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Ichthyophonus hoferi disease in the  
herring in Norwegian waters.

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**Abstract**

After the discovery of *I. hoferi* disease in Norwegian spring spawning herring in summer 1991, a program for systematic surveillance of the disease in the herring in Norwegian waters was developed. The programme, which aims primarily at monitoring the prevalence of the disease, is described. Macroscopic lesions in the heart emerged as the standard diagnostic criterium. The results so far indicate that the situation for Norwegian spring spawning herring is not alarming, although it still deserves attention. For the North Sea herring, the situation is less clear. The diseased herring seem to be less prone to follow normal schooling behavior, which causes sampling problems that must be taken into account when interpreting prevalence results.

## Introduction

*Ichthyophonus hoferi* is a well known pathogen on a wide range of fish species (McVicar 1982). In herring, it has caused several epizootics in the North-Western Atlantic (Sindermann 1965). Similar outbreaks of this disease have hitherto not been reported from the North-Eastern Atlantic and adjacent waters.

During a pair trawl survey in the Northern Norwegian Sea in July-August 1991, reduced condition and skin ulcerations were noted in a substantial fraction of the herring. It was soon confirmed that the herring was infected by *I. hoferi*.

This finding attracted attention and concern, since apparently a large fraction of the population in the area was infected, and in particular because the stock of Norwegian spring spawning herring is now recovering after a prolonged stock collapse. Therefore, a surveillance program was established, aiming primarily at evaluating the impact of the disease on the mortality in the stock. Once one became aware of the problem, it was also discovered that the disease was present in the North Sea, affecting both the North Sea and Baltic stocks. The surveillance therefore was designed to comprise all Norwegian waters.

## Surveillance programme

### Strategy

The strategy of the surveillance programme was to record the prevalence of the disease in a wide selection of samples, both from research surveys and from the commercial fishery. The intention was that this should give both the geographical and temporal distribution of the disease, and a measure of the prevalence in the whole population. To convert prevalence to mortality rate, it is necessary to know the time it takes from the diagnostic criteria are present until the fish dies. According to reports in the literature, a duration in the order of 3 - 6 months may be reasonable (Sindermann 1965), but such figures are poorly substantiated. Experiments to provide better data at this point are not planned within our surveillance programme. Instead, we have attempted to measure the stock acoustically, and evaluate the total mortality by the decrease in the number of fish in the stock.

### Diagnostics

Since the primary goal of the programme was surveillance of a possible epizootic, it was considered imperative to use standardized diagnostic criteria. Preferably, the diagnostic procedures should be easy to perform and the criteria should be easy to recognize, even for unexperienced people. Finally,

the diagnostic approach should have a high specificity, if necessary at the expense of the sensitivity.

According to descriptions in the literature (Laukner 1984), manifestations of the disease include reduced condition factor, ulcerations in the skin and granulomas in the subcutis, muscle and internal organs. To get background material for establishing diagnostic criteria, a standardized check-list was designed. As a standard, 50 fish were studied from each sample.

This procedure came into use in September 1991, and was used in its complete form until the end of the year. In addition, biopsies were also collected for microscopic examination on some occasions. A translated version of the form, and the accompanying instructions, are included in appendix 1.

In order to get the best possible coverage, the intention was to examine samples both from our own surveys and from the commercial fishery. The control of the commercial catches has been performed by the official quality control system. The fishery in Northern Norway has been covered quite well this way, while we only have had occasional samples from the purse seine fishery in the North Sea.

#### **Macroscopic manifestations.**

The results presented here are from a survey in the North Sea in October - November 1991, Thirty-four samples were studied, with 2 - 50 fish in each, totalling 682 fish. The lesions recorded are given in the text table below.

Heart only:	31
Heart + external manifestations:	2
Heart + internal organs:	84
Heart + ext. + int:	16
External lesions only:	5
Internal organs only:	17
No sign of disease:	529
Total	682

#### **Signs of *I. hoferi* disease in herring.**

'External manifestations' include reduced condition (judged subjectively by inspection only), and/or lesions in the skin. 'Internal organs' means lesions in at least one of the organs spleen, kidney or red muscle, or ascites.

Of the 155 individuals with some kind of lesion, 133 had granulomas in the heart, either alone or in combination with other lesions. Of those with heart lesions, a large fraction had manifestations from other internal organs. External

manifestations were far less common, and were most often found in combination with multiple organ manifestations. Lesions indicative of disease without heart affection were comparatively uncommon.

The general impression by the observers was that the heart lesions were easy to recognize, and they were rarely in doubt whether the heart was affected or not. Other organ manifestations were more difficult to evaluate. Searching for such lesions also was more cumbersome and time-consuming.

### Microscopic examination

During the same survey, spleens were collected for microscopic examination. During sampling, they were sorted as healthy or diseased. The material was stored frozen, and examined as native squash preparations after thawing. The results are shown in the text table below.

	Micro healthy	Micro diseased
Macro healthy:	147	21
Macro diseased:	9	51

These results indicate that macroscopic evaluation of the spleen lesions give a substantial fraction of false positives (15%). There are also some (12.5%) false negatives. These may also be due to misjudgement. Seemingly, the amount of spores was less in the macroscopically normal spleens, however, so these may represent an earlier stage of the disease.

From the present findings, it appears that the heart lesions is an early (but probably not always the first) macroscopic manifestation. Lesions in the inner organs also may occur quite early, but are more difficult to evaluate. The external signs seem to occur late in the course of the disease. Therefore, macroscopic lesions in the heart was adopted as the diagnostic criterium for our epidemiologic studies. This is also in accordance with the recommendation from the Special meeting on the *Ichthyophonus* problem in Lysekil in November 1991 (Anon. 1991)

### Representativeness of samples.

It soon turned out that there was great differences between prevalences in samples taken with different gears. The prevalence tended to be much higher in samples taken with trawl

or gill-net, than in samples from purse seine catches. It was suspected that diseased herring would tend to be scattered, instead of forming dense schools. This was later confirmed by trawling within and outside dense concentrations of Norwegian spring spawning herring in the wintering area in Ofoten. In the periphery of the dense concentrations, a prevalence of 2 - 24% was found. When trawling through the densest concentrations (with the codend open), prevalences of 1 - 2% were found. A detailed description of these observations is being prepared.

## Results

### Norwegian spring spawning herring (NSSH)

For this stock, there are data from both scientific surveys and commercial fishery. In the pair trawl survey in the Northern Norwegian Sea, where the disease was first noted, the weighted average catch was 174 individuals per haul, of which 44% were infected. The 1983 year class dominated the catches. Due to the gear used, these catches cover only the upper 15 metres of the water column. No acoustic measurements are available. Estimates of the population covered by the survey using the swept area approach depends on the effective width of the trawl, which was not measured. The distance between the wings is assumed to be approximately 20 fathoms, and the distance between the doors approximately 50 fathoms. Using these values, we arrive at total numbers of 460 and 180 million herring respectively, which represents 3-9% of the 1983 year class.

Throughout the autumn, a number of catches from the Lofoten - Vestfjorden area were controlled. In the earliest phase, before standardized diagnostic criteria were established, the general impression was that infected herring were rare or absent in purse seine catches, while more were found in gill net catches. In October-November, twelve purse seine catches were controlled in this area, having 0 - 6% diseased fish (weighted average 0.6%). In January 1992, eight purse seine catches from Tysfjord (see map in fig. 1) had a prevalence of 0 - 24% (weighted average 8.5%). It is likely that these are not representative of the densest concentrations of herring.

A survey covering the Norwegian fjords took place in November/December 1991 (Figure 1). Some infected herring were found near the wintering areas in the Ofotfjord and Tysfjord. In several other fjords, disease was found in 0-group herring. This was surprising, since the disease previously seemed to be confined to adult herring.

The herring in the Trondheimsfjord is a separate stock. Here, no disease was found during the fjord survey. Neither was any disease seen in 6 commercial purse seine catches from this fjord in the same period. Hence, hitherto, the disease has not

been observed in this local stock.

The wintering area in the Ofotfjord and Tysfjord is measured acoustically each year in early January. In later years, virtually the whole adult stock of NSSH has wintered in this restricted area. The conditions for acoustic measurement are usually very good. The results of the 1991 and 1992 surveys are shown in the text table below.

Year	Year-class=>	82+	83	84	85	86	87	88	89
1991		440	5500	150	180	20	70	220	90
1992		30	5290	140	580	70	290	930	460

Acoustic estimates of wintering herring in Ofotfjord and Tysfjord, in million individuals.

According to these results, there is no evidence of any dramatic reduction of the stock. It was also observed that when the herring started to migrate out of these fjords in mid January, the diseased herring lagged behind.

### North Sea herring

In this area, sampling has been largely from research vessel catches. The main sources have been the yearly acoustic surveys for herring in July, and some of the quarterly International Bottom Trawl Surveys (IBTS). Our data only cover our own part of these international cooperative surveys. In addition, occasional samples have been taken during other surveys in the area. Only a few commercial catches have been controlled.

The 1991 herring acoustic survey in July took place before the *I. hoferi* problem had been recognized. A number of samples that had been frozen at sea could however be analyzed. The results are presented in Figure 2, showing prevalences and acoustic abundance estimates by ICES rectangle. The results clearly indicate that the disease was present in the North Sea at that time - without having been recognized. The samples with high prevalence were scattered with no definite geographical pattern. These catches were mainly taken with pelagic trawl close to the surface, mostly without aiming at definite schools. Based on vertebrae counts, approximately 15% of the biomass measured was estimated to belong to Baltic spring spawners, mainly from the eastern part of the area. Somewhat less than 10% was assumed to be Norwegian Spring spawners, mainly from the northern part of the area. The available data do not permit allocation of each infected individual to specific stocks.

The results of the IBTS survey in October-November 1992 is shown in Figure 3. The observations south of 57° N were made during another survey immediately after the IBTS, no acoustic data are available from this part. The results indicate that the diseased fish were concentrated in the northern part (stratum I in Fig. 3), while lower prevalences were found to the South - East of Shetland (stratum II in Fig. 3). Further south, virtually no diseased herring was found. Very little of the herring appeared in schools, as judged by the echograms. The sample prevalences may therefore be quite representative of the population prevalence in this case. Assuming this, it is estimated that 710 million herring were diseased north of 57° N, out of a total estimated population of 4008 millions in the same area. For comparison, the VPA estimate for 2 years and older for the North Sea and Skagerrak was 9492 millions at the end of 1991 (Anon 1992). The number estimated as diseased in the restricted area covered by the survey represents 7.5% of this stock estimate.

During the IBTS in January-February 1992, 10 samples of adult herring were available. The pattern was quite similar to that in oct-nov 1991, with high prevalences to the east of Shetland. No acoustic estimates were made.

Preliminary data from the acoustic herring survey in July 1992 are shown in fig. 3. Again, the high prevalences are scattered, perhaps with a trend increasing towards the north. The areas near Shetland were not covered by this survey. No attempt has been made to estimate the total number of diseased individuals. It is clear, however, that the infection by no means has disappeared from the population.

### **Conclusions.**

It is not clear whether we now are confronted with an epizootic of limited duration, or have just become aware of a more permanent phenomenon.

Evaluation of the state of the disease in the stock is severely hampered by the sampling problems. There is no simple solution to this problem. Our recipe at present is to obtain samples together with acoustic registrations. To be useful, such observations must include both the schooling behaviour of the herring that is actually caught, and an evaluation of the fraction of the population in the area having that type of behaviour. An additional problem is then that herring that are scattered near the surface are difficult to recognize acoustically. Another consequence of the sampling problem is that, if the control is concentrated on commercial catches, in particular those taken with purse seine, there is a risk of underestimating the severity of the epizootic.

For the Norwegian spring spawning herring, the independent

stock estimates do not indicate a sudden increase in the mortality. Our attitude therefore is that the situation at present is not alarming, but certainly deserves further attention.

For the North Sea herring, the situation is less clear, partly because our observations cover only part of the distribution area for this stock. It may seem that during winter, there is an area of high prevalence near Shetland. Since *I. hoferi* disease is known to be a problem also in other species in this area (McVicar 1982), one may speculate if this area represents a focus for exchange of the agent between species.

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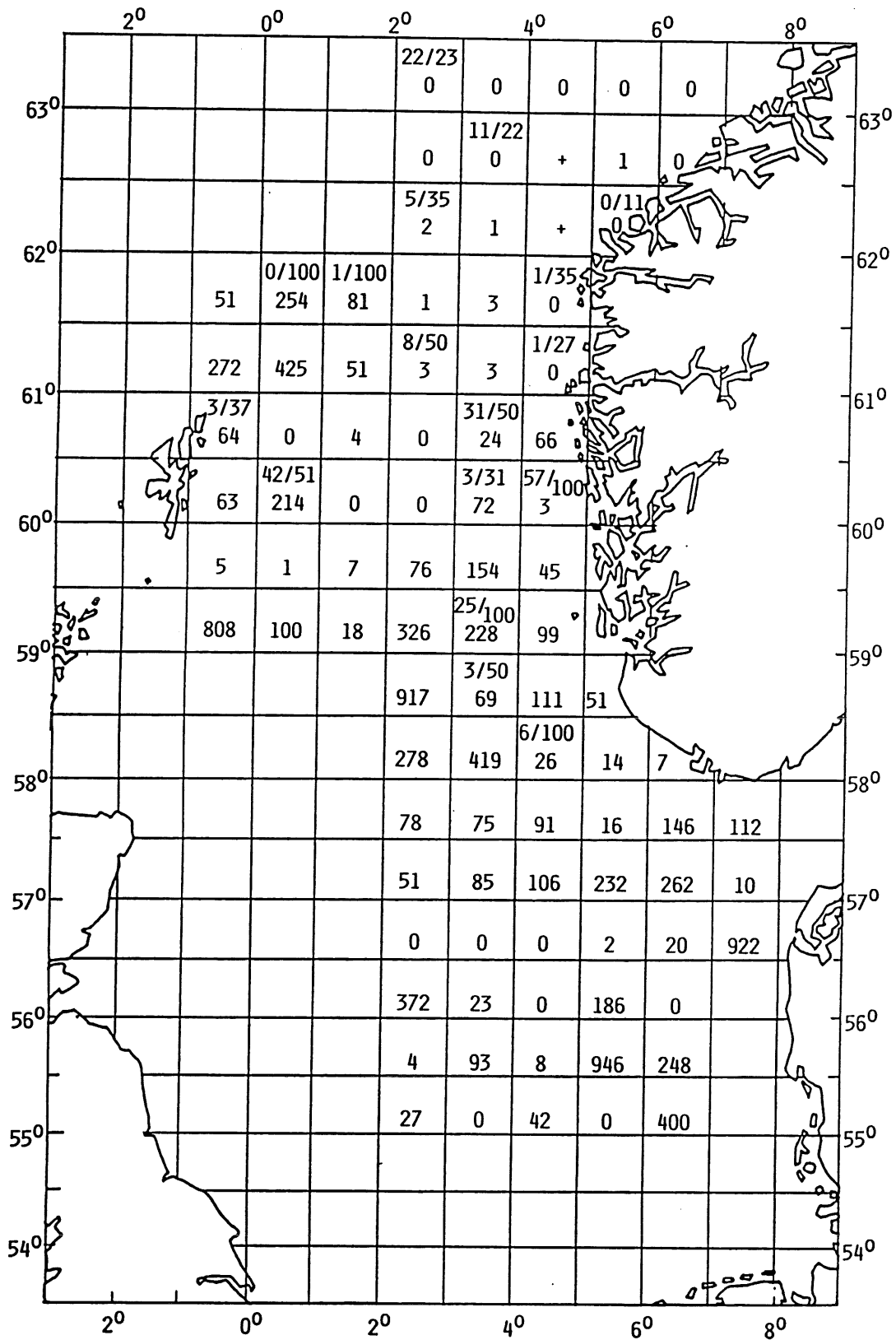


Figure 2.

R/V 'Johan Hjort' July 1991.  
 Prevalence of *I. hoferi* infection (number diseased/number investigated) and acoustic abundance estimate (millions of individuals) of herring by ICES rectangle.

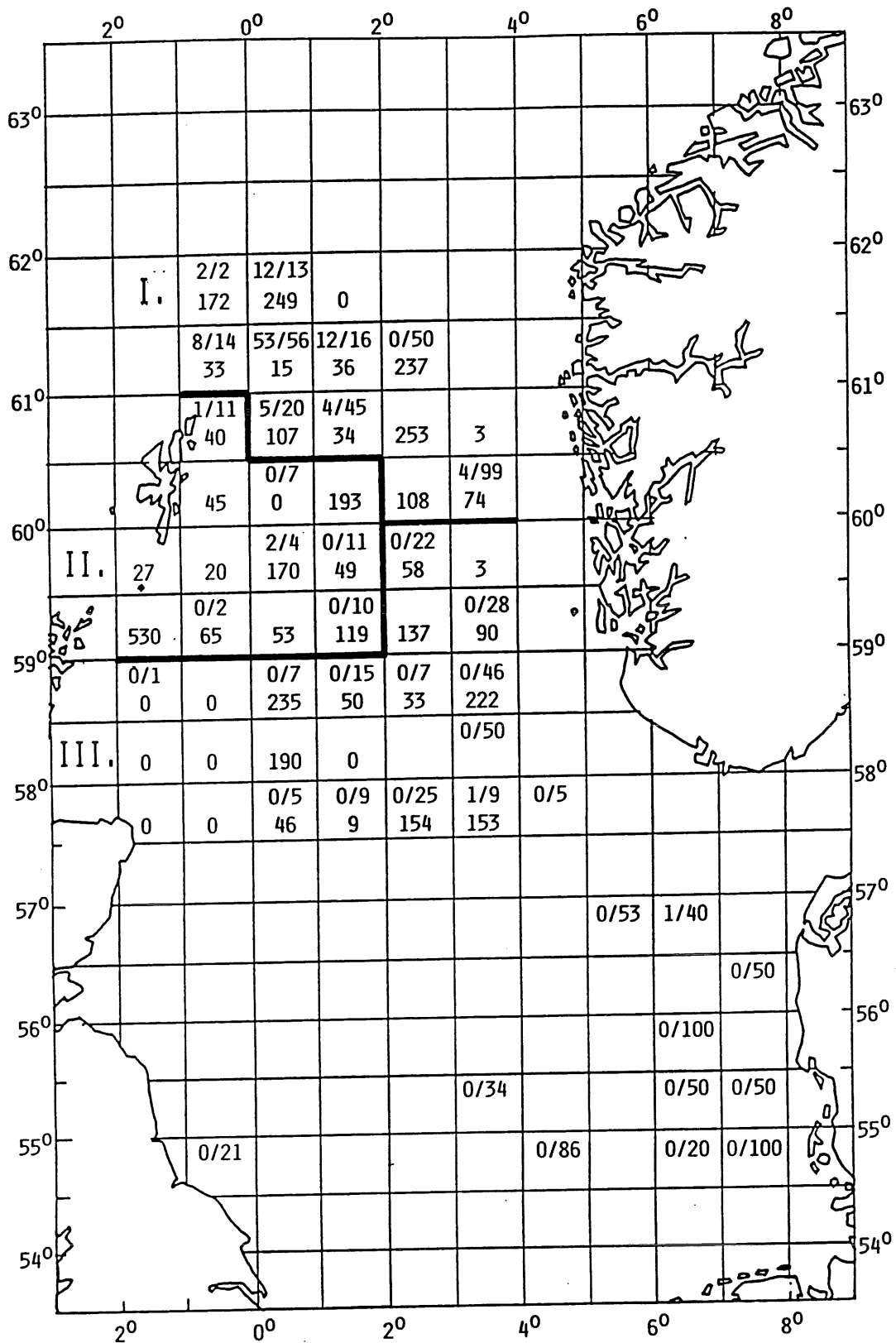


Figure 3.

R/V 'G.O.Sars' October/November 1991.  
 Prevalence of *I. hoferi* infection (number diseased/number investigated) and acoustic abundance estimate (millions of individuals) of herring by ICES rectangle.

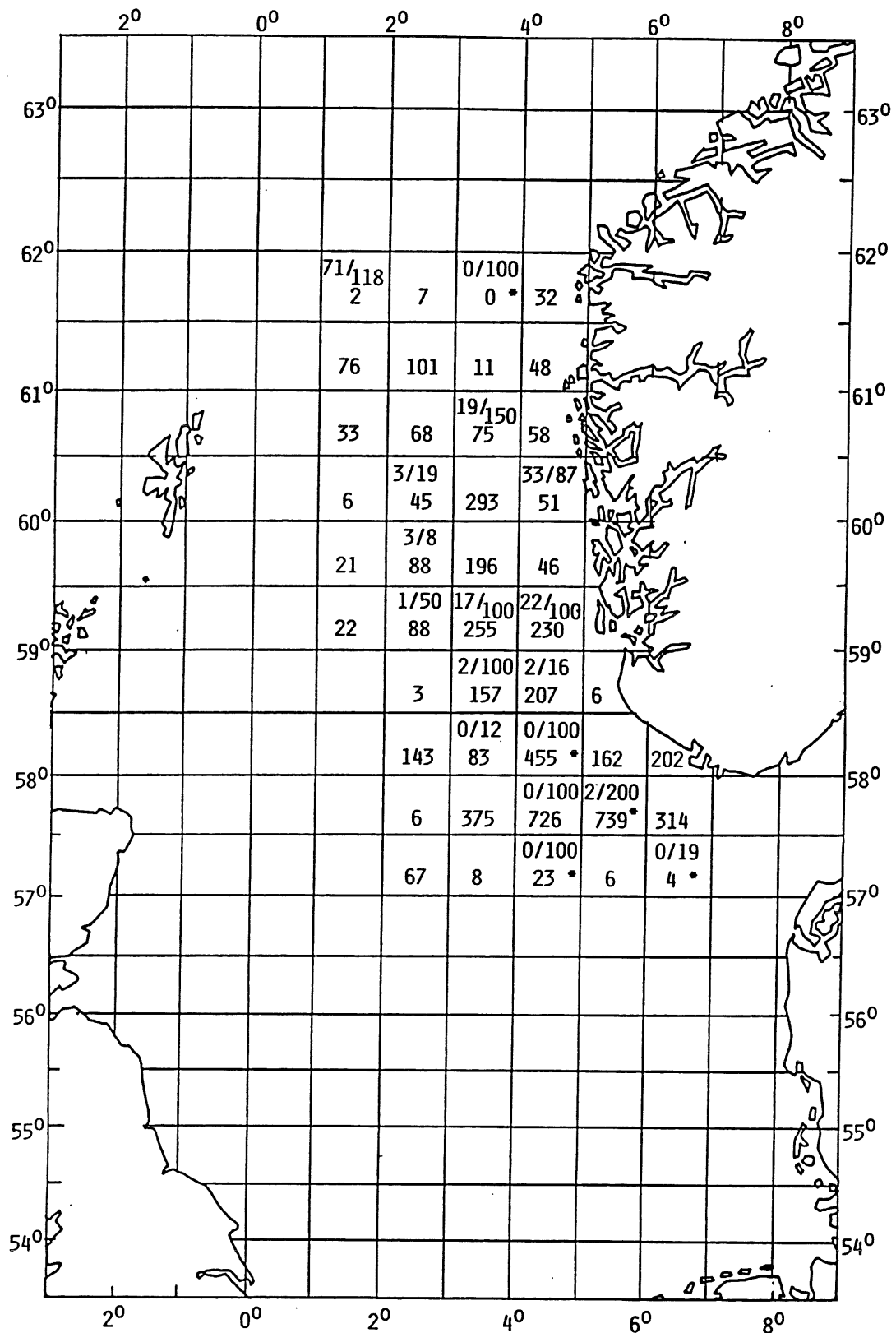


Figure 4.

R/V 'Johan Hjort' July 1992.

Prevalence of *I. hoferi* infection (number diseased/number investigated) and acoustic abundance estimate (millions of individuals) of herring by ICES rectangle.

Procedure for investigating herring for I. hoferi disease

Pick 50 individuals randomly from the catch. Each fish is investigated according to the procedure below. Lesions which are believed to be caused by I. hoferi are graded according to the main rule:

- 0: No lesions
- 1: Moderate lesions
- 2: Severe lesions
- : Not investigated

1. The first impression of the condition is graded as follows:

- 0: Normal
  - 1: Slightly below normal
  - 2: Clearly below normal
- Then, the fish is measured and weighed.

2. External lesions:

Note ulcerations/bleedings in the skin. These can vary from small bleedings (1-2 mm) to large ulcerations in the skin. The lesions appear most typically in the tail part.

- 0: No visible external ulcerations/bleedings.
- 1: A few ulcerations/bleedings
- 2: Larger lesions, open ulcerations.

3. Break the neck to expose the heart. Remove the pericardium. Check the heart for white nodules.

- 0: No visible changes
- 1: A few, single nodules
- 2: Many white nodules.

If there is no sign of disease by the investigation so far, the rest can be skipped.\*

4: Subcutis/ muscle.

Make a slice just beneath the surface towards the root of the tail. Note formation of pus beneath the skin and nodules in the muscle.

- 0: No nodules or pus.
- 1: A few nodules and/or a little pus.
- 2: Many nodules and/or abundant pus.

5: Open the belly, note accumulation of fluid in the cavity. The fluid can vary in colour from yellowish to pink.

- 0: No fluid
- 1: A little fluid
- 2: Abundant fluid

6: Look for changes in the spleen and kidney. Note white nodules in these organs.

- 0: No visible lesions
- 1: A few white nodules
- 2: Many white nodules.

7: Other observations/ comments.

If changes are observed in other organs, or other abnormalities are found, this is noted in the column 'other organs'. If disease is found by further control of the rest of the catch, this should be noted under 'comments'.

