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Changes in abundance of demersal fish species in the North Sea between 1906–1909 and 1990–1995

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A comparison of catch rates of demersal fish during beam trawl and otter trawl surveys carried out in the period 1990–1995 and 1906–1909 indicates lower abundance in recent years for the total assemblage as well as for individual groups. There appear to have been shifts in the community associated with reduced diversity and evenness indices. Length-frequency distributions of roundfish and flatfish show a shift towards smaller-sized fish.

Key words: diversity, exploitation, fish assemblage, North Sea.

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Introduction

Over the last decades, there has been increasing concern about the impact of man on the seas around us (Salomons *et al.*, 1988; North Sea Task Force, 1993; ICES, 1993). The marine environment may be affected, both directly and indirectly, by a variety of human activities, including coastal engineering works, pollution, eutrophication, fisheries, and global warming. However, to evaluate the potential impact of human activities, detailed knowledge of the dynamics of the marine ecosystem is required, but this is difficult to obtain without empirical evidence of the changes that have already taken place. Time-series data have indicated major shifts in abundance of some commercial fish species over periods of several decades or even hundreds of years (Hempel, 1978). These studies highlighted the effects of exploitation (Pope and Macer, 1996; Rijnsdorp and Millner, 1996) but also of the natural dynamics of the system that may be related to variability in ocean climate (Cushing, 1982). Large-scale variability has also been shown in zooplankton abundance from the Continuous Plankton Recorder Programme (Franz *et al.*, 1991).

Even when detailed information is available, the assessment of anthropogenic changes is difficult because of the complex nature of the system in which natural processes and human activities interact, and because of the paucity of time-series data needed to test hypotheses. Commercial fish stocks represent an exception, because they are continuously and extensively monitored, and at least the rates of mortalities inflicted by fisheries are well understood. However, for many other biota, including non-commercial fish species, reliable long-term time series are sparse. This hampers the evaluation of the impact by man.

Recent North Sea monitoring data have been used to study changes in community parameters, but, although some effects have been detected which may well be related to increased rates of exploitation (Rice and Gislason, 1996), there is a great need for comparable data from the old days so that potential changes in size distribution and diversity can be evaluated. Therefore, it is useful to see whether published and archived data can be utilized in this respect.

Research vessel surveys carried out in the North Sea irregularly since the beginning of the century (Garstang, 1905; Anon., 1908) although not properly standardized at least provide some information on the fish fauna of these days warranting further analysis. In this paper, demersal trawl catches of research vessel surveys conducted in the southern North Sea during the first decade of this century are analysed and compared with recent data. Emphasis is on catch rates, species composition, size distributions, and community parameters of the demersal fish assemblage, with a view to establishing some perspective on recent observations in relation to the potential impact of industrialized fishing.

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Table 1. Details of survey gear used in the trawl surveys between 1906–1909 and 1990–1995.

	1906–1909 BT	1906–1909 OT90	1906–1909 OT20	1990–1995 GOV	1990–1995 BT
Haul duration (min)	60–180	60–180	30–180	30	30
Codend mesh (stretched, mm)	63	68	(±40)	20	40
Tickler chains	0	0	0	0	8
Towing speed (knots)	2	2	(2)	4	4
Headline	—	26	6	36	—
Sweep (m)	13	17	4	72	8
Swept area (1000 m^2 h^{-1})	50	60	15	530	60
Relative catch efficiency	0.85	1	0.25	10	1

Material and methods

Data for 1906–1909 (third and fourth quarters)

Trawl surveys using three different gear types were carried out in the first decade of the present century by fisheries laboratories in England (Garstang, 1905; Anon., 1912) and The Netherlands (Anon., 1908, 1909, 1910). The English research vessel RV "Huxley" used either an 86 foot (26.5 m) headline otter trawl (OT90), with a groundrope of 125 feet (38.5 m) consisting of a wire core without a chain, or a 43 foot (13 m) beam trawl (BT13). Gear characteristics are summarized in Table 1. In some hauls, a fine meshed cover was used. Tow duration varied between 1 and 3 h for both gears. For each haul, the numbers of the larger fish species caught are available and for the principal species (flatfish, roundfish, gurnards, rays, skates, sharks, dogfish) size distribution data are available for 10-cm groups. Station information includes position, depth, date, time of day, and haul duration. Information on the bottom fauna was also recorded. Smaller fish species not considered "food fish" were not recorded systematically but were sometimes identified under the heading "bottom fauna".

The Dutch vessel RV "Wodan" used a similar 86 foot (26.5 m) otter trawl to RV "Huxley" or a 20 foot (6 m) otter trawl (OT20). The mesh size of the latter was not specified, but from the size distribution of the fish caught it can be inferred that stretched mesh size must have been between 2 and 4 cm. Tow duration was generally 1–2 h, but sometimes the catch was recorded as the sum over two to four hauls. The same station information was collected as for the RV "Huxley" surveys and a record of all fish species and invertebrate species caught was maintained.

Data for 1990–1995 (third and fourth quarters)

The recent composition of the demersal fish fauna was analysed using data from an 8 m beam trawl (BT8; RV "Isis") and "grande ouverture verticale" trawl surveys (GOV; RV "Tridens"). Gear characteristics are given in Table 1.

The BT8 survey was carried out in August–September and covered the southern and south-eastern North Sea (largely area 6; Fig. 1). The sampling area was stratified by ICES rectangle of 0.5° latitude and 1° longitude (±30 × 30 mile) in which one to four hauls were made. The beam trawl was equipped with a ground rope consisting of a chain with rubber discs (20 cm diameter) in the central part. Eight tickler chains ran in front of the groundrope. Further details of the rigging can be found in ICES (1990).

The GOV survey deployed an otter trawl with a relatively high vertical net opening of 5 to 6 m. The standard sweeps measured 50 m and the horizontal opening was approximately 20 m. The groundrope consisted of a wire with small rubber discs (10–20 cm). For further details see ICES (1992). The survey extended from the very south to the northern North Sea.

The procedures for recording fish catches were the same for the two surveys. The catch was sorted by species, subsampled if necessary, and the numbers caught and their length distributions (cm below) were recorded. Some species of pipefish (*Syngnathus* sp.) and gobies (*Pomatoschistus* sp.), which are difficult to identify on board, were only identified to genus. The records of the dragonet (*Callionymus lyra*) may include a small number of reticulated dragonet (*C. reticulatus*).

Data selected for the comparison

The distribution of fishing stations in the different surveys was fairly uneven (Fig. 1), but the south-eastern North Sea was fairly well covered during most surveys. We therefore restricted the comparison to ICES roundfish Area 6. Tows in which the gear was damaged were excluded from the analysis. RV "Huxley" and RV "Wodan" hauls made with the OT90 were combined into one data set.

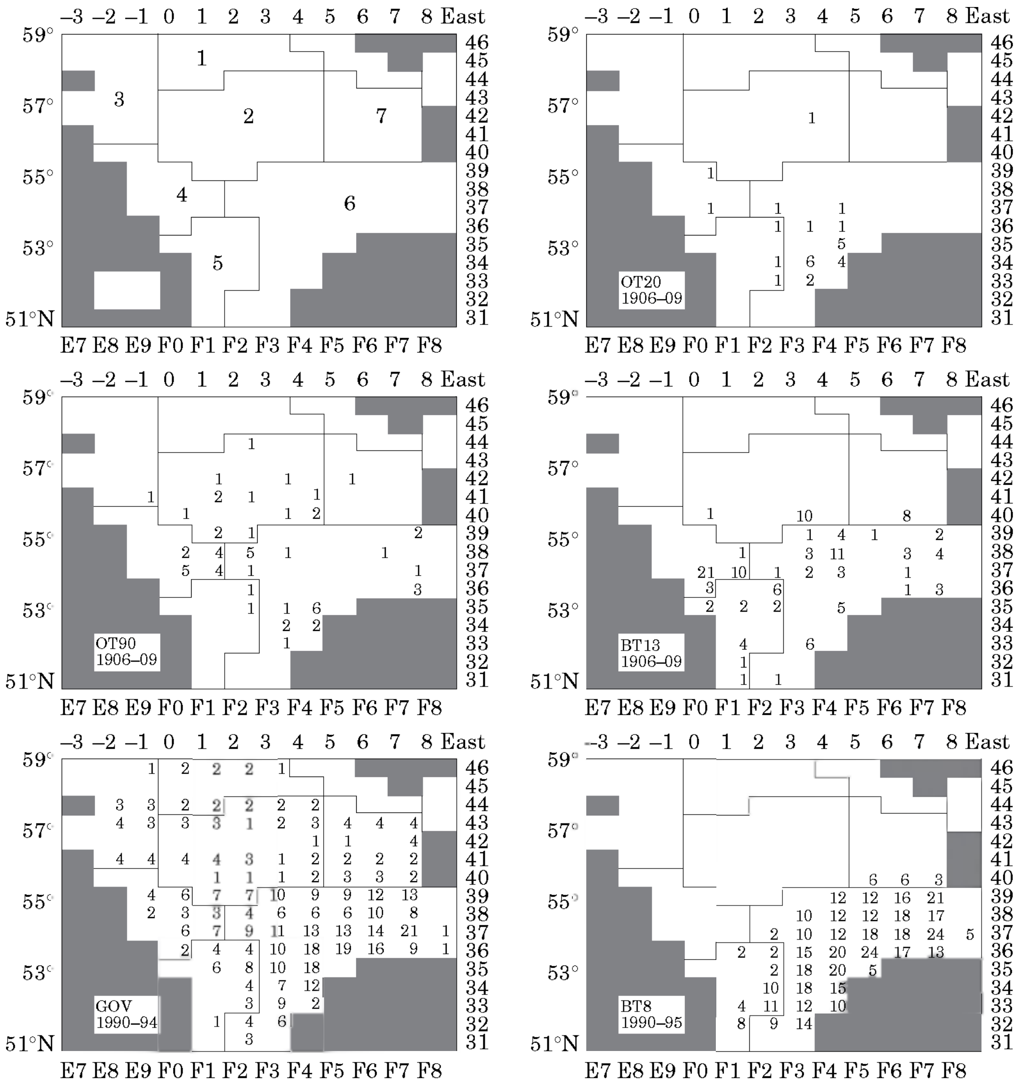

Figure 1. Number of hauls by statistical rectangle taken in the third and fourth quarters between 1906 and 1909 (RV "Wodan" – OT20 and OT90; RV "Huxley" – OT90 and BT13) and in the third and fourth quarters between 1990 and 1995 (RV "Tridens"/RV "ISIS" – GOV; RV "ISIS" – BT8). The numbers in the top-left panel indicate Roundfish Areas.

Swept area correction factors

Different fishing gears vary in efficiency in catching individual species of fish (or even in catching different sizes of fish within one species) due to a multitude of factors (Gunderson, 1993). This is the overwhelming problem in comparing faunistic data between one survey and another. We follow a pragmatic approach here and restrict ourselves to using the swept area as a correction factor for the catch rates obtained with any one gear. In the discussion, we return to this problem and base our interpretation on a judgement of the likely differences.

The area swept by the gear was estimated from the towing speed and the horizontal net opening. The latter is fixed for beam trawls by the size of the beam but depends on towing speed and depth for otter trawls. For the otter trawl used by RV "Huxley", the horizontal net opening was estimated at 2/3 of the length of the headline (Garstang, 1905) and the same conversion factor was applied to the smaller otter trawl deployed by RV "Wodan". In the GOV trawl employed in recent years, the swept area is increased by an extension of the groundrope (sweep) between the wings of the net and the trawl doors (Knijn *et al.*, 1993), but the distance between the doors is routinely measured during the survey.

The estimated swept area per hour fishing is the same for the OT90 and BT8, but differed considerably between the other gears. Expressed relative to the swept

Table 2. Number of hauls, number of rectangles fished, fishing hours, and mean standardized catch rate (number h^{-1}) of demersal fish in Roundfish Area 6 during trawl surveys carried out in 1906–1909 and 1990–1995. Catch rates were standardized to the area swept per hour with the OT90.

	1906–1909 OT20	1906–1909 OT90	1906–1909 BT13	1990–1994 GOV	1990–1995 BT8
No. hauls	21	26	21	319	429
No. rectangles	8	12	16	33	30
No. fishing h	18	79	151	159	211
Sharks/dogfish	10.0	0.2	0.2	0.1	0.1
Rays	3.0	0.7	0.3	0.0	0.2
Roundfish	344.6	43.5	15.0	380.8	146.3
Gurnards	91.6	22.5	31.7	13.9	49.0
Flatfish	1494.0	325.7	269.0	190.6	2475.5
Others	1577.0	13.5	3.8	20.0	297.6
Total demersal	3520.2	406.2	320.1	605.5	2968.6

area of the OT90/BT8, the swept area is 0.85 for the BT13, about 0.25 for the OT20, and about 10 for the GOV (Table 1). These factors will be used to standardize roughly the trawl catches in approximately similar units.

Data analysis

The mean catch rate (N, h^{-1}) was estimated for roundfish area 6 taking account of the unbalanced spatial distribution of hauls (Fig. 1):

$$N=\sum_{j}^{q}\left(\sum_{i}^{p} n_{ij}/p\right)/q$$

with n_{ij} the standardized catch rate in haul i in rectangle j, p the number of hauls in rectangle j, and q the number of rectangles sampled.

The comparison of the size distributions between the two periods was restricted to flatfish (plaice, sole, dab, turbot, brill, long rough dab, lemon sole) and roundfish (cod, haddock, whiting, ling), because length measurements for both periods were only available for these species.

Other community parameters analysed were the number of species, Shannon-Wiener (H′) and Simpson (D) index of diversity and the index of evenness (cf. Pielou, 1969).

Results

Catch rates of major groupings of demersal fish varied considerably between gears and periods (Table 2). Only the catch rates in the large meshed OT90 and BT13 were in the same order of magnitude for all groups. In contrast, total catch rates of demersal fish in the small meshed OT20 were almost a factor 10 higher. Although it is likely that mesh size explains part of these differences, one would not expect major effects of mesh size on the catch of elasmobranchs, which were also higher in the OT20. Moreover, there is an extreme difference for "other" demersal fish, which is likely to be explained partly by the poor records for some of the non-commercial fish species in the RV "Huxley" catches. Notwithstanding these differences, the relative catch rates of all major groupings except "others" are remarkably similar in all three gears.

The difference in catch rates in the GOV and BT8 in recent years are much more pronounced (Table 2). Although the BT8 catches overall five times as many fish as the GOV per swept area, this difference is largely due to flatfish. For roundfish, the GOV catches twice as many fish as the BT8.

When comparing the two periods, the catch rates of elasmobranchs appear to have decreased substantially in recent years. For other groups it would seem more appropriate to compare recent data with the OT20 because of their similar mesh sizes. Thus, gurnards appear to have decreased using both recent gears, but the observed changes in flatfish and roundfish depend on the choice of gear. The GOV suggests a decrease in flatfish and an increase in roundfish, whereas the BT8 indicates a decrease in roundfish and an increase in flatfish.

Data for individual species are given in Table 3. There appear to have been marked declines in spiny dogfish (*Squalus acanthias*), haddock (*Melanogrammus aeglefinus*), poor cod (*Trisopterus minutus*), five-bearded rockling (*Ciliata mustela*), grey gurnard (*Eutrigla gurnardus*), greater weever (*Trachinus draco*), lesser weever (*Echiichthys vipera*), sandeels (Ammodytidae), and long rough dab (*Hippoglossoides platessoides*). In contrast, bib (*Trisopterus luscus*), bullrout (*Myoxocephalus scorpius*), pogge (*Agonus cataphractus*), mullet (*Mullus surmuletus*), dragonets (*Callionymus* spp.), lemon sole (*Microstomus kitt*), and flounder (*Platichthys flesus*) appear to have sharply increased.

Community parameters, based on data from the small-meshed gear only, indicate that the demersal catch

Table 3. Standardized mean catch rate (number per hour fishing) of individual fish species by survey in Roundfish Area 6. In the OT90 and BT13 surveys, small fish species have not been recorded (indicated by —). Catch rates were standardized to the area swept per hour with the OT90. The asterisk denotes demersal species; + indicates less than 0.05.

	1906–1909 OT20	1906–1909 OT90	1906–1909 BT13	1990–1995 GOV	1990–1995 BT8
Lampetra fluviatilis	0	—	—	+	0
Petromyzon marinus	0	—	—	+	0
Scyliorhinus caniculus	0	—	—	+	0.1
*Galeorhinus galeus**	0	0.2	0.1	+	+
*Mustelus asterias**	0	—	—	+	0
*Mustelus mustelus**	+	0.1	+	0	0
*Squalus acanthias**	10.0	0.1	0.1	0.1	+
*Raja radiata**	0	0.2	+	+	0.1
*Raja batis**	0	+	0.1	0	0
*Raja montagui**	0	—	—	+	+
*Raja clavata**	2.8	0.5	0.2	+	0.1
*Dasyatis pastinaca**	0	—	+	0	0
*Anguilla anguilla**	0	—	—	+	0.1
Alosa fallax	0	—	—	0.7	+
Clupea harengus	8.4	0.5	—	645.4	1.2
Sprattus sprattus	17.6	0.1	—	229.9	2.4
Sardina pilchardus	0	—	—	0.5	0
Engraulis encrasicolus	0	—	—	0.7	0
Salmo salar	0	—	—	+	0
Osmerus eperlanus	0	—	—	0.6	+
*Lophius piscatorius**	0	+	—	+	0.1
*Gadus morhua**	5.6	1.8	2.6	22.0	7.5
*Pollachius virens**	0	+	+	+	0
*Melanogrammus aeglefinus**	9.2	12.3	6.1	0.1	0.1
*Rhinonemus cimbrius**	0	—	+	0.3	10.1
*Trisopterus minutus**	21.6	—	—	6.8	2.4
*Trisopterus luscus**	1.2	0.1	+	4.5	10.4
Trisopterus esmarki	0	—	—	0.1	0.2
*Merlangius merlangus**	307.2	29.3	6.2	346.9	115.5
*Molva molva**	+	—	+	+	0
*Gaidropsarus vulgaris**	1.2	—	—	+	0
*Ciliata mustela**	11.2	—	—	0.2	0
*Merluccius merluccius**	0	—	+	+	0.1
*Zoarces viviparus**	0	—	—	+	0.5
Belone belone	0	—	—	+	0.1
Gasterosteus aculeatus	0	—	—	0.1	0.9
Syngnatidae*	0	—	—	0	0.1
*Entelurus aequoreus**	0	—	—	+	0
*Helicolenus dactylopterus**	0	—	—	+	0
*Zeus faber**	+	—	0.1	0	0
*Trigla lucerna**	1.2	2.8	1.6	0.6	8.4
*Eutrigla gurnardus**	90.0	19.7	29.5	13.3	40.3
*Aspitrigla cuculus**	0.4	+	0.6	+	0.3
*Myoxocephalus scorpius**	0.8	—	—	0.2	10.6
*Agonus cataphractus**	2.4	—	—	1.1	78.9
*Cyclopterus lumpus**	0	—	—	+	+
Trachurus trachurus	6	0.4	0.1	271.6	5.7
*Spondyliosoma cantharus**	0	—	—	0.1	0
*Mullus surmuletus**	0	—	+	1	1.6
*Dicentrarchus labrax**	0	—	—	+	0
Mugilidae*	0	—	—	+	0
*Crenimugil labrosus**	0	—	—	+	0
*Echiichthys vipera**	808.8	—	—	9.4	47.5
*Trachinus draco**	178.0	13.3	3.6	0	0
*Anarhichas lupus**	0	+	+	+	0
Ammodytidae	7.6	—	—	0.2	0.7
Hyperoplus lanceolatus	7.2	—	—	2.2	3.5
*Callionymus lyra**	74.0	—	—	1.7	133.6

Table 3 continued on next page

Table 3. *Continued from previous page*

	1906–1909 OT20	1906–1909 OT90	1906–1909 BT13	1990–1995 GOV	1990–1995 BT8
*Pomatoschistus**	29.2	—	—	3.5	19.4
Scomber scomber	0.8	0.4	+	19.2	0.2
*Scophthalmus maximus**	1.2	0.7	0.4	0.1	2.4
*Scophthalmus rhombus**	+	0.2	0.4	+	1.5
*Arnoglossus laterna**	186.8	—	—	0.1	114.8
*Phrynorhombus norvegicus**	0	—	—	0	0.1
*Glyptocephalus cynoglossus**	0	—	—	—	+
*Hippoglossus platessoides**	96.0	—	0.4	0.3	2.5
*Limanda limanda**	975.2	164.5	147.5	176.8	1605.2
*Microstomus kitt**	0.4	—	0.4	0.2	5.2
*Platichthys flesus**	0	0.2	+	0.5	12.6
*Pleuronectes platessa**	227.6	159.4	119.5	12.0	514.8
*Solea solea**	7.2	0.8	0.6	0.2	83.2
*Solea lascaris**	0	—	—	0	+
*Buglossidium luteum**	457.6	—	—	0.5	133.1
*Michrochirus variegatus**	0	—	—	0	+

Table 4. Community parameters for the demersal fish species caught in Roundfish Area 6 by gear.

	1906–1909 OT20	1990–1995 GOV	1990–1995 BT8
No. of species	29	48	42
SW diversity (H′)	2.10	1.23	1.68
Evenness	0.62	0.32	0.45
Simpson diversity (D)	0.83	0.58	0.67

was more diverse at the beginning of the century than at present, despite the lower number of species caught (Table 4). The recent catch composition was dominated by a single species (GOV: whiting; BT8: dab) which made up more than 50% of the catch. As a consequence, cumulative catch rates against species rank are much steeper in the OT20 data (Fig. 2).

Comparison of the size distributions of the roundfish and flatfish species indicates that the relative contribution of the larger fish has markedly decreased since 1906–1909 (Fig. 3). A test of the differences in slopes of the declining limb of the log catch numbers against size between both periods (Table 5) showed highly significant differences for both flatfish ($F_{2,37}=716$; $p<0.001$) and roundfish ($F_{2,40}=141$; $p<0.001$).

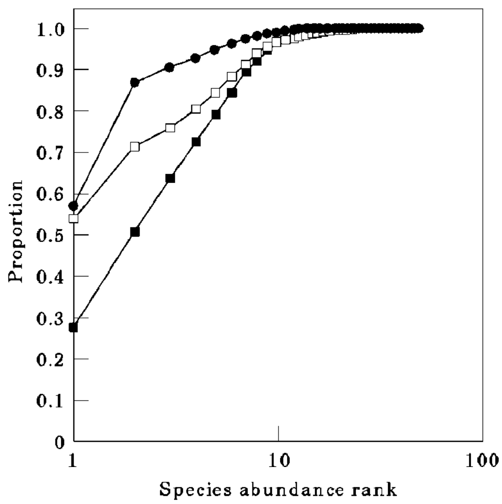

Figure 2. Dominance plot showing the cumulative catch rates against species rank for 1906–1909 (OT20) and 1990–1995 (GOV and BT8). ■=OT20, 1906–1909; □=BT8, 1990–1995; ●=GOV, 1990–1995.

Discussion

It is generally accepted that trawl catches made with the same gear reflect relative differences in abundance of demersal fish species. However, problems arise when different species caught with the same trawl are compared, or when different gears are used for a single species, because all fishing gears are more or less selective and catchabilities vary accordingly. Standardization to swept areas per unit of time does not resolve the gear differences in this respect, and relative catchabilities of different gears can only be established when they have been employed simultaneously within the same area (Knijn *et al.*, 1993).

Although the interpretation of catch rates obtained by means of different trawls in terms of changes in species abundance is difficult without empirical estimates of relative catchabilities, the historic data at hand are so unique that we will attempt to make a tentative assessment of the likely changes that have occurred in the demersal fish assemblage of the southern North Sea

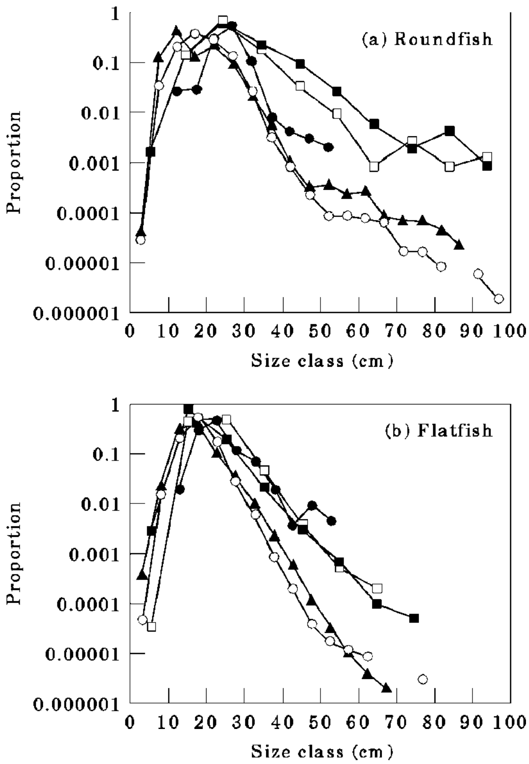

Figure 3. Size-frequency distributions of (a) roundfish and (b) flatfish by trawl survey in 1906–1909 and 1990–1995. ■ = BT13, 1906–1909; □ = OT90, 1906–1909; ● = OT20, 1906–1909; ○ = GOV, 1990–1995; ▲ = BT8, 1990–1995.

taking into account some obvious differences in gear characteristics.

Of the three historic surveys, only the OT20 used a small codend mesh comparable with the two gears used in recent years. Therefore, potential changes in abundance since the turn of the century can best be studied by comparing these three gears. The catch ratios of the GOV/OT20 and the BT8/OT20 were 0.17 and 0.84, respectively, suggesting a decline in overall abundance of demersal fish.

The catch compositions of the OT90/BT13 and the OT20 differed mainly with regard to smaller species, reflecting the difference in mesh size used (Table 3). However, small species like solenette (*Buglossidium luteum*), gobies and scaldfish (*Arnoglossus laterna*) were recorded by RV "Wodan", whereas they were not recorded in the RV "Huxley" catches. The differences are therefore likely to be overestimated because some of the smaller fish species may have been caught without being recorded (Anon., 1912).

The differences in the catch composition of the GOV and BT8 reflect differences in efficiency of the net for roundfish compared with flatfish. The GOV trawl has a high net opening and is expected to be more efficient than the OT20 in catching species which move around free of the bottom or try to escape the approaching trawl by swimming upwards. This is for instance expressed in the much higher catch rates of pelagic species in the GOV. In a comparison between GOV catches and catches in a more traditional Granton trawl during recent surveys, catch rates of cod, haddock, and whiting were higher in the former by factors of 2.3, 1.1, and 2.9, respectively (Knijn *et al.*, 1993). Thus, the more reliable change in roundfish is probably reflected by the BT8/OT20 ratio. In contrast, tickler chains have been developed by the commercial fishery to increase the catch efficiency of flatfish which are often buried in the sediment (Creutzberg *et al.*, 1987). Since the BT8 deploys a number of tickler chains, the more reliable change in abundance of flatfish is more likely to be reflected in the

Table 5. Slopes of the regression of $\log_e$ numbers against size for roundfish and flatfish.

Period	Gear	Slope	S.E.	r^2	Size range
Roundfish					
1906–1909	BT13	− 0.092	0.009	0.94	20–100
	OT90	− 0.096	0.017	0.85	20–100
	OT20	− 0.225	0.044	0.87	25–55
	Pooled	− 0.085	0.013	0.69	20–100
1990–1995	GOV	− 0.132	0.013	0.89	20–90
	BT8	− 0.182	0.016	0.91	20–85
	Pooled	− 0.147	0.011	0.87	20–90
Flatfish					
1906–1909	BT13	− 0.170	0.008	0.99	20–80
	OT90	− 0.201	0.017	0.99	20–70
	OT20	− 0.158	0.027	0.87	20–55
	Pooled	− 0.177	0.009	0.96	20–80
1990–1995	GOV	− 0.257	0.006	0.99	15–70
	BT8	− 0.267	0.018	0.96	15–65
	Pooled	− 0.260	0.009	0.98	15–70

ratio of the GOV/OT20. Following this argument, the data would indicate that both roundfish and flatfish have decreased in abundance since the turn of the century. Noticeably, the haddock appears to have been much more abundant during the earlier period. In fact, the apparent decrease in roundfish and flatfish may be underestimated, because the higher towing speed in recent years has probably reduced the chance to escape.

The catch rate of grey gurnard (*Eutrigla gurnardus*) appears to have decreased since the beginning of the century, corroborating the substantial decline between 1920–1950 and 1980–1990 reported by Greenstreet and Hall (1996). The comparison of catch rates of the thornback ray clearly indicates reduced abundance in recent years, but for other species the situation is less clear. The results for spiny dogfish indicate a sharp decline in the south-eastern North Sea, whereas the lesser-spotted dogfish (*Scyliorhinus canicula*) appears to be a newcomer. The general disappearance of elasmobranchs from coastal waters along the continent corroborates earlier reports of a decline (Hempel, 1978; Walker and Heessen, 1996).

Inspection of major changes in individual species shows that the greater weever has virtually disappeared in the southern and central North Sea. This species was exploited commercially until the late 1950s, but virtually disappeared from the southern North Sea in the early 1960s with commercial catches suddenly dropping to zero after the severe winter of 1963.

There are many indications of other decreases as well as increases among the non-target species. Whether these are caused by gear differences or reflect a shift in species composition due to fisheries or other human activities remains as yet an open question. However, community parameters do suggest a less diverse and less even fish assemblage. A similar though more modest change was observed in a comparison of Scottish research vessel survey data between 1920–1950 and 1980–1990 (Greenstreet and Hall, 1996).

The comparison of the size distribution of both the roundfish and the flatfish species clearly indicates a relative decrease of the larger sizes, but this may also be partly explained by differences in species composition. Within both groups there is an indication that the smaller-sized species like whiting and dab increased in relative abundance as compared with the larger-sized species such as cod and plaice.

This study is only a first step in exploring changes in North Sea fish assemblages based on existing trawl survey data with only part of the archived data being analysed. A comprehensive analysis of these data in conjunction with recent data from the International Bottom Trawl Survey (Heessen, 1996; Heessen and Daan, 1996) may prove a valuable baseline from which to evaluate the possible effects of human activities on the North Sea ecosystem in relation to the natural variability of the system. This enterprise would be greatly facilitated if it could be combined with comparative research of the gear efficiencies of the different trawls used in the past and present.

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