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OBSERVATIONS ON FISH DISEASES IN THE GERMAN BIGHT AND THEIR POSSIBLE RELATION TO POLLUTION

Volkert Dethlefsen
Institut für Küsten- und Binnenfischerei
Toxikologisches Labor Cuxhaven
Niedersachsenstraße
2190 Cuxhaven
Federal Republic of Germany

ABSTRACT

In August 1977, May 1978, and January 1979 three cruises were carried out to investigate the occurrence and abundance of fish diseases in the German Bight. The first two cruises concentrated on dumping areas, the third cruise covered the whole area of the German Bight.

Altogether 162 bottom trawls were accomplished. 31 different species were inspected. Abnormalities found were classified in skeletal deformities a) dwarfism, b) backbone curvatures, c) bullnoses; fish diseases a) fin rot, b) ulcers, c) lymphocystis, d) epidermal papillomas, e) stomato papillomas, f) cauliflower, g) pseudobranchial tumors, h) melanism, i) hemorrhages. Ulcers were more abundant in summer than during the winter cruise . Also fin rot was frequently found in summer, but almost absent during the winter cruise and was predominantly associated with flatfish species like dab, plaice and flounder. Fin rot was less frequently found on cod and other species. Dabs, flounders and plaice were found to be infested with lymphocystis, while epidermal papillomas were exclusively found on dab. Stomato papillomas were encountered on dab and plaice. Pseudobranchial tumors were encountered on cod.

Results during the summer surveys clearly indicate that for the frequency of some of these phenomena like ulcers, fin rot of cod and dab, skeletal deformities of cod, there seems to exist a clear relationship between quantity and distance from the coast: high percentages of infested species near the coast, i.e.: areas considered to be highly polluted, and lower infection rates in comparison areas up to 120 miles offshore. For the occurrence of lymphocystis and epidermal papillomas of dab this correlation did not exist. Here highest infection rates were found near the TiO_2 wastes dumping area. Possibly due to on- and offshore migrating of dab this picture could not be replicated during the winter survey, when the majority of dabs were caught in an onshore area north of the Elbe estuary.

INTRODUCTION

The problem of "red sores" of cod, cauliflower of eel , lymphocystis of flounder, skeletal deformities of many fish species was long known to exist in the German Bight (AKER, 1970; ANWAND, 1962; KOOPS and MANN, 1966, 1969; KOOPS et al., 1970; MANN, 1970; PETERS, 1975; PETERS et al., 1972; WUNDER, 1975)). But for most of these phenomena quantitative data were not available. MÖLLER (1977, 1978) gave information on the occurrence of different fish diseases in the North Sea, but only some few sampling stations were located in the German Bight. Therefore a program was started to investigate the occurrence and abundance of fish diseases in the more onshore part of the German Bight in order to obtain information on the frequency of diseases in the polluted parts of German coastal waters. Although large numbers of fish were handled during three cruises (30.000 cod, 35.000 dab, 40.000 whiting etc) the information obtained must be considered rather preliminary especially concerning possible links between pollution and the frequency of certain diseases.

This paper summes up some of the results, but it should be noted that the program is not finished and that some of the views expressed here could change during the further course of the investigation .

MATERIAL AND METHODS

The cruises were carried out in August 1977 with RV "Solea", in April/May 1978 with RV "Victor Hensen" and in January 1979 with RV "Anton Dohrn". During the first two cruises attention was focussed to the fish population in two dumping areas, 1. sewage sludge dumping area, 2. dumping area for wastes from TiO_2 production (for location of these dumping sites look Figures 2 - 3). During the third cruise stations were randomly distributed over a wider area of the German Bight (Figure 1). In the dumping areas trawls were carried out in the center where the dumping operations take place and in comparison areas south, east, west, and north of these areas. During the second cruise a comparison area 120 miles northwest from Cuxhaven was included in the survey, 8 one-hour bottom trawls were accomplished in this unpolluted area in order to obtain reference material. Altogether 31 different species were investigated (Table 1) for skeletal deformities and diseases.

RESULTS

The phenomena found were classified in

1. skeletal deformities
   a) dwarfism
   b) backbone curvatures
   c) bullnoses

2. fish diseases

a) fin rot
b) ulcers
c) lymphocystis
d) epidermal papillomas
e) stomato papillomas
f) cauliflower
g) pseudobranchial tumors
h) melanism
i) hermorrhages

Although many of the species investigated showed the symptoms looked for only in a few species larger percentages of skeletal deformities and diseases could be found. These species were cod, dab, plaice, and flounder. Some of the results of the winter survey are displayed in Table 2.

Skeletal deformities were most frequently found on cod. 0.8 - 1.9 % showed body curvatures, dwarfism and in some few instances bullnoses. Detailed information can be taken from Figures 2 and 3. The smallest deformed cod measured 15 cm, the longest 70 cm. For those cod arbitrarily classified as medium deformed length distribution ranged from 24 to 37 cm thus representing more than 1 year class.

In January 1979 a total of 0.53 % of cod from the German Bight was found with skeletal deformities. The percentage was 0.88 % in onshore waters and 0.43 % in offshore waters.

Further species displayed skeletal deformities only sporadically, these were whiting, haddock, flounder, plaice, dab, bastard mackerel, mackerel, herring, and sprat. Bullnoses were found rather rarely on cod, poor cod, whiting, sprat, mackerel, and haddock.

Fin rot

Highest incidences of fin rot were found on dab. Again a high variability was encountered in the respective area, the percentages found ranged from 1.2 to 13.9 %. During the winter survey the percentages of dabs with fin rot were 1.06 % in onshore and 0.1 % in offshore waters. Fin rot was less frequently found on cod. Here the percentages ranged from 0 to 1.4 %. Again in winter the percentages were significantly lower than during the summer survey. Fin rot occurred on caudal fins predominantly and was rarely found on pectoral fins of cod.

Also on flounder and plaice fin rot was encountered; percentages were 2.04 % (n = 554, flounders were only caught in the sewage dumping area) and for plaice in the TiO_2 area 1.4 % (n = 641) and in the sewage sludge dumping area 1.68 % (n = 617). Occasionally fin rot also occurred on whiting, and other species.

Ulcers

Ulcers were mainly found on cod. They were highly variable in size and location on fish body. Classification was made to distinguish between open and closed ulcers.

Size ranged from some few mm to some cm in diameter. Often closed and open ulcers were found on the same fish and in some cases hemorrhages occurred in combination with closed and open ulcers. Ulcers on cod were predominantly located under the second dorsal fin near the lateral line. The percentages of infested cod ranged from 0.1 to 3.5 % during the summer survey and in January 1979 0.22 % of the cod encountered in onshore waters were infested as compared to 0.14 % of cods living in offshore waters. The size distribution of cod with ulcers was not different from that of cod without ulcers ranging from 17 to 36 cm having a maximum at 34.5 cm. Dab was also infested with ulcers in relatively high percentages ranging from 1.6 to 7.1 %. In winter 1.49 % of the onshore dabs were infested with ulcers, the percentage of dabs living in offhsore waters was 0.49 %. Ulcers on dab varied in size and were classified in open and closed and the majority occurred on the ventral side, most of them near the caudal fin.

1.4 - 5.4 % of the flounders (n = 554) from the sewage sludge dumping area showed ulcers which were very similar to those found on dab. But only 3 plaice out of 617 investigated were infested with ulcers. Other species displayed ulcers very rarely, the species were horse mackerel, whiting and poor cod. Wound healing on cod, but more frequently on dab, might have been overlooked during the first 2 cruises, but was thoroughly investigated during the winter cruise. 0.26 % of the offshore and 0.54 % of the onshore dabs displayed obvious signs of healed wounds.

Lymphocystis

Lymphocystis was found on dab, flounder and plaice. The percentages of dabs encountered with lymphocystis varied from 0 to 1.0 % during the summer survey and in the winter survey from 7.87 % in onshore waters to 1.14 % in offshore waters. During the summer survey 2.1 to 5.4 % of flounders, caught in the sewage sludge dumping area, were infested with lymphocystis.

Epidermal papillomas

Epidermal papillomas were found on dab during the summer survey, percentages encountered in the sewage sludge dumping area ranged from 0 to 1.0 %, while infection rates of dabs caught in the TiO_2 area ranged from 2.0 to 6.6 %. Infection rates of dabs caught in the comparison area during the April/May 1978 cruise was 0.6 %. During the winter survey in January 1979 2.34 % of dabs caught in onshore waters were encountered with epidermal papillomas compared to 0.71 % of the offshore dabs.

Stomato papillomas

Stomato papillomas were found on dab and plaice in relatively low numbers. This disease has so far been characterized as lymphocystis, but it is now histologically identified as a stomato papilloma.

Pseudobranchial tumors

Three specimen out of more than 8.000 cod investigated displayed pseudobranchial tumors, a disease so far not found on any other species from the German Bight (January 1979).

Hemorrhages

Hemorrhages were quite frequently found on cod, dab, flounder, plaice, sole, and some other species, but since these hemorrhages are often caused by the impact of fishing gear, no separation between disease and injury was possible. But it is stressed that in case of cod, dab, flounder, and plaice the occurrence of ulcers was positively correlated with the occurrence of hemorrhages.

DISCUSSION

While fishing during the first two cruises was almost exclusively restricted to the dumping areas, major purpose of the third cruise was to cover a wider area (German Bight) with no special reference to these two dumping areas. It might well be that phenomena like epidermal papillomas, which were found in rather large frequencies during the second and third cruise might have been overlooked at the beginning of this study. The discussion will concentrate on 1. fish diseases in dumping areas and in comparison areas located in the vicinity of the dumping places, 2. frequency of diseased fishes in onshore waters as compared to offshore places.

a) Sewage area

In April/May 1978 highest percentages of skeletal deformities were found in the central area, while highest incidences of cod infested with ulcers were encountered in southwest and north (Figures 2 and 3). Percentages of fin rot were high in the center and in north and southwest, but low in the west, so the situation is highly variable as could be expected for a migrating species. Also for flatfishes like dab, plaice, and flounder variability encountered was so high, that from the data available no conclusion can be drawn as to a direct influence of the sewage sludge dumping on the frequency of diseases in the area.

b) TiO_2 area

The assumption that highest infection rates of cod should be found in the center of the dumping area cannot be proved by my data. Percentages of diseased fishes in the center were not higher than the averages estimated for the total area (Figures 2 and 3). For dab in the first two surveys relatively low rates of infection were found in the western comparison area, high infection rates in the eastern area. Low rates in the south, increased rates in the center and higher rates in the northern comparison area.

The fact that this pattern was found during the first two cruises might be an indication for a link between TiO_2 wastes and diseases of dab, because currents are transporting the diluted wastes in a northerly direction. High infection rates in the eastern area

would then not be caused by TiO_2 wastes, but could be explained by the fact that this area is located nearest to the coast, receiving high pollution loads from the Elbe estuary.

c) Comparison between onshore and offshore waters

When comparing the frequency of diseases fishes from onshore waters with that of offshore waters it becomes clear that a correlation between infection rates and distance from the coast exists for most of the diseases investigated. For cod in April/May 1978 highest percentages of fin rot, ulcers and skeletal deformities were found in the nearshore sewage sludge dumping area. Average percentages of these three phenomena were lower in the TiO_2 area and no diseased cod could be found on the station 120 miles offshore, although it must be stressed that here only 138 specimens could be inspected. These findings are supported by results obtained in August 1977, when also highest average infection rates were found in the area nearest to the shore. During the winter survey the percentages of cod diseased with ulcers was generally lower than in the preceding surveys, ranging from 0 to 0.5 % with an average of 0.1 %, but it was generally to low to detect a correlation between frequency of this disease and the distance from the coast (Fig. 4).

Also for dabs highest rates of fin rot and ulcers were encountered in the nearshore area and a clear gradient, decreasing infection rates with increasing distance from the coast could be found. This could also be shown for the winter survey, although frequency of these diseases were then lower than during the two preceding cruises. The fact that especially during the cruise in April/May 1978 relatively high percentages of dabs infested with ulcers and fin rot were caught in relatively offshore waters does possibly indicate that even in that distance from the coast the habitat is somewhat degraded. Infection rates with lymphocystis and epidermal papillomas were significantly higher in the TiO_2 area, thus possibly indicating a specific influence of TiO_2 waste.

Mass occurrence of epidermal papillomas of dabs and occurrence of pseudobranchial tumors of cod have so far not been described for West Atlantic waters. Careful histological investigation now revealed the occurrence of epidermal papillomas on flatfish in the German Bight (WATERMANN, personal communication). The question arises wether these papillomas have been overlooked in the past or wether there is any correlation to dumping of TiO_2 wastes, which started in 1969. Fisherman confronted with dabs covered by numerous epidermal papillomas claimed, that they never saw these phenomena before.

MÖLLER investigated the occurrence of certain diseases of cod and dab in the more offshore region of the North Sea in February 1977 and August 1978 (MÖLLER, 1977, 1978). For lymphocystis and vibrio disease of dab (vibrio obviously stands for ulcers) relatively high infection rates were found in offshore waters while on 6 stations in the more onshore waters in the German Bight no especially high infection rates of dab occurred.

This interesting finding certainly needs deeper consideration. Firstly because it is obvious that no data are available to characterize the degree of pollution of f.e.: the Dogger Bank, although it seems to be accepted that this area is less polluted than certain coastal zones. But there is no reason to believe that the Dogger area is completely unpolluted. Extremely interesting results of investigation of water movements in the North Sea (KAUTSKY, 1977) show, that 30 - 40 % of the water masses transported from the Irish Sea enter the North Sea at 55°N. On the other hand this finding might give an indication that certain fish diseases are not restricted to coastal areas and it furthermore shows that pollution is not the only factor influencing the occurrence and abundance of fish diseases. Also the results of MÖLLER show that the geographical occurrence of certain fish diseases is highly variable. Stations with 0 infection were located in the immediate vicinity of stations of 5 - 10 % infection. This variability also became obvious during my investigation and it was higher when the numbers of fish investigated per station were low.

For this reason it is clear that in order to characterize the infection rate of f.e. dab on a certain place it is not sufficient to investigate 100 specimen. One diseased fish more or less changes the result by ± 100 %. Only when numbers in the range of 500, better even more, per station could be investigated, the findings became more stable. Unfortunately MÖLLER gives no indication as to how many fish were investigated per station, the variability could therefore be due to the fact that the n of fish investigated per station was to low.

d) Pollution of the areas investigated

Since it was not the major purpose of this paper to describe the pollution of the area under survey no attempt will be made to give a full literature review on this subject. Nevertheless it seems to be generally accepted that the inner part of the German Bight, i.e.: the estuary of the river Elbe, is rather heavily polluted. This area is receiving effluents of a large variety of industries located in the middle and lower regions of the river Elbe (PETERS, 1978). Major branches of industry are: different types of power plants, refineries, alumina plants, and chemical industry like production of chlorinated hydrocarbons and chloralkalielectrolysis, which also can be found in the Jade- and Weser-area, also contributing to the water discharge into the German Bight. In addition to that this area is receiving high loads of organic pollution (WACHS, 1971).

SCHMIDT (1976) investigated concentrations of heavy metals in the seawater of the inner German Bight. For some elements SCHMIDT was able to show that the concentration decreased with increasing distance from the coast (iron, manganese, nickel) while the toxic elements cadmium, copper, and lead were more evenly distributed over this area.

The concentration of mercury, absorbed to suspended solids, is showing a very clear gradient, the concentration is decreasing with increasing distance from the coast being high in the inner part of the Elbe estuary (ALBRECHT, personal communication). Some of these gradients are reflected in the regional distribution of lead and mercury in soft tissues of Mytilus edulis from the German coast (KARBE et al., 1977; SCHULZ-BALDES, 1973). DE WOLF, 1975, described that mercury contentsin soft tissues of Mytilus edulis in 1971 and 1973 in the German Bight were significantly higher than in unpolluted areas.

HARMS (1975) provided information on heavy metal residues in on- and offshore fish species. He found elevated levels of Cd, Pb and Hg in tissues from cod and plaice from onshore waters. Highest concentrations of mercury in fish tissues were found in species from the Elbe estuary (Anguilla anguilla, Osmerus eperlanus, Alosa fallax and Acerina cernua) (KRÜGER, et al., 1975). Also fish species from the Ems estuary displayed high mercury body burdens (GÜNTHER, et al., 1972). Benthic invertebrates from the Elbe estuary were shown to have elevated Hg residue levels (ZAUKE, 1977). Pesticide pollution of the German Bight is less good established. STADLER (1977) gives concentrations of certain organochlorines in the water column but no information is available as to differences between pesticide concentrations in on- and offshore waters. Several papers deal with organochlorine residues in North Sea fish species (SCHAEFER et al., 1976; HUSCHENBETH, 1973), from the information offered no evaluation as to regional differences of pesticide body burdens in fish of the German Bight is possible.

According to WEICHART (1973) the inner German Bight, which is the area between Helgoland and Cuxhaven, is characterized by significantly increased concentrations of nitrate and phosphate. WEICHART describes this area to be rather heavily polluted. And this was the area where the frequency of most of the diseases described in this paper was higher than on stations more offshore.

WEICHART (1975 a und b) investigated the possible influence of the dumping of wastes from TiO_2 industry on Fe content and pH of the seawater in the dumping area and its vicinity. He found that iron was not accumulating in the area under survey but that the pH was lowered by 0.1 to 0.2 units. During one of our cruises this area was characterized by increased frequencies of dabs infested with epidermal papillomas.

The finding of increased rates of diseased fishes in the inner part of the German Bight coincides with a result obtained by RACHOR (1977), who was able to show that in the last 10 years the number of species of macrobenthic organisms decreased significantly on a station in the vicinity of the dumping of sewage sludge.

CONCLUSIONS

The high variability of the occurrence and abundance of fish diseases and skeletal deformities as obtained during this investigation makes it questionable, wether monitoring of fish diseases can be useful to detect small scale pollution effects.

Identification of small scale pollution hot spots is only possible if attention is restricted to nonmigrating flatfishes. When migrating species like cod are used, the information obtained, will characterize pollution effects on a greater scale like gradients in relation to distance from the coast. But the knowledge of the abundance of certain fish diseases in certain areas seems to be useful to characterize the stress imposed on estuarine fish species.

One of the preliminary conclusions drawn from this investigation is that the German Bight can be characterized by different frequencies of certain fish diseases,
1. the inner part of the German Bight (area between Helgoland and Cuxhaven) heavily polluted, highest frequency of diseases,
2. a zone 20 to 60 miles offshore from the heavily polluted area characterized by still increased frequencies of certain fish diseases,
3. an area of unknown dimension characterized by low abundance of pollution induced fish diseases.

It is obvious that reduction of the introduction of pollutants into the first zone also reduces pollution loads entering the second and the third zone. It is also obvious that no dumping, what so ever, should be carried out in the first zone, the one already displaying significant sublethal effects. Also the second zone, the one with still increased frequencies of certain fish diseases, should not be used for dumping purposes, unless only small quantities of relatively harmless substances are introduced.

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Table 1

Species investigated for diseases and skeletal deformities during cruises in August 1977, April/May 1978 and January 1979

1. Gadus morhua
2. Merlangius merlangus
3. Trisopterus minutus
4. Trisopterus luscus
5. Osmerus eperlanus
6. Pleuronectes platessa
7. Platichthys flesus
8. Limanda limanda
9. Psetta maxima
10. Solea solea
11. Clupea harengus
12. Sprattus sprattus
13. Anguilla anguilla
14. Scomber scombrus
15. Trachurus trachurus
16. Lampetra fluviatilis
17. Chelidonichthys gurnadus
18. Agonus cataphractus
19. Acanthocottus scorpius
20. Callionymus lyra
21. Engraulis encrasicolus
22. Pomatoschistus minutus
23. Syngnathus acus
24. Onos mustelus
25. Alosa alosa
26. Melangogrammus aeglefinus
27. Hippoglossoides platessoides
28. Alosa fallax
29. Microstomus kitt
30. Chelidonichthys lucerna
31. Scophthalmus rhombus

Table 2

Percentages of infestation of cod (Gadus morhua) and dab (Limanda limanda) with certain diseases in on- and offshore waters of the German Bight in January 1979

dab	onshore	offshore
n	2401	20.385
fin rot	1.06	0.09
ulcers	1.49	0.49
healed ulcers	0.54	0.26
epidermal papillomas	2.34	0.71
lymphocystis	7.87	1.14
cod		
n	8150	932
skeletal deformities	0.88	0.43
ulcers	0.22	0.14

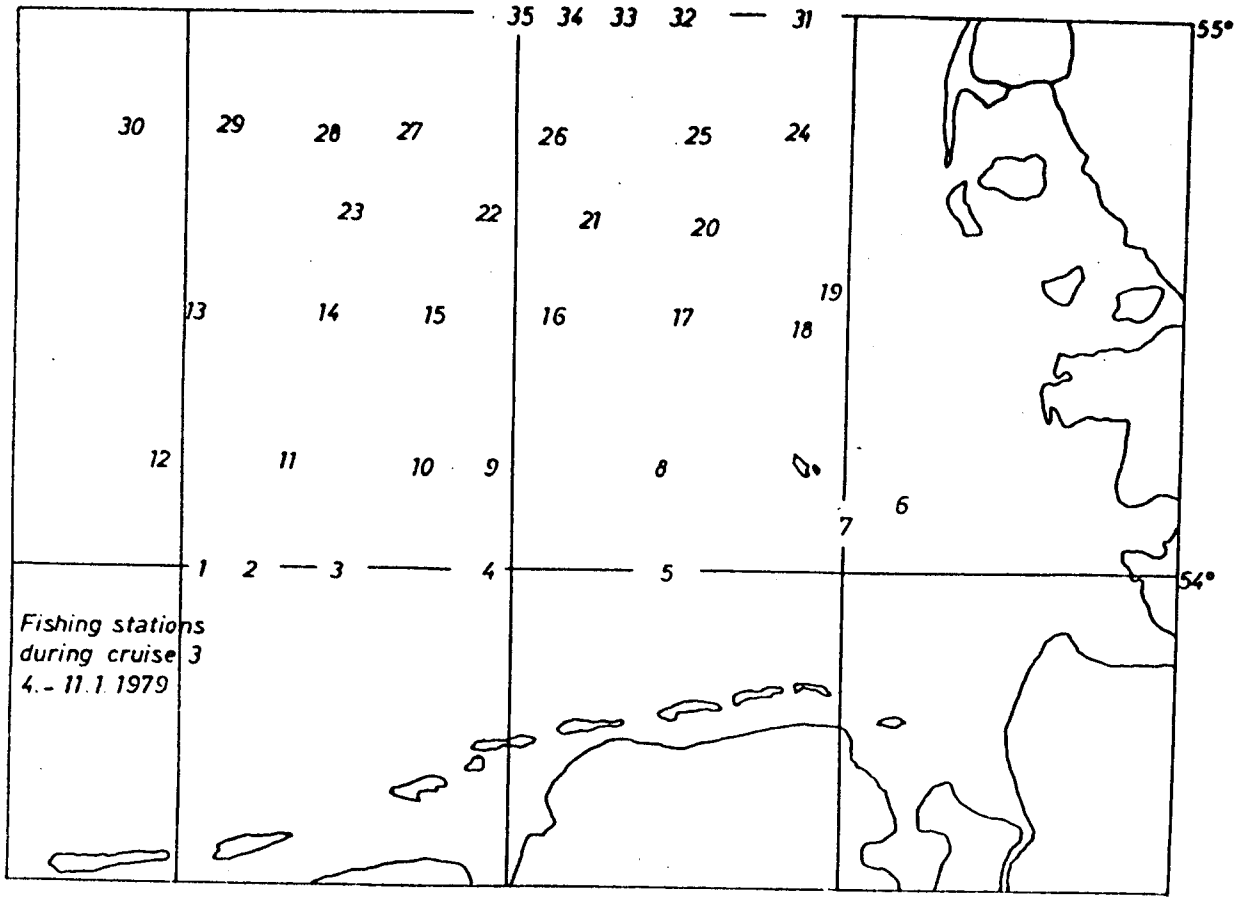

Figure 1

Fishing stations during cruise 3
4. - 11.1.1979

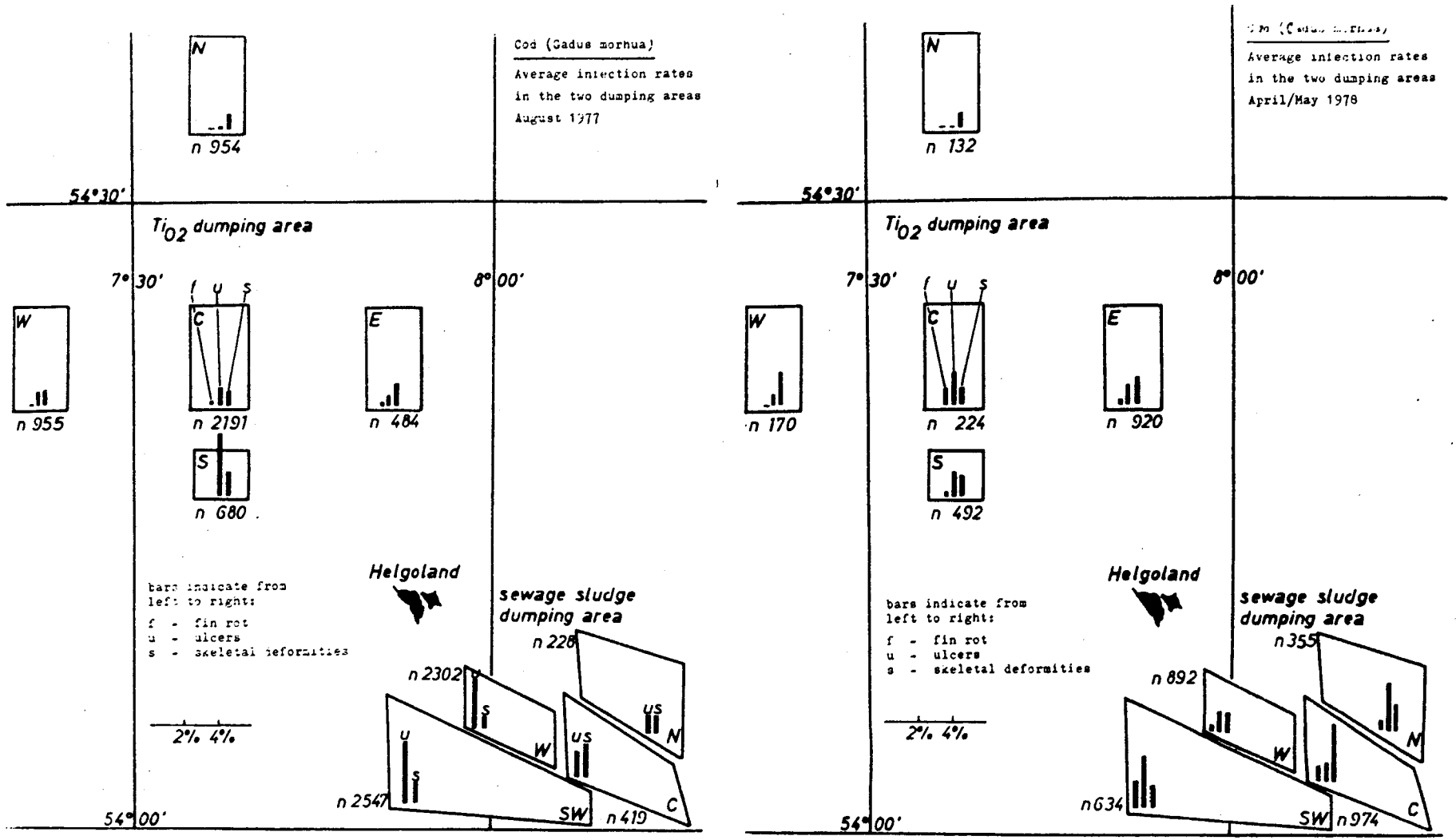

Figure 2

Infection rates and percentages of skeletal deformities of cod (Gadus morhua) in the centers of TiO_2 wastes and sewage sludge dumping areas as well as in comparison areas in August 1977 (left) and April/May 1978 (right).

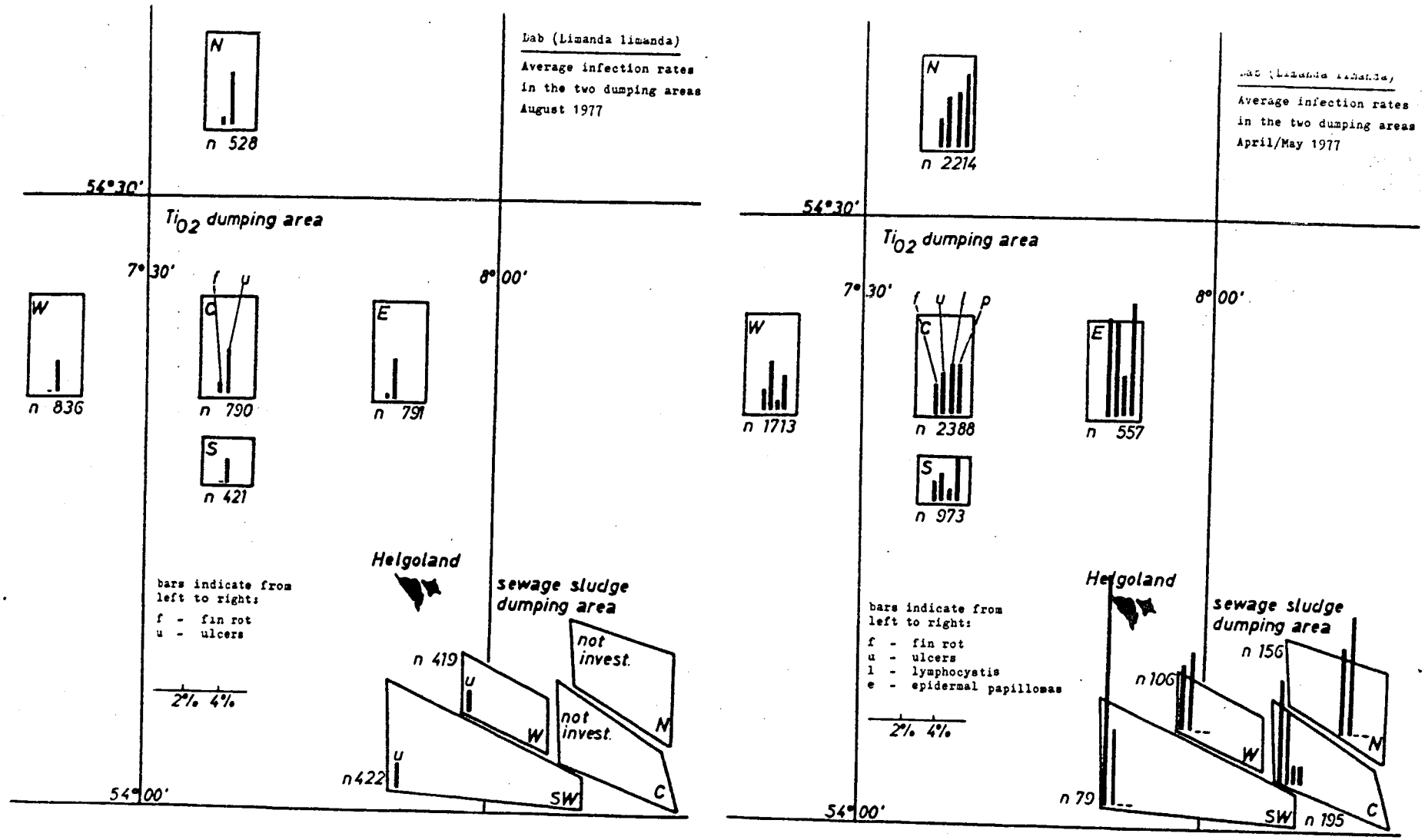

Figure 3

Infection rates of dab (Limanda limanda) in the centers of TiO_2 wastes and sewage sludge dumping areas as well as in comparison areas in August 1977 (left) and in April/May 1978 (right).

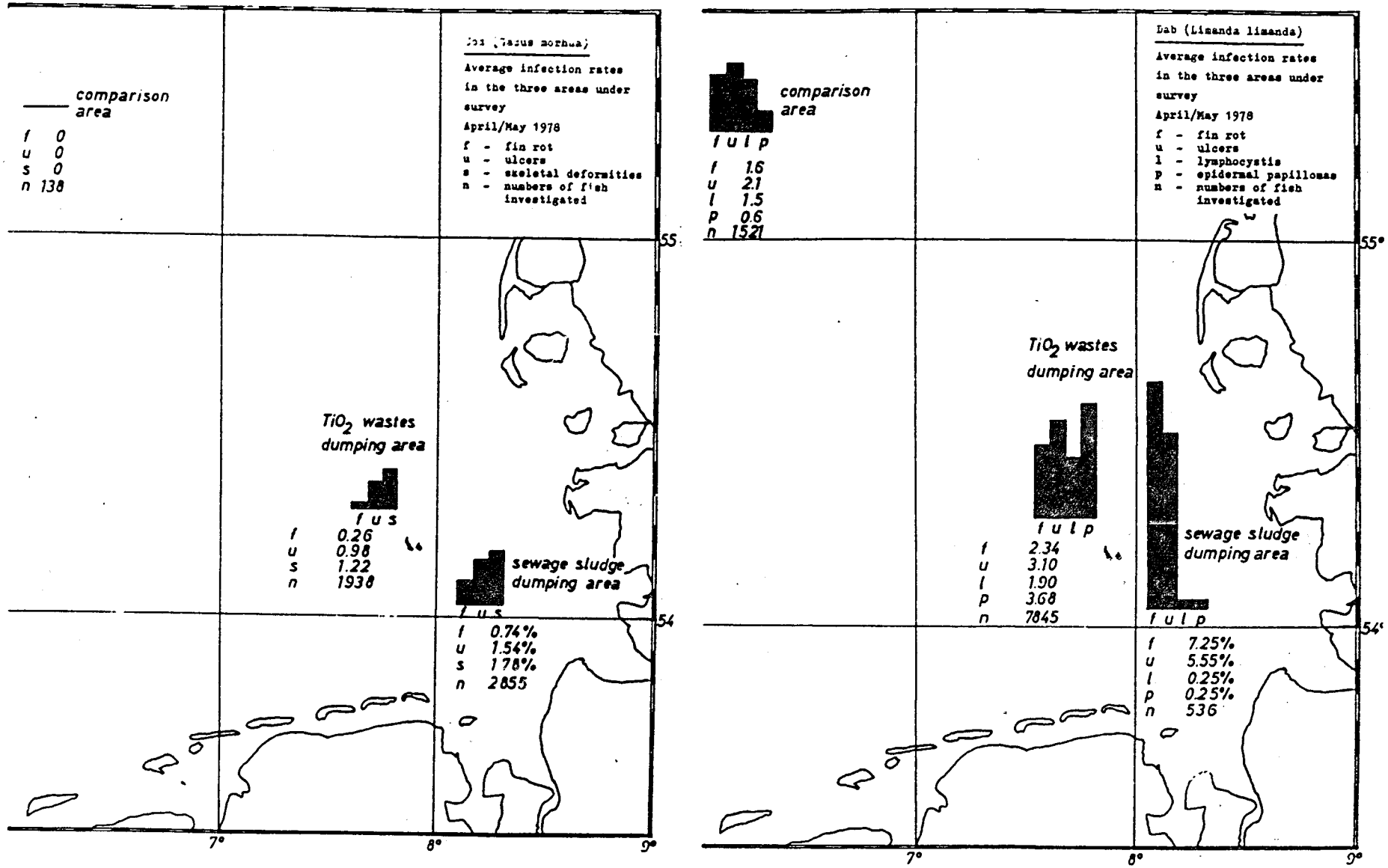

Figure 4

Average infection rates of cod (Gadus morhua) (left) and dab (Limanda limanda) (right) in the three areas under survey in April/May 1978.