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ASTERIAS RUBENS AND THE INFLUENCE OF THE BEAMTRAWL-FISHERY OF THE BOTTOMFAUNA.

by

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Introduction

Indications on differences in percentages of regenerating arms of Asterias rubens between animals from the North Sea and those caught in the Dutch Waddensea and the Zeeland estuary, did suggest that these differences might be correlated with different types of fisheries being practised in the two areas. In contrast with the North Sea hardly any beamtrawlfishing for soles takes place in the estuarine waters, where only a limited amount of shrimp-trawling is carried out.

From the literature it is known that Asterias rubens, like most Echinodermata, once the animal has lost one or more arms, by evisceration following an injury most of the times will regenerate as many arms as it has lost.
Miss Helen Dean King (1898 and 1900) did some observations and experiments on the regeneration in Asterias vulgaris and found that even a disc which has lost all arms, will regenerate all of the missing arms. Single arms, however, can live for a week or two only but are not able to regenerate the rest of the animal.
Thus autotomy and regeneration will not lead to an increase in the Asterias population.

In the case that the injuries of the starfishes are mainly caused by the fishery, differences in the percentage of regenerating animals can possibly give an indication of the magnitude of the influence of the fishery on the bottomfauna. The purpose of this paper is to study this possibility.

Methods

Since 1971 Asterias rubens has been counted and collected during cruises of the various researchships of our Institute. In addition a number of samples were collected from commercial beamtrawlers.

The samples have been worked out separately for the following areas: North Sea (south and central), the Dutch Waddensea, the Zeeland estuary, the Irish Sea and the Bristol Channel (Smalls). The Asterias of each sample have been analysed in four groups: A - those without any injury and with normal arms, B - those with regenerating arms, D - the broken ones either very recently injured or injured in the net of the researchship, C - the number of single arms.

The average of the percentages B and D for each journey are shown in the tables 1 and 2 in which data on type of gear and number of tickler chains used are given.
In order to proof that the loss of one or more arms means an injury caused by the fishery, the number of starfishes with one, two, three or four arms regenerating resp. missing have been counted separately also.

Measurements refer to the distance between the tip of the arm and the point where the arm starts growing out of the disc.

In the laboratory some experiments were carried out on the growth rate of Asterias rubens in order to be able to interprete differences in length frequencies found in nature. The specimens were kept in small tanks supplied with running seawater. They were of different original length and were fed throughout with mussels.

Results

I - length-frequency diagrams.

When comparing the length frequency diagrams of the regenerating arms of starfishes from the North Sea with those from the Irish Sea (figs. 1 and 2) it is obvious, that for the North Sea the frequencies are very much the same throughout the year, while the Irish Sea records show a striking difference for the category with the shortest regenerating arms in the two seasons. The difference can be understood by bearing in mind that the Dutch beamtrawlfishery in the Irish Sea has a seasonal character viz. from March to august. The damage to Asterias by the fishery with beamtrawls can only be inflicted in this period. When the Dutch fishermen come back in next March the regenerating arms of the starfishes have had the opportunity to grow for half a year. Only regenerating arms of the longer length groups are therefore found in the March samples (fig. 2).

The beamtrawl fishery in the North Sea, however, is carried out all over the year and there is no appreciable seasonal difference in the frequency diagrams during the year indeed.

When a regenerating arm has attained a length comparable to that of a normal arm it is difficult to distinguish it from a normal arm and the starfish will be called normal. For this reason a number of Asterias with nearly full-sized regenerating arms will be overlooked and thus are missing in our graphs. Owing to this the frequencies in the right hand side of the graphs are too low and decreasing in values.

II - percentage of regenerating (B) and injured Asterias (D) in the samples.

Evidence of the different percentages B and D following the typical kinds of fisheries in the four areas is given in table 1.

When comparing the North Sea values with those from the estuarine waters, it turns out that in the former area the percentages are much higher than in the latter, especially in the case of the sole beamtrawl with ticklerchains used by RV "Tridens" (see perc. D).

The engine power of the research ships is different, "Tridens" having an engine of 1600 BHP, "Beukelsz" 300 BHP, "Waddenzee" and "Schollevaar" each 150 BHP.

When comparing the percentages of D for the shrimpbeamtrawl for the four ships it is clear that there is a distinct relationship between percentage injured Asterias (D) and engine power of the ship.

For the Irish Sea the seasonal fishery results in a bigger amount of regenerating starfishes in August than at the beginning of the fishing season in March. At the Smalls there is little fishing activity with beamtrawls. Few regenerating starfishes but a very high percentage of broken ones pictures the situation there.

According to the Wilcoxon signed ranks test the percentage B is significantly different for the sole and the shrimp beamtrawl for two of the four samples collected by the "Tridens" in the North Sea (table I).
In the case of percentage D the four samples of the "Tridens" in the North Sea are all significantly different regarding the records of the sole and the shrimp beamtrawl, in which data for the two nets for the same positions were compared. The dependence of the percentage B and D on the number of tickler chains used in beamtrawling is given in table 2. In July 1972 "Tridens" fished on one ground with the sole beamtrawl in which the number of chains were randomly altered during the experiments. Remarkable is that Asterias caught in the hauls with no chains yielded a much lower percentage of animals with regenerating arms than in the hauls with chains and that the highest number of chains also showed the highest percentage of Asterias with regenerating arms. With increasing number of chains the net reaches deeper layers in the substrate and the results suggest that Asterias with regenerating arms tend to select deeper sites in the bottom e.g. minor depressions.

The relationship of the percentages B and D with the length of the normal arms of Asterias with regenerating arms is shown in figure 3. The two curves, fitted by eye through the points, decline in the same way which is in favour with the assumption that the phenomenon of regenerating arms is mainly caused by former capture in the commercial fishery. The higher percentage of B in the Irish Sea samples compared with the Smalls also points to the explanation that most of the injuries leading to regenerating arms are due to the fishery.

III - the chance of catching a regenerating (p_B) and a injured Asterias (p_D).

Assuming that the chance of losing a second, third or fourth arm is the same as for the first arm we can calculate the average chance to find an Asterias with one or more regenerating arms and an injured Asterias missing one or more arms by counting the number of Asterias with normal arms and with one of more arms regenerating resp. missing. The chance p is then derived from the term $p + p^2 + p^3 + p^4$.

North Sea	Tridens	shrimpbeamtrawl	$p_B = 0.29$	$p_D = 0.26$	Oct. '72
North Sea	Tridens	solebeamtrawl	0.27	0.33	Oct. '72
North Sea	all ships	solebeamtrawl	0.26	0.37	year '72
Waddensea	all ships	shrimpbeamtrawl	0.19	0.19	year '72
Irish Sea	Tridens	solebeamtrawl	0.41	0.25	year '72

The chance of catching a regenerating or an injured Asterias is less for the estuarine waters than for the North Sea and the Irish Sea. Moreover the higher value of p_D for the solebeamtrawl in comparison with the one for the shrimp-beamtrawl is in agreement with the idea that the former, having a number of tickler chains which the shrimpbeamtrawl does not have, inflicts more damage to the starfishes than the latter.

IV - Correlation between the relative number of regenerating Asterias and the fishing intensity at a particular place.

In order to find out whether in practise the information on regenerating Asterias can be used to form an idea about the fishing intensity comparisons must be made between these quantities on a scale as detailed as possible. Unfortunately the data on fishing intensity are given in statistical rectangles. Moreover the incidence of regenerating arms may be a result of cumulative fishing intensity. Thus when comparing statistical rectangle data for one or more months with the restricted number of data on relative incidence of regenerating Asterias we should not expect a high correlation.

The correlation coefficients of the percentage regenerating Asterias (B) and the number of hours fishing by Dutch beamtrawlers per statistical rectangle for 1971 is:

second quarter $r = 0.045$ $(n = 15)$ third quarter $r = 0.0055$ $(n = 17)$

The restriction to only Dutch data has little effect on the above correlations because the Dutch fishermen catch more than 80% of the soles in the areas concerned. The apparent non-existing correlation can be understood by bearing in mind that the number of records is small and restricted to a small part of the North Sea.

V - Factors influencing the growth rate of Asterias rubens.

In the case of a seasonal fishery, as for instance in the Irish Sea, it should in theory be possible to back-calculate the time when the starfish was injured, with regenerating as a result, from the length of the regenerating arms, provided the growth rate of normal and regenerating arms is known for the region.

The experiments at the laboratory, however, show a direct dependence of the growth rate on the foodsupply. Previous investigators found a density dependent growth, which also was governed by temperature and food (Bull, 1934; Hancock, 1958; Orton and Fraser, 1930; Smith, 1940). Vevers (1949) kept starfishes in tanks and his data show that growth is fastest in summer. In figure 4 the increment of length, measured at intervals, of the Vevers experiments is shown graphically.

Since the growth of Asterias is dependent on a number of factors it is not possible at the moment to make an reliable back-calculation of the moment of injury to Asterias and therefore it is still uncertain on how many months of fishing-intensity a given situation of regenerating Asterias is based.

Conclusions

The results obtained thus far are in agreement with the idea that fishery and especially beamtrawlfishery is mainly responsible for the injury to starfishes resulting in the phenomenon of regenerating arms.

Significant differences have been found for the injury effect of shrimp-beamtrawls using no chains and solebeamtrawls using a number of chains.

Applying the percentage of Asterias with regenerating arms as an index of the local fishing intensity, however, turns out to be not reliable at the moment owing to the fact that too many other factors such as temperature, condition of the substrate will cloud the relationship.

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ds

Table 1. Percentage of Asterias with regenerating arms (B) and injured during the haul of the research ship (D).

Area	time	ship	gear	B (%)	D (%)
North Sea	9-19 Aug. '71	Tridens	solebeamtrawl	11.94	21.08
North Sea	Sept.-Oct. '71	Tridens	solebeamtrawl	12.91	16.61
North Sea	April '72	Tridens	solebeamtrawl	11.27	10.72
North Sea	Oct. '72	Tridens	solebeamtrawl	16.26	16.32
North Sea	Sept. '72	commercial ships	solebeamtrawl	16.06	13.24
North Sea	9-19 Aug. '71	Tridens	shrimpbeamtrawl	9.64	12.01
North Sea	Sept. -Oct. '71	Tridens	shrimpbeamtrawl	10.86	5.41
North Sea	April '72	Tridens	shrimpbeamtrawl	8.53	2.36
North Sea	Oct. '72	Tridens	shrimpbeamtrawl	8.21	9.34
North Sea	Sept.-Oct. '71	Beukelsz	shrimpbeamtrawl	6.68	1.93
North Sea	April '72	Beukelsz	shrimpbeamtrawl	4.88	1.71
North Sea	Oct. '72	Beukelsz	shrimpbeamtrawl	11.33	4.27
Estuaries	Sept.-Oct.'71	Schollevaar	shrimpbeamtrawl	6.13	0.37
Estuaries	April '72	Waddenzee	shrimpbeamtrawl	3.02	0.56
Estuaries	Oct. '72	Schollevaar	shrimpbeamtrawl	5.28	0.00
Irish Sea	March '72	Tridens	solebeamtrawl	19.53	11.15
Irish Sea	Aug. '72	Tridens	solebeamtrawl	24.87	15.93
Smalls	March '72	Tridens	solebeamtrawl	3.76	13.52
Smalls	Aug. '72	Tridens	solebeamtrawl	9.43	27.95

Table 2. Effect on percentages B and D of the number of tickler chains used with the solebeamtrawl.

Area	time	ship	number of chains	B (%)	D (%)
North Sea	July '72	Tridens	0	13.74	10.44
North Sea	July '72	Tridens	4	22.22	11.11
North Sea	July '72	Tridens	8	26.05	7.30
Irish Sea	March '72	Tridens	5	19.53	11.15
Irish Sea	August '72	Tridens	5	24.87	15.93
Smalls	March '72	Tridens	5	3.76	13.52
Smalls	August '72	Tridens	5	0.43	27.95

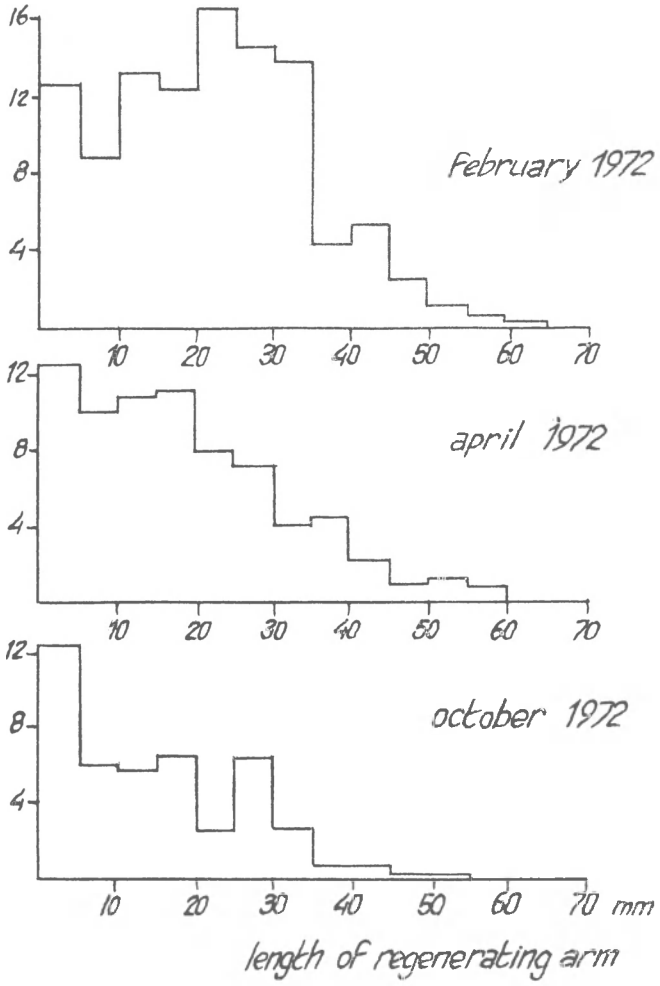

Fig. 1. length frequency distribution of regenerating arms of Asterias rubens

North Sea

Fig. 2. ditto

Irish Sea

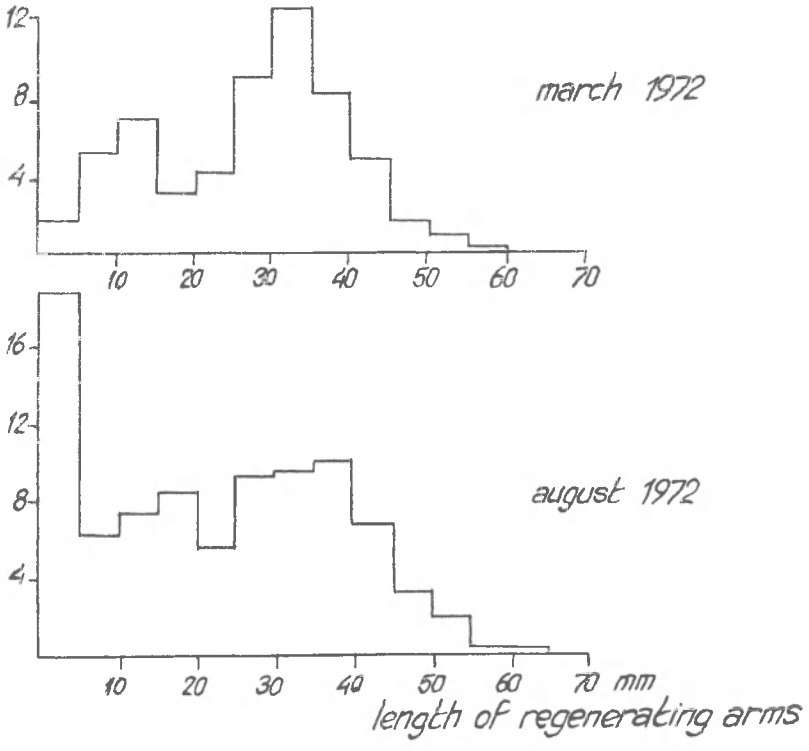

Fig. 3. relationship between percentage Asterias with regenerating arms (B), percentage injured Asterias (D) and length of the normal arms of these animals

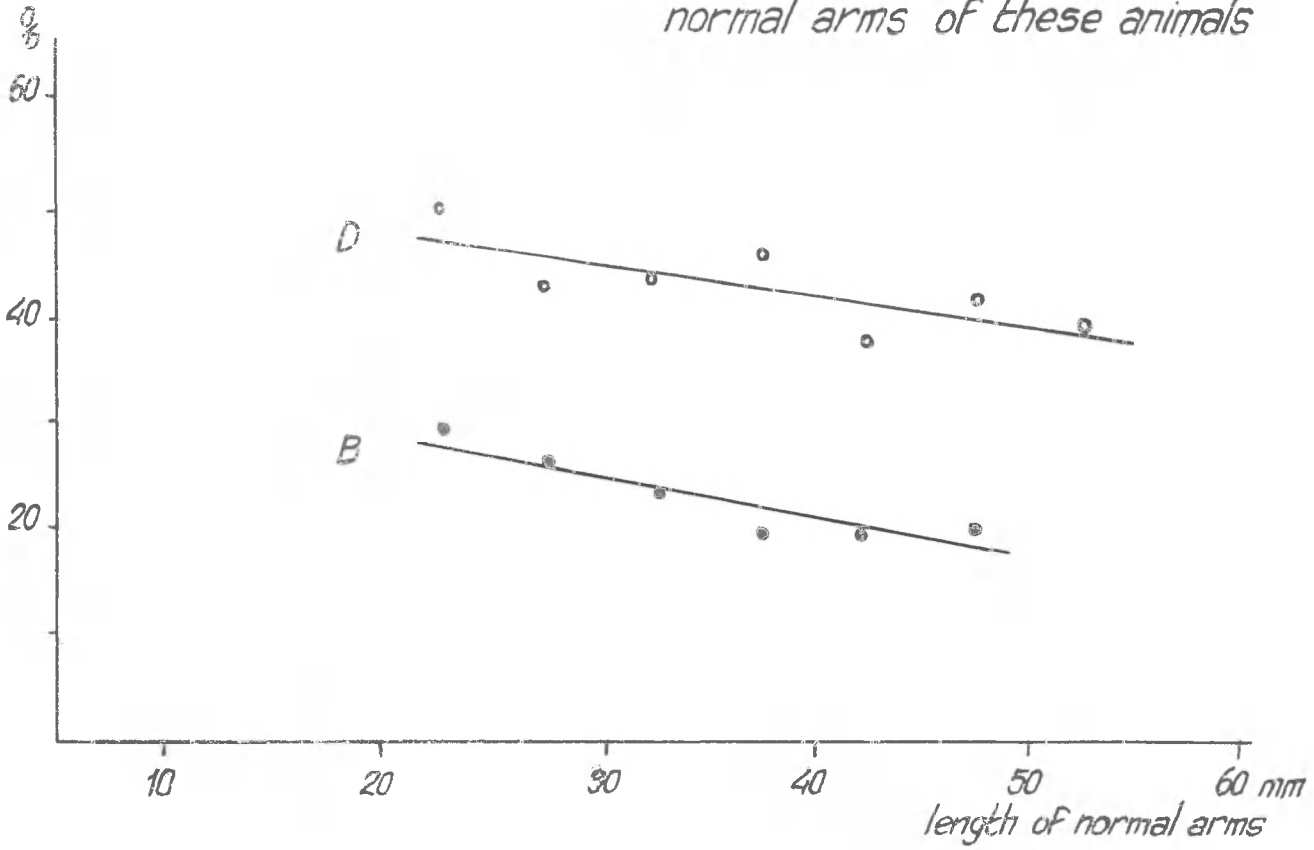

Fig. 4. monthly increments in the length of the normal arms of Asterias rubens (Vevers, 1949)