ICES J. mar. Sci., 49: 5–11. 1992

Direct effects of beamtrawling on macrofauna in a sandy sediment in the southern North Sea

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Bergman, M. J. N., and Hup, M. 1992. Direct effects of beamtrawling on macrofauna in a sandy sediment in the southern North Sea. – ICES J. mar. Sci., 49: 5–11.

The presence of certain species of benthic infauna in catches from a beamtrawl indicated that tickler chains and the ground chain can scrape off successive layers of sediment and reach at least 6 cm into the sediment. Direct effects of beamtrawling on benthic species in the North Sea were determined by comparing faunal abundance before and after commercial beamtrawling on a hard-sandy sediment. In autumn 1989 three-fold trawling of the experimental area resulted in a decrease in density (10–65%) of a number of species of echinoderms, polychaetes and molluscs.

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Introduction

In the North Sea during the last 20 years not only have the numbers and sizes of vessels engaged in beamtrawling increased considerably but also the size, weight and towing speed of the fishing gear used (ICES, 1988). Rauck (1985) and Welleman (1989) calculated that in certain areas with high trawl intensity, on average each part has been fished three to five times (in 1975) to seven times (in 1982) a year.

The effects of bottomtrawls, both ottertrawls and beamtrawls, on the benthos were studied frequently in the 1970s, when gears were still relatively light and the trawl speed was much lower than at present. According to research carried out in the period 1955–1975, the depth of penetration of the beamtrawl shoes varied with bottom type from 1.5 cm on hard sediments to 8–10 cm on soft sediments (Margetts and Bridger, 1971). Observations on the penetration of tickler chains into the seabed, using a light beamtrawl of 700 kg with 15 tickler chains, revealed that the disturbance was restricted to the upper 1 (sandy) to 3 (muddy-silty) cm of the sediments (Bridger, 1972).

The mere passage of a light beamtrawl at a speed of about 4–7 km h^{-1}, with each tickler chain scraping a few millimetres off the sediment surface, may cause damage to both epifauna and infauna. Beamtrawls rigged out with more or heavier tickler chains will catch more infaunal organisms (Graham, 1955; Bridger, 1970; de Groot, 1984; Creutzberg *et al.*, 1987). Once caught in the net, benthic organisms may be damaged or killed by the mass of debris and other fauna in the net (Houghton *et al.*, 1971) or during their escape through the meshes of the net. Further damage may occur during sorting on board the trawler, before the animals are returned to the sea. Evidence is available of serious effects of beamtrawling on coelenterates (*Tubularia*), annelid worms (*Lagis*), molluscs (*Ensis*, *Solen*), echinoderms (*Echinocardium*, brittle stars) and crustaceans (*Corystes*, *Macropipus*, *Hya*) (Graham, 1955; Bridger, 1970; Margetts & Bridger, 1971; de Groot, 1973). Conclusions on the effects of bottomtrawls on bottom fauna have been summarized by de Groot (1973, 1984), ICES (1988), Welleman (1989), Rees and Eleftheriou (1989) and Witbaard (1989).

In order to gain more information on the depth of penetration of modern, heavy, high-speed beamtrawls and their possible effects on the benthic system, some trawling experiments were carried out in a well-defined area with hard-sandy sediments in the southern North Sea. Sampling of benthic fauna was carried out before and after experimental fishing with a commercial beamtrawler had taken place. Differences in densities of benthic animals before and after trawling gave information on the direct effects of modern beamtrawling on benthic fauna.

Materials and methods

Area of investigation

The direct effects of beamtrawling on the bottom fauna in the North Sea was studied in August 1989 in an area (3.6×3.6 km^2) with fine to medium hard-sandy, well-packed sediments situated 45 km north of Ameland (centre position 53°51′45″N and 05°49′00″E; ICES quadrant 36F5). Water depth was about 30 m; water temperature was 19°C; temperature in the bottom sediment was 18°C. The intensity of beamtrawling (based on fishing hours per 100 square nautical miles without correction for engine power) in ICES quadrant 36F5 may be described as representative for the mean intensity on the Dutch continental shelf (data 1981–1982 in Welleman, 1989). A relatively

1054–3139/92/010005+07 $03.00/0

Table 1. Characteristics of the commercial Dutch beamtrawler equipped for the fishery on sole north of 53°N (van der Hak and Blom, 1990).

BEAMER	
length	40 m
engine	2100 Hp
towing speed	11 km h^{-1}
GEAR	
width	12 m
weight	7000 kg
towing force	9000 kg
	Diameter:
groundrope chain	22 mm
roller	250 mm
tickler chains	5 × 22 mm
	3 × 18 mm
net-tickler chains	3 × 20 mm
	8 × 14 mm
mesh size cod-end	9 cm

small quadrant (200 × 200 m^2) was chosen in the centre of the area of investigation to determine the direct effects of heavy beamtrawling on the benthos. During the experiments all positions were verified with high accuracy navigational equipment (Hyperfix) (Sydow, 1990).

Trawling

After initial sampling of the bottom fauna (t_0 sampling) in the quadrant, a commercial beamtrawler (2100 Hp, fishing speed 11 km h^{-1}) using conventional gears (Table 1) trawled over the quadrant in a series of parallel hauls. Continuous parallel hauls were made with a run-up and braking distance of ca. 2 km outside the quadrant. About 8 h after the first series of hauls the coverage of the quadrant was checked with side-scan sonar. After trawling the benthos was sampled again (t_1 sampling). To be sure of a complete coverage of the quadrant with trawl tracks, immediately after this sampling, trawling over the quadrant was repeated twice, each series of parallel hauls perpendicular to the preceding one. Coverage of the quadrant with trawl tracks was checked again with side-scan sonar after 16 h and the benthos was sampled again (t_2 sampling).

Penetration of the trawl into the sediment

The penetration depth of the commercial trawl was assessed in an indirect way by means of the catches of "indicator" organisms such as the heart urchin *Echinocardium cordatum* and the bivalve *Arctica islandica* in the first series of hauls. However, this possibility was not realized until the t_2 sampling had been finished. Therefore the length-dependent depth preference of *Echinocardium* could not be determined until the t_3 sampling started. The boxcore samples were collected along extended diagonals of the experimental quadrant, just outside this quadrant, in sediments not disturbed by foregoing experimental trawling. The vertical distribution of the animals in the sediment was established by opening one side of the box-cores, scraping off the sediment in the box layer by layer and measuring both the distance of the sediment surface to the lower side of *Echinocardium* and their size (see Fig. 1).

Sampling of bottom fauna

The macrobenthic fauna in the quadrant (200 m × 200 m) was sampled before and after each trawling series by 24 bottom grabs with a 0.071 m^2 Reineck boxcorer. Samples were sieved over 1 mm mesh size and preserved in 8% neutralized formalin in seawater solution stained with rose Bengal. Macrobenthic fauna was sorted and identified in the laboratory within 3 months of sampling. Benthic fauna was sampled four times:

(1) t_0 sampling: before trawling started.
(2) t_1 sampling: next day, about 8 h after the trawler had fished the quadrant once.
(3) t_2 sampling: next day, about 16 h after the trawler had fished the quadrant for the second and third times.
(4) t_3 sampling: 2 weeks after the t_2 sampling.

It was assumed that animals which had been touched by the tickler chains or had escaped through the meshes of the trawl would have died or had sufficient opportunity to recover within 2 weeks after the t_2 sampling. Recolonization during the 2 weeks was assumed to be negligible because an extensive area (approximately 7 km^2) had been trawled around the experimental quadrant as well, because of the run-up and braking distance of ca. 2 km outside the quadrant. Only the t_0 and t_3 samples have been completely analysed. In the t_1 and t_2 samples only the heart urchin *Echinocardium cordatum* was counted.

Larger and less abundant epibenthic macrofauna was sampled with a 2.80-m beamtrawl rigged without tickler chains and a ground chain wound around by a rope (mesh size 2 cm, cod-end 1 cm) by the four hauls of 300 m length around the small quadrant. Due to weather conditions fishing for macrobenthic epifauna was not possible during t_2 sampling. During the t_3 sampling epifauna was not collected because emigration and immigration of fast moving animals may have taken place within the 2-week gap.

Results

Penetration of the trawl into the sediment

Large individuals of *Echinocardium cordatum* were found in the commercial 12-m trawl (Bergman *et al.*, 1990). The size-dependent vertical distribution of this species in the sediment is shown in Figure 1. Small individuals (0.5–1.0 cm) were mainly found at a depth of 2–4 cm, while

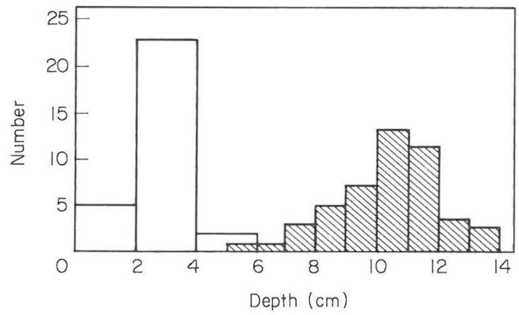

Figure 1. Length-dependent depth preference of *Echinocardium cordatum* just outside the quadrant. Depth is the distance of the sediment surface to the lower side of *Echinocardium*. □ = mean length 0.8 ± 0.1 cm (n = 30). ▧ = mean length 4.3 ± 0.3 cm (n = 46).

large individuals (3.6–4.8 cm) were mainly found at 10–12 cm. Even when the trawl only caught *Echinocardium* living in the upper layers of their depth distribution the tickler chains must have penetrated at least 6 cm into the sediment.

Individuals of *Artica islandica*, were also caught in the commercial trawlnet (Bergman *et al.*, 1990). To catch these large molluscs with a size of about 8 × 10 cm, which occur vertically in the upper 10 cm of the sediment, tickler chains must have penetrated at least 6 cm deep into the sediment.

Effects on densities of benthic fauna on the quadrant

The mean densities of macrobenthic fauna on the quadrant before the start of experimental beamtrawling are given in Table 2. Species composition is characteristic of the "Terschellinger Bank", a transition zone between the more sandy coastal area north of the Wadden Islands and the deeper muddier "Oyster Grounds". Typical species with a high abundance are *Montacuta ferrigunosa*, *Tellina fabula* and *Echinocardium cordatum*. Mean biomass is considerably higher than in the more southerly parts of the North Sea and comparable with the mean values on the Dogger Bank. Higher values of biomass are found in the frontal zone south of the "Oyster Grounds" (Duineveld, NIOZ, pers. comm.).

Based on a comparison of the t_0 and t_3 samplings, changes in densities of benthic fauna in consequence of the three-fold trawling followed by a stabilization period of 2 weeks are expressed as percentages of the densities before trawling (Table 3). In the case of *Asterias rubens* the effect of one single series of trawling is given, based on the comparison of the t_0 and t_1 samplings, carried out 16 hours after the trawler had fished the quadrant once. Differences were tested with the Mann–Whitney test. Low densities were observed in many species, so a number of species have been clustered. Changes in densities of species or groups of species were estimated only if more than 35 individuals were caught at the t_0 sampling.

Table 3 shows that the direct effect of a three-fold trawling was a significant lowering of the densities (40–60%) of the echinoderms *Asterias rubens* and *Echinocardium cordatum* (small individuals) as well as the tube-dwelling polychaete worms *Lanice conchilega* (especially the small individuals) and *Spiophanes bombyx*. An indication for a decrease in density (10–25%), although not significant, was also found for small crustaceans (Cumacea, Natantia and Amphipoda) and larger individuals of both *Tellina fabula* (> 4 mm) and *Echinocardium cordatum* (> 3.6 cm). Direct effects were not found on densities of *Ophiura* spec., molluscs (except *Tellina fabula*), and worms (except *Magelona papillicornis*, *Lanice conchilega* and *Spiophanes bombyx*). The densities of larger individuals of *Magelona papillicornis* were significantly increased after experimental trawling. Also, the densities of small individuals of *Magelona papillicornis* and small-sized *Tellina fabula* appear to have increased, although not significantly.

For *Echinocardium cordatum* the direct effects on densities after a single beamtrawling (t_1 sampling), a three-fold beamtrawling (t_2 sampling) and a three-fold beamtrawling followed by a stabilization period of 2 weeks (t_3 sampling) have been estimated separately (Table 4). The differences in mean densities of the small *Echinocardium cordatum* (mean length 0.8 cm) in the t_0, t_1 and t_2 samplings are not significant. The mean density in the t_3 sampling, however, is significantly lower than the density at t_0. The increasing standard deviation of the mean densities of small *Echinocardium cordatum* with an increasing number of trawl operations is interesting, because it points to a more and more heterogenous distribution during the successive trawlings.

Discussion

Penetration of the trawl into the sediment

The depth at which the shoes of the beamtrawl pass through the sediment may be different from the thickness of the sediment layer scraped off by the many tickler chains and passing through the net. In the present study tracks of the beamtrawl shoes were still detectable by side-scan sonar after 16 h, but their actual depth could not be established (Sydow, 1990).

The occurrence in the trawl catches of different species of animals living in the bottom may give an indication of the thickness of the sediment layer scraped off by the tickler chains of the trawl. In this respect *Arctica islandica* and the heart urchin *Echinocardium cordatum* are valuable "indicator" species. *Arctica*, a large bivalve with a size of about 8 × 10 cm, lives vertically in the upper 10 cm of the sediment. From their occurrence in the commercial trawl catches, also in the first series of hauls, it can be concluded that the tickler chains of the net must penetrate

Table 2. Mean densities (n m^{-2}) and size (cm) of macrobenthic fauna, sampled with Reineck boxcore (0.071 m^2) on the experimental quadrant at t_0.

	Numbers of samples	Size range (cm)	Mean density n m^{-2} ± s.d.
Crustaceans			
Total small, e.g.	10	0.3–0.7	309 ± 178
Cumacea			
Natantia			
Amphipoda			
Total large	24		5 ± 10
Corystes cassivelaunus	24	2.5	1 ± 3
Liocarcinus holsatus	24	4.0	1 ± 3
Liocarcinus spec. juv.	24	0.4–0.6	4 ± 9
Molluscs			
Total	24		214 ± 101
Tellina fabula small	24	0.2–0.4	20 ± 25
Tellina fabula large	24	0.4–1.8	130 ± 79
Rest, e.g.	24		62 ± 41
Mactra spec.	24	0.3–2.1	2 ± 4
Montecuta ferruginosa	24	0.2–0.6	29 ± 36
Thracia spec.	24	0.2–1.0	4 ± 9
Dosinia spec.	24	0.8	2 ± 4
Spisula subtruncata	24	0.3–0.9	1 ± 3
Venus striatula	24	0.2–2.5	8 ± 14
Ensis spec.	24	3.1–14.0	
Cultellus spec.	24	0.6–0.7	
Natica alderi	24	0.5–1.6	11 ± 15
Cyligna cylindracea	24	0.4–0.9	2 ± 4
Abra prismatica	24	0.5–0.7	2 ± 5
Mysella bidentata	24	0.2–0.3	2 ± 6
Echinoderms			
Total	24		244 ±
Asterias rubens	24	10.0–10.5	1 ± 4
**Asterias rubens*	4	6.0 ± 4.6*	0.01 ± 0.005*
Echinocyamus spec.	24	0.4	2 ± 4
Acrocnida spec.	24	0.8	1 ± 3
Ophiura spec.	24	0.1–0.4	118 ± 120
Amphiura filiformis	24	0.5–0.6	2 ± 7
Echinocardium cordatum small	24	0.5–1.0	97 ± 51
Echinocardium cordatum large	24	3.6–4.8	23 ± 21
Chordates			
Amphioxus	10	0.7–1.3	6 ± 7
Coelenterates			
Anthozoa	10	0.5–2.0	25 ± 27
Worms			
Total	10		5179 ± 1482
Magelona papillicornis small	10	2.0–3.0	1904 ± 976
Magelona papillicornis large	10	3.0–6.0	2011 ± 449
Total except *Magelona papillicornis*, e.g.	10		1265 ± 556
Lanice conchilega small	10	0.5–1.5	355 ± 288
Lanice conchilega large	10	1.5–5.0	38 ± 39
Spiophanes bombyx	10	1.5–2.5	496 ± 268
Total except *Magelona papillicornis, Lanice conchilega, Spiophanes bombyx*, e.g.	10		373 ± 127
Anaïtides mucosa	10	1.0–2.1	69 ± 52
Spio filicormis	10	1.0–2.5	69 ± 46
Scolelepis bonnieri	10	2.0–4.0	51 ± 44
Eumida sanguinea	10	0.5–1.0	30 ± 33
Goniada maculata	10	2.0 ± 4.0	9 ± 18
Owenia fusiformis	10	0.5–2.5	23 ± 24
Scoloplos armiger	10	3.0–4.0	9 ± 10
Sigalion mathildae	10	4.0–6.0	17 ± 17
Glycinde nordmanni	10	1.5–2.5	35 ± 40
Anaïtides groenlandica	10	1.5–3.0	21 ± 17

Table 2. (*Continued*)

	Numbers of samples	Size range (cm)	Mean density $n\,m^{-2} \pm$ s.d.
Nepthys hombergii	10	5.0–1.0	7 ± 10
Nepthys cirrosa	10	2.5–3.5	3 ± 6
Nereis longissima	10	2.5	1 ± 5
Nereis spec.	10	1.5	1 ± 5
Harmothoë spec.	10	0.5	1 ± 5
Eteone flava	10	2.0–3.0	3 ± 9
Chaetozone setosa	10	1.0–1.5	18 ± 23
Poecilochaetus serpens	10	1.5–2.0	3 ± 6
Lumbrinerus latreilli	10	2.5	1 ± 5
Anaïtides maculata	10	2.0	1 ± 5
Lagis koreni	10	1.8	1 ± 5

*Based on four hauls with 2.80-m beamtrawl (mean length $\pm$ s.d.).

Table 3. Mean densities of macrobenthic fauna ($n\,m^{-2}$) sampled with Reineck boxcore on the quadrant at t_0 and t_3, and the change in densities after a three-fold beamtrawling as percentage of densities at t_0. Statistical significance is estimated with the Mann–Whitney test.

	Numbers of samples	Actual number of individuals at t_0	$n\,m^{-2}$ at t_0	$n\,m^{-2}$ at t_3	Percentage change in density $100 \times (t_0 - t_3) \times t_0^{-1}$	Statistical significance
Crustaceans						
Total small, e.g.	10	219	309	235	−24	
Cumacea						
Natantia						
Amphipoda						
Molluscs						
Total	24	365	214	195	−9	
Tellina fabula small	24	35	20	41	+106	
Tellina fabula large	24	223	130	98	−25	
Total except *Tellina fabula*	24	106	62	62	0	
Echinoderms						
Asterias rubens	4	45	0.0134	0.0077	−43*	0.1
Ophiura spec.	24	201	118	120	+2	
Echinocardium cordatum small	24	165	96	43	−55	0.001
Echinocardium cordatum large	24	36	22	19	−14	
Worms						
Total	10	3673	5179	6065	+17	
Magelona papillicornis small	10	1350	1904	2618	+38	
Magelona papillicornis large	10	1426	2011	2671	+33	0.025
Total except *Magelona papillicornis*, e.g.	10	897	1265	767	−39	0.025
Lanice conchilega small	10	251	355	125	−65	0.025
Lanice conchilega large	10	26	37	42	+15	
Lanice conchilega	10	277	392	168	−43	0.05
Spiophanes bombyx	10	352	496	213	−57	0.025
Total except *Magelona papillicornis*, *Lanice conchilega*, *Spiophanes bombyx*	10	267	376	386	+3	

*Shift in density (%) after a single beamtrawling based on four 300-m hauls with a 2.80-m beamtrawl at t_1.

Table 4. Mean densities of *Echinocardium cordatum* in the t_0, t_1, t_2 and t_3 sampling, based on 24 grab samples. t_0 = reference density, t_1 = density after unifold beamtrawling, t_2 = density after three-fold beamtrawling, t_3 = density after three-fold beamtrawling followed by a stabilization period of 2 weeks.

	Mean $n\ m^{-2} \pm$ s.d.	Mean ln (n+1) $m^{-2} \pm$ s.d.
Small individuals		
t_0	97 ± 51	2.142 ± 1.172
t_1	88 ± 72	1.726 ± 0.762
t_2	109 ± 206	1.207 ± 1.303
t_3	45 ± 92	0.932 ± 0.888
Large individuals		
t_0	23 ± 21	0.771 ± 0.560
t_1	24 ± 14	0.885 ± 0.397
t_2	16 ± 15	0.628 ± 0.489
t_3	20 ± 17	0.733 ± 0.503

about 6 cm deep into the sediment. Since no independent estimates of the actual density of *Arctica* are available, it cannot be proved that the net reached this depth in the whole area.

About 90% of the *Arctica* caught in the 12-m beamtrawl were severely damaged (Bergman *et al.*, 1990). Arntz & Weber (1970) mentioned the occurrence of *Arctica* in the stomachs of cod (*Gadus morhua*) in Kiel Bay, during the season with intensive ottertrawl fishery. The boards of the ottertrawl, going as deep as 15 cm through the sediment, dig out and break up the bivalves, which then become available for cod. In the southern North Sea *Arctica* were also often found (without valves) in the stomachs of cod in winter (Cramer and Daan, 1986). However, it is not yet clear whether this is related to commercial beamtrawling.

The heart urchin *Echinocardium cordatum* was also found in the catches of the first series of hauls of the 12-m trawl. After three-fold trawling on the experimental quadrant, the large individuals of *Echinocardium* showed a decrease in density of 14% (Table 3). This decrease suggests that only a minor part of the population is actually reached by the net, possibly the animals living slightly higher in the sediment (6–9 cm below the surface) as compared to the majority living at 10–12 cm (Fig. 1). It can be concluded that the tickler chains of the commercial net must penetrate at least 6 cm into the sediment to catch these *Echinocardium*.

Direct effects of beamtrawl fishing on density of benthos on the quadrant

After three-fold trawling some benthos species showed a decrease (10–65%) in density (Table 3). Except for starfish *Asterias rubens* most of these animals live in the sediment (to a depth of 15 cm). The vertical distribution of the different species in the sediments seems to be an important factor determining the catchability of the fauna. Even the size-dependent depth preference of one single species, e.g. *Echinocardium cordatum*, appears to be essential: the effect of trawling on densities of small individuals (mean depth 2–4 cm) was much larger than on densities of larger individuals (mean depth 10–12 cm). The difference in effect of trawling on small and large *Lanice conchilega* is probably related to the better escape possibilities of larger worms into their living tubes, which extend deeper into the sediment.

Decrease in numbers of species on the quadrant could have been the result of both local destruction during the passage of the trawl and transport by the trawl nets. Some of the transported animals were returned to the sea alive outside the quadrant after sorting of the catch on board the trawler. Especially, the starfish *Asterias rubens* seems to have a high chance of survival after returning to the sea (Bergman *et al.*, 1990).

Animals escaping through the meshes of the net are possibly found again in the t_1 and t_2 samplings. Actual survivors are only found in the t_3 sampling, after a stabilization period of 2 weeks. This is probably the case with the small heart urchins *Echinocardium* (mean length 0.8 cm), which are mainly found at a depth of 2–4 cm: damaged individuals could not be distinguished in the t_1 and t_2 samplings. The t_3 sampling after 2 weeks stabilization gives a better impression of the actual change in density: 55% of the population had disappeared. The standard deviations of mean densities of small *Echinocardium* in the quadrant increase from t_0 to t_3 sampling, indicating that a considerable part of the population of small heart urchins were probably redistributed over the quadrant in a less homogeneous way after they passed through the meshes of the net.

The polychaete worm, *Magelona papillicornis*, showed a considerable and significant increase in numbers after three-fold trawling. This increase is difficult to account for but may be related to a change in vertical distribution of the worms in the sediment in the 2-week period after the three-fold trawling. Recolonization within 2 weeks or sufficient growth of juveniles so that they are retained by the 1 mm sieve seems unlikely, especially considering the relatively large minimum length of juveniles (2 cm) found in the t_3 samples. The small individuals of *Tellina fabula* (<0.4 cm) also showed an increase in density, although this was not significant. Their increased abundance may be explained by growth during the period of 2 weeks after the trawling, estimated at 0.5–1.0 mm (Dekker, NIOZ, pers. comm.), which may have been sufficient for the small bivalves to be retained on a 1-mm sieve.

The numbers of small individuals of the brittle star *Ophiura* (0.1–0.4 cm) living in the upper centimetre of the sediment did not change after three-fold experimental trawling, suggesting that these animals escape undamaged through the meshes. Three-fold trawling appears to have little effect on the total densities of about 20 less abundant worm species (all other worm species except *Magelona*, *Lanice* and *Spiophanes*). Nor did the total density of some 10 less abundant species of molluscs, all species except *Tellina fabula*, change after three-fold trawling.

Future research

In this study the direct effects of beamtrawling on some benthic species in the investigated hard-sandy area appear to be considerable. Probably the effects on the benthic communities in this area, which has already been beamtrawled for over 30 years, are even less clear than the effects should have been in areas in the North Sea, where the benthic structure is undisturbed by commercial beamtrawling in the past.

Based on the direct effects and the relative high frequency of commercial beamtrawling in the North Sea (Welleman, 1989) it should be supposed that beamtrawling may contribute to changes in the benthic system. These changes may be expressed in changes in species composition and possibly in changes in production rate. However, direct effects cannot be extrapolated to long-term effects of beamtrawling on benthic communities. Only the comparison of the benthic fauna in an untrawled area with that of an adjacent trawled area may yield valuable information on possible long-term effects. However, such locations appear to be rather uncommon in the North Sea and uncertainty will always exist about the degree of trawling in a particular area.

A study of long-term effects of beamtrawling on the North Sea ecosystem seems only possible when trawling is banned in a representative fishing area with a sufficient extent. Monitoring the sediment characteristics, benthic fauna and fish populations in both this closed area and a comparable normal trawled area will provide the information which is necessary to assess the actual impact of beamtrawling on the ecosystem.

Acknowledgements

Thanks are due to the crew of RV "Mitra" (Ministry of Transport and Public Works – North Sea Directorate), A. Stam and P. van der Puyl (NIOZ) for assistance during sampling. Publication no. 33 of the project Applied Scientific Research Netherlands Institute for Sea Research (BEWON).

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