densities were found in June. The maximum densities observed in the coastal zone of about 300 to 500 ind.1000 m^2 are in the same range as those found at the tidal flat areas in the Wadden Sea. After immigration stops, a period of decreasing numbers occurs until densities stabilize at the end of July. In autumn numbers increase due to emigration from the Wadden Sea (ZIJLSTRA *et al.*, 1982).

The period of decreasing numbers in July and August permitted the estimate of mortality rates according to the methods also used by ZIJLSTRA *et al.* (1982) and VAN DER VEER (1986) and summarized by ILES & BEVERTON (1991). Although the estimate based the parallel hauls differed slightly from that based on rectangular hauls, both estimates, respectively 0.019 and 0,015 d^{-1}, are in the same range as the mortality rates found at the tidal flats in the Wadden Sea (ZIJLSTRA *et al.*, 1982; VAN DER VEER, 1986) and in open British bays (VAN DER VEER *et al.*, 1990; ILES & BEVERTON, 1991). However, the mortality factors will differ. At the tidal flats of the Wadden Sea, the main factor is predation by crustaceans, especially shrimps on plaice smaller than 3 cm and crabs on plaice smaller than 5 cm (VAN DER VEER & BERGMAN, 1987). In the coastal zone, mortality occurs later in July and August at a size range of about between

7.5 and 12.5 cm. Although no information exists, it is expected that as in British and Swedish bays especially predatory fish will be responsible (VAN DER VEER *et al.*, 1990).

Under the assumption of no migration movements comparison between the coastal zone and the Wadden Sea of the number of settling 0-group plaice and the mortality during the first year of life suggest no important difference between the two areas. This means that the coastal zone also appears to be an important nursery area of 0-group plaice.

4.3. GROWTH

The increase of the mean length of 0-group plaice in the coastal zone corresponded with the estimated maximal growth, according to the growth model of GLAZENBURG (1983). This suggests that food conditions for 0-group plaice were optimal in the coastal zone and that growth was only determined by prevailing water temperatures.

Such a conclusion depends mainly on the accuracy of the water temperature measurements and on the growth model. FONDS *et al.* (1992) expanded the maximum growth model of GLAZENBURG (1983) to juvenile plaice between 5 and 15 cm, which resulted in a polynomial equation:

$$\Delta L = 0.0136 * T^{1.5} - 6.10^{-9} * T^{6} \qquad (mm.d^{-1})$$

A comparison of the observed growth with the expectations of this more refined growth model also resulted in a good fit, and thus in a similar conclusion.

The similarity between observed and predicted maximum growth of 0-group plaice in the open coastal zone was even higher than that at the tidal flats of the Wadden Sea (ZIJLSTRA *et al.*, 1982; VAN DER VEER, 1986). Based on such a comparison, both ZIJLSTRA *et al.* (1982) and VAN DER VEER (1986) concluded that 0-group plaice showed the maximum possible growth at the Balgzand tidal flats in the Wadden Sea. BERGMAN *et al.* (1988) suggested that such optimal food conditions were one of the key-factors making the area an important nursery for flatfish. However, recently VAN DER VEER & WITTE (1993) concluded that growth of 0-group plaice in the Wadden Sea was not always maximal. Food quality did influence growth, although density-dependent growth did never occur. VAN DER VEER & WITTE (1993) suggested that growth was directly related to the presence of the lugworm *Arenicola marina* as a food item. Since *A. marina* is only present in the intertidal zone, this also explained the observed difference in growth between the intertidal and the subtidal. No information is present about the food sources for juvenile plaice in the coastal zone. However, *A. marina* will be almost absent. Nevertheless, the present data suggest that growth was maximal in the open coastal zone. More information about the benthic community is necessary before this discrepancy can be solved. This observation corresponds with the conclusion of DE VRIES (1974) who also found a higher growth rate in the open coastal zone than inside the Wadden Sea. However, his data were biased, because they were not corrected for net efficiency. Before definitive conclusions can be drawn the growth observations should be validated by means of otolith microstructure analysis (KARAKIRI *et al.*, 1989), to exclude the potential bias of immigration and emigration movements.

4.4. TEST OF THE HYPOTHESES

Two hypotheses were postulated: one expecting a higher mortality in the open coastal zone compared with the Wadden Sea due to the presence of more predators and the other one implying a lower growth rate due to more severe interspecific competition for food. Both hypotheses were falsified. Mortality rates in the coastal zone were comparable to those found in the Wadden Sea, and growth appeared to be maximal and only determined by the prevailing water temperatures. Investigations about the predator abundance and benthic food availability in the coastal zone are required to get more insight in the functioning of the coastal zone as nursery area for juvenile plaice. In contrast to earlier suggestions by a.o. BERGMAN *et al.* (1988), the coastal zone appears to be an important nursery area for 0-group plaice, with a quality similar to the intertidal areas in the estuarine Wadden Sea. This suggests that the habitat quality and quantity of nursery areas, as discussed by GIBSON (1994) should be reconsidered.

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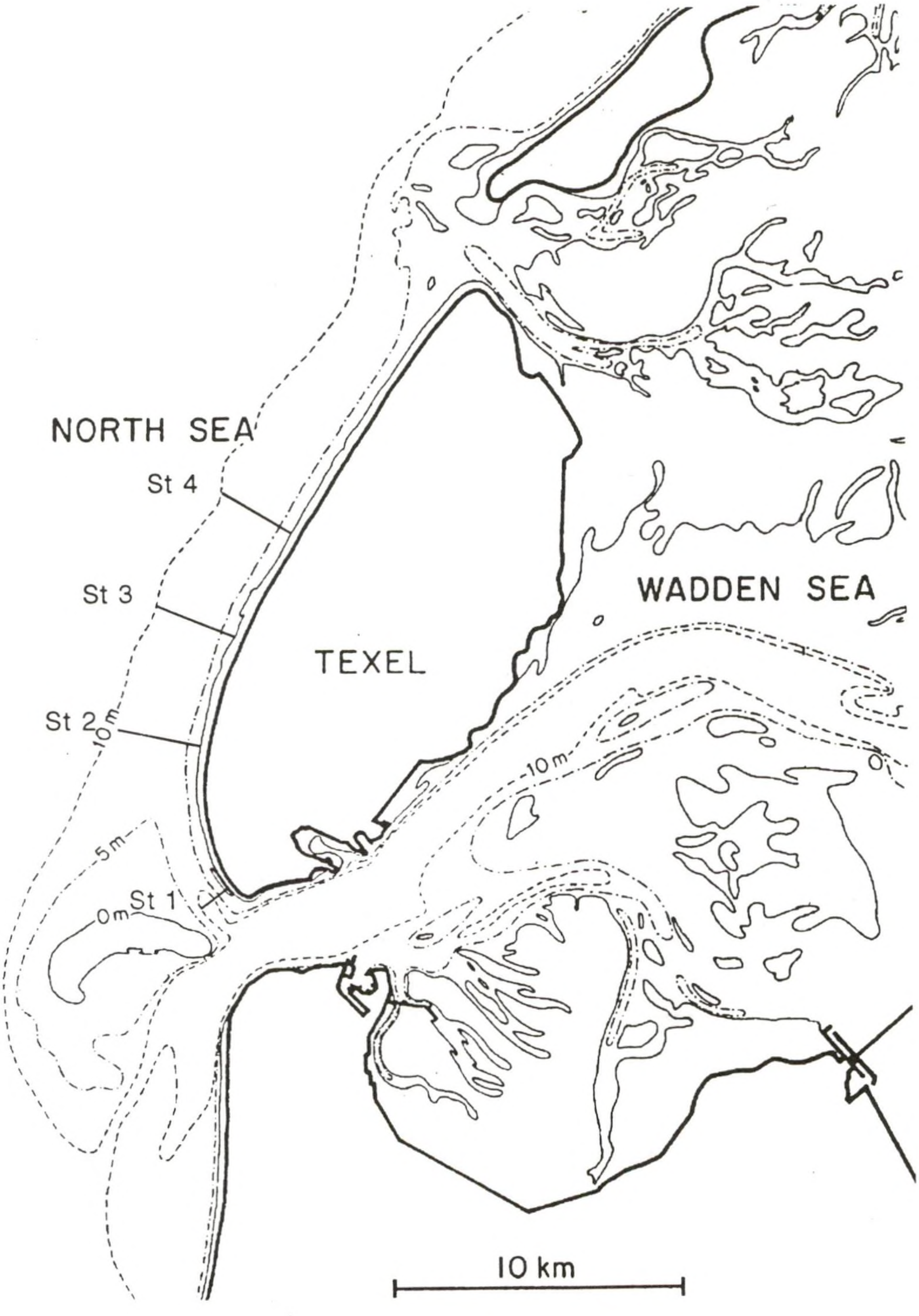

Fig. 1. Sampling stations along the coastline of Texel in 1992. At each station a number of hauls at different depths were made. For more information see text.

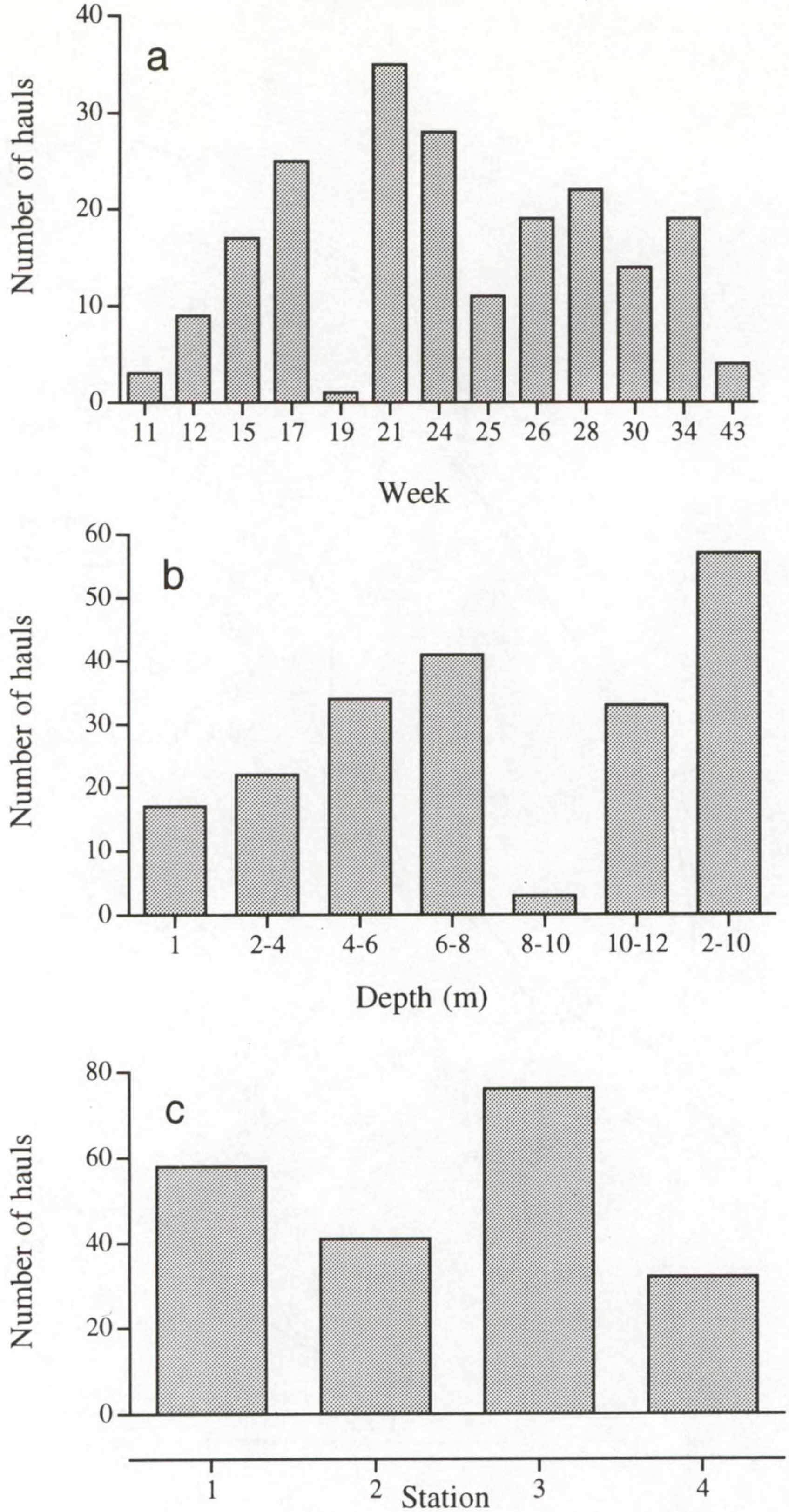

Fig. 2. Numbers of hauls done in 1992, per week (a), per depth zone (b) and at each station (c).

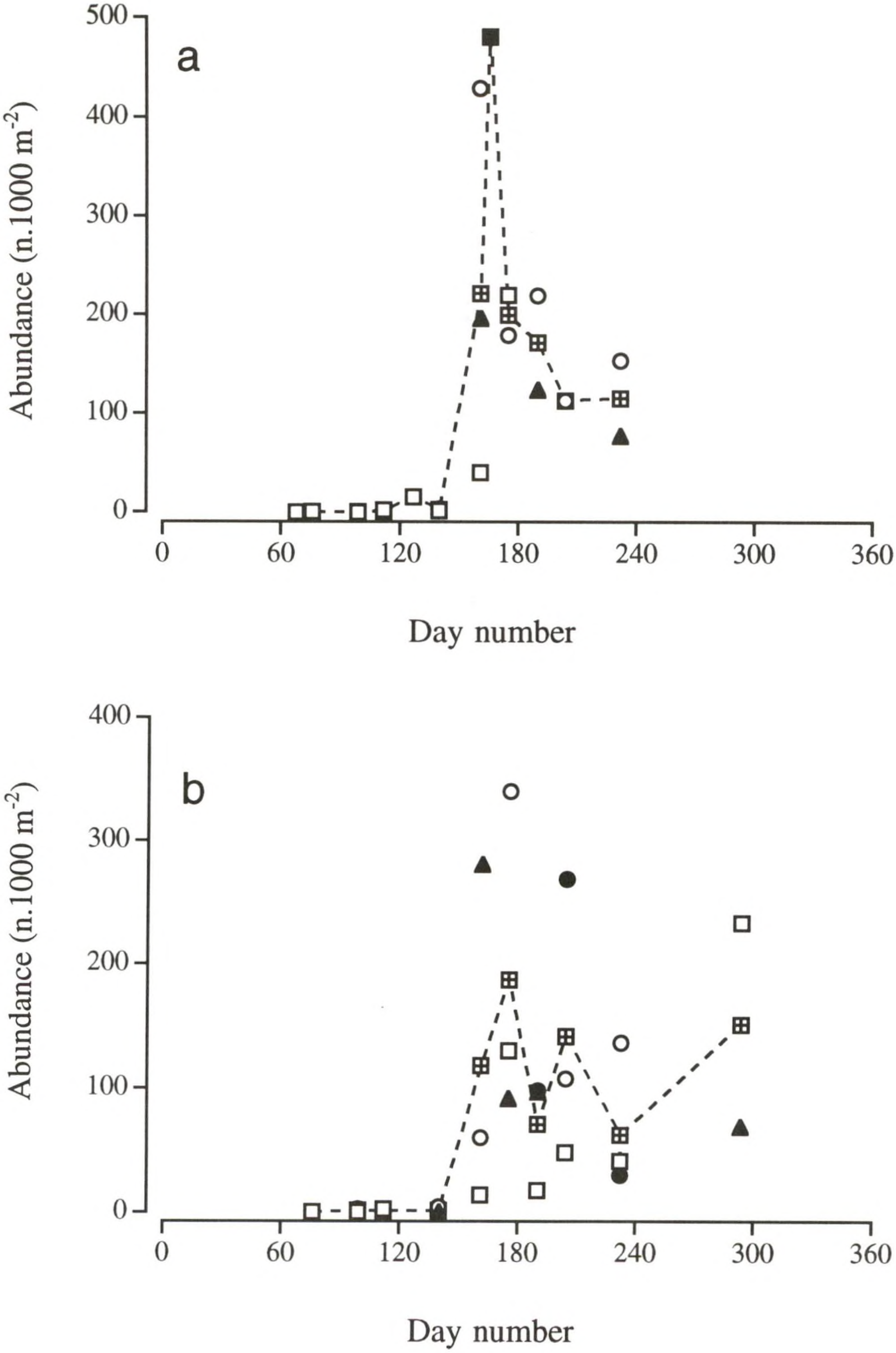

Fig. 3. Seasonal pattern of abundance of 0-group plaice corrected for net efficiency in the coastal zone along Texel in 1992. a: mean density (n.1000 m^{-2}) of the hauls parallel to the coast. b: mean density (n.1000 m^{-2}) of the hauls perpendicular to the coast. □ = Station 1; ▲ = Station 2; ○ = Station 3; ● = Station 4; ⊞ = Mean.

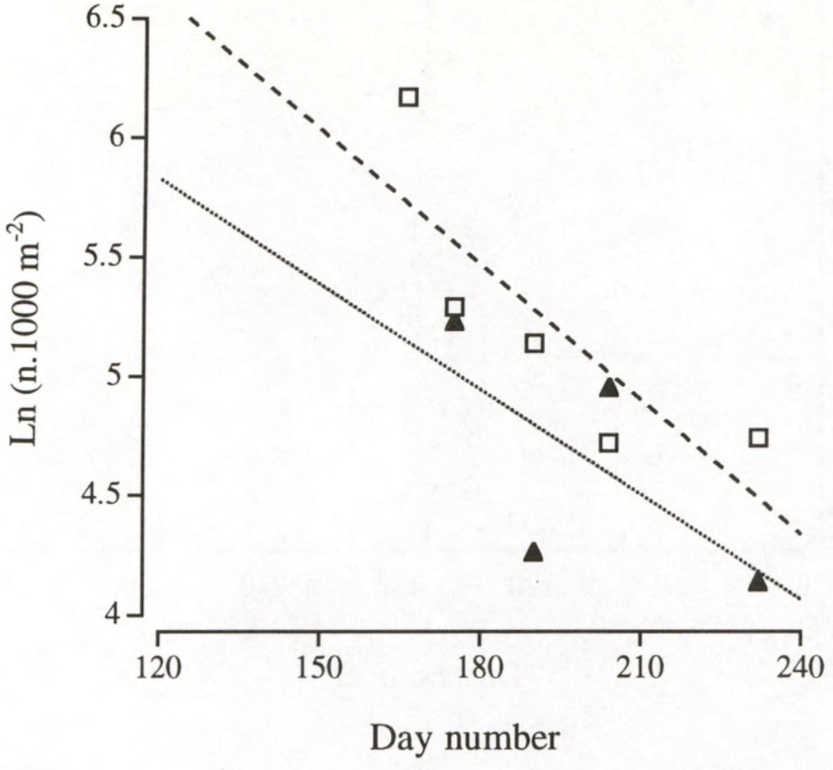

Fig. 4. Mean instantaneous mortality rate (Z; d^{-1}) of 0-group plaice in the coastal zone along the isle of Texel in 1992, based on the hauls parallel to the coastline (□) and the hauls rectangular to the coast (▲).

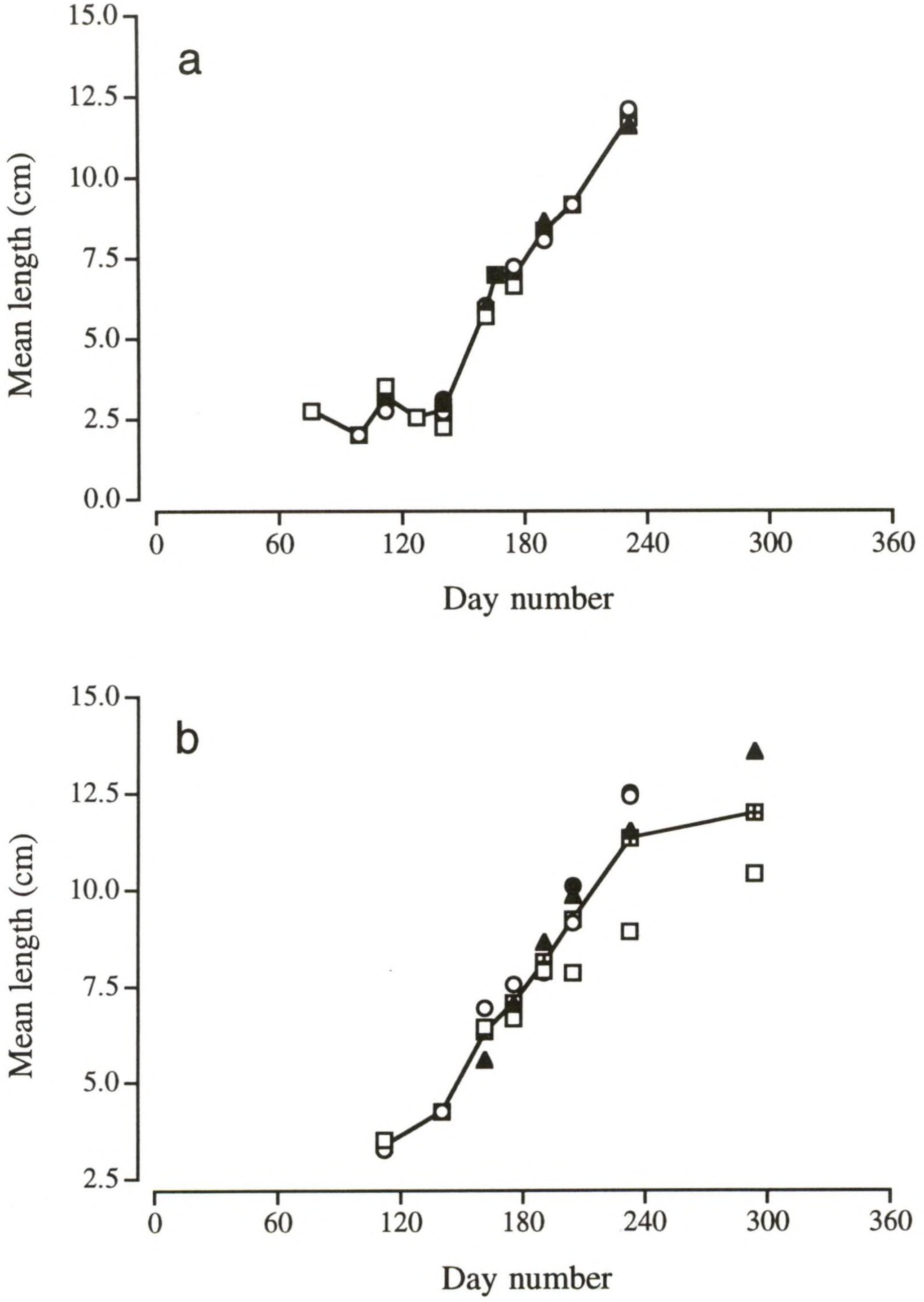

Fig. 5. Mean length (cm) of 0-group plaice corrected for net efficiency in the coastal zone along Texel in 1992. a: of the hauls parallel to the coast. b: of the hauls rectangular to the coast. □ = Station 1; ▲ = Station 2; ○ = Station 3; ● = Station 4; ⊞ = Mean.

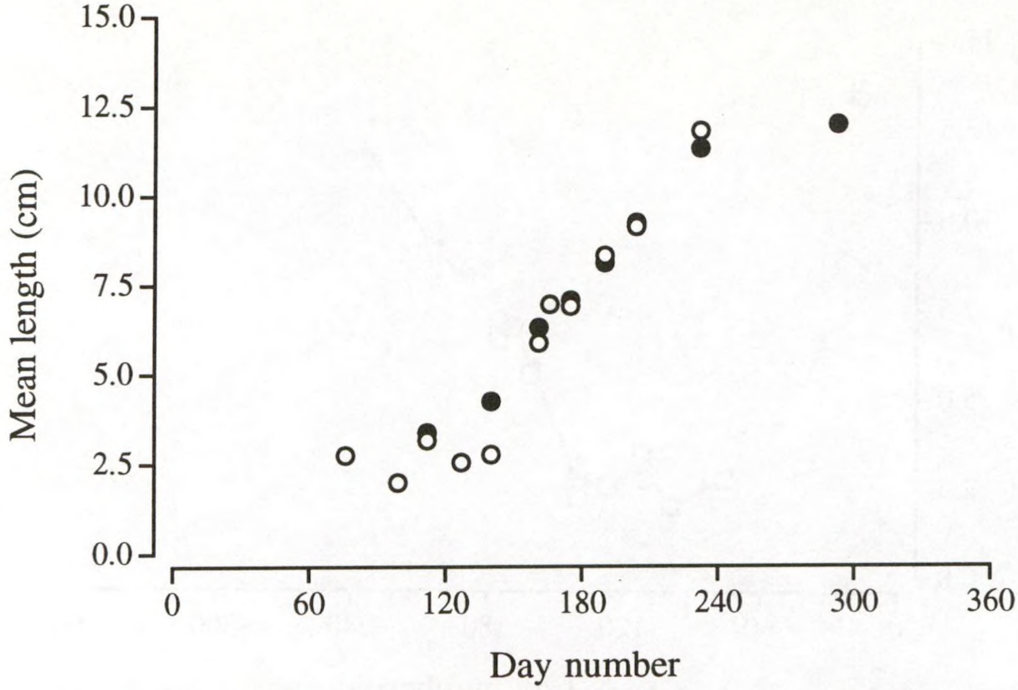

Fig. 6. Comparison of mean length (cm) of 0-group plaice corrected for net efficiency in the coastal zone along Texel in 1992 of the hauls parallel to the coast (O) and of the hauls rectangular to the coast (●).

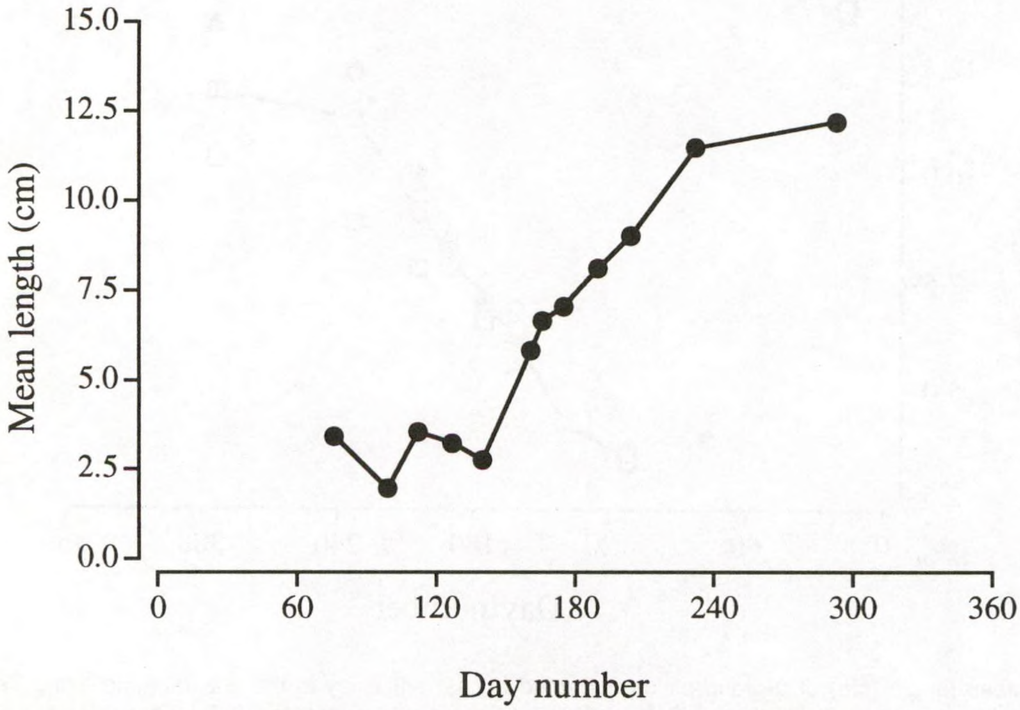

Fig. 7. Corrected mean length (cm) of the 0-group plaice population along the coast of the isle of Texel in 1992, based on GLM. For more information see text.

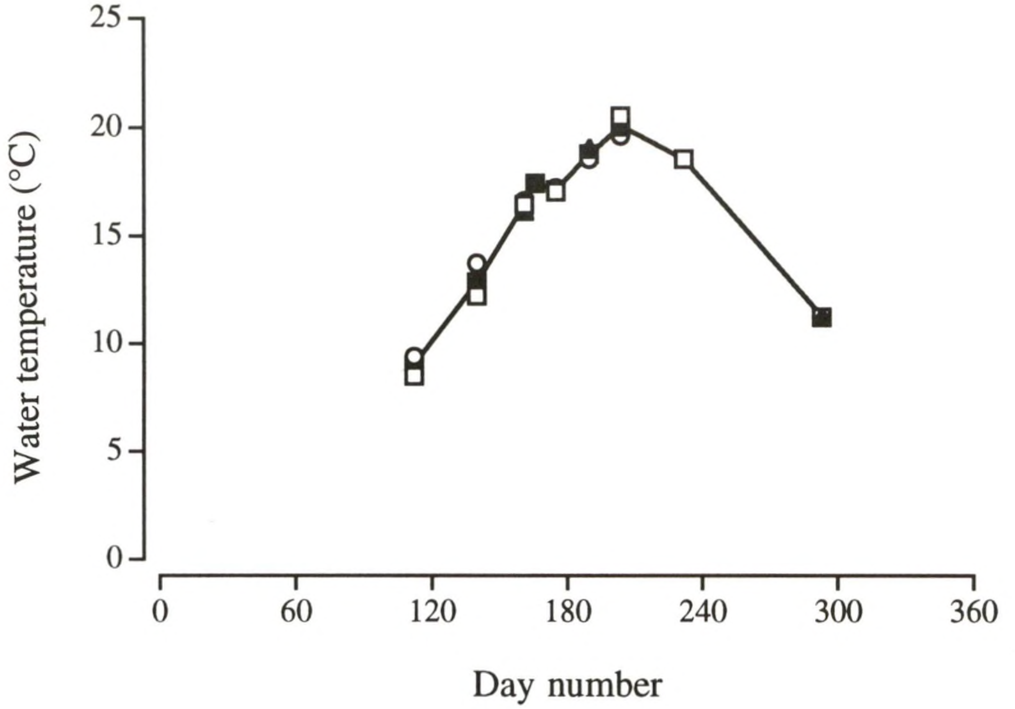

Fig. 8. Seasonal pattern in mean water temperature (°C) of surface water along the coast of Texel in 1992. □ = Station 1; ▲ = Station 2; ○ = Station 3; ● = Station 4; ⊞ = Mean.

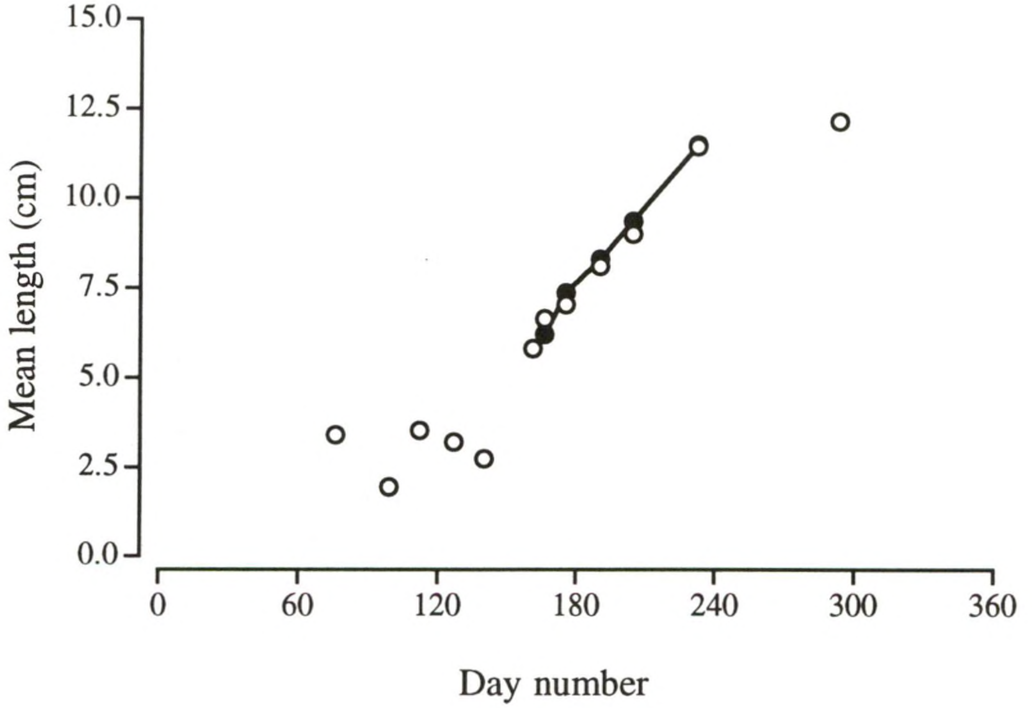

Fig. 9. Comparison of mean length (cm) of 0-group plaice in the coastal zone along Texel in 1992 (○) and predicted growth according to an experimental established model of maximal growth in relation to water temperature (●). For more information see text.

TABLE 1

Mean weekly size-frequency distribution of 0-group plaice, all hauls combined after correction for net efficiency.

	Date (Week)												
	11-Mar (11)	18-Mar (12)	8-Apr (15)	22-Apr (17)	6-May (19)	20-May (21)	10-Jun (24)	17-Jun (25)	24-Jun (26)	8-Jul (28)	22-Jul (30)	19-Aug (34)	1-Oct (43)
Size class (mm)													
6-10													
11-15			2.7										
16-20					2.1	3.1							
21-25					2.0	19.4	1.0						
26-30		1.0	1.0	1.0	2.0	1.0	2.0						
31-35				6.0	1.0	3.0	14.0	1.0					
36-40				3.0	1.0	6.0	35.0	6.0		2.0			
41-45						6.0	132.0	12.0	9.0	2.0			
46-50						2.0	335.0	35.0	31.0	2.0			
51-55						1.0	431.0	77.0	94.0	14.0			
56-60							472.0	107.0	154.0	48.0			
61-65							499.4	102.3	203.5	113.3	3.3		
66-70							344.7	156.2	249.2	166.2	16.1		
71-75							257.2	154.3	271.1	253.0	65.3	1.4	
76-80							111.6	151.9	258.9	252.7	108.5	6.2	1.6
81-85							17.1	100.9	196.7	282.2	106.0	22.2	3.4
86-90							3.8	32.0	137.2	276.4	144.8	15.0	1.9
91-95								12.4	55.6	226.6	171.0	49.4	14.4
96-100								2.2	22.4	141.1	190.4	44.8	2.2
101-105									14.5	99.2	140.4	58.1	9.7
106-110										62.9	102.2	102.2	18.3
111-115										25.3	95.5	140.5	11.2
116-120											87.3	168.6	12.0
121-125											35.4	186.8	19.3
126-130											20.6	144.1	24.0
131-135											18.3	124.1	29.2
136-140											3.9	73.5	15.5
141-145												61.4	20.5
146-150												26.0	4.3
151-155												18.2	9.1
156-160												14.4	19.2
161-165												5.0	5.0

APPENDIX 1

Summary of basic catch data of 0-group plaice of coastal survey in 1992, after correction for net efficiency. For more information, see text.

TREK No.	WEEK	DATE	STATION	DEPTH	LENGTHCLASS (0.5cm)																																	Catch	Distance	Surface	Density
					O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		(Counts)	area (m2	(n.m-2)
1	11	9/3/92	1	2-4 m																																			52	346.32	
2	11	9/3/92	1	6-8 m																																			39	259.74	
3	11	9/3/92	1	8-10m																																			51	339.66	
7	12	18/3/92	1	2-10 m (L)																																			75	499.5	
8	12	18/3/92	1	2-10 m (L)																																			133	885.78	
9	12	18/3/92	1	2-4 m						1																												1.00	113	752.58	1.33
10	12	18/3/92	1	4-6 m																																			96	639.36	
11	12	18/3/92	1	6-8 m																																			65	432.9	
12	12	18/3/92	1	8-10 m																																			69	459.54	
13	15	8/4/92	1	2-10 m (L)																																			12	79.92	
14	15	8/4/92	1	2-4 m																																			50	333	
15	15	8/4/92	1	4-6 m																																			44	293.04	
16	15	8/4/92	1	6-8 m																																			70	466.2	
17	15	8/4/92	1	8-10m																																			33	219.78	
18	15	9/4/92	1	1 m(R)																																			36	239.76	
19	15	9/4/92	1	1 m(R)																																			133	885.78	
30	17	21/4/92	1	2-4 m																																			70	466.2	
31	17	21/4/92	1	4-6 m							2																											2.00	78	519.48	3.85
32	17	21/4/92	1	6-8 m																																			72	479.52	
33	17	21/4/92	1	8-10m																																			44	293.04	
38	17	22/4/92	1	2-10 m (L)								1																										1.00	74	492.84	2.03
39	17	22/4/92	1	2-10 m (L)							1																											1.00	55	366.3	2.73
40	17	22/4/92	1	1 m(R)																																			77	512.82	
41	17	22/4/92	1	1 m(R)								2																										2.00	31	206.46	9.69
55	19	7/5/92	1	2-4 m				2.08	2.04	2	1	1																										8.12	80	532.8	15.24
83	21	21/5/92	1	2-4 m					2.04																													2.04	114	326.04	6.26
84	21	21/5/92	1	2-4 m					1.02																													1.02	78	223.08	4.57
85	21	21/5/92	1	4-6 m					1.02																													1.02	108	308.88	3.30
86	21	21/5/92	1	4-6 m																																			56	160.16	
87	21	21/5/92	1	6-8 m																																			184	526.24	
88	21	21/5/92	1	6-8 m																																			126	360.36	
89	21	21/5/92	1	8-10 m																																			184	526.24	
90	21	21/5/92	1	8-10 m																																			259	740.74	
91	24	9/6/92	1	2-10 m (L)							1		2	2	2	1	4.4	1.24	1.39																			15.03	217	620.62	24.22
92	24	9/6/92	1	2-10 m (L)														1.24		1.55																		2.79	274	783.64	3.56
93	24	9/6/92	1	2-4 m						1	2		1	1	4	3		1.24																				13.24	213	609.18	21.73
94	24	9/6/92	1	2-4 m							1		1	5	4	5	6.6	2.48	1.39		1.71																	28.18	48	137.28	205.27
95	24	9/6/92	1	4-6 m												1	1.1																					2.10	65	185.9	11.30
96	24	9/6/92	1	4-6 m									4	4	2	7	3.3	3.72	1.39																			25.41	155	443.3	57.32
97	24	9/6/92	1	6-8 m												1	1.1		1.39																			3.49	230	657.8	5.31
98	24	9/6/92	1	6-8 m									1	5	1			1.24																				8.24	194	554.84	14.85
99	24	9/6/92	1	8-10 m																																			125	357.5	
100	24	9/6/92	1	8-10 m												1																						1.00	188	537.68	1.86
130	26	23/6/92	1	2-10 m (L)										2	3	4	3.3	1.24	2.78					2.24														18.56	38	108.68	170.78
131	26	23/6/92	1	2-10 m (L)											3	2		2.48																				7.48	29	82.94	90.19
132	26	23/6/92	1	4-6 m									4	4	20	19	30.8	19.84	12.51	1.55				2.24														113.94	143	408.98	278.60
133	26	23/6/92	1	4-6 m										6	12	16	15.4	4.96	6.95	3.1	1.71		4.12		2.42													72.66	99	283.14	256.62
134	26	23/6/92	1	6-8 m											2	2	2.2	1.24	5.56						2.42													15.42	28	80.08	192.56
135	26	23/6/92	1	6-8 m										1	5	5	17.6	8.68	9.73	7.75		1.88			2.42													59.06	75	214.5	275.34
136	26	23/6/92	1	8-10 m												3	2.2	4.96	2.78	1.55																		14.49	55	157.3	92.12
149	28	7/7/92	1	2-10 m (L)												1	2.2										2.81											6.01	208	594.88	10.10
150	28	7/7/92	1	2-10 m (L)												3	1.1	2.48	2.78						2.42													11.78	168	480.48	24.52
179	30	24/7/92	1	2-10 m (L)														1.24	8.34		6.84	1.88																18.30	142	406.12	45.06
180	30	24/7/92	1	2-10 m (L)															6.95	15.5			6.18															28.63	186	531.96	53.82
192	34	20/8/92	1	2-10 m (L)																	13.68	1.88	10.3	4.48														30.34	285	815.1	37.22
193	34	20/8/92	1	2-10 m (L)																4.65	5.13	7.52	8.24			5.24												30.78	236	674.96	45.60
204	43	20/10/92	1	2-10 m (L)																	1.71		6.18	2.24	2.42	2.62												15.17	43	122.98	123.35
205	43	20/10/92	1	2-10 m (L)																1.55	1.71	1.88	8.24		7.26	10.48	8.43	3.01		6.86	3.65	3.87	4.09					61.03	62	177.32	344.18
34	17	21/4/92	2	2-10 m (L)																																			79	526.14	
35	17	21/4/92	2	2-10 m (L)																																			96	639.36	
36	17	21/4/92	2	6-8 m																																			58	386.28	
37	17	21/4/92	2	8-10 m																																			75	499.5	

TREK No.	WEEK	DATE	STATION	DEPTH	LENGTHCLASS (0.5cm)																																	Catch	Distance	Surface	Density
					0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		(Counts)	area (m2)	(n.m-2)
75	21	20/5/92	2	2-10 m (L)																																			107	712.62	
76	21	20/5/92	2	2-10 m (L)																																			100	666	
77	21	20/5/92	2	6-8 m																																			72	479.52	
78	21	20/5/92	2	6-8 m					2.04			1	1																									4.04	75	499.5	8.09
79	21	20/5/92	2	8-10 m					1.02			1																										2.02	105	699.3	2.89
80	21	20/5/92	2	8-10 m					1.02				1																									2.02	93	619.38	3.26
81	21	20/5/92	2	10-12 m					1.02				1																									2.02	96	639.36	3.16
82	21	20/5/92	2	10-12 m					1.02																													1.02	129	859.14	1.19
101	24	9/6/92	2	2-10 m (L)							5	5	13	21	36	27	26.4	12.4	8.34	7.75																		161.89	123	351.78	460.20
102	24	9/6/92	2	2-10 m (L)								2	1	10	11	8	8.8	6.2		1.55																		48.55	166	474.76	102.26
103	24	9/6/92	2	4-6 m					1.02			2	7	9	8	11	13.2	7.44	2.78	3.1																		64.54	147	420.42	153.51
104	24	9/6/92	2	4-6 m								1	1	5	5	2	2.2	1.24	1.39	1.55																		20.38	220	629.2	32.39
105	24	9/6/92	2	6-8 m									8	5	7	4	8.8	4.96	2.78	1.55																		42.09	193	551.98	76.25
106	24	9/6/92	2	6-8 m							1	11	16	32	29	33	33	18.6	8.34	6.2																		188.14	140	400.4	469.88
107	24	9/6/92	2	8-10 m							2	6	13	25	29	24	26.4	14.88	8.34	3.1																		151.72	229	654.94	231.65
108	24	9/6/92	2	8-10 m									6	11	19	10	9.9	8.68	9.73	4.65																		78.96	132	377.52	209.15
137	26	25/6/92	2	2-10 m (L)									1	2	6	9	7.7	6.2	16.68	9.3	8.55	1.88	2.06		2.42													72.79	240	686.4	106.05
138	26	25/6/92	2	2-10 m (L)									1	1	2	2	6.6	3.72	9.73	6.2	3.42	3.76																39.43	178	509.08	77.45
163	28	9/7/92	2	2-10 m (L)									1				1.1		2.78	1.55	10.26	3.76	10.3	4.48	2.42	2.62												40.27	222	634.92	63.43
164	28	9/7/92	2	2-10 m (L)											1	1	5.5	4.96	13.9	15.5	15.39	20.68	12.36	17.92	2.42	5.24	2.81											118.68	315	900.9	131.73
165	28	9/7/92	2	4-6 m													4.4	2.48	8.34	23.25	20.52	20.68	37.08	35.84	26.62	18.34	5.62											203.17	210	600.6	338.28
166	28	9/7/92	2	4-6 m													1.1	3.72	1.39	4.65	3.42	1.88	4.12	8.96	4.84	5.24	2.81											42.13	248	709.28	59.40
167	28	9/7/92	2	6-8 m										1		4	7.7	3.72	5.56	6.2	3.42	9.4	8.24	4.48	2.42	2.62	2.81											61.57	227	649.22	94.84
168	28	9/7/92	2	6-8 m												3	1.1	3.72	8.34	15.5	6.84	5.64	8.24	2.24	7.26	2.62												64.50	259	740.74	87.08
169	28	9/7/92	2	8-10 m													2.2	2.48	6.95	7.75	8.55	9.4	8.24	6.72	2.42	2.62												57.33	264	755.04	75.93
170	28	9/7/92	2	8-10 m												2	2.2	2.48	12.51	3.1	13.68	16.92	12.36	2.24	2.42	2.62												72.53	306	875.16	82.88
181	30	24/7/92	2	2-10 m (L)														1.24	1.39	3.1	5.13	13.16	22.66	8.96	12.1	7.86	5.62	9.03	3.22	3.43	3.65							100.55	241	689.26	145.88
182	30	24/7/92	2	2-10 m (L)															1.39	13.95	6.84	18.8	14.42	24.64	21.78	5.24	11.24	9.03	3.22									130.55	303	866.58	150.65
185	34	19/8/92	2	2-10 m (L)																	1.71		4.12		7.26		2.81	6.02			3.65							25.57	224	640.64	39.91
186	34	19/8/92	2	2-10 m (L)																			4.12			7.86	2.81	9.03	9.66	3.43		3.87					5.04	45.82	295	843.7	54.31
187	34	19/8/92	2	4-6 m																						5.24	2.81	6.02			7.3							21.37	198	566.28	37.74
188	34	19/8/92	2	6-8 m																			2.06	4.48	7.26	5.24	5.62	3.01	6.44									34.11	217	620.62	54.96
189	34	19/8/92	2	6-8 m																			4.12	13.44	4.84	18.34	14.05	18.06	6.44	6.86	3.65							89.80	249	712.14	126.10
190	34	19/8/92	2	8-10 m																1.55		1.88	2.06	2.24	4.84		8.43	6.02	12.88		7.3		8.18					55.38	269	769.34	71.98
191	34	19/8/92	2	8-10 m																	1.71	1.88	6.18	2.24	4.84		14.05		3.22	20.58	14.6	3.87	4.09					77.26	293	837.98	92.20
206	43	20/10/92	2	2-10 m (L)																								6.02	12.88	6.86	14.6	3.87	4.09	4.33	4.56		5.04	62.25	333	952.38	65.36
207	43	20/10/92	2	2-10 m (L)																						5.24	2.81	3.01	6.44	10.29	10.95	7.74	12.27		4.56	19.2		82.51	391	1118.26	73.78
4	12	17/3/92	3	6-8 m																																			62	412.92	
20	15	9/4/92	3	1 m(R)																																			152	1012.32	
21	15	9/4/92	3	1 m(R)						1																												1.00	60	399.6	2.50
22	15	9/4/92	3	2-10 m (L)			2.68																															2.68	84	559.44	4.79
23	15	9/4/92	3	2-10 m (L)																																			32	213.12	
24	15	9/4/92	3	2-4 m																																			92	612.72	
25	15	9/4/92	3	4-6 m																																			89	592.74	
26	15	9/4/92	3	4-6 m																																			66	439.56	
27	15	9/4/92	3	6-8 m																																			64	426.24	
28	15	9/4/92	3	8-10 m																																			34	226.44	
29	15	9/4/92	3	10-12 m																																			108	719.28	
42	17	23/4/92	3	1 m (R)																																			23	153.18	
43	17	23/4/92	3	1 m (R)																																			49	326.34	
44	17	23/4/92	3	1 m (R)																																			20	133.2	
47	17	23/4/92	3	2-10 m (L)							1																											1.00	65	432.9	2.31
48	17	23/4/92	3	2-10 m (L)																																			54	359.64	
49	17	23/4/92	3	4-6 m																																			38	253.08	
50	17	23/4/92	3	6-8 m						1																												1.00	38	253.08	3.95
56	21	19/5/92	3	2-10 m (L)																																			26	173.16	
57	21	19/5/92	3	2-10 m (L)							1		1		1																							3.00	55	366.3	8.19
58	21	19/5/92	3	2-4 m				1.04	1.02			1	1	1																								5.06	94	626.04	8.08
59	21	19/5/92	3	2-4 m				1.04			1	1																										3.04	84	559.44	5.43
60	21	19/5/92	3	4-6 m					2.04	1		1																										4.04	86	572.76	7.05
61	21	19/5/92	3	4-6 m				1.04																														1.04	53	352.98	2.95
62	21	19/5/92	3	6-8 m																																			66	439.56	

TREK No.	WEEK	DATE	STATION	DEPTH	LENGTHCLASS (0.5cm)																																	Catch	Distance	Surface	Density
					O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		(Counts)	area (m2)	(n.m-2)
63	21	19/5/92	3	6-8 m																																			74	492.84	
64	21	19/5/92	3	8-10 m					1.02																													1.02	98	652.68	1.56
65	21	19/5/92	3	8-10 m																																			54	359.64	
109	24	12/6/92	3	2-10 m (L)																3.1																		3.10	130	371.8	8.34
110	24	12/6/92	3	2-10 m (L)								1	1	3	5	6	3.3	11.16	4.17	1.55																		36.18	114	326.04	110.97
111	24	12/6/92	3	2-4 m								5	13	80	127	149	169.4	106.6	97.3	29.45	6.84																	783.63	238	680.68	1446.54
112	24	12/6/92	3	2-4 m							1	1	19	50	55	65	70.4	49.6	36.14	23.25	3.42																	373.81	136	388.96	1012.47
113	24	12/6/92	3	4-6 m								1	8	39	45	65	44	38.44	29.19	12.4	3.42	1.88																287.33	235	672.1	430.49
114	24	12/6/92	3	4-6 m									4	15	16	22	30.8	28.52	25.02	1.55		1.88																144.77	250	715	202.48
115	24	12/6/92	3	6-8 m									7	1	11	12	20.9	9.92	6.95	4.65																		73.42	233	666.38	129.69
116	24	12/6/92	3	6-8 m						1	1		5	9	7	9	7.7	8.68	8.34	3.1																		59.82	164	469.04	127.54
117	24	12/6/92	3	8-10 m											4	1	2.2	1.24																				8.44	110	314.6	26.83
118	24	12/6/92	3	8-10 m									1	3	4	5	5.5	4.96	2.78	1.55	1.71																	29.50	215	614.9	47.98
139	26	25/6/92	3	2-10 m (L)										1		2	9.9	11.16	16.68	26.35	15.39	7.52		2.24	2.42													94.66	143	408.98	231.45
140	26	25/6/92	3	2-10 m (L)									1	1	1	7	16.5	32.24	30.58	37.2	29.07	18.8	6.18	4.48														185.05	144	411.84	449.32
141	26	25/6/92	3	2-4 m										2	3	12	3.3	13.64	8.34	3.1	6.84	3.76																55.98	246	703.56	79.57
142	26	25/6/92	3	2-4 m											1	6	1.1	1.24	2.78	1.55	3.42	3.76	2.06															22.91	223	637.78	35.92
143	26	25/6/92	3	4-6 m										4	8	12	11	18.6	15.29	13.95	13.68	3.76	2.06															102.34	213	609.18	168.00
144	26	25/6/92	3	4-6 m										3	8	8	18.7	13.64	22.24	17.05	1.71	9.4	2.06	4.48														108.28	255	729.3	148.47
145	26	25/6/92	3	6-8 m										1	3	15	27.5	44.64	54.21	77.5	71.82	58.28	20.6		2.42													375.97	275	786.5	478.03
146	26	25/6/92	3	6-8 m											1	7	6.6	17.36	16.68	13.95	20.52	9.4	6.18	2.24														100.93	219	626.34	161.14
147	26	25/6/92	3	8-10 m									1	1	12	14	15.4	35.96	26.41	21.7	8.55	5.64	6.18	2.24														150.08	251	717.86	209.07
148	26	25/6/92	3	8-10 m									1	2	4	9	7.7	7.44	11.12	17.05	11.97	9.4	4.12	2.24														87.04	205	586.3	148.46
151	28	8/7/92	3	1 m (R)													2.2	2.48	2.78																			7.46	42	120.12	62.10
152	28	8/7/92	3	1 m (R)														1.24			1.71	1.88	2.06			5.24												12.13	27	77.22	157.08
153	28	8/7/92	3	2-10 m (L)											1	6	6.6	6.2	8.34	6.2	8.55	7.52	8.24		2.42													61.07	210	600.6	101.68
154	28	8/7/92	3	2-10 m (L)										1	1	4	5.5	6.2	6.95	6.2	5.13	13.16	2.06		2.42	7.86												61.48	227	649.22	94.70
155	28	8/7/92	3	2-4 m								1			2	7	19.8	24.8	33.36	27.9	18.81	11.28	6.18	4.48	2.42		2.81											161.84	251	717.86	225.45
156	28	8/7/92	3	2-4 m											3	5	12.1	32.24	18.07	17.05	11.97	3.76	2.06	4.48	2.42													112.15	170	486.2	230.67
157	28	8/7/92	3	4-6 m									1		3	4	13.2	8.68	30.58	12.4	11.97	20.68	6.18	2.24	4.84													118.77	207	592.02	200.62
158	28	8/7/92	3	4-6 m											1	3	8.8	13.64	25.02	24.8	20.52	24.44	26.78	11.2	12.1	2.62												173.92	194	554.84	313.46
159	28	8/7/92	3	6-8 m								1			1	3	4.4	26.04	34.75	40.3	58.14	56.4	32.96	15.68	7.26	2.62												283.55	271	775.06	365.84
160	28	8/7/92	3	6-8 m											1	2	12.1	18.6	30.58	40.3	63.27	47	39.14	20.16	12.1	2.62	5.62											294.49	165	471.9	624.05
161	28	8/7/92	3	8-10 m																																			179	511.94	
162	28	8/7/92	3	8-10 m																		1.88																1.88	122	348.92	5.39
171	30	22/7/92	3	2-10 m (L)														4.96		4.65	3.42	5.64		11.2	2.42			3.01										35.30	126	360.36	97.96
172	30	22/7/92	3	2-10 m (L)															6.95	6.2	1.71	9.4	8.24	6.72	7.26	2.62	2.81	6.02										57.93	173	494.78	117.08
173	30	22/7/92	3	4-6 m													2.2	6.2	13.9	15.5	29.07	9.4	8.24	17.92	2.42													104.85	284	812.24	129.09
174	30	22/7/92	3	4-6 m													1.1		5.56	12.4	5.13	1.88	2.06															28.13	225	643.5	43.71
175	30	22/7/92	3	6-8 m														1.24	6.95	17.05	6.84	7.52	8.24	4.48			2.81											55.13	252	720.72	76.49
176	30	22/7/92	3	6-8 m																		3.76				5.24												9.00	182	520.52	17.29
177	30	22/7/92	3	8-10 m															2.78	1.55	6.84	16.92	20.6	20.16	19.36	23.58	11.24	18.06	12.88	3.43	7.3							164.70	250	715	230.35
178	30	22/7/92	3	8-10 m														1.24	2.78	1.55	8.55	9.4	12.36	29.12	16.94	15.72	5.62	12.04										115.32	242	692.12	166.62
194	34	20/8/92	3	2-10 m (L)																				2.24			8.43	9.03	6.44	6.86		3.87	4.09					40.96	110	314.6	130.20
195	34	20/8/92	3	2-10 m (L)																					2.42	5.24	5.62	3.01		3.43	3.65		8.18	4.33				35.88	87	248.82	144.20
196	34	20/8/92	3	4-6 m																			4.12	6.72	4.84	2.62	5.62	6.02	9.66	3.43		3.87	4.09					50.99	289	826.54	61.69
197	34	20/8/92	3	4-6 m															1.39					6.72	4.84	13.1	11.24	15.05	12.88	3.43								68.65	290	829.4	82.77
198	34	20/8/92	3	6-8 m																			2.06	2.24	2.42	7.86	2.81	6.02	19.32	10.29	3.65	3.87	4.09					64.63	243	694.98	93.00
199	34	20/8/92	3	6-8 m																			2.06			10.48	16.86	18.06	28.98	6.86	7.3	3.87			4.56			99.03	269	769.34	128.72
200	34	20/8/92	3	8-10 m																		1.88			9.68	10.48	22.48	30.1	38.64	41.16	62.05	30.96	20.45	17.32	13.68	4.8		303.68	271	775.06	391.81
201	34	20/8/92	3	8-10 m																					2.42	5.24	8.43	27.09	25.76	20.58	10.95	15.48	8.18	4.33		4.8		133.26	293	837.98	159.03
5	12	17/3/92	4	6-8 m																																			44	293.04	
6	12	17/3/92	4	6-8 m																																			125	832.5	
45	17	23/4/92	4	1 m (R)																																			33	219.78	
46	17	23/4/92	4	1 m (R)							1																											1.00	52	346.32	2.89
51	17	23/4/92	4	2-10 m (L)																																			78	519.48	
52	17	23/4/92	4	2-10 m (L)																																			127	845.82	
53	17	23/4/92	4	4-6 m							1																											1.00	111	739.26	1.35
54	17	23/4/92	4	6-8 m																																			97	646.02	
66	21	19/5/92	4	2-10 m (L)																																			142	945.72	
67	21	19/5/92	4	2-10 m (L)																																			97	646.02	
68	21	19/5/92	4	2-4 m																																			60	399.6	

TREK No.	WEEK	DATE	STATION	DEPTH	LENGTHCLASS (0.5cm)																																	Catch	Distance	Surface	Density
					O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		(Counts)	area (m2)	(n.m-2)
69	21	19/5/92	4	2-4 m							1																											1.00	66	439.56	2.28
70	21	19/5/92	4	4-6 m																																			62	412.92	
71	21	19/5/92	4	4-6 m					1.02			1		1																								3.02	66	439.56	6.87
72	21	19/5/92	4	6-8 m									1																									1.00	81	539.46	1.85
73	21	19/5/92	4	6-8 m					2.04																													2.04	51	339.66	6.01
74	21	19/5/92	4	8-10 m					2.04																													2.04	103	685.98	2.97
119	25	15/6/92	4	1 m (R)							1	3	6	17	47	67	49.5	75.64	72.28	54.25	25.65	9.4	4.12															431.84	38	108.68	3935.59
120	25	15/6/92	4	1 m (R)									3	8	8	8	4.4	11.16	8.34	4.65	5.13																	60.68	60	171.6	353.61
121	25	15/6/92	4	1 m (R)								3	2	5	9	9	16.5	16.12	9.73	4.65	1.71																	76.71	77	220.22	348.33
122	25	15/6/92	4	1 m (R)									1		1	1	3.3	2.48	1.39	1.55	1.71																	13.43	106	303.16	44.30
123	25	15/6/92	4	2-4 m										3	5	8	5.5	4.96	13.9	26.35	18.81	5.64	6.18															97.34	289	826.54	117.77
124	25	15/6/92	4	2-4 m										2	6	12	15.4	33.48	26.41	20.15	10.26	3.76		2.24														131.70	237	677.82	194.30
125	25	15/6/92	4	4-6 m														1.24	8.34	10.85	20.52	11.28	2.06															54.29	255	729.3	74.44
126	25	15/6/92	4	4-6 m														1.24	6.95	20.15	13.68	1.88																43.90	237	677.82	64.77
127	25	15/6/92	4	6-8 m												1	1.1	1.24	1.39	3.1																		7.83	63	180.18	43.46
128	25	15/6/92	4	6-8 m													2.2	3.72																				5.92	184	526.24	11.25
129	25	15/6/92	4	8-10 m											1	1	4.4	4.96	5.56	6.2	3.42																	26.54	180	514.8	51.55
183	30	24/7/92	4	2-10 m (L)															4.17	10.85	13.68	11.28	41.2	33.6	16.94	23.58	14.05	18.06	6.44	10.29	3.65							207.79	321	918.06	226.34
184	30	24/7/92	4	2-10 m (L)															4.17	6.2	11.97	35.72	26.78	33.6	41.14	18.34	42.15	12.04	9.66	3.43	3.65	3.87						252.72	283	809.38	312.24
202	34	20/8/92	4	2-10 m (L)																							5.62	3.01	3.22			3.87				4.8		20.52	270	772.2	26.57
203	34	20/8/92	4	2-10 m (L)																					2.42	5.24	2.81	3.01	3.22	17.15								33.85	353	1009.58	33.53

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