DANISH MARINE MONITORING METHODS AND DATA

PART I

Σ DDT, DIELDRIN, PCB AND MERCURY IN FISH FROM MARINE AREAS, 1968-1976

MARCH 1977.

NATIONAL AGENCY OF ENVIRONMENTAL PROTECTION
KAMPMANNSGADE 1. DK-1604 COPENHAGEN V.
DENMARK

DANISH MARINE MONITORING METHODS AND DATA

PART I
Σ DDT, DIELDRIN, PCB AND MERCURY IN FISH FROM MARINE AREAS, 1968-1976

MARCH 1977.

NATIONAL AGENCY OF ENVIRONMENTAL PROTECTION
KAMPMANNSGADE 1. DK-1604 COPENHAGEN V.
DENMARK

DANISH MARINE MONITORING

METHODS AND DATA

PART I

Σ DDT, Dieldrin, PCB and Mercury in Fish from Marine Areas, 1968-1976

Compiled

for

The National Agency of Environmental Protection

THE WATER QUALITY INSTITUTE, ATV
11, Agern Alle
DK 2970 Hørsholm

THE DANISH ISOTOPE CENTRE, ATV
2, Skelbækgade
DK 1717 Copenhagen V.

February 1977

GK
1977-o2-1o

TABLE OF CONTENTS

PREFACE

This report is the first in a series aiming at giving a record of the marine monitoring activities carried out by Danish institutes in order to establish the state of pollution of the coastal and open waters around Denmark.

Denmark participates in a number of intergovernmental and other international activities devoted to the prevention of marine pollution. An exchange of information on the monitoring activities of the participating nations is common to all of these activities, even if there are discrepancies between the details to be reported. By reporting as fully as possible methods and data for significant monitoring activities that have been carried out, this series of compilations aims at fulfilling in a unified way the various obligations to inform the different international bodies concerned.

This first report deals with determinations of substances to which high priority is given: a number of chlorinated hydrocarbons and mercury. Time series covering a number of years of determinations of these substances in fish from different areas of the sea are given.

Later reports will deal also with investigations of the spatial distribution of selected pollutants carried out for specified periods only, covering determinations in water, sediments, benthic flora and fauna, fish, birds and mammals.

This series of reports will not deal with radioactive fall out products, hygienic beach properties (Escherichia coli) and more common hydrographic properties. Regular activities covering these fields have been carried out for many years. They are reported elsewhere /1/, /2/, /3/.

C H A P T E R 1

Σ DDT, DIELDRIN AND PCB IN HERRING, FLOUNDER, COD AND COD LIVER FROM THE BALTIC, THE SOUND, THE KATTEGAT, AND THE NORTH SEA, 1969-1975.

1.1 INTRODUCTION

In 1969 the National Food Institute, Division of Pesticides, and the Municipal Food Inspection Service of Århus initiated a study of the content of DDT and its metabolites in fish used for consumption in Denmark.
It was planned for a period of two years to analyse monthly samples of plaice, herring, cod, mackerel and salmon from the Baltic, the Kattegat, and the North Sea. The sampling plan further included eel and trout from unspecified bodies of fresh water. During the spring of 1971 analyses were made on samples of cod livers from cod caught in the Baltic , the Belts, the Kattegat and the North Sea. Results of the investigations in 1969-1971 were published in 1973 /4/.

In 1973 the National Food Institute,Division of Pesticides continued the investigations of DDT in fish for consumption in Denmark. The investigation was restricted to herring, flounder, cod and cod liver. Besides Σ DDT, the content of dieldrin, lindan and PCB (polychlorinated biphenyls) was analysed. It was planned to analyse monthly samples from the Baltic, the Sound, the Kattegat, and the North Sea for a period of five years (1973-1978), after the termination of which a final and evaluating report is anticipated. Preliminary distribution tables from 1973 are allready published /5/, and similar summaries from 1974 and 1975 are under preparation. The results reported

here comprise all individual results from these periods and they are brought with kind permission from the National Food Institute.

The unpublished results have not been scrutinized by the National Food Institute. In a final publication there may, therefore, be deviations from the values and statements given here due to further evaluation of the material.

Acknowledgement:

Sincere thanks are expressed to Mr. F. Bro-Rasmussen and Mr. K. Voldum-Clausen, the National Food Institute for placing unpublished results at our disposal and for assisting in the preparation of the present compilation. It should be pointed out that the results are not for publication without prior reference to the National Food Institute.

1.2 MATERIALS AND METHODS

Sampling

By agreement with the Ministry of Fisheries monthly samples were collected by the fisheries control stations in Neksø (the Baltic), Århus (the Kattegat) and Esbjerg (the North Sea) in 1969-1971, and Neksø, Copenhagen (the Sound) Grenå (the Kattegat) and Hvide Sande (the North Sea) from 1973. The greater part of the fish was caught by commercial fishermen within a distance of about 20 nautical miles from these control stations, while the rest was caught within 100 nautical miles (Appendix 1).

Preparation of samples

At the control station samples of at least 500 g wet weight of each species were prepared in the following way:
The fish were gutted, weighed and measured (total length). In 1969-1971 fillets of all the fish in the sample were prepared, divided into two subsamples and packed in aluminium foil. The subsamples were sent under ice to the participating laboratories with information, including the place and date of catch. In 1973 and later on fish were received in a gutted state, and the fillets were prepared at the National Food Institute. The samples were stored at $-20^{\circ}C$ until analysis.

In 1969-1971 all samples were analysed at the Municipal Food Inspection Service of Århus, and one third of the samples, randomly selected, was analysed also at the National Food Institute to verify the results. From 1973 all samples were analysed at the National Food Institute.

Besides analyses for chlorinated insecticides and PCB, the fish material from 1973 was analysed for selected heavy metals /6/.

Methods of analysis

In 1969-1971 the samples were analysed for DDT in the following way:

After disintegrating and grinding with sand and anhydrous sodium sulphate, the samples were extracted with petroleum-ether in a Soxhlet extractor. Clean up and gas chromatographic analysis followed the method described for determination of chlorinated insecticides in butterfat etc. (Zeitschrift für Lebensmittel-Untersuchung und -Forschung 138. p.276, 1968). Each analysis was performed in duplicate and included a determination of total fat content by evaporation of extracts for constant weight at 40-60°C. The detection limit for each DDT-component was 0.01 ppm, and for total DDT equivalents 0.03 ppm.

During the preliminary test of the method, and during analysis of regular samples in the first months of the study, some difficulties were encountered in achieving identical results in the two laboratories. A collaborative study of the method revealed that this was mainly due to different extraction rates in the Soxhlet extraction. For this reason only results for samples taken after 1 September 1969 are published /4/.

During the analysis of fish samples it was recognized that the fish often contained PCBs in varying amounts. At the time of this observation the participating laboratories were not able to determine separately chlori-

nated insecticides and PCBs. It was also recognized, that the presence of PCBs did interfere with DDT-determination resulting in some overestimating of results. In spite of this it was considered more important to evaluate the order of magnitude and possible maximum contents of DDT rather than wait for the development of analytical methods for separate determination of PCB and DDT.

From 1973 the samples were analysed for residues of organochlorine pesticides and PCB in the following way:

As in 1969-1971 each sample consists of a minimum of 500 g. The fillets (livers) or representative parts are homogenized, and 10 g of homogenized sample, mixed with sand and sodium sulphate, anhydrous, are extracted with petroleumether. The extract is cleaned up by liquid-liquid partitioning with dimethylformamide/petroleumether and column chromatography on alumina. PCB and p.p'-DDE are separated from dieldrin, p,p'-DDD and p,p'-DDT by column chromatography on silicagel. The gaschromatography is performed on a gaschromatograph with EC-detector and an OV 17-column. Arochlor 1260 has been used as standard substance for determination of PCB.

The procedure for extraction and clean up is a modification of the procedure of M.J. De Faubert Maunder, H. Egan, E.W. Godby, E.W. Hammond, J. Roburn and J. Thomson, (Analyst 89, 168 (1964). The procedure for separation and determination of pesticides and PCB is a modification of procedure of C.B. Collins, C.C. Holmes and F.J. Jackson (J. of Chromatography 71, 443 (1972).

1.3 RESULTS

Σ DDT

The contents of Σ DDT in all the samples that were analysed are listed in Appendix 11-20 expressed in ppm on the basis of the raw weight of the fillets or the cod livers.

In evaluating the results from 1969-1971 it should be taken into consideration, that PCB may be included in the Σ DDT determinations which may have caused an overestimation of the Σ DDT content. In 1971 it became possible to make separate determinations of PCB,and a few samples were analysed again. Generally it was not possible to assess the degree of the overestimation of Σ DDT, but in a few samples it was about 20-30% /4/.

Herring

The contents of Σ DDT in herring in 1969-1971 and 1973-1975 are shown in Appendix 2.

For the whole of the period the highest content is found in fish from the Baltic and the lowest in fish from the North Sea. Fish caught in the Kattegat have intermediate levels of DDT, and the same seems to be true of the few samples of fish analysed from the Sound.

Flounder

The contents of Σ DDT in flounder in 1973-1975 are listed in Appendix 3. The content of Σ DDT in flounder is about ten times less than in herrings in all areas.

As in herring the highest content is found in fish from the Baltic. A considerably lower level of Σ DDT is found in the Sound and in the Kattegat. In the North Sea the content of Σ DDT is below the detection limit in more than half of the samples analysed.

Cod

The contents of Σ DDT in cod fillets are listed in Appendix 16-19.

Generally the content of Σ DDT in cod fillets is lower than in flounders. In most of the samples from the Baltic the content of Σ DDT is above the detection limit in the whole period from 1969-1971 and 1973-1975. In the period 1969-1971 most of the samples from the Kattegat and from the North Sea have Σ DDT content around the detection limit (0.03 ppm), but in 1973, 1974 and 1975 the Σ DDT content was not detectable except in a very few samples from the Kattegat. In the same period Σ DDT was detected in 20% of the samples analysed from the Sound.

Cod liver

The contents of Σ DDT in cod liver are shown in Appendix 4.

The content of Σ DDT is high, and compared to the content in cod fillets the ratio is 500-1000. By far the highest content of Σ DDT is found in samples from the Baltic, where most of the values are around 10-20 ppm. The contents decrease from the Baltic to the North Sea.

Dieldrin

The contents of dieldrin in all samples analysed in the period 1973-1975 are listed in Appendix 21-24. The detection limit is 0.01 ppm.

Herring

The contents of dieldrin in herring are shown in Appendix 5.

Generally the highest content is found in samples from the Baltic, where most of the values are higher than 0.02 ppm. The level of dieldrin in the Baltic is about 20-30 times less than the level of Σ DDT.

The small number of samples from the Sound makes it impossible to detect the level, but in the Kattegat and in the North Sea most of the values are scattered around a level of 0.02 ppm.

Flounder

The contents of dieldrin in flounder are listed in Appendix 22.

A total of 138 samples was analysed in the four catching areas, and only in three samples from the Baltic and in three samples from the Sound the content of dieldrin was above detection limit.

Cod

The contents of dieldrin in cod are listed in Appendix 23.

A total of 114 samples was analysed in the four catching areas, and the content of dieldrin was below detection limit in all samples.

Cod liver

The contents of dieldrin in cod liver are shown in Appendix 6.

Generally the highest content is found in samples from the Baltic, where the content of dieldrin is about 50 times less than Σ DDT in cod liver. In contrast to the Σ DDT content no decreasing tendency is found in the dieldrin content from the Sound to the North Sea. In the North Sea the dieldrin content is only about four times less than the Σ DDT content in cod liver, and especially in 1975 the values found were as high as in the Baltic.

PCB

The contents of PCB in all samples analysed in the period 1973-1975 are listed in Appendix 25-28. The detection limit is 0.03 ppm.

Herring

The contents of PCB in herring are shown in Appendix 7.

The highest content of PCB is found in samples from the Baltic. The few samples from the Sound indicate a level between those of the Baltic and the Kattegat. The North Sea level seems to be slightly lower.

Flounder

The contents of PCB in flounder are shown in Appendix 8.

For the samples from the Baltic and the Sound there are great variations in the content of PCB in relation to the catching time. Maximum values around 0.2 ppm are recorded. Samples from the Kattegat and the North Sea show minor variations below the level of 0.1 ppm. In these areas the content of PCB in about one third of the samples are below detection limit.

Cod

The contents of PCB in cod are shown in Appendix 9.

In the Baltic and in the Sound about 1/3 of the samples analysed have a PCB content above detection limit, and about 1/4 in the Kattegat and 1/5 in the North Sea.

Cod liver

The contents of PCB in cod liver are shown in Appendix 10.

In most of the samples from the Baltic the PCB content ranges between 4-10 ppm. The same is true in the Sound, but the variations are greater, and smaller values are found. The variations in PCB content are also great in the Kattegat and the North Sea, but generally around a lower level.

1.4. REFERENCES

/1/ AARKROG, A. & LIPPERT, J.: Environmental Radioactivity in Denmark in 1975.
Research Establishment Risø, June, 1976.

/2/ Badevand og Strandkvalitet 1976
En oversigt fra Miljøministeriet.

/3/ Kemiske og Biologiske Undersøgelser
Miljøstyrelsen, Bæltprojektet 1976.

/4/ Publikation nr. 18 fra Statens Levnedsmiddelinstitut, marts 1973: Undersøgelse over DDT i danske konsumfisk, 1969-1971. (DDT content in edible Danish Fish. English summary pp. 16-20).

/5/ Publikation nr. 27 fra Statens Levnedsmiddelinstitut, august 1975: Rapport over pesticidrester i danske levnedsmidler 1973-1974.
(Pesticide residue in Danish food).

/6/ Publikation nr. 33 fra Statens Levnedsmiddelinstitut, december 1976: Rapport over tungmetaller i fisk 1973-1975.

CHAPTER 2

MERCURY IN FISH FROM MARINE AREAS, 1968-1976

2.1 INTRODUCTION

A great number of fish from different marine areas, both nearshore waters and the open sea, have been analysed during the period 1968-1976.

The results of the analyses are reported by

1. The Danish Isotope Centre /1/ and /2/
2. The National Food Institute /3/

The present report has been worked out in order to evaluate such data from these reports as are fit for monitoring purposes.

A graphic survey of data on the following species of fish are given:

flounder
plaice
cod
herring

2.2 BACKGROUND

Background information concerning the abovementioned data-reports is given below.

The Danish Isotope Centre /1/ and /2/

These reports present data on mercury concentrations in approximately 1450 fish samples analysed between 1968 and 1976.

The investigations were mainly carried out for the National Health Service of Denmark, the Ministry of Fisheries and local authorities.

Data are presented in tables referring to:

Open sea
Fjords and Bays
Fresh water

The parameters in these tables are:

Species, weight, length, date of catching, sex, age, area and locality of catching, and mercury concentration in muscle expressed as ng Hg per gram of wet weight (1 ng = 1 nanogram = 10^{-9} gram).

Plots of mercury concentration versus fish weight are shown for a number of fish species. For unpolluted areas a linear relationship between fish weight and mercury concentration has been found for a number of species, and the straight lines resulting from linear regression have been drawn.

National Food Institute /3/

As part of current studies of the normal contents of certain heavy metals in food at the National Food Institute, a study has been made of the contents of mercury, lead, cadmium, copper and zinc in flounders, cods and herrings.

The fish which are the normal size for consumption, are caught in the open sea in the Baltic, the Sound, the Kattegat and the North Sea.

In addition flounders from the coastal waters of Sjælland have been analysed.

The investigations were carried out during the period 1973-1975.

In each investigation a number of fish has been pooled into a single sample so the number of analysed samples have been:

Open sea: 120 samples (274 fish)
Coastal waters of Sjælland: 87 samples (430 fish)

A homogenate of whole fillets from each fish in the sample (1-12) has been analysed and thereby giving weighted mean values.

In the case of fish from the open sea the fish weights in a gutted state are reported.

Fish from coastal waters of Sjælland have been weighed in an ungutted state.

Concerning mercury, data are presented in tables including:

Area of catching
number of samples in catching area
total number of fish
geometric mean, 95% range of confidence *)
and total range of mg Hg per kg wet weight
arithmetric mean and range of fish weight

*) The geometric mean is the n'th root of the product of n numbers. With 95 % probability the values will be within the confidence interval of the mean value.

In case of samples from the coastal waters of Sjælland, the results for every sample are shown on a map, too.

2.3 METHODS OF SAMPLING AND ANALYSIS

The Danish Isotope Centre

The fish samples were frozen immediately after landing and forwarded to the laboratory.

The determination of mercury was performed by neutron activation analysis according to SJÖSTRAND /6/.

Approximately 0.3 g was cut out of the muscle of the back (without skin) and transferred to a quartz vial.

After irradiation by neutrons in a nuclear reactor, the sample and a known standard were wet-ashed in conc. HNO_3 and conc. H_2SO_4. Mercury was separated by destillation and subsequent electrolysis and gammacounting performed on a multichannelanalyser.

Limit of detection 0.1 - 0.3 ng Hg
approx. 1 ng/g

The standard deviation, from inhomogenity of the sample and analytical error is less than 10 %.

Where samples were pooled 1 g of the muscle of the back from each fish was pooled and homogenized and a 0.3 g subsample of the mixture analysed. These samples are in the following called arithmetic mean samples. Each individual fish forming part of the pooled sample participates with equal weight in the result, because equal weights(1 gram) of each fish go into the pooled sample.

The National Food Institute

All samples were frozen shortly after landing and forwarded to the laboratory.

As previously stated the fillets of all fish of the same species taken simultaneously in the same position were pooled and homogenized and analysed as a single sample. These samples are in the following called weighted mean samples. As whole fillets with <u>different</u> weights are pooled, the mercury concentration of a large fish will influence the pooled sample more than the mercury concentration of a small fish. Generally, the mercury concentration increases with weight. Therefore, a weighted

mean sample will generally have a higher mercury concentration than an arithmetic mean sample of the identical fish. A method for correction of this discrepancy is described in Appendix 29.

Samples of 0.5 g of fillet were analysed.

The determination of mercury was carried out according to Method Description F.73008, National Food Institute.

The sample was wet-ashed for 24 hours at 60°C with H_2SO_4, HNO_3 and $KMnO_4$. After reduction of excessive permanganate with hydroxylamine, the mercury was reduced to the elementary state with $SnCl_2$ and measured by flameless atomic absorption spectrometry with D_2-background correction.

The variance s^2_{tot} for the whole analytical procedure depends on the concentration level, C, according to the following expression:

$$s^2_{tot} = (12 \text{ ng/g})^2 + (0.010 \cdot C \text{ ng/g})^2$$

Consequently, the detection limit at 95% significance level is 25 ng Hg/g.

Intercalibration

An intercalibration of the two methods of analysis was performed in october 1972 on samples of flounders.

Sample no.	Danish Isotope Centre ng Hg/g	National Food Institute ng Hg/g
S2	298	287
S3	463	504
S4	320	273
S11	125	127
S12	104	133
S13	117	142

A comparison between the results of the two methods indicates no systematic deviation, however it should be noticed that the concentration level is higher than 100 ng/g, and at this level the two methods have nearly the same standard deviation, while, the Danish Isotope Centre results have a smaller standard deviation than the National Food Institute results for contents below 100 ng/g.

2.4 CONSISTENCY OF DATA

Concerning the mercury concentrations and the fish weights there is a lack of consistency between data presented by the Danish Isotope Centre and data presented by the National Food Institute.

This is pointed out in the scheme below

	National Food Institute	Danish Isotope Centre
Mercury concentration	Geometric mean of weighted mean values for a number of fish is reported	Values for a single fish or arithmetic mean for a number of fish is reported
Weight	Arithmetic mean of total weight or weight in a gutted state is reported	Total weight for a single fish or arithmetic mean for a number of fish is reported

For a given species of fish from a given locality the mercury concentration increases linearly with weight.

By averaging Hg-concentrations for fish with different weight, the weight dependance of the Hg-concentrations is not considered. This increases the uncertainty of the results and thus decreases the sensitivity for detection of variations of the concentration in space and time.

Therefore, data on mercury concentration in fish should be given for individuals rather than for groups of fish for monitoring purposes.

For some of the fishes, unfortunately only the results of the mercury analysis (weighted mean value for a number of fish) the mean weight, and the standard deviation of weight for each sample were available from the National Food Institute, but the figures were made comparable to the values of single fish in the weight-concentration diagrams by a mathematical transformation. The theoretical background for this transformation is given in appendix 29.

It has only been necessary to transform National Food Institute data on flounders and herrings in the outlined way since nearly all samples of cod include only one fish.

Maximum corrections for the two species are:

flounders: 0.32 mg Hg/kg corrected to 0.28 mg Hg/kg
Herrings: 0.25 mg Hg/kg corrected to 0.18 mg Hg/kg

As previously stated, fish from the open sea have been weighed in a gutted state.

By experience the weight of the different fishes in gutted state in percent of total fish weight is:

Flounders:	approx. 95 %	OLE BAGGE /4/
Cod:	approx. 82 %	OLE BAGGE /4/
Herring:	Winter 93 %	POPP-MADSEN /5/
	Summer 70-75 %	

Due to the great seasonal variation of values on herring a gutted average weight of approx. 90 % of total weight has been used.

Weights of flounder, cods, and herrings have been corrected according to the values stated.

2.5 AREAS OF CATCHING

The catching areas and the approximate corresponding number of fish samples of the different areas analysed in /1/, /2/ and /3/ are shown on maps.

Appendix	30	Open Sea, DIC
Appendix	31	Fjords and Bays, DIC
Appendix	1	Open Sea, NFI
Appendix	54	Coastal waters of Sjælland, NFI

2.6 RESULTS

Results evaluated from /1/, /2/ and /3/ are presented as diagrams of mercury concentration vs. total fish weight.

The following diagrammes are given:

Area	Species	Flounder	Cod	Herring	Plaice
The North Sea	Years DIC		68-72,74	68-72,74	68-72,74
	Years NFI	73, 74, 75	73	73	
	Appendix no.	32	4o	45	5o
The Baltic	Years DIC	68-72	68-72,73,74	68-72, 74	
	Years NFI	73	73	73	
	Appendix no.	33	41	46	
Kattegat	Years DIC	68-72	68-72,74	68-72	68-72,74
	Years NFI	73	73	73	
	Appendix no.	34	42	47	51
Skagerrak	Years DIC		68-72, 74	68-72,74	68-72,74
	Years NFI				
	Appendix no.		43	48	52
Århus Bay	Years DIC	68-72, 75			68-72,75
	Years NFI				
	Appendix no.	35			53
Ho Bay	Years DIC	71-76			
	Years NFI				
	Appendix no.	36			
The Sound	Years DIC	68-72	68-72		
	Years NFI	73	73	73,74,75	
	Appendix no.	37	44	49	
Karrebæks-minde Bay area	Years DIC	68-72, 73			
	Years NFI	73			
	Appendix no.	38			
Køge Bay	Years DIC	68-72			
	Years NFI	73			
	Appendix no.	39			

Abbreviations: DIC The Danish Isotope Centre
NFI The National Food Institute

In 1973 the National Food Institute carried out a study on selected heavy metals (Hg, Cd, Pb, Cu, Zn) in the coastal waters around Sjælland /3/. The The results for mercury in flounders are shown on the map, appendix no. 54. The results are discussed in detail in /3/.

2.7 COMMENTS

Brief comments on changes during periods indicated in the previous table are given below.

Species / Areas	Flounder	Cod	Herring	Plaice
North Sea	no change level higher than uncontaminated level	slightly decreased level uncontaminated level	no change uncontaminated level	slightly decreased level uncontaminated level
the Baltic	no change uncontaminated level	no change uncontaminated level	no change uncontaminated level	
Kattegat	no change uncontaminated level	slightly decreased level uncontaminated level	no change uncontaminated level single high values	no change uncontaminated level
Skagerrak		no change uncontaminated level	no change uncontaminated level	no change uncontaminated level
Århus Bay	decreasing level in 1975 uncontaminated level			decreased level uncontaminated level
Ho Bay *)	slowly decreasing level contaminated level			
The Sound **)	no change contaminated level	no change contaminated level	only few samples Single high values	
Karrebæksminde Bay area ***)	For some localities pronounced decreasing level contaminated level			
Køge Bay	no change contaminated level			

*) Industrial source (chemical industry) identified by monitoring 1970. Emission eliminated 1971.

**) A detailed study of the mercury situation in the Sound is reported in /7/.

***) Industrial source (paper industry). Emission eliminated in 1970.

In the diagrams the mercury concentration in fish muscle is plotted versus fish weight assuming a linear relationship.

Such a relationship has first been demonstrated by Westermark /8/ for pike. In /1/ the DIC shows that a linear relationship also is indicated for a number of other fish species, such as:

Pike
Plaice
Herring
Flounder
Cod

At present this relationship is only established empirically, as there is no theory explaining this finding.

Generally, the relationship is only evident in uncontaminated areas. In polluted areas the spatial distribution of mercury will often be so uneven, that fish of the same weight will have mercury concentrations in such a wide range that the weight-concentration relationship becomes insignificant. Thus, the linear plot of mercury concentration versus fish weight is mainly used to define the base line for uncontaminated areas. This is done by constructing the line defining the level below which uncontaminated samples will fall with 95% significance. This construction is based on the assumption that the mercury concentration for fish with a given weight is normally distributed. This assumption has not been tested. Åse Engberg /9/ suggests a possible log-normal distribution for a population within a limited weight range.

In the diagrams the 95% significance line for uncontaminated samples is based solely on the DIC measurements for the period 1968-72.

2.8 References

/1/ THE DANISH ISOTOPE CENTRE, Kviksølv i fisk 1968-1972 (mercury in fish), Report, september 1972 (in Danish with English Summary).

/2/ THE DANISH ISOTOPE CENTRE, Kviksølv i fisk fra marine områder 1972-1976 (mercury in fish from marine areas) Report, in press (in Danish with English Summary).

/3/ STATENS LEVNEDSMIDDELINSTITUT, afdeling for Pesticider og forureninger. Rapport over Tungmetaller i fisk 1973-1975. Publikation nr. 33. Dec. 1976 (The National Food Institute, Studies of Heavy Metals in Fish from the Open Sea and Coastal Waters, 1973-1975, Report in Danish).

/4/ BAGGE, OLE, Danmarks Fiskeri- og Havundersøgelser, Charlottenlund, personal communication.

/5/ POPP MADSEN, K., Danmarks Fiskeri- og Havundersøgelser, Charlottenlund, personal communication.

/6/ SJÖSTRAND, B., Anal. Chem. 36 (1964) 814.

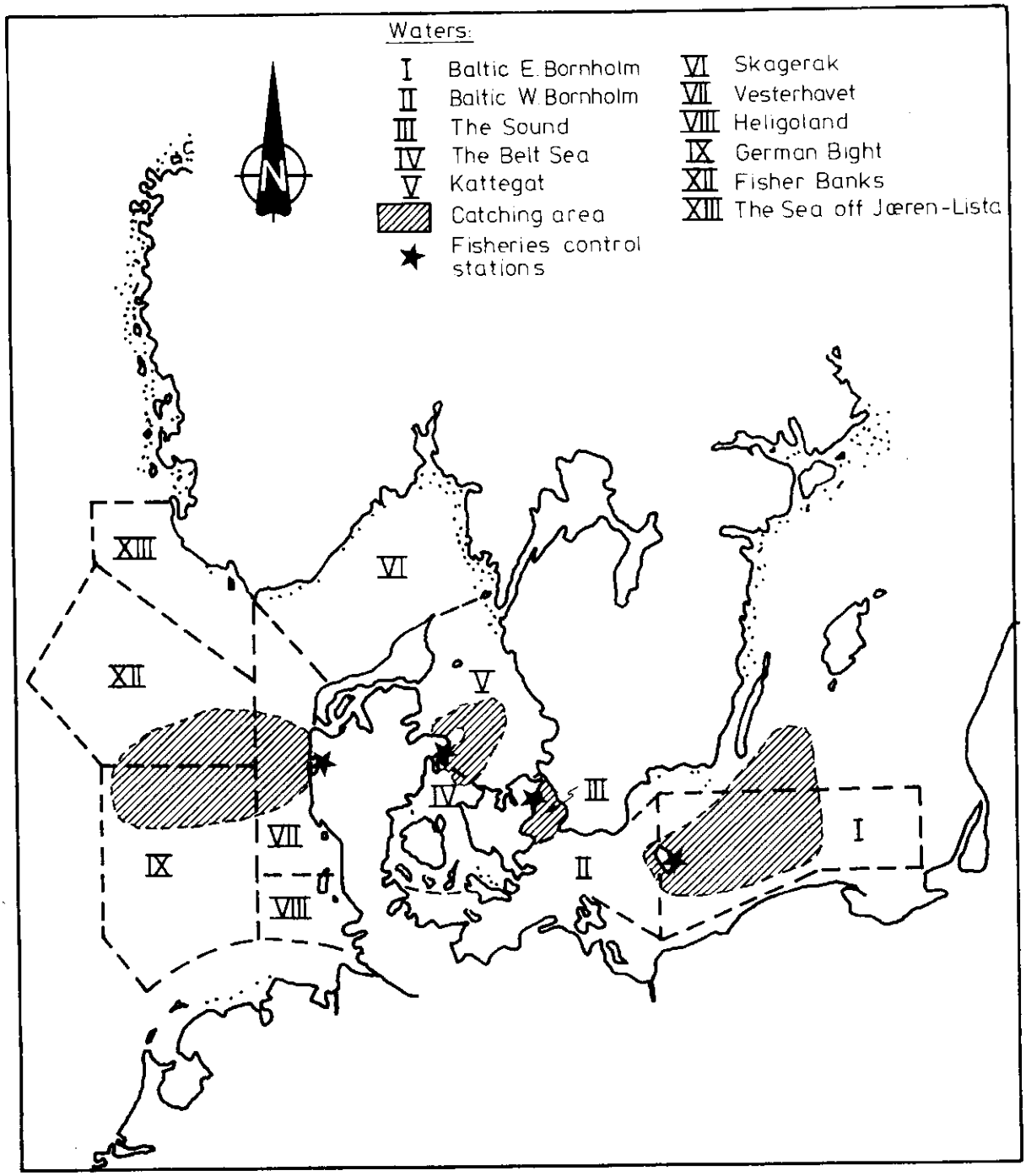
/7/ PEDERSEN, K., LARSEN, B., Statusrapport for Bæltprojektets kviksølvundersøgelser, in press.

/8/ WESTERMARK, T., "Kvicksilver hos vattenslevande organismer" Kvicksilverfrågan i Sverige (1964 års naturresursutredning), Kvicksilverkonferencen 1965, p.25-42.

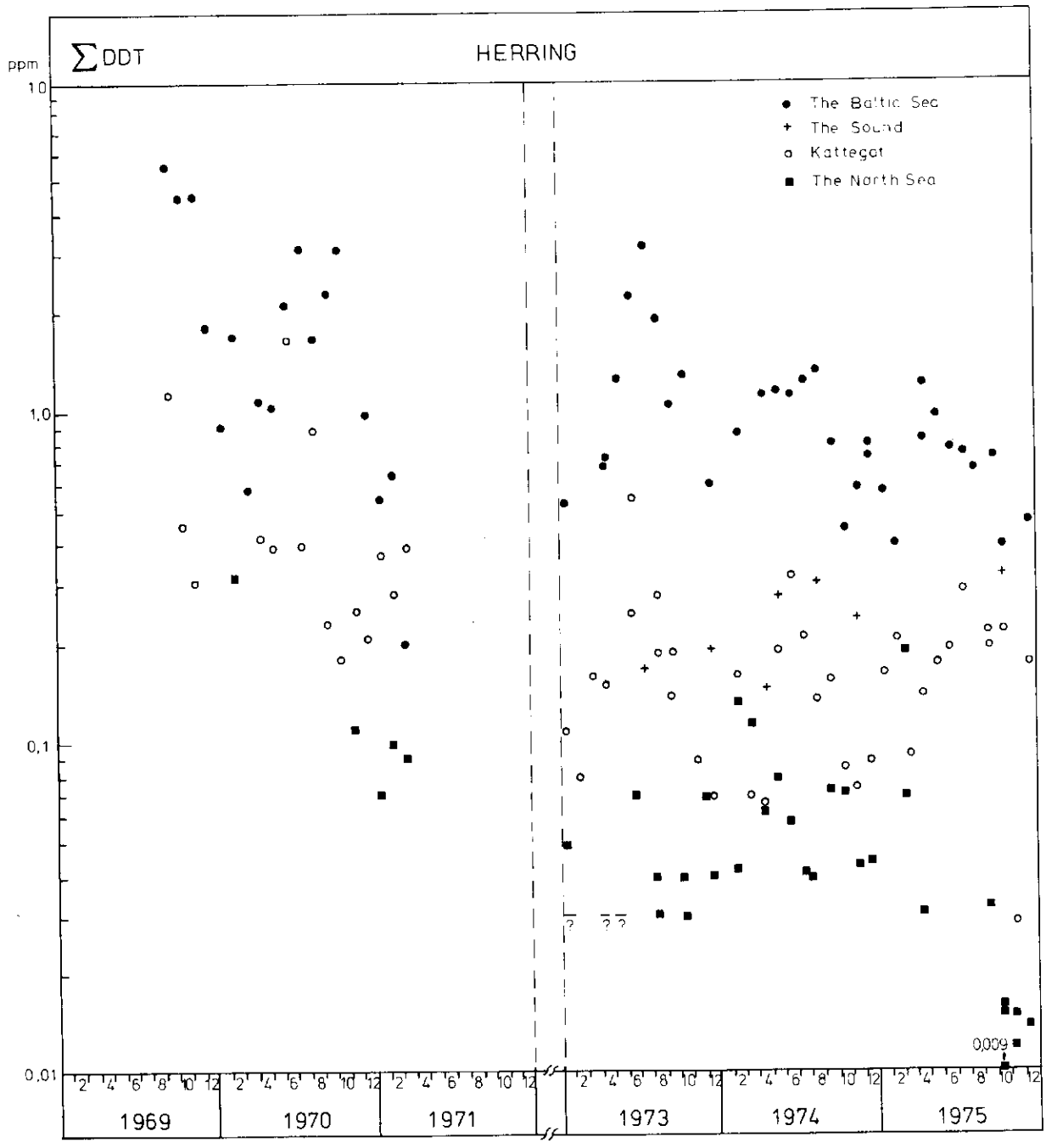
/9/ ENGBERG, ÅSE, The National Food Institute, personal communication.

Acknowledgement

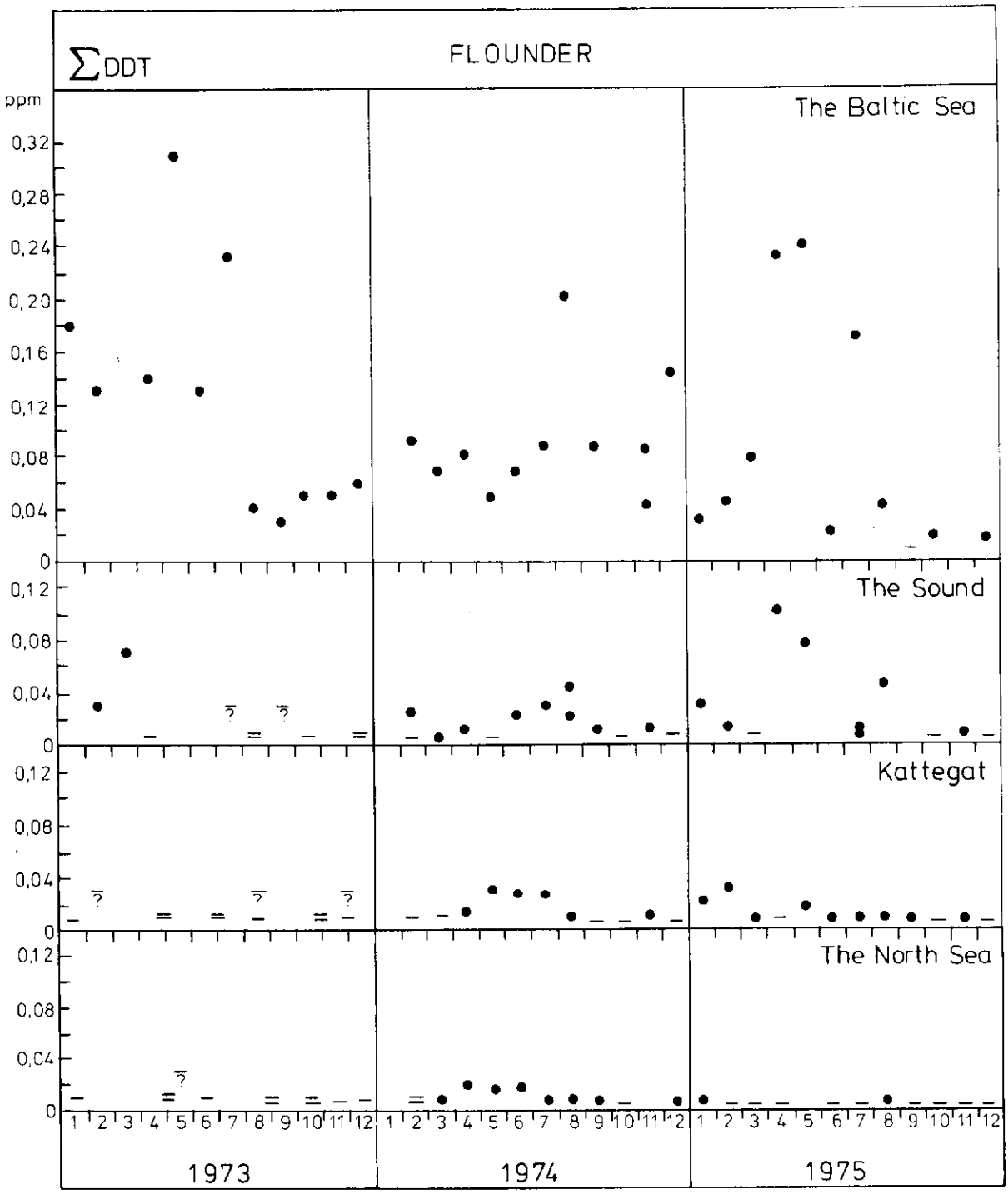
Sincere thanks are expressed to Mr. F. Bro-Rasmussen, Mrs. Åse Engberg and Mr. K. Voldum-Clausen, the National Food Institute for placing unpublished results at our disposal and for assisting in the preparation of the present compilation. It should be pointed out that the results are not for publication without reference to the National Food Institute.



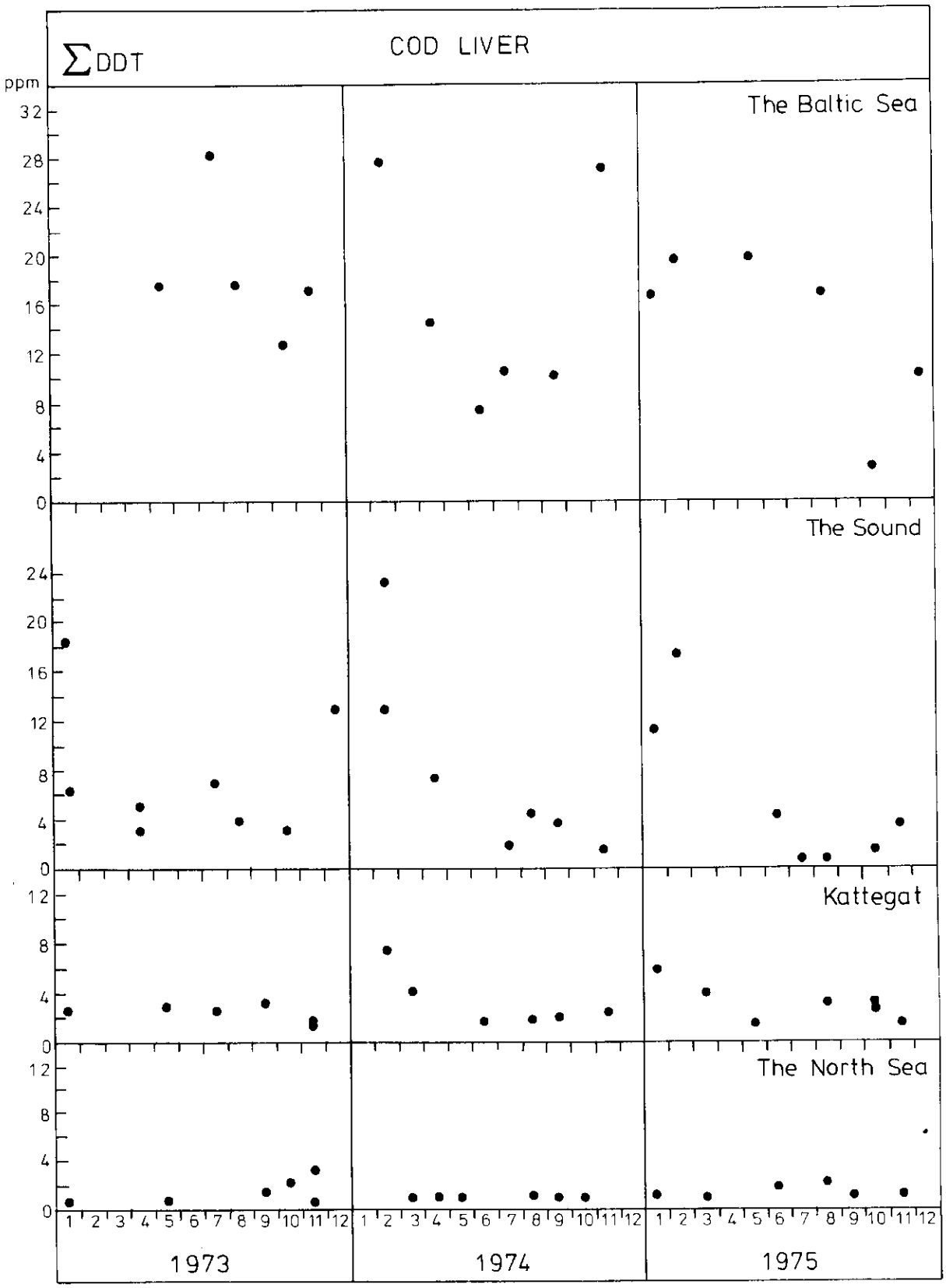
Fisheries control stations and catching areas in 1973-1975.



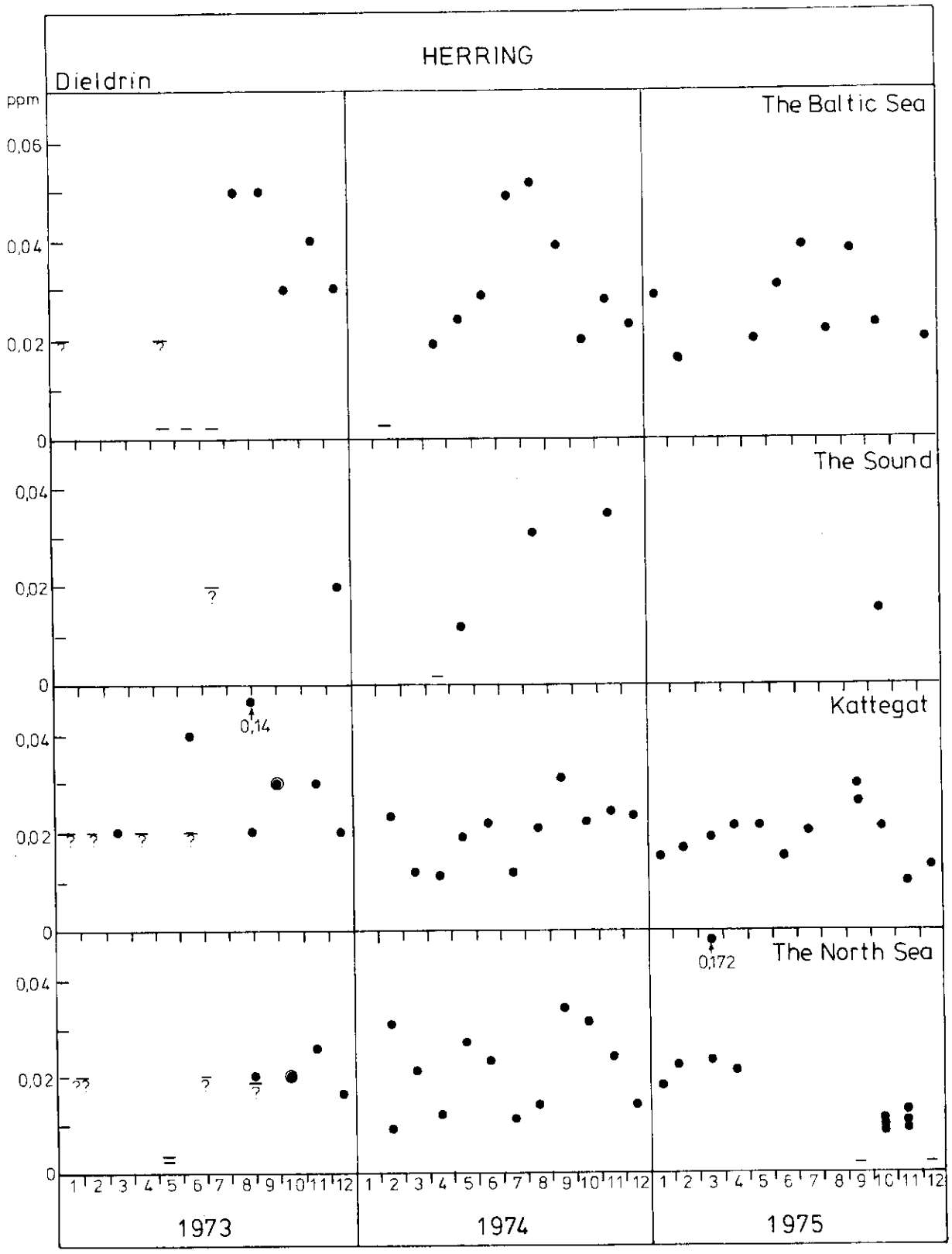
The content of Σ DDT in herring 1969-1971 and 1973-1975.
(ppm of raw weight)
(note logarithmic scale of Σ DDT-axis)



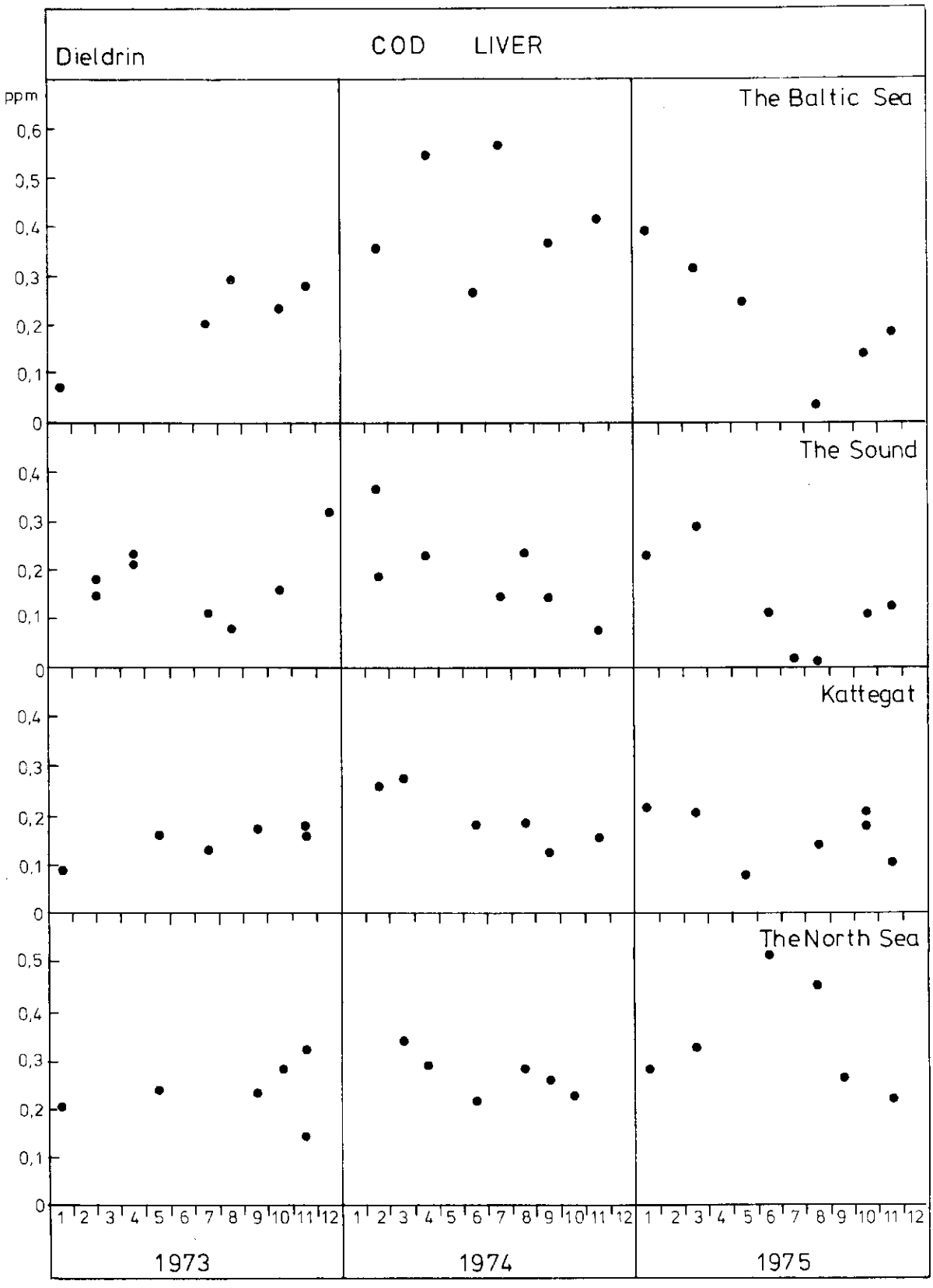
The content of ΣDDT in flounder 1973-1975 (ppm of raw weight)



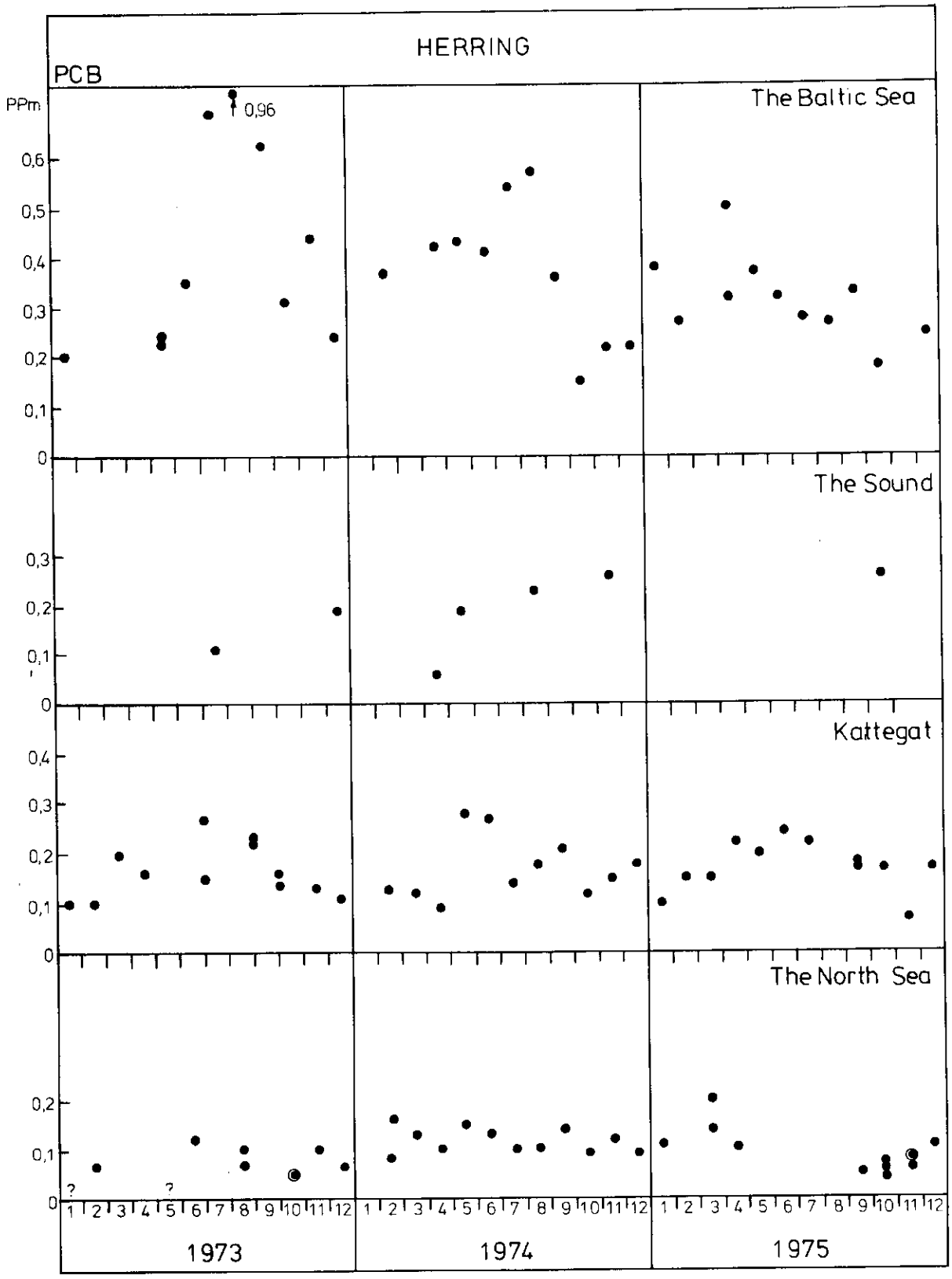
The content of Σ DDT in cod liver 1973-1975 (ppm of raw weight)



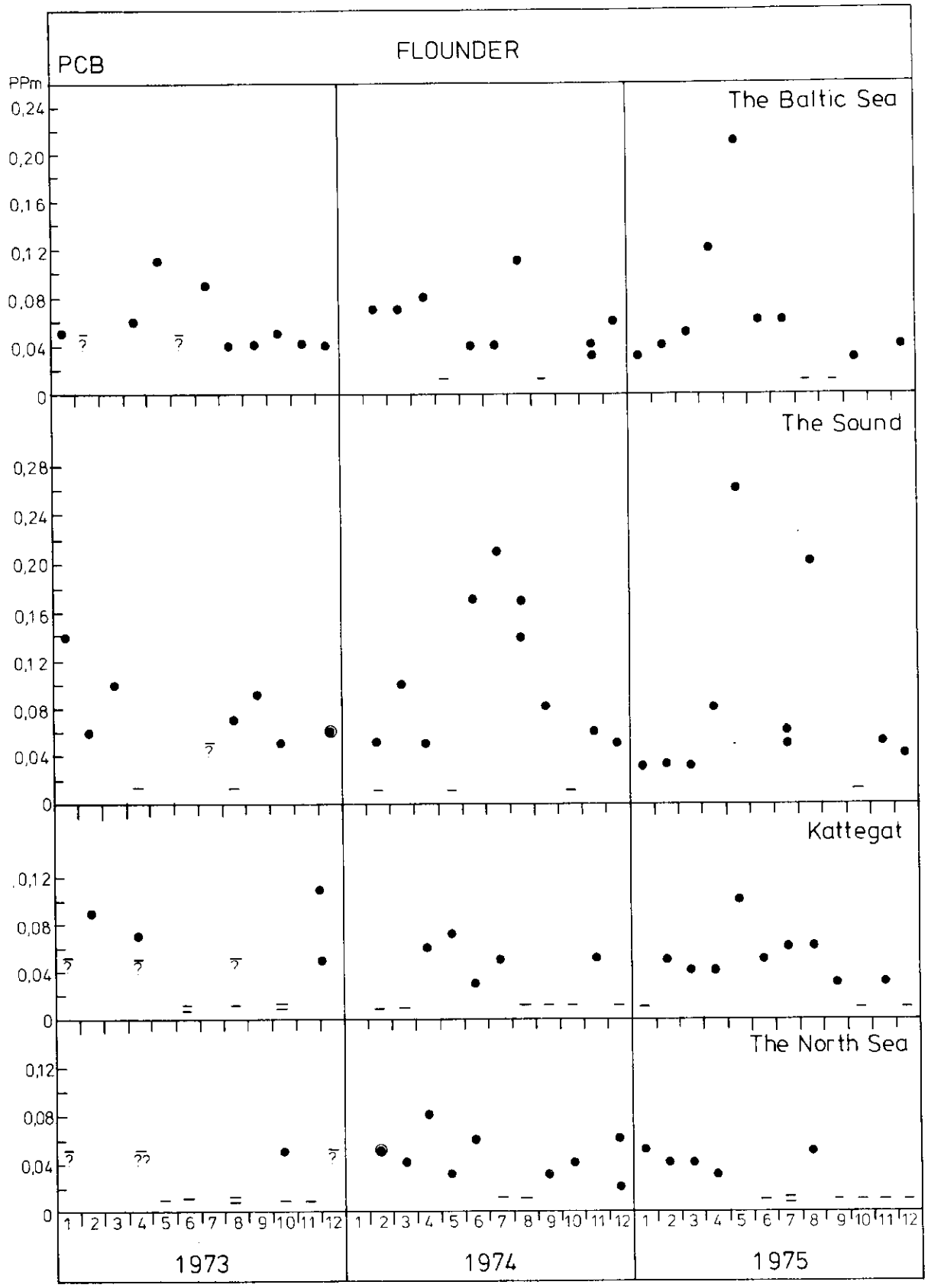
The content of dieldrin in herring 1973-1975 (ppm of raw weight)



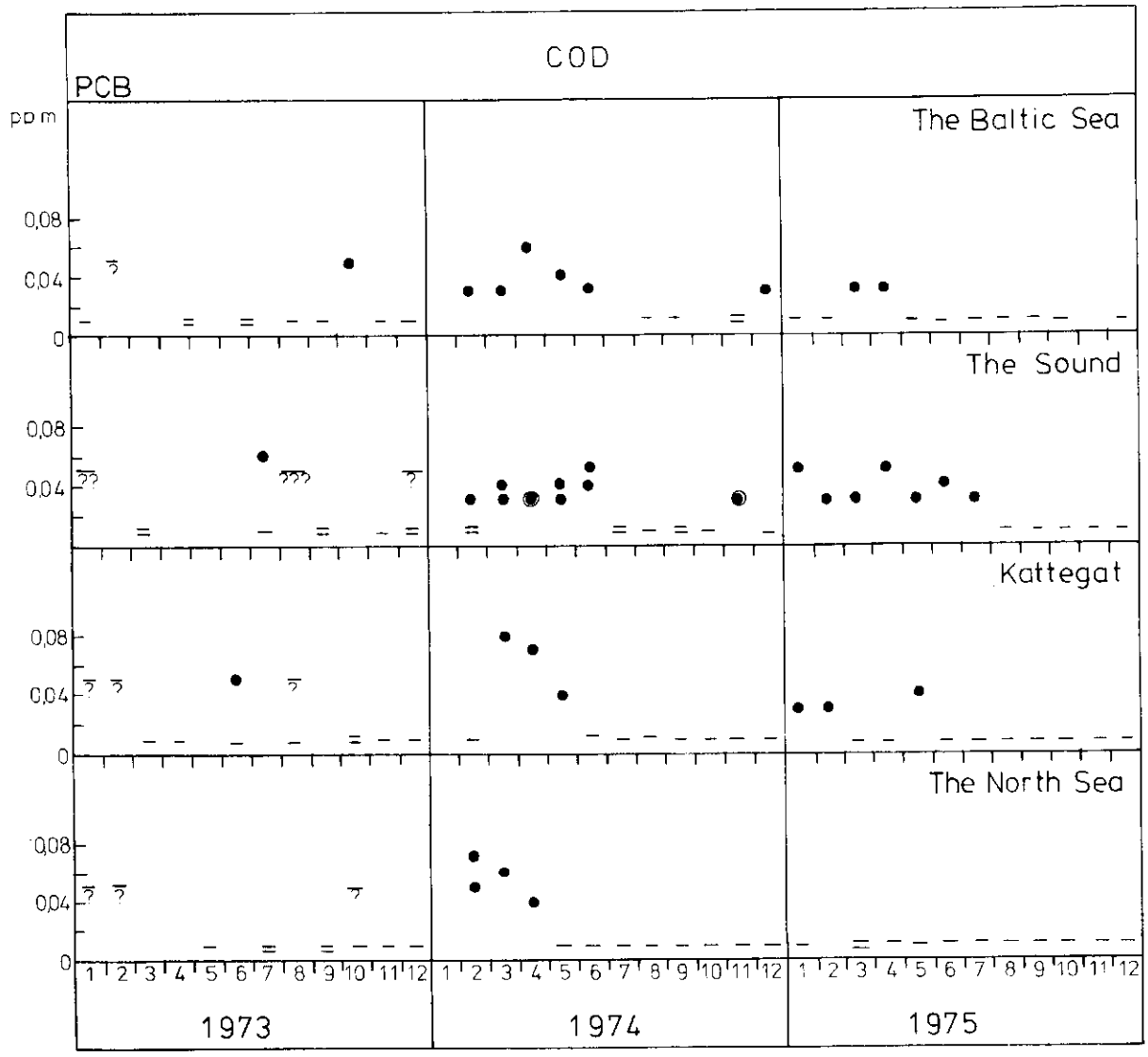
The content of dieldrin in cod liver 1973-1975 (ppm of raw weight)



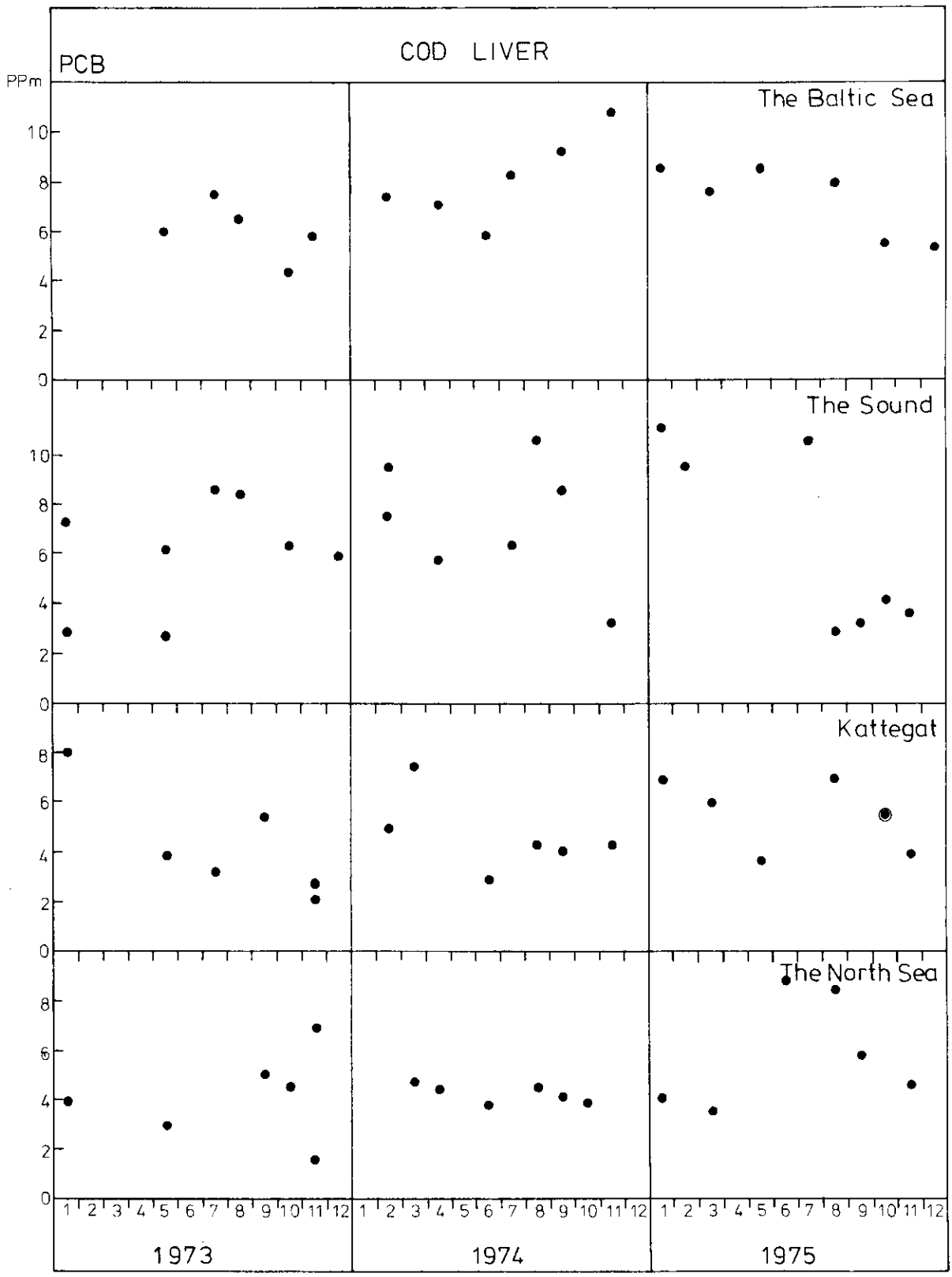
The content of PCB in herring 1973-1975 (ppm of raw weight)



The content of PCB in flounder 1973-1975 (ppm of raw weight)



The content of PCB in cod 1973-1975 (ppm of raw weight)



The content of PCB in cod liver 1973-1975 (ppm of raw weight)

The Baltic Sea

	1969	1970	1971	1973	1974	1975
January		0.90	0.55	0.53		0.58
February		1.71	0.64		0.88	0.40
March		0.59	0.20			
April		1.09			1.14	0.83 1.24
May		1.03		0.68 0.71	1.18	0.98
June		2.13		1.28	1.12	0.80
July		3.29		2.25	1.24	0.7.
August		1.69		3.25	1.34	0.69
September	5.49	2.32		1.93	0.80	0.75
October	4.40	3.12		1.06	0.44	0.40
November	4.51			1.30	0.59	
December	1.81	0.97		0.60	0.63	0.47

- content below detection limit: 0.03 ppm (1969-71)
0.01 ppm (1973-75)

The content of Σ DDT in herring in THE BALTIC SEA (ppm of raw weight)

The Sound

	1969	1970	1971	1973	1974	1975
January						
February						
March						
April					0.15	
May					0.27	
June						
July				0.17	0.31	
August						
September						
October						0.32
November					0.24	
December				0.19		

- content below detection limit: 0.01 ppm

The content of Σ DDT in herring in THE SOUND (ppm of raw weight)

Kattegat

	1969	1970	1971	1973	1974	1975
January			0.37	0.11		0.17
February			0.28	0.08	0.16	0.21
March			0.39	0.16	0.07	0.09
April		0.42		0.15	0.07	0.14
May		0.39			0.19	0.16
June		1.69			0.32	0.20
July		0.40		0.25 0.55	0.16	0.20
August		0.88			0.14	
September	1.16	0.23		0.28 0.19 0.19	0.15	0.20 0.22
October	0.45	0.18		0.14	0.09	0.22
November	0.31	0.25		0.09	0.07	0.03
December		0.21		0.07	0.09	0.18

- content below detection limit: 0.03 ppm (1969-71)
0.01 ppm (1973-75)

The content of Σ DDT in herring in KATTEGAT (ppm of raw weight)

The North Sea

	1969	1970	1971	1973	1974	1975
January			0.07			0.06
February		0.32	0.10	<0.03 0.05	0.05 0.13	
March			0.09		0.12	0.19 0.06
April					0.06	0.03
May				<0.03 <0.03	0.08	
June					0.06	
July				0.07	0.04	
August					0.04	
September				0.03 0.04	0.07	0.03
October				0.04 0.03	0.07	0.02
November		0.11		0.07	0.04	0.02
December				0.04	0.04	-

- content below detection limit: 0.03 ppm (1969-71)
0.01 ppm (1973-75)

The content of Σ DDT in herring in THE NORTH SEA (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	0.18		0.03			0.033	-		0.02	-		0.01
February	0.11	0.09	0.05	0.03	0.03	0.02	<0.03	-	0.03		-	-
March		0.07	0.08	0.07	-	-		-	0.01		0.01	-
April	0.14	0.08	0.23	-	-	0.10	=	0.01	-	=	0.02	-
May	0.31	0.05	0.24		-	0.08		0.03	0.02	<0.03	-	
June	0.13	0.07	0.02		0.03		=	0.03	0.01	-	0.02	-
July	0.23	0.09	0.17	<0.03	0.03	0.01 0.01		0.03	0.01		-	=
August	0.04	0.20	0.04	=	0.02 0.05	0.05	<0.03	-	0.01	=	-	-
September	0.03	0.09	-	<0.03	0.02			-	-		-	-
October	0.05		0.02	-	-	-	=	-	-	=	-	-
November	0.05	0.04 0.09		-	-	0.01	<0.03	0.01	-	-		-
December	0.06	0.15	0.02	-	-	-		-	-	-	=	-

- content below detection limit: 0.01 ppm

The content of Σ DDT in flounder (ppm of raw weight)

The Baltic Sea

	1969	1970	1971	1973	1974	1975
January		0.11	0.05	-		0.01
February		0.04	0.07	<0.03	-	0.03
March		0.06	0.08		0.01	0.02
April		0.03			0.02	0.01
May		-		=	0.03	0.01
June		0.05			0.03	-
July		0.06		<0.03		-
August		0.04		0.01	0.02	-
September	0.09	-		0.02	-	0.01
October	0.08	0.04		0.03		-
November	0.08	0.04		-	0.02 0.0	-
December	0.14	-		-	0.04	

- content below detection limit: 0.03 ppm (1969-71)
0.01 ppm (1973-75)

The content of Σ DDT in cod in THE BALTIC SEA (ppm of raw weight)

The Sound

	1969	1970	1971	1973	1974	1975
January						0.01
February				=	=	0.02
March					=	0.01
April				=	0.012	0.01
May					=	-
June					=	-
July				0.06	0.03	-
August				=	-	-
September				=	=	-
October					-	0.02
November				-	=	-
December				=	-	-

- content below detection limit: 0.01 ppm

The content of Σ DDT in cod in THE SOUND (ppm of raw weight)

Kattegat

	1969	1970	1971	1973	1974	1975
January		-	-	-		0.01
February			-	-	-	0.01
March			0.04	-	-	-
April		-		-	-	-
May		-			0.02	-
June		-			-	-
July		0.08		< 0.03	-	-
August		0.04			-	-
September	0.03	-		=	-	-
October	0.06	-			-	-
November	0.03	0.04		= -	-	-
December		-		-	-	-

- content below detection limit: 0.03 ppm (1969-71)
0.01 ppm (1973-75)

The content of DDT in cod in KATTEGAT (ppm of raw weight)

The North Sea

	1969	1970	1971	1973	1974	1975
January			0.03	-		-
February		0.03	0.03 0.05	-	=	
March		0.03	0.03		-	=
April		0.03			-	-
May		0.03		-	-	-
June		0.03			-	-
July		0.03		=	-	-
August		0.03			-	-
September	0.05	0.04		=	-	-
October	0.04	0.03		=	-	-
November	-	0.03		-	-	-
December	-	0.03		-	-	-

- content below detection limit: 0.03 ppm (1969-71)
0.01 ppm (1973-75)

The content of Σ DDT in cod in THE NORTH SEA (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	7.58		16.67			11.34	2.62		5.81	0.60		1.39
February		27.75		18.36 6.20	13.05 23.71			7.44				
March			19.58			17.42		4.00	3.93		0.96	1.02
April		14.50		4.99 2.91	7.62						0.90	
May	17.74		19.80				2.80		1.16	0.77		
June		7.91				4.10		1.51			0.85	1.96
July	28.16	10.78		6.91	1.98	0.45	2.56					
August	17.37		16.85	3.95	4.67	0.63		1.72	3.11		1.04	2.23
September		10.33			3.73		3.21	1.99		1.44	0.87	1.28
October	12.85		2.96	3.43		1.61			3.01 2.96	2.14	1.05	
November	17.26	27.05			1.53	3.59	1.52 1.43	2.16	1.45	3.27 0.43		1.13
December			10.14	13.34								

- content below detection limit: 0.01 ppm

The content of Σ DDT in cod liver (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	<0.02		0.01				<0.02		0.02			0.02
February		-	0.02				<0.02	0.02	0.02	<0.02 <0.02	0.03 0.01	
March							0.02	0.01	0.02		0.02	0.17 0.02
April		0.01	- -		-		<0.02	0.01	0.02		0.01	0.02
May	<0.02	0.02	0.02		0.01			0.02	0.02	- -	0.03	
June	-	0.03	0.03				<0.02	0.02	0.02		0.02	
July	-	0.05	0.04	<0.02			0.04	0.01	0.02	<0.02	0.01	
August	0.05	0.05	0.02		0.03		0.02	0.02			0.01	
September	0.05	0.04	0.04				0.14 0.03	0.03	0.03 0.03	<0.02 0.02	0.03	-
October	0.03	0.02	0.02			0.01	0.03	0.02	0.03	0.02 0.02	0.03	0.01 0.01 0.01
November	0.04	0.03			0.04		0.03	0.02	0.01	0.026	0.02	0.01 0.01 0.01
December	0.03	0.02	0.02	0.02			0.02	0.02	0.01	0.016	0.01	-

content below detection limit: 0.01 ppm.

The content of dieldrin in herring (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	-		-	-		-	-		-	-		-
February	-	-	-	-	=	-	-	-	-		=	-
March		-	=	-	-	-		-	-		-	-
April	-	-	-	-	-	-		-	-		-	-
May	-	-	0.01		-	0.01	=	-	-	= -	-	
June	-	0.01	-		-			-	-	-	-	-
July	-	-	-	-	-	=	=	-	-		-	=
August	-	0.01	-	=	- 0.01	0.01		-	-		-	-
September	-	-	-	-	-		=	-	-	=	-	-
October	-		-	-	-	-		-	-	=	-	-
November	-	=			-	-	=	-	-	-		-
December	-	-	-	=	-	-	=	-	-	-	-	-

- content below detection limit: 0.01 ppm

The content of dieldrin in flounder (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	-		-			-	-		-	-		-
February	-	-	-		-	-	-	-	-	-	=	
March		-	-		-	-	-	-	-		-	=
April		-	-		=	-	-	-	-		-	-
May		-	-		=	-		-	-	-	-	-
June		-	-		=	-		-	-		-	-
July			-	-	=	-		-	-	=	-	-
August	-	-	-	=	-	-		-	-		-	-
September	-	-	-	=	=	-		-	-	=	-	-
October	-		-		-	-		-	-	=	-	-
November	-	=		-	=	-	-	-	-	-	-	-
December	-	-	-	=	-	-	-	-	-	-	-	-

- content below detection limit: 0.01 ppm

The content of dieldrin in cod (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	0.07		0.39			0.23	0.09		0.22	0.20		0.28
February		0.36		0.15 0.18	0.19 0.37			0.26				
March			0.32			0.29		0.27	0.21		0.34	0.32
April		0.54		0.21 0.23	0.23						0.29	
May	–		0.25				0.16		0.08	0.24		
June		0.27				0.12		0.18			0.21	0.52
July	0.20	0.56		0.11	0.15	0.02	0.13					
August	0.29		0.03	0.08	0.23	0.01		0.19	0.14		0.28	0.45
September		0.37			0.15		0.17	0.13		0.23	0.26	0.26
October	0.23		0.14	0.16		0.12			0.21 0.18	0.28	0.23	
November	0.28	0.42	0.18		0.08	0.12	0.16 0.18	0.16	0.11	0.14 0.32		0.22
December				0.32								

– content below detection limit: 0.01 ppm

The content of dieldrin in cod liver (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	0.20		0.38				0.10		0.10			0.11
February		0.37	0.27				0.10	0.13	0.15	<0.05 0.07	0.08 0.16	
March							0.20	0.12	0.15		0.13	0.20 0.14
April		0.42	0.32 0.50		0.06		0.16	0.09	0.22		0.10	0.10
May	0.23 0.24	0.43	0.37		0.19			0.28	0.20	<0.05	0.15	
June	0.35	0.41	0.32				0.15 0.27	0.27	0.24	0.12	0.13	
July	0.69	0.54	0.28	0.11				0.14	0.22		0.10	
August	0.96	0.57	0.27		0.23		0.22	0.18		0.07	0.10	
September	0.62	0.36	0.33				0.23 0.16	0.21	0.17 0.18	0.10	0.14	0.05
October	0.31	0.15	0.18			0.26	0.14	0.12	0.17	0.05 0.05	0.09	0.04 0.06 0.07 0.06
November	0.44	0.22			0.26		0.13	0.15	0.07	0.10	0.12	0.08 0.08
December	0.24	0.22	0.25	0.19			0.11	0.18	0.17	0.06	0.09	0.11

- content below detection limit: 0.03 ppm.

The content of PCB in herring (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	0.05		0.03	0.14		0.03	<0.05		-	<0.05		0.05
February	<0.05	0.07	0.04	0.06	0.05 -	0.03	0.09	-	0.05		0.05 0.05	0.04
March		0.07	0.05	0.10	0.10	0.03		-	0.04		0.04	0.04
April	0.06	0.08	0.12	-	0.05	0.08	0.07	0.06	0.04	<0.05	0.08	0.03
May	0.11	-	0.21		-	0.26	<0.05	0.07	0.10	<0.05 -	0.03	
June		0.04	0.06		0.17			0.03	0.05	-	0.06	-
July	<0.05 0.09	0.04	0.06	<0.05	0.21	0.05 0.06	=	0.05	0.06		-	-
August	0.04	0.11	-	0.07 -	0.14 0.17	0.20		-	0.06	=	-	0.05
September	0.04	-	-	0.09	0.08		<0.05 -	-	0.03		0.03	-
October	0.05		0.03	0.05	-	-		-	-	0.05	0.04	-
November	0.04	0.03 0.04			0.06	0.05	=	0.05	0.03	-		-
December	0.04	0.06	0.04	0.06 0.06	0.05	0.04	0.11 0.05	-	-	<0.05	0.06 0.02	-

- content below detection limit: 0.03 ppm.

The content of PCB in flounder (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	-		-	<0.05		0.05	<0.05		0.03	<0.05		-
February	<0.05	0.03	-	<0.05	0.03	0.03	<0.05	-	0.03	<0.05	0.05 0.07	
March		0.03	0.03		0.04 0.03	0.03	-	0.08	-		0.06	
April		0.06	0.03		0.03 0.03	0.05	-	0.07	-		0.04	-
May		0.04	-		0.04 0.03	0.03		0.04	0.04	-	-	-
June		0.03	-		0.05 0.04	0.04		-	-		-	-
July			-	- 0.06	=	0.03	0.05 -	-	-	-	-	-
August	-	-	-	<0.05 <0.05 <0.05	-	-		-	-		-	-
September	-	-	-	=	=	-	<0.05 -	-	-	=	-	-
October	0.05		-		-	-		-	-	<0.05 -	-	-
November	-	=		-	0.03 0.03	-	= -	-	-	-	-	-
December	-	0.03	-	- <0.05 -	-	-	-	-	-	-	-	-

- content below detection limit: 0.03 ppm.

The content of PCB in cod (ppm of raw weight)

	The Baltic Sea			The Sound			Kattegat			The North Sea		
	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
January	10.76		8.54	7.24 2.71		11.14	8.00		6.88	3.93		4.07
February		7.48			7.48 9.48			4.91				
March			7.60			9.46		7.43	5.94		4.63	3.50
April		7.06		6.18 2.61	5.75						4.40	
May	5.86		8.46				3.84		3.69	2.99		
June		5.80						2.91			3.85	8.76
July	7.44	8.27		8.51	6.38	10.69	3.29					
August	6.40		7.97	8.40	10.75	2.87		4.27	6.97		4.41	8.46
September		9.20			8.47	3.18	5.40	4.01		5.00	4.02	5.80
October	4.12		5.42	6.37		4.11			5.42 5.43	4.25	3.86	
November	5.71	10.78			3.21	3.61	2.73 2.10	4.21	3.89	6.96 1.52		4.49
December			5.38	5.87								

- content below detection limit: 0.03 ppm.

The content of PCB in cod liver (ppm of raw weight)

APPENDIX 29

Theoretical background for estimation of arithmetic mean values from weighted mean value

Assuming an approximately linear relationship between mercury concentration and total weight of fish in each sample, the arithmetic mean value of concentration for each sample has been calculated according to the equation

$$\bar{C} = \frac{1}{1 + \frac{n-1}{n} \cdot \left(\frac{S}{\bar{m}}\right)^2} \cdot C_W$$

Where

$\bar{C}$ = arithmetic mean value of concentration
n = number of fish in sample
S = standard deviation of weight
$\bar{m}$ = arithmetic mean value of weight
C_W = weighted mean value of concentration

The theoretical background for the equation is stated below.

The following symbols are used:

n = number of fish in sample
m_i = weight of individual fish; $i = 1,2, ...,12$
C_i = concentration of individual fish, $i = 1,2, ...,12$
$\bar{m}$ = arithmetic mean value of weight
$\bar{C}$ = arithmetic mean value of concentration
s_m = standard deviation of weight
s_c = standard deviation of concentration
$R_{c,m}$ = correlation coefficient between concentration and weight
C_W = weighted mean value of concentration

Strictly the weighted mean value of concentration for the sample is given by the equation

$$(1) \qquad C_W = \frac{1}{n \cdot \bar{m}} \sum_{i=1}^{n} C_i \cdot m_i$$

According to the definition of the correlation coefficient $R_{c,m}$

$$(2) \quad R_{c,m} = \frac{1}{n-1} \cdot \frac{1}{s_c \cdot s_m} \left(\sum_{i=1}^{n} c_i \cdot m_i - n\bar{m}\bar{c} \right)$$

the weighted mean value of concentration, eq. (1), can be written

$$(3) \quad C_W = \bar{C} + R_{c,m} \cdot \frac{n-1}{n} \cdot \frac{s_m}{m} \cdot \frac{s_c}{C} \cdot \bar{C}$$

Equation (3) offers the following expression for the arithmetic mean value of concentration

$$(4) \quad \bar{C} = C_W \left(1 + R_{c,m} \cdot \frac{n-1}{n} \cdot \frac{s_m}{m} \cdot \frac{s_c}{c} \right)^{-1}$$

As the correlation coefficient, $R_{c,m}$, and the relative standard deviation of concentration, S_c/C, are not known parameters from the National Food Institute the exact transformation factor between weighted and arithmetic mean value of concentration cannot be calculated.

Based on earlier investigations, cf. ref. /1/, it seems reasonable to adopt as a best guess the following assumptions

$$(5) \quad \frac{s_c}{C} \approx \frac{s_m}{m}$$

$$(6) \quad R_{c,m} > 0$$

Inserting these assumptions in eq. (4) we get

$$(7) \quad \bar{C} \approx C_W \left(1 + R_{c,m} \cdot \frac{n-1}{n} \cdot \frac{s_m^2}{\bar{m}^2} \right)^{-1}$$

From eq. (7) it is seen that the weighted mean value of concentration, C_W, is greater than the arithmetic mean value of concentration, $\bar{C}$.

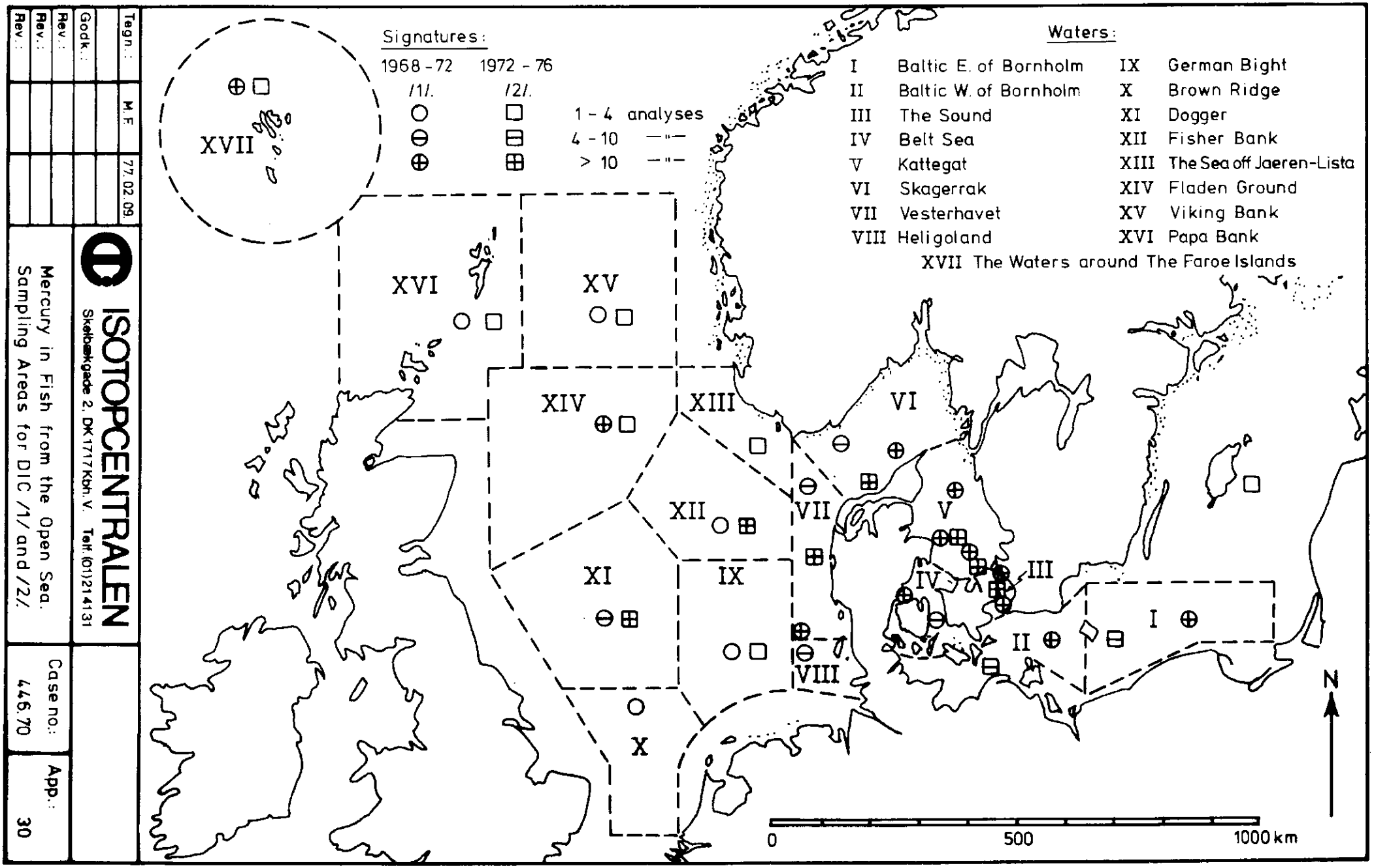
PJ/GK
1977-02-10

Assuming further a nearly linear relationship between fish weight, m_i, and fish concentration, C_i, the correlation coefficient is approximately equal to one

$$(8) \quad R_{c,m} \approx 1$$

This gives from eq. (7) the relationship

$$(9) \quad \bar{C} \approx C_W \left(1 + \frac{n-1}{n} \cdot \frac{s_m^2}{\bar{m}^2}\right)^{-1}$$



Tegn.: M.F. 77.02.09.
Godk.:
Rev.:
Rev.:
Rev.:

ISOTOPCENTRALEN
Skelbækgade 2, DK1717 Kbh. V. Telf. (01) 21 41 31

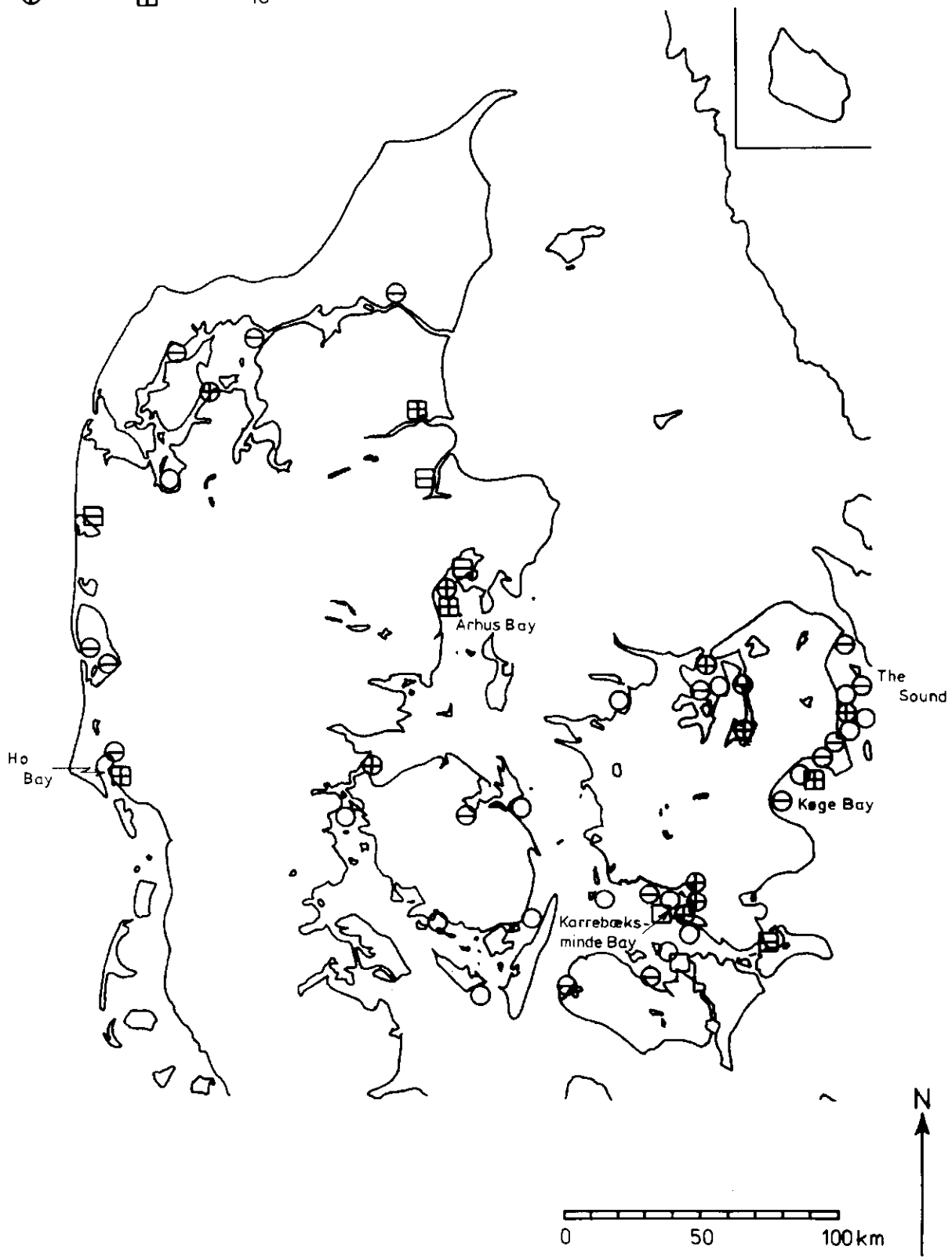
Mercury in Fish from the Open Sea.
Sampling Areas for DIC /1/ and /2/.

Case no.: 446.70

App.: 30

Signatures :

1968 - 72 /1/.	1972 - 76 /2/.	
○	□	1 - 4 analyses
⊖	⊟	4 - 10 —"—
⊕	⊞	> 10 —"—



Tegn.:	M.F.	77.02.10	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:					
Rev.:			Mercury in Fish from Fjords and Bays. Sampling Areas for DIC /1/ and /2/.	Case no.: 446.70	App.: 31
Rev.:					
Rev.:					

AGF 4240

Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

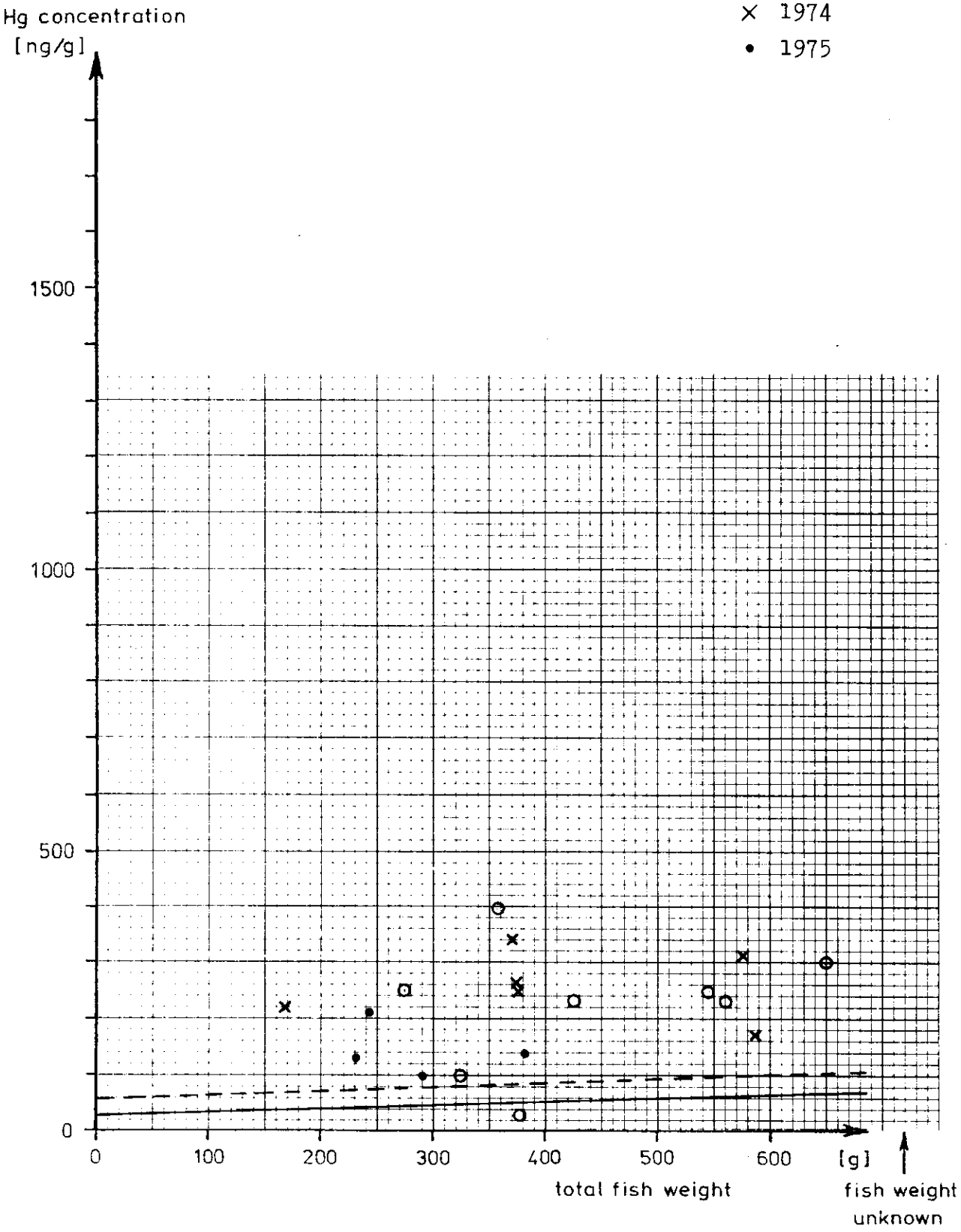
FLOUNDER

The North Sea

o 1973

× 1974

• 1975



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 214131		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Flounder, The North Sea, 1973, 74 and 75	Case no.: 446.70	App.: 32
Rev.:					
Rev.:					

AGF 6240

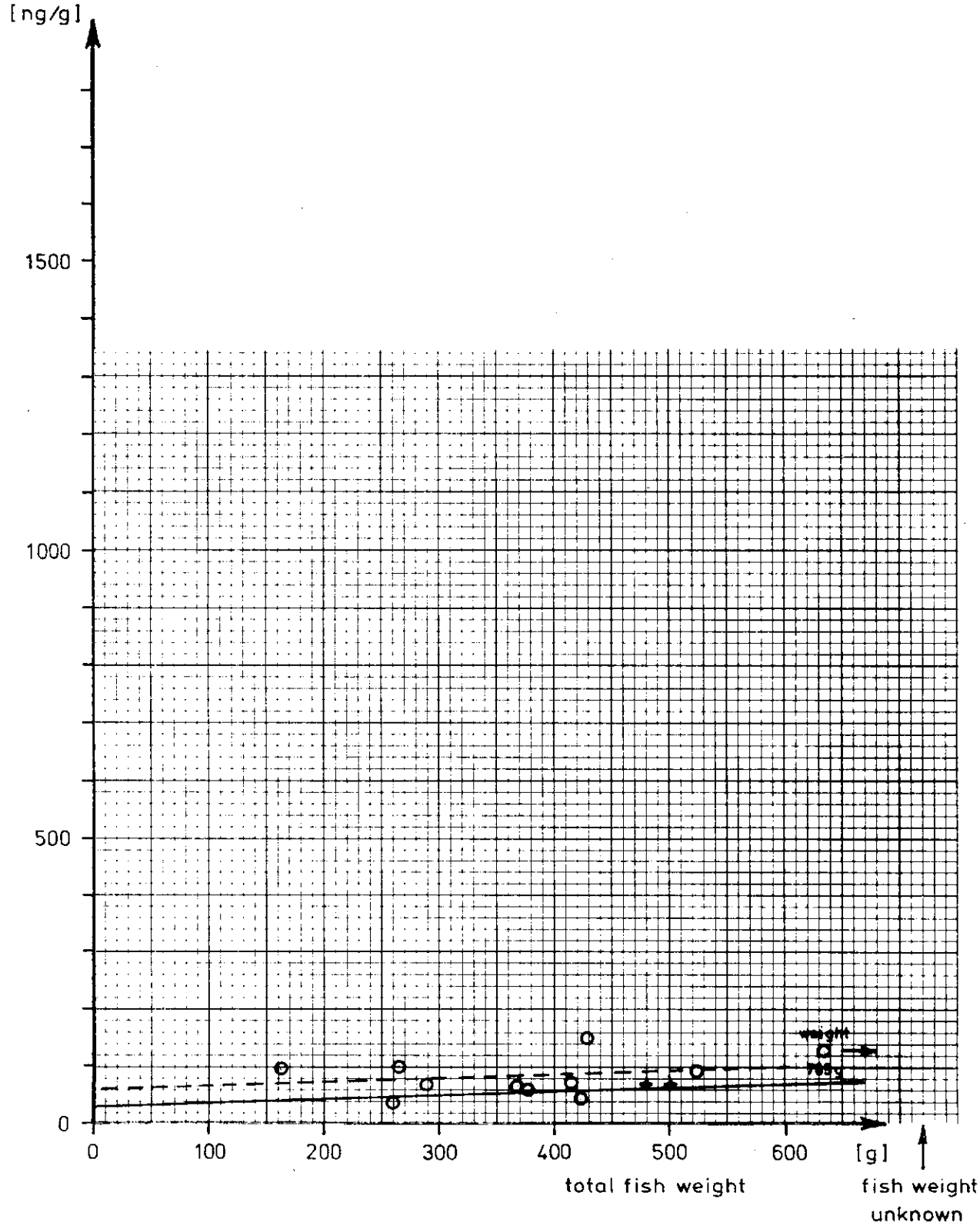
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

FLOUNDER

The Baltic

\+ 1968-72

o 1973



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK1717 Kbh. V. Telf.(01)214131		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Flounder, The Baltic, 1968-72 and 73	Case no.: 446.70	App.: 33
Rev.:					
Rev.:					

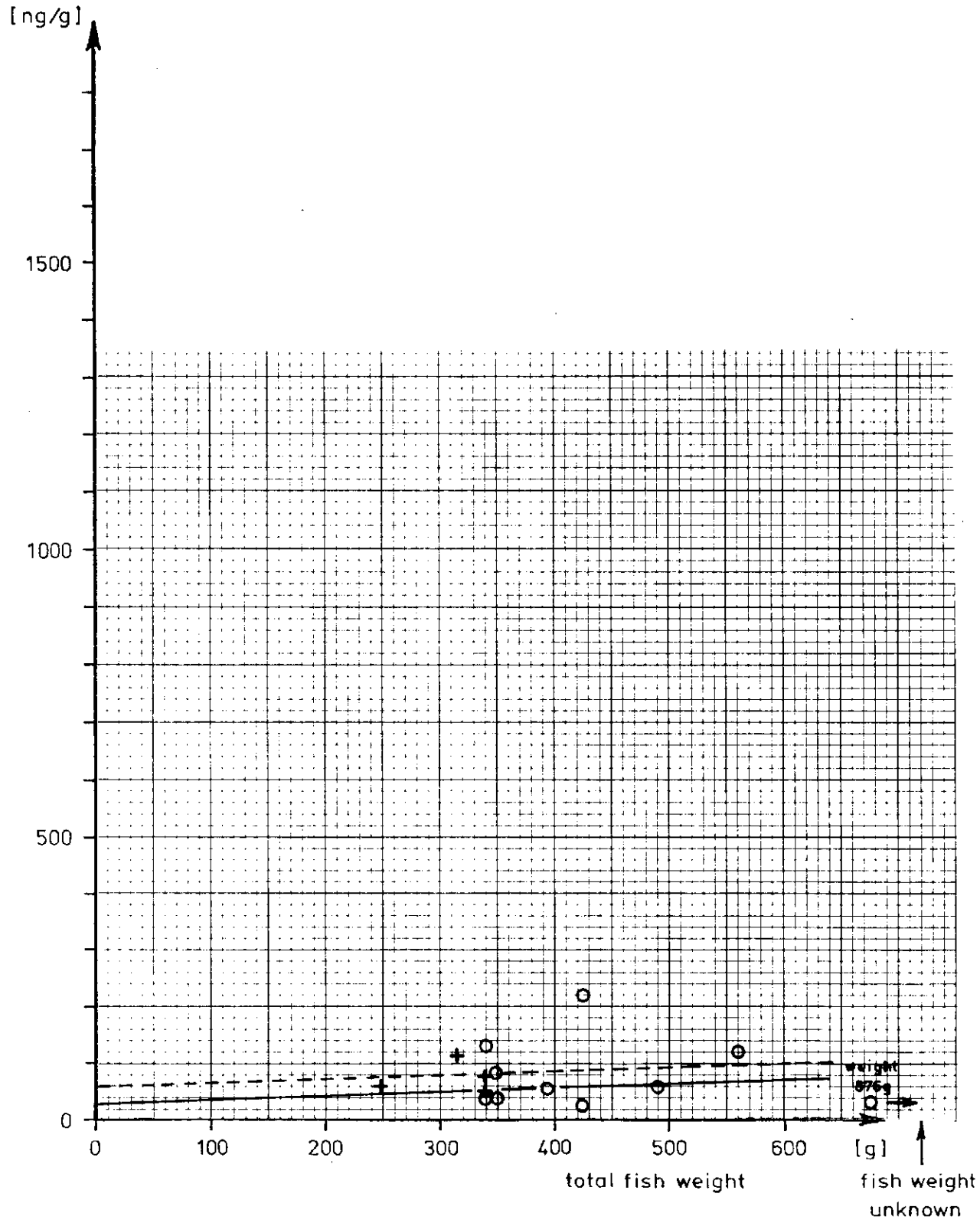
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

FLOUNDER

Kattegat

\+ 1968-72

o 1973



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Flounder, Kattegat, 1968-72 and 73	Case no.: 446.70	App.: 34
Rev.:					
Rev.:					

AGF 4248

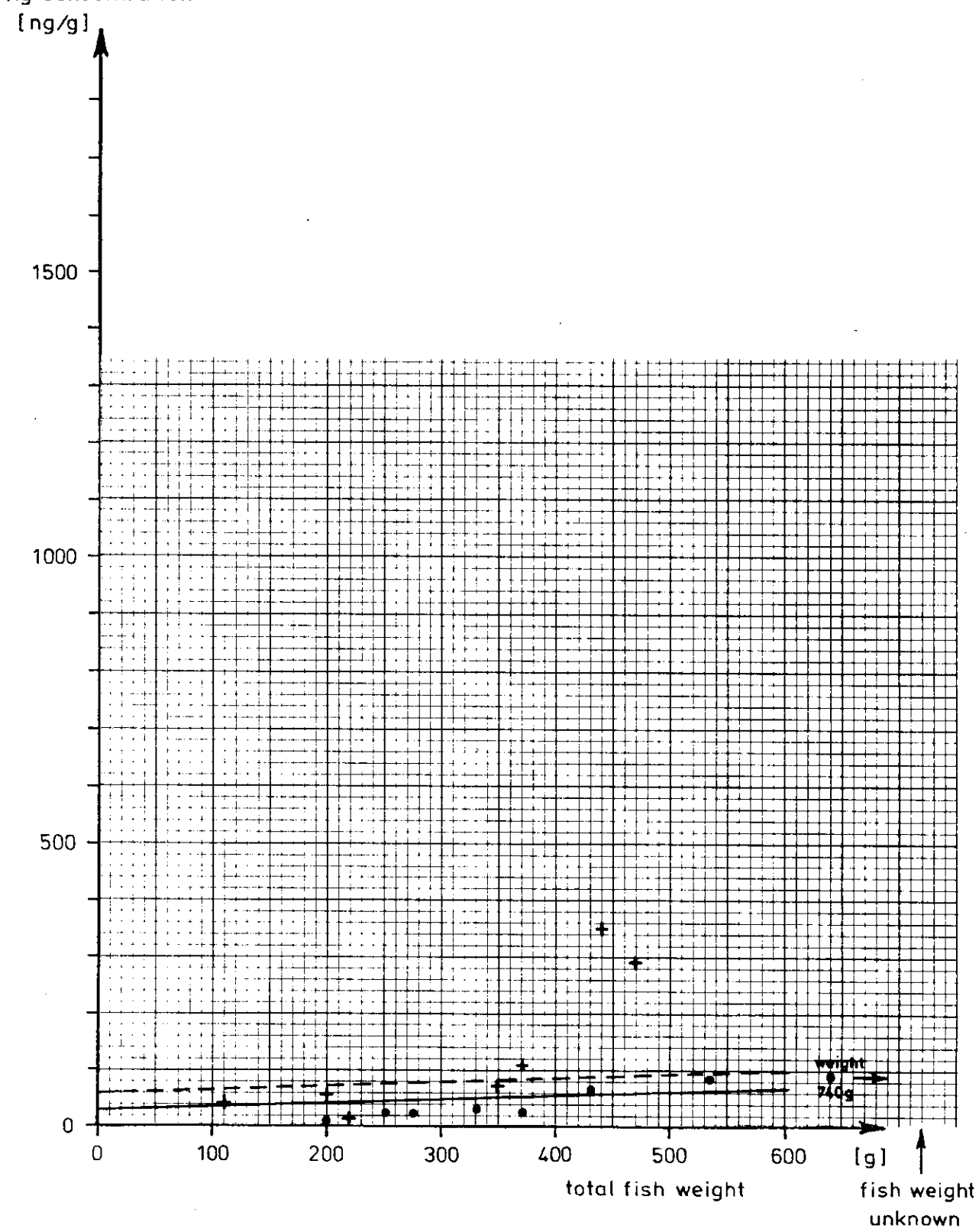
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

FLOUNDER

Århus Bay

\+ 1968-72

• 1975



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:			Mercury in marine fish 1968-76 Flounder, Århus Bay 1968-72 and 75	Case no.: 446.70	App.: 35
Rev.:					
Rev.:					
Rev.:					

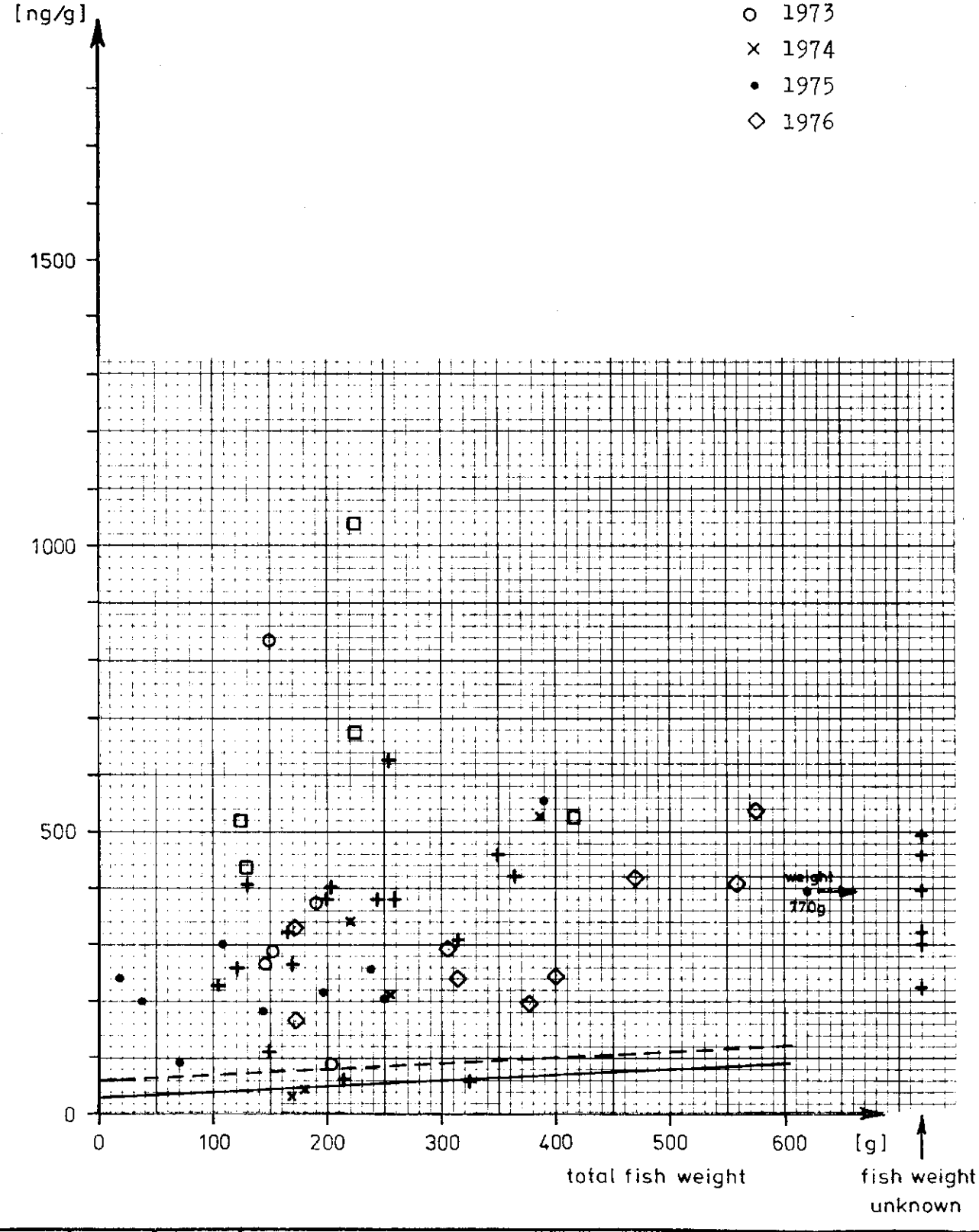
AGF 4248

Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

FLOUNDER

Ho Bay

+ 1971
□ 1972
○ 1973
× 1974
• 1975
◇ 1976



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK1717 Kbh. V. Telf.(01)214131		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Flounder, Ho Bay 1971-76	Case no.: 446.70	App.: 36
Rev.:					
Rev.:					

AGF 4240

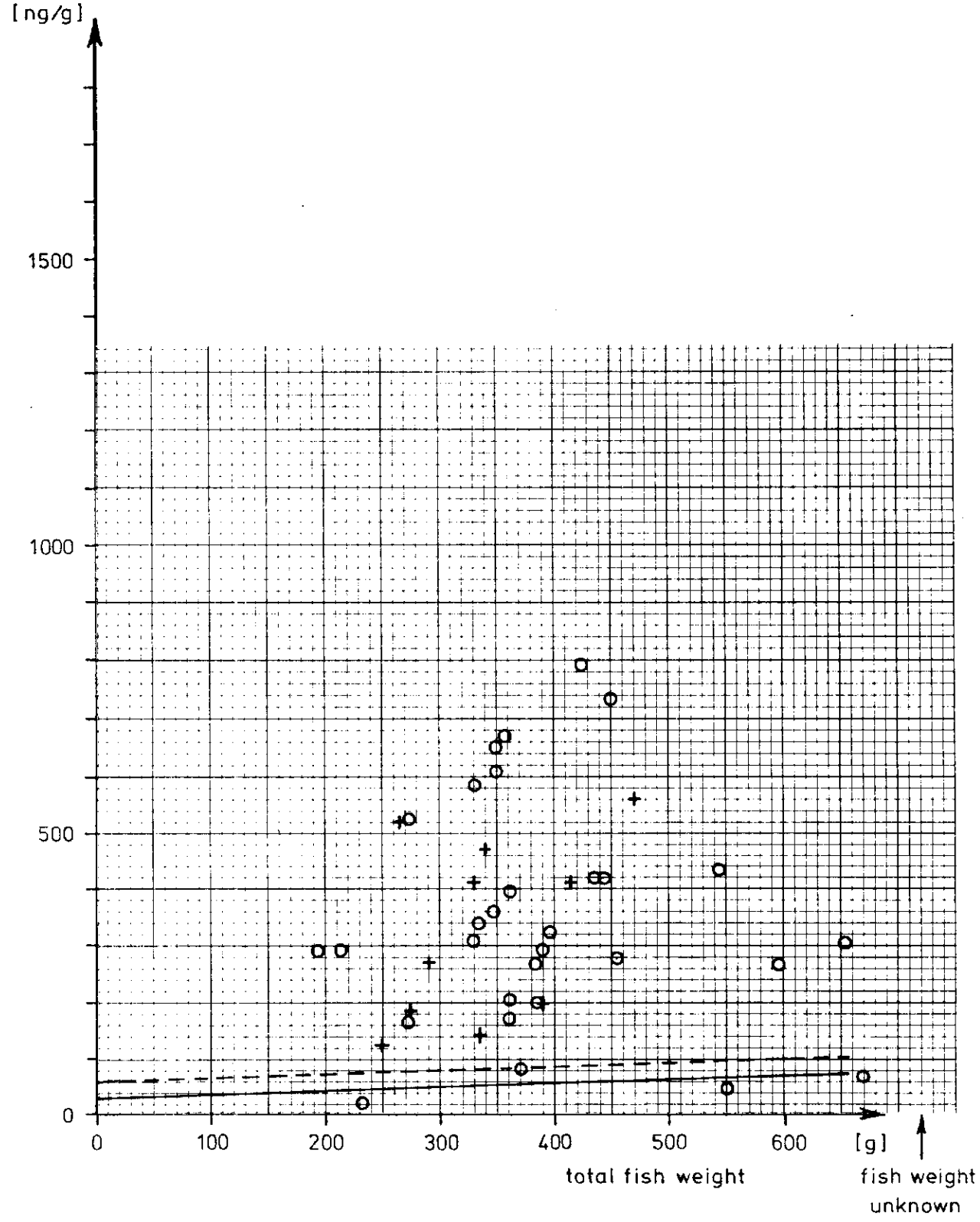
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

FLOUNDER

The Sound

\+ 1968-72

o 1973



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf.(01)214131		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Flounder, The Sound, 1968-72 and 73	Case no.: 446.70	App.: 37
Rev.:					
Rev.:					

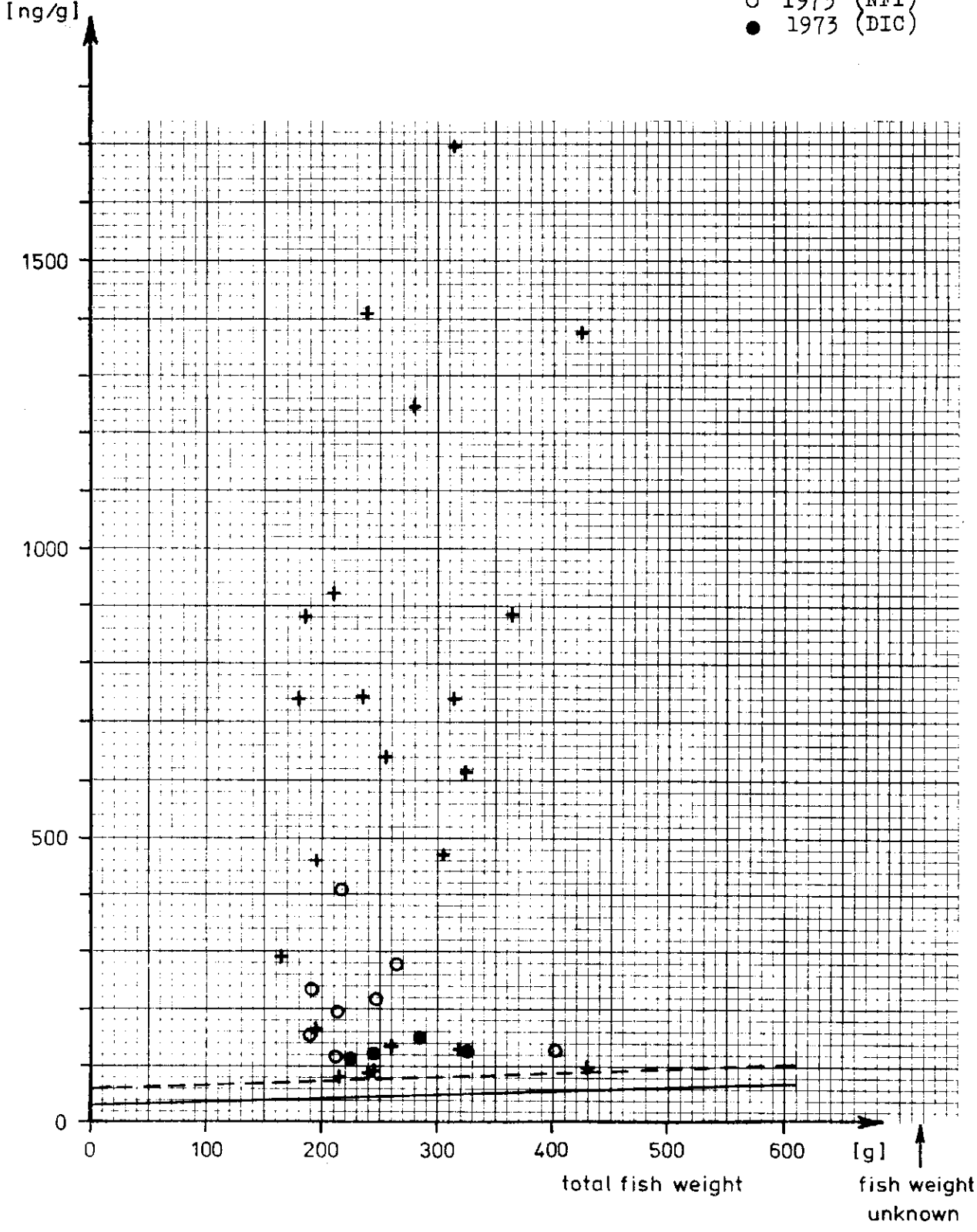
AGF 4240

Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

FLOUNDER

Karrebæksminde Bay-area

+ 1968-72
○ 1973 (NFI)
● 1973 (DIC)



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf.(01)21 41 31		
Godk.:			Mercury in marine fish 1968-76 Flounder, Karrebæksminde Bay-area 1968-72 and 73	Case no.: 446.70	App.: 38
Rev.:					
Rev.:					
Rev.:					

AGF 4240

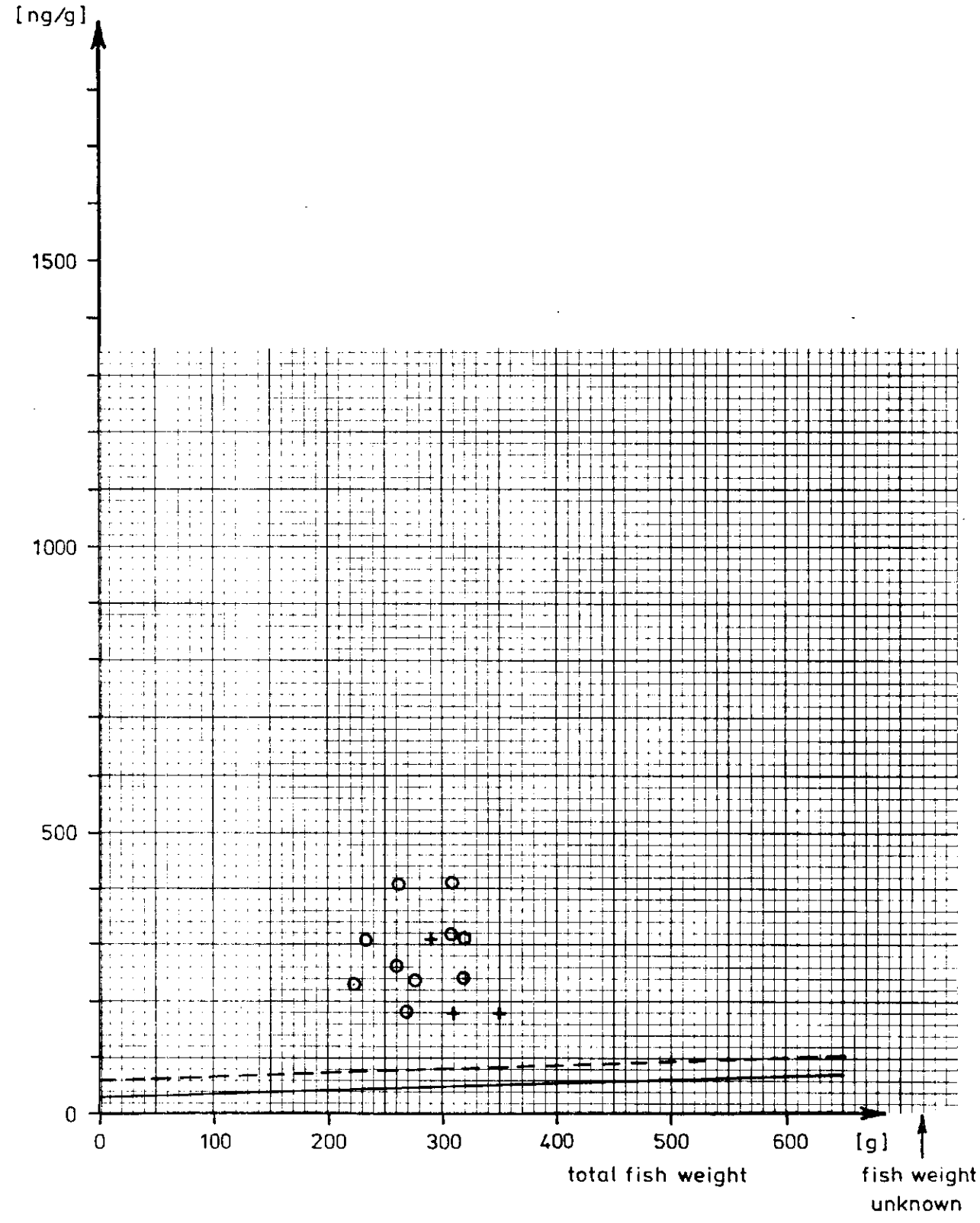
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

FLOUNDER

Køge Bay

\+ 1968-72

o 1973



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:			Mercury in marine fish 1968-76 Flounder, Køge Bay, 1968-72 and 73	Case no.: 446.70	App.: 39
Rev.:					
Rev.:					
Rev.:					

AGF 4240

Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

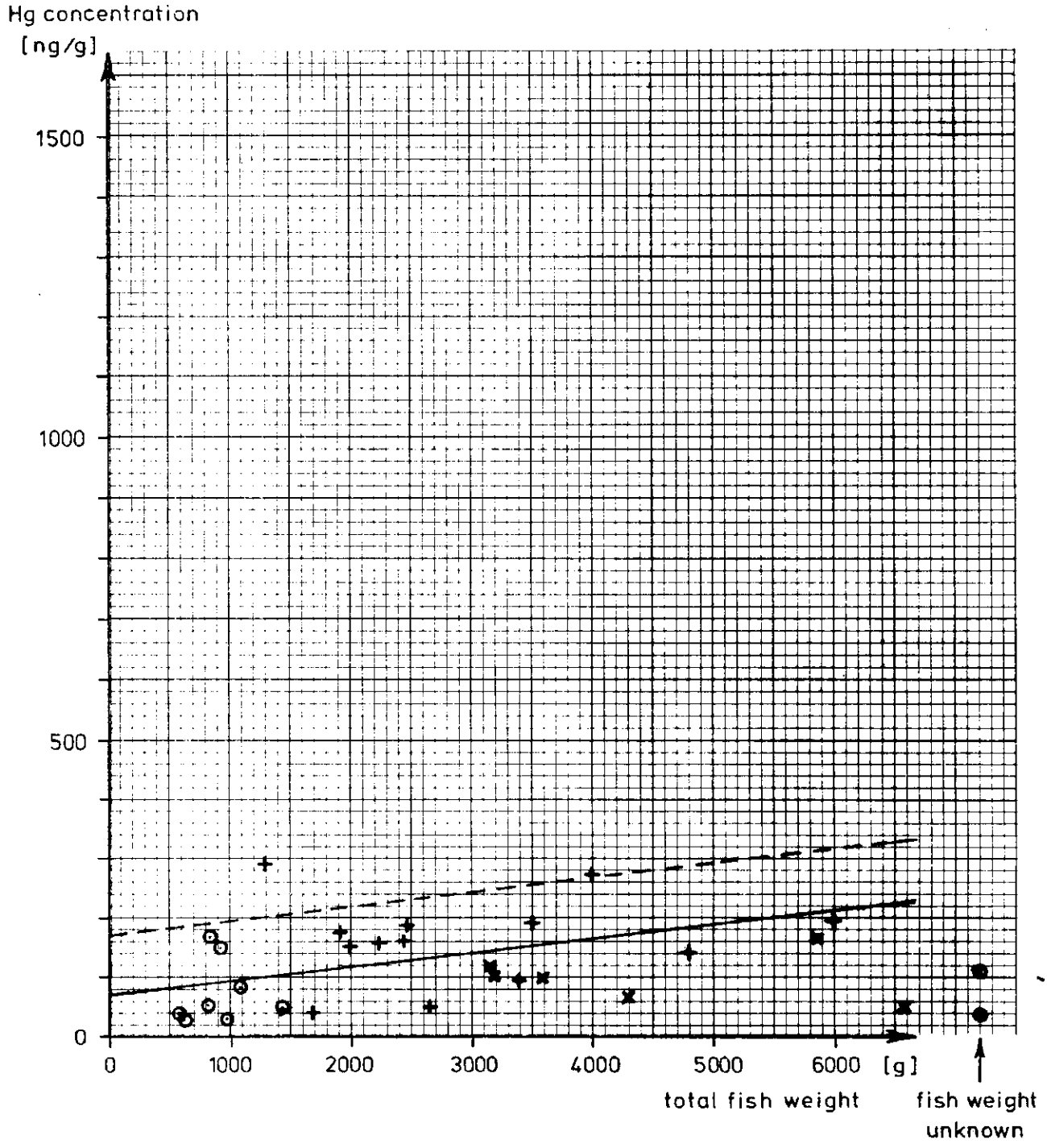
COD

The North Sea

\+ 1968-72

o 1973

× 1974



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK1717 Kbh.V. Telf.(01)214131
Godk.:			
Rev.:			Mercury in marine fish 1968-76 Cod, The North Sea, 1968-72, 73 and 74
Rev.:			Case no.: 446-78 App.: 40
Rev.:			

Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

COD

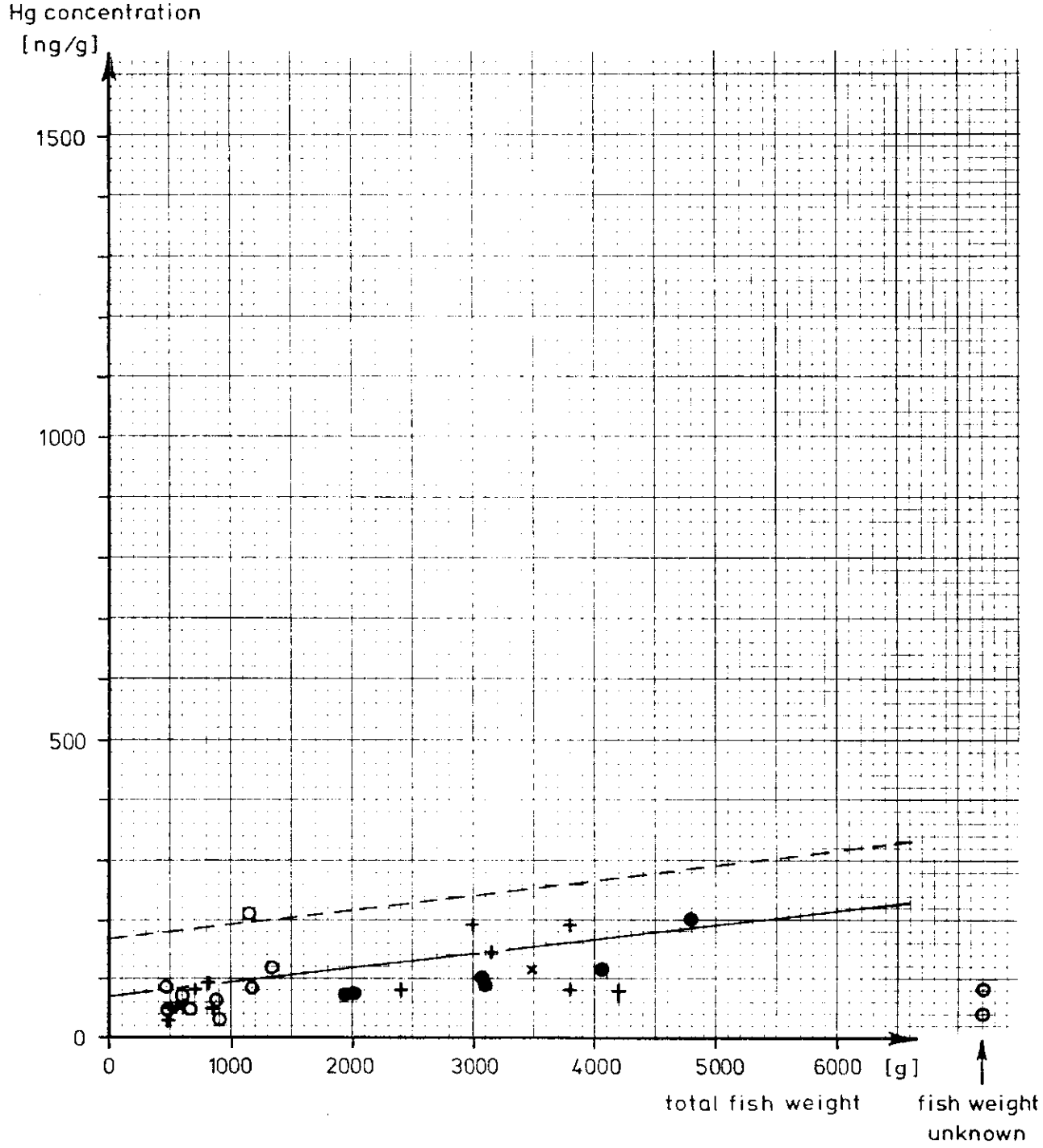
The Baltic

+ 1968-72

○ 1973 (NFI)

● 1973 (DIC)

× 1974



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Cod, The Baltic, 1968-72, 73 and 74	Case no.: 446.70	App.: 41
Rev.:					
Rev.:					

AGF 4240

Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

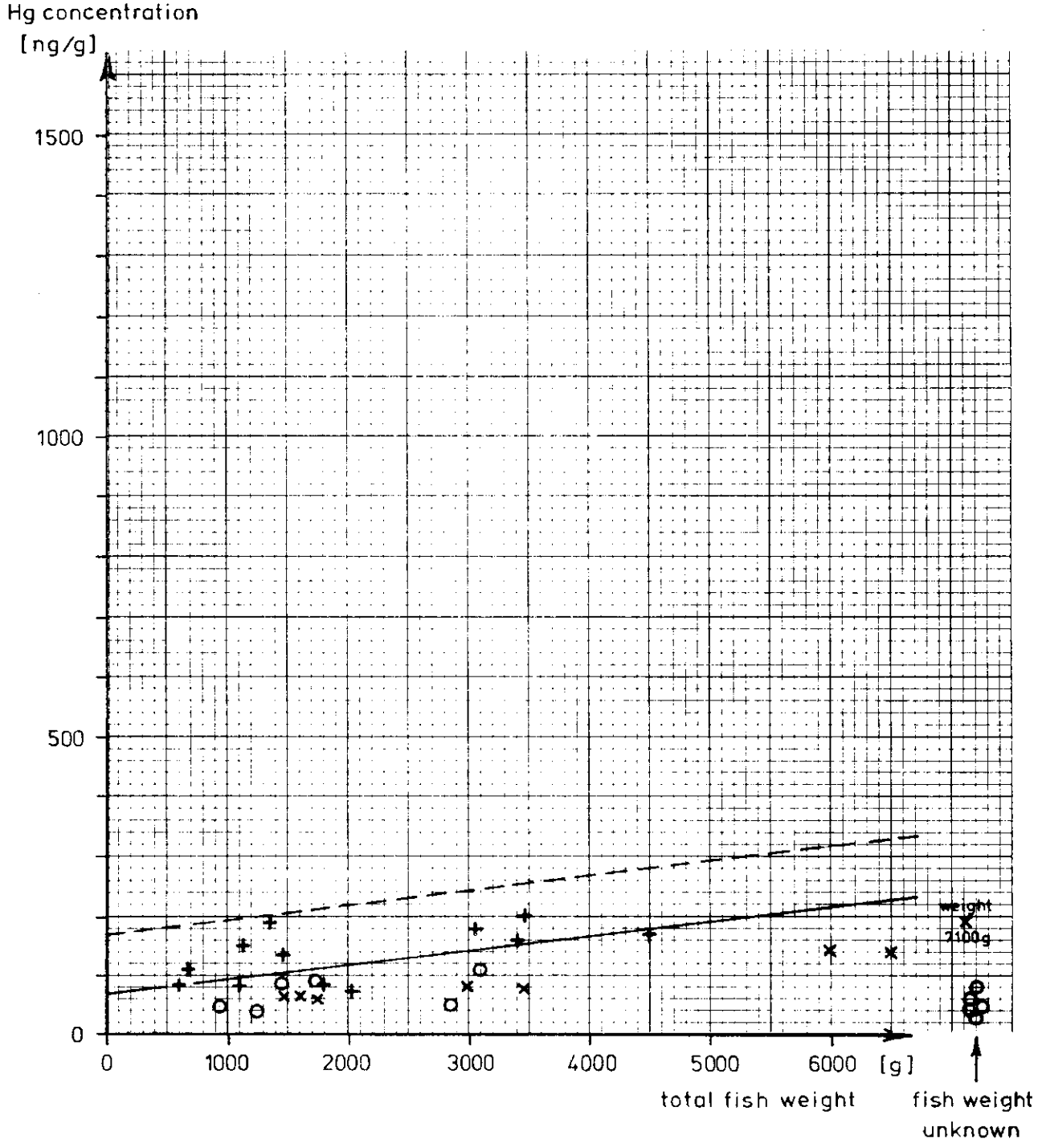
COD

Kattegat

\+ 1968-72

o 1973

× 1974



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK1717 Kbh V. Telf.(01)214131		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Cod, Kattegat, 1968-72, 73 and 74	Case no.: 446.70	App.: 42
Rev.:					
Rev.:					

AGF 4240

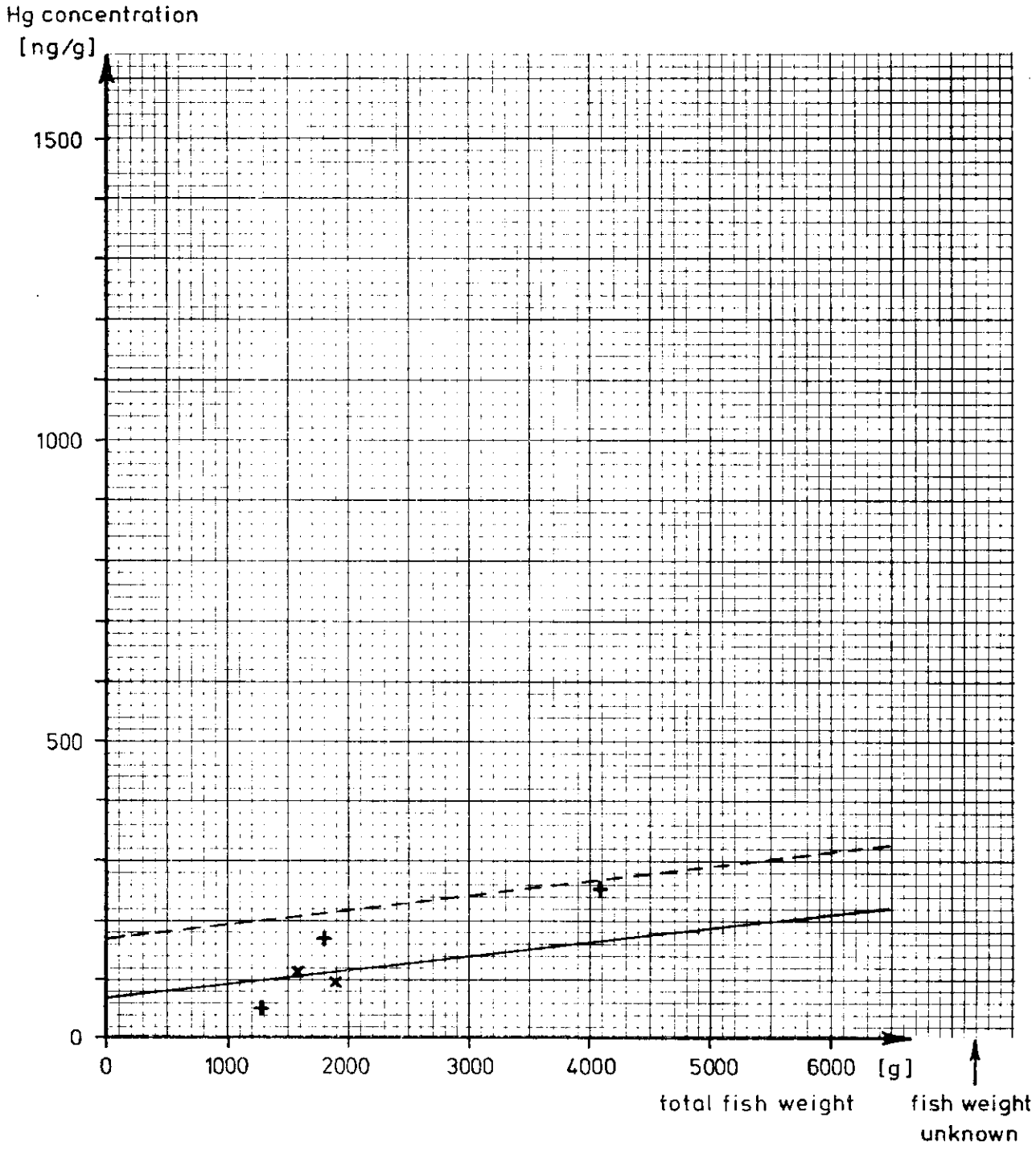
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

COD

Skagerrak

\+ 1968-72

× 1974



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Cod, Skagerrak, 1968-72 and 74	Case no.: 446.70	App.: 43
Rev.:					
Rev.:					

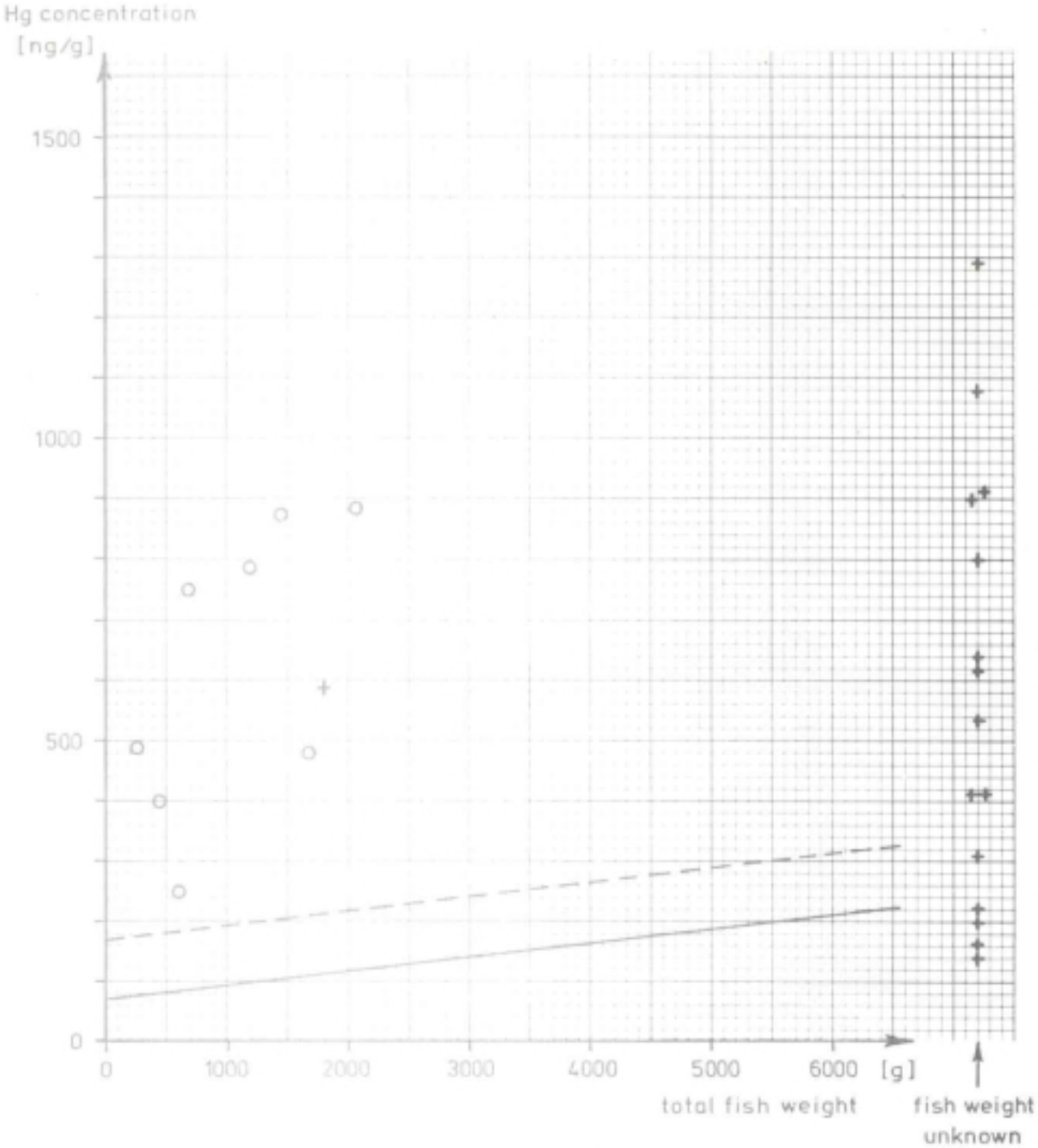
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

COD

The Sound

\+ 1968-72

o 1973



Tegn.:	GK/MF	77o132	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Cod, The Sound, 1968-72 and 73	Case no.: 446.70	App.: 44
Rev.:					
Rev.:					

AEF 4240

Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

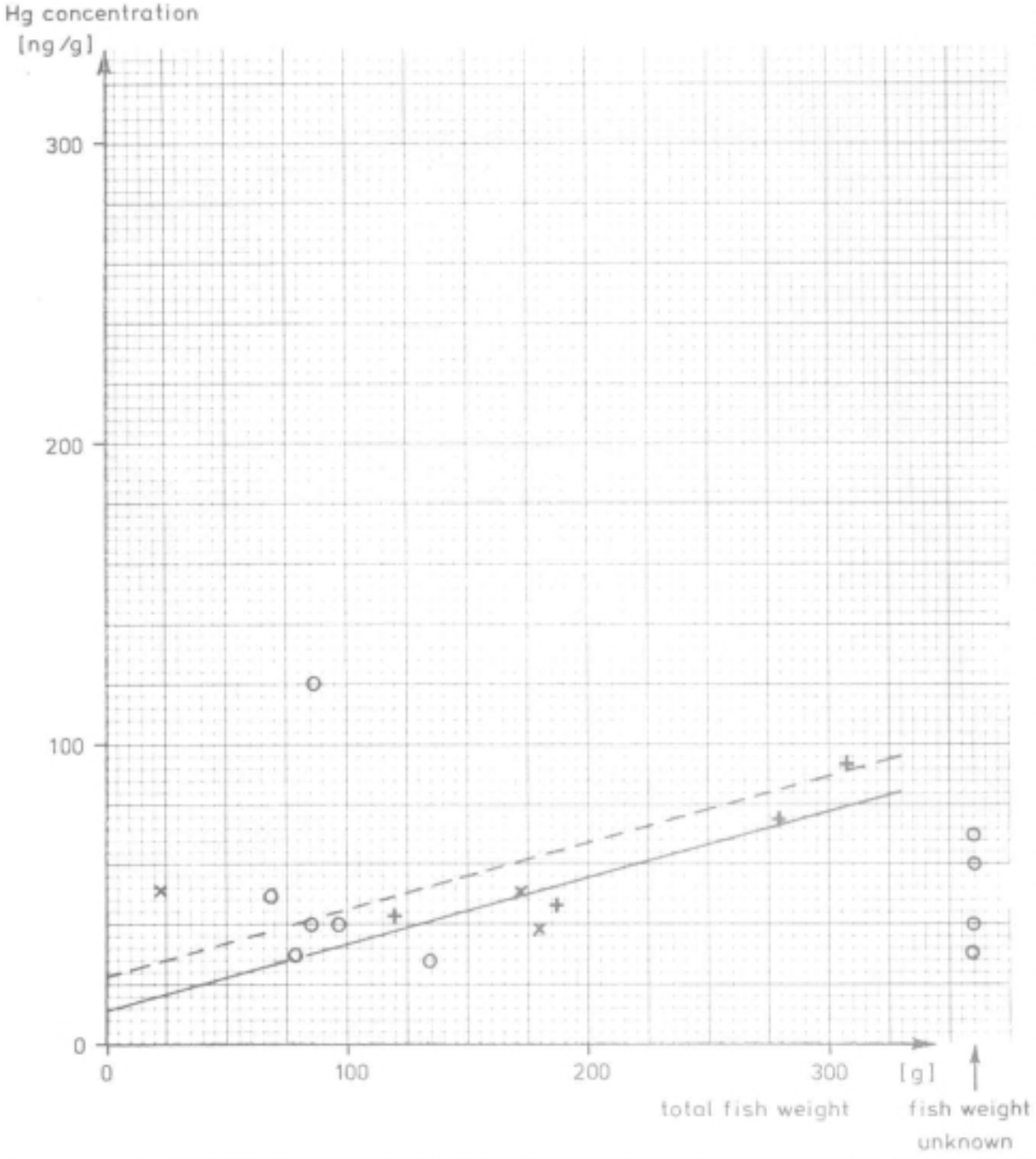
HERRING

the North Sea

\+ 1968-72

.o 1973

× 1974



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Sølvbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Herring, the North Sea, 1972, 73 and 74	Case no.: 446.70	App.: 45
Rev.:					
Rev.:					

AGF 4240

Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

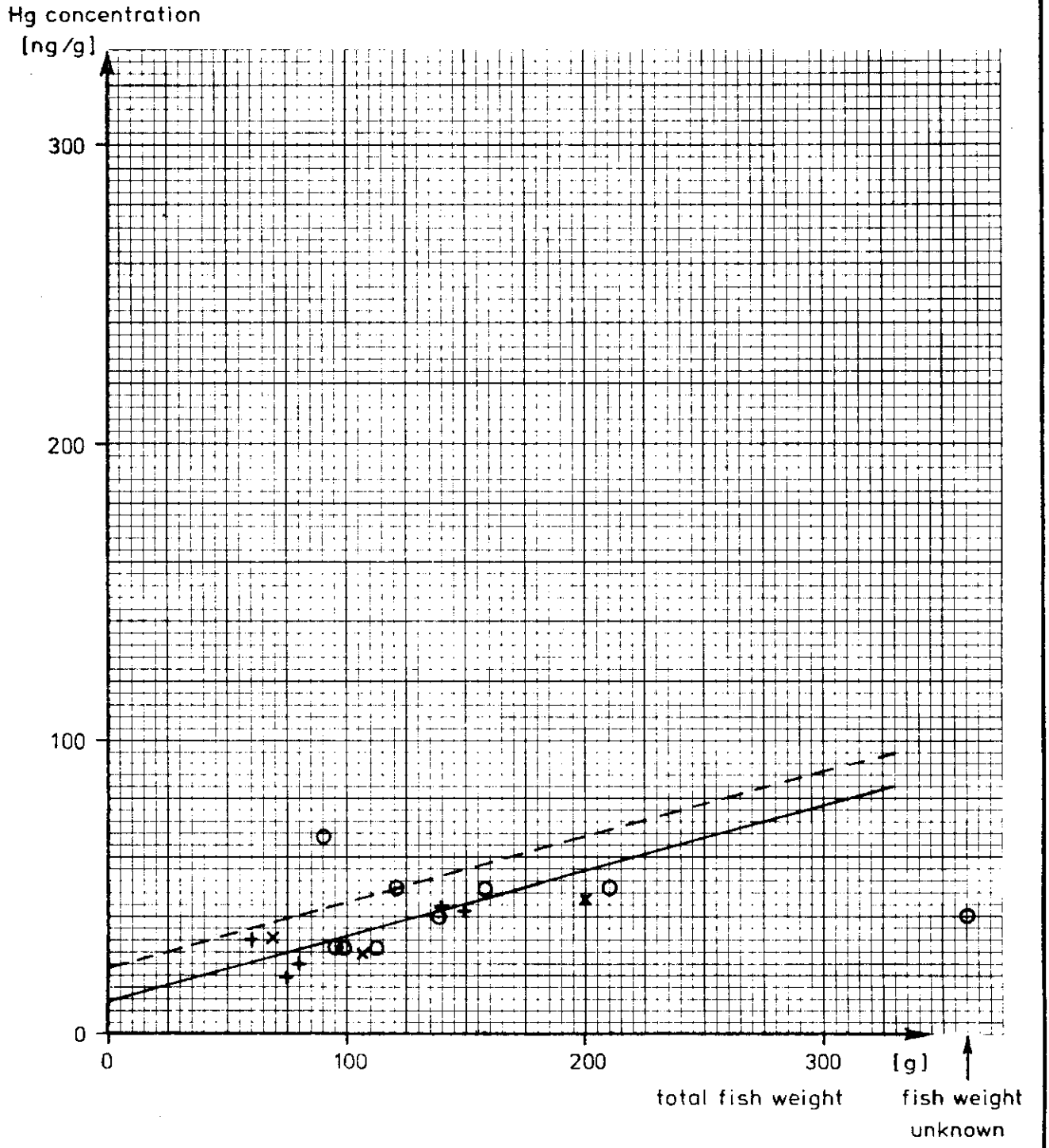
HERRING

The Baltic

\+ 1968-72

o 1973

× 1974



Tegn.:	GK/MF	770131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf.(01)214131		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Herring, the Baltic 1968-72, 73 and 74	Case no.: 446.70	App.: 46
Rev.:					
Rev.:					

AGF 4240

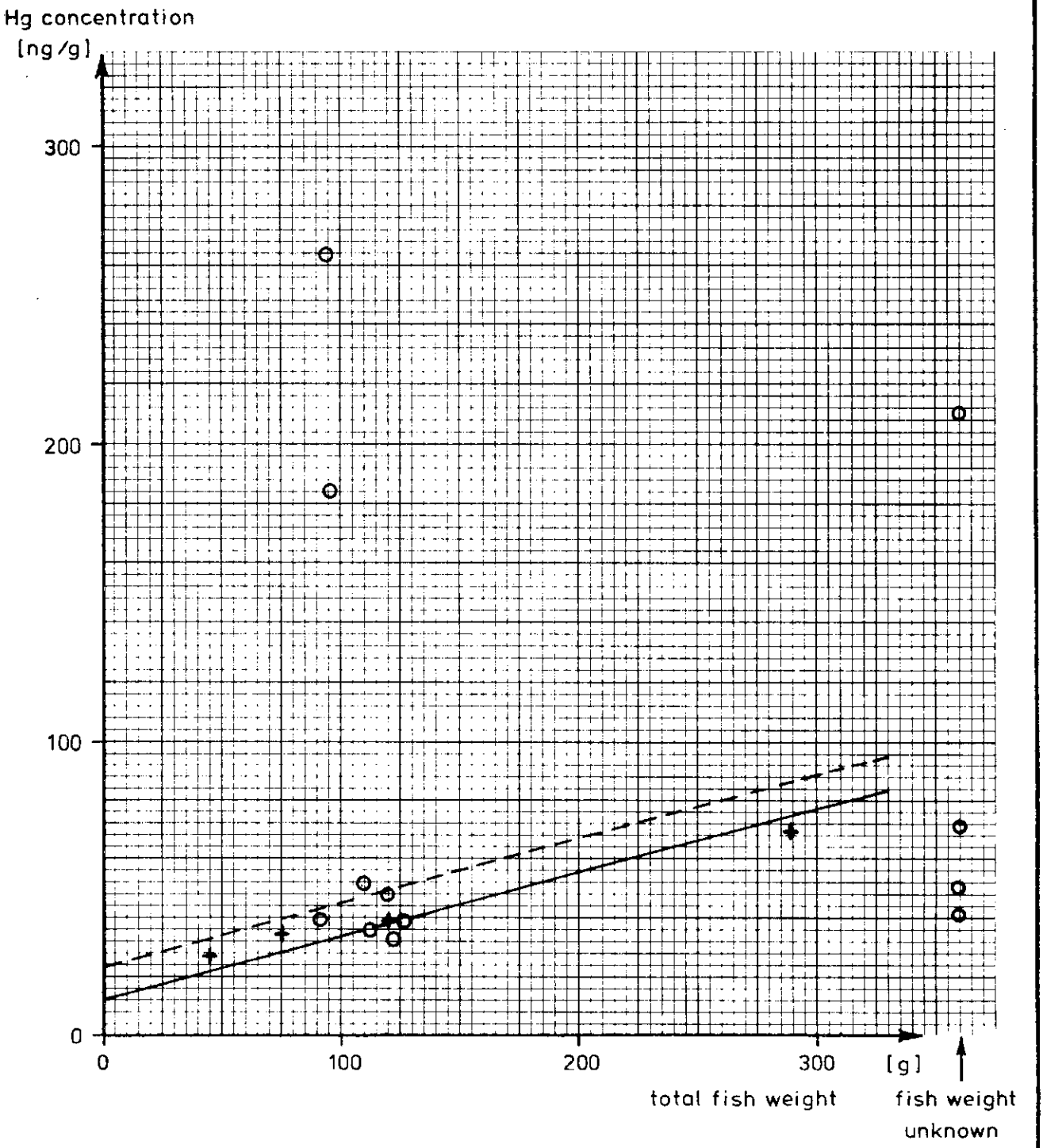
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

HERRING

Kattegat

\+ 1968-72

o 1973



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf.(01)214131		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Herring, Kattegat, 1968-72 and 73	Case no.: 446.70	App.: 47
Rev.:					
Rev.:					

AGF 4240

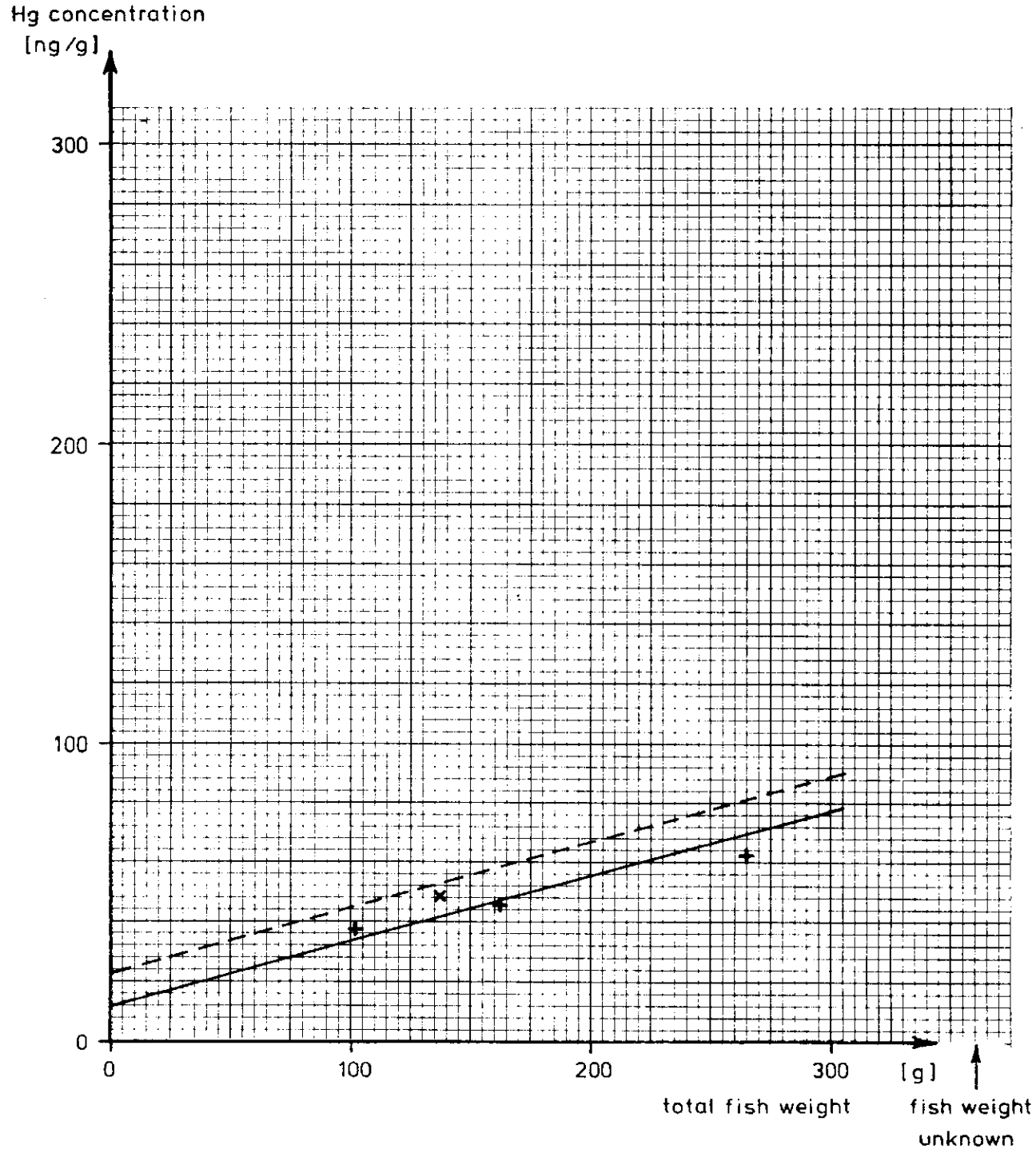
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

HERRING

Skagerrak

\+ 1968-72

× 1974



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf.(01)214131		
Godk.:			Mercury in marine fish 1968-76 Herring, Skagerrak, 1968-72 and 74	Case no.: 446.70	App.: 48
Rev.:					
Rev.:					
Rev.:					

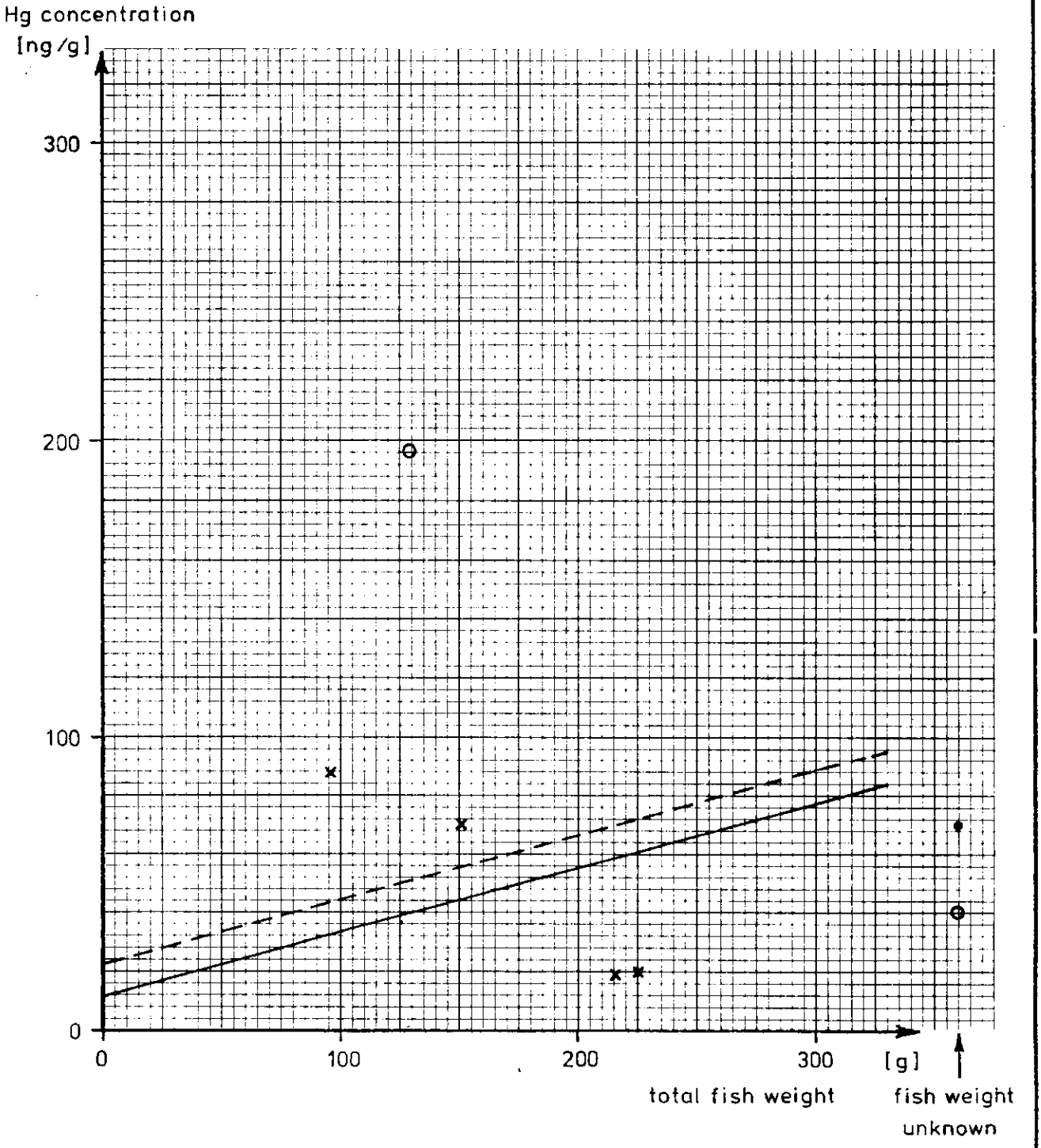
AGF 4248

Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

HERRING

The Sound

o 1973
× 1974
• 1975



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf.(01)214131		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Herring, the Sound, 1973, 74 and 75	Case no.: 446.70	App.: 49
Rev.:					
Rev.:					

AGF 4240

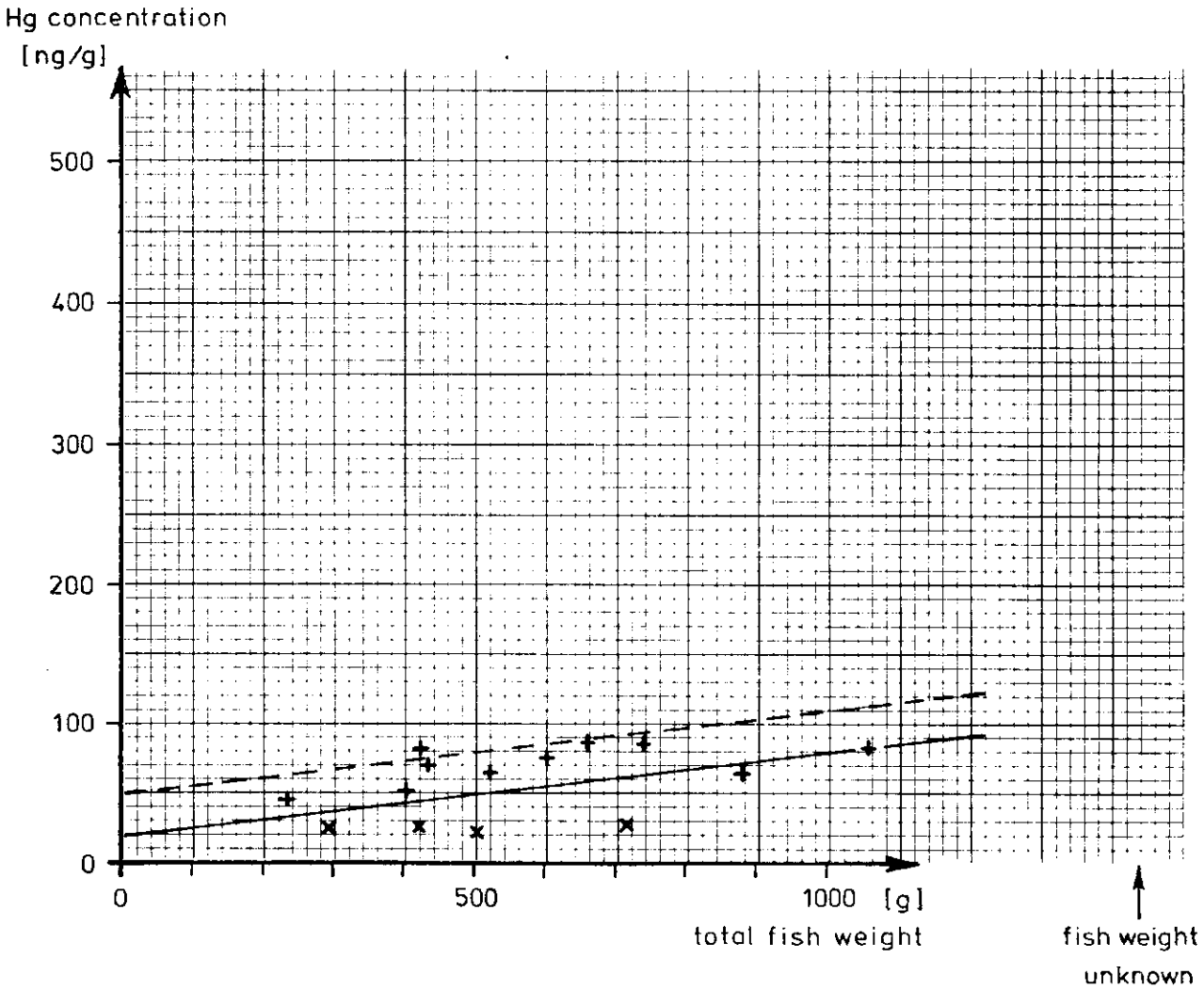
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

PLAICE

The North Sea

\+ 1968-72

× 1974



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Plaice, The North Sea, 1968-72, 73 and 74	Case no.: 446.70	App.: 50
Rev.:					
Rev.:					

AGF 4248

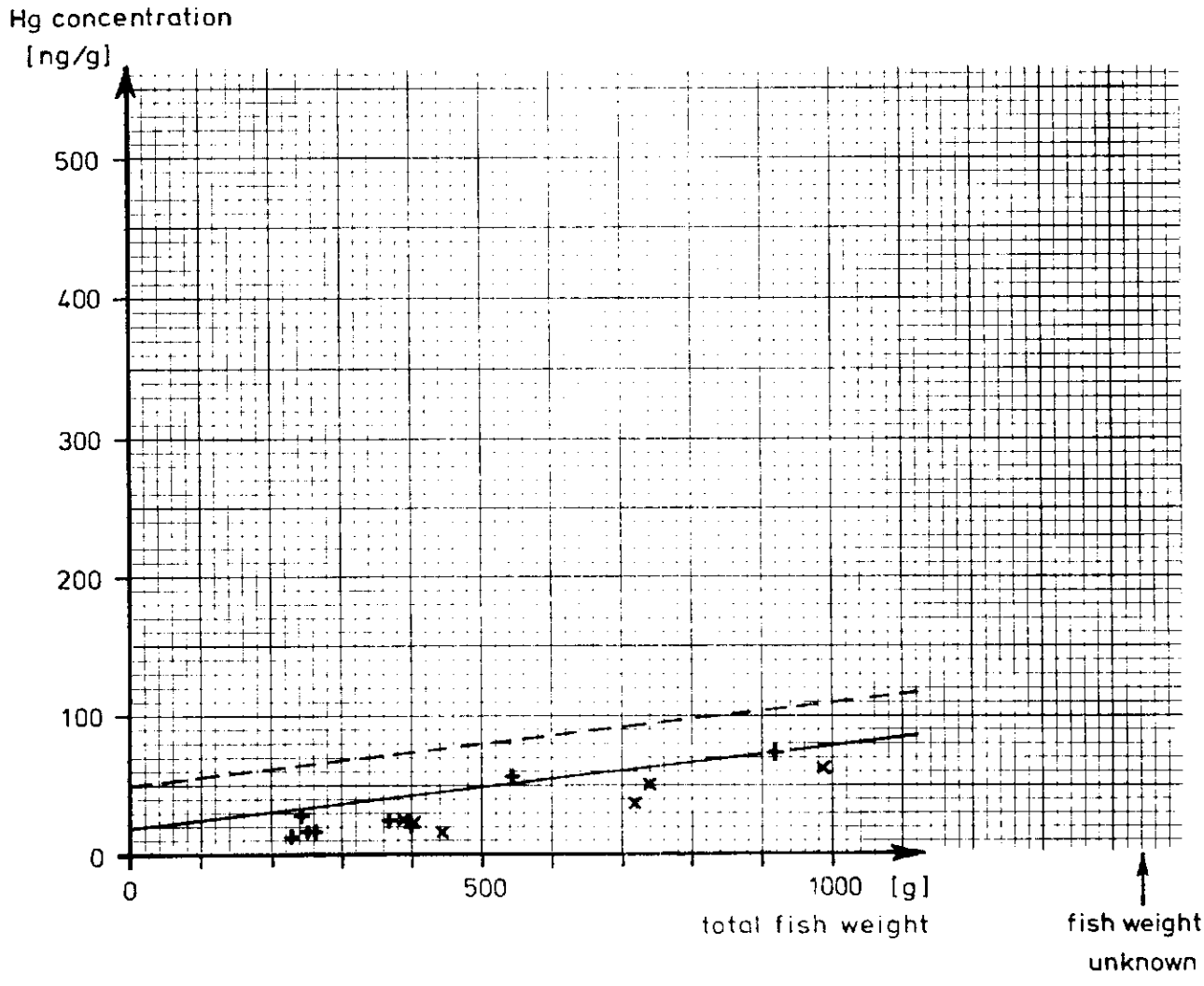
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

PLAICE

Kattegat

\+ 1968-72

× 1974



Tegn.:			ISOTOPCENTRALEN Skelbækgade 2, DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:			Mercury in marine fish 1968-76 Plaice, Kattegat, 1968-72 and 74	Case no.: 446.70	App.: 51
Rev.:					
Rev.:					
Rev.:					

AGF 4248

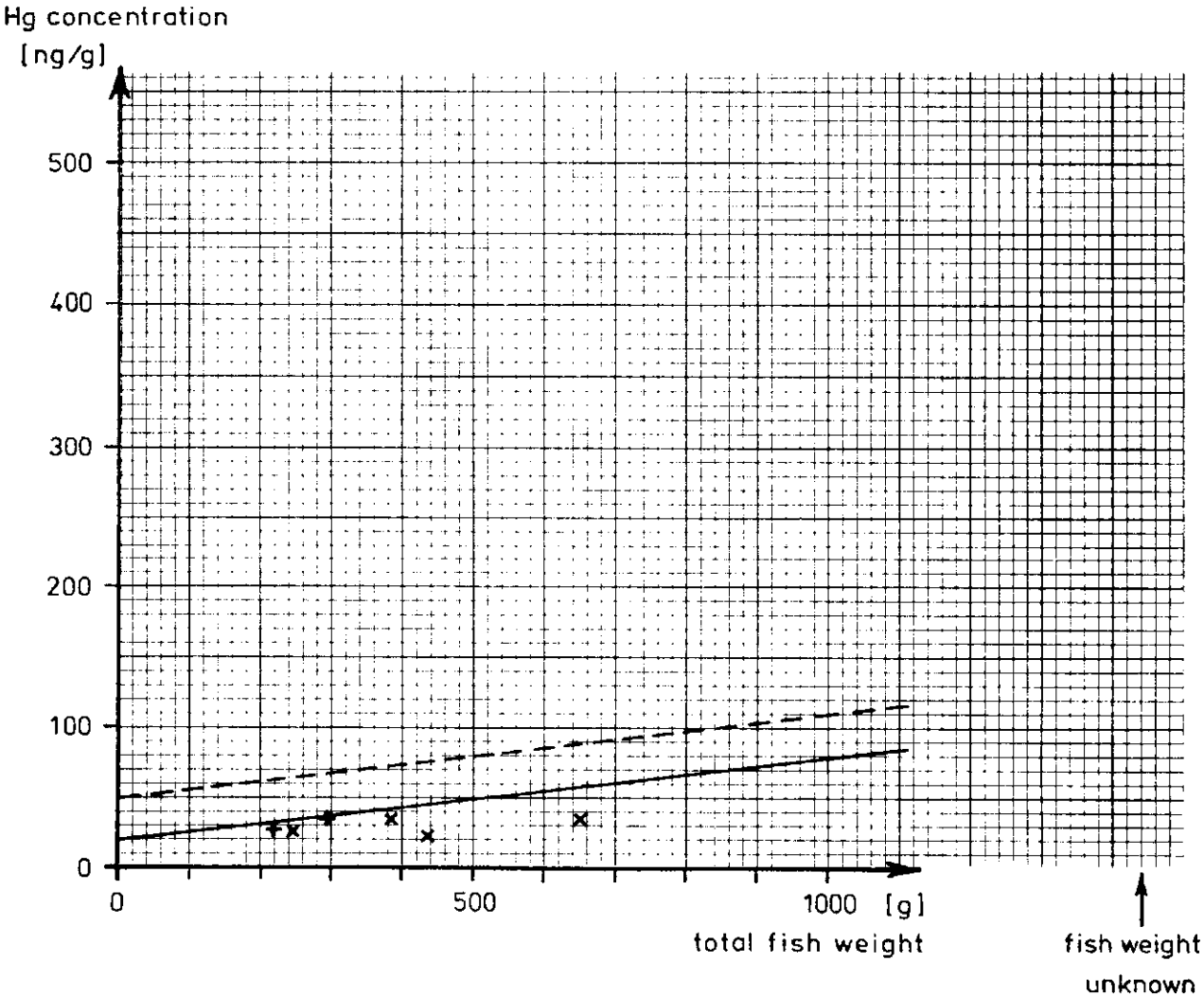
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

PLAICE

Skagerrak

\+ 1968-72

× 1974



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2, DK1717 Kbh. V. Telf.(01)214131		
Godk.:					
Rev.:			Mercury in marine fish 1968-76 Plaice, Skagerrak, 1968-72 and 74	Case no.: 446.70	App.: 52
Rev.:					
Rev.:					

AGF 4298

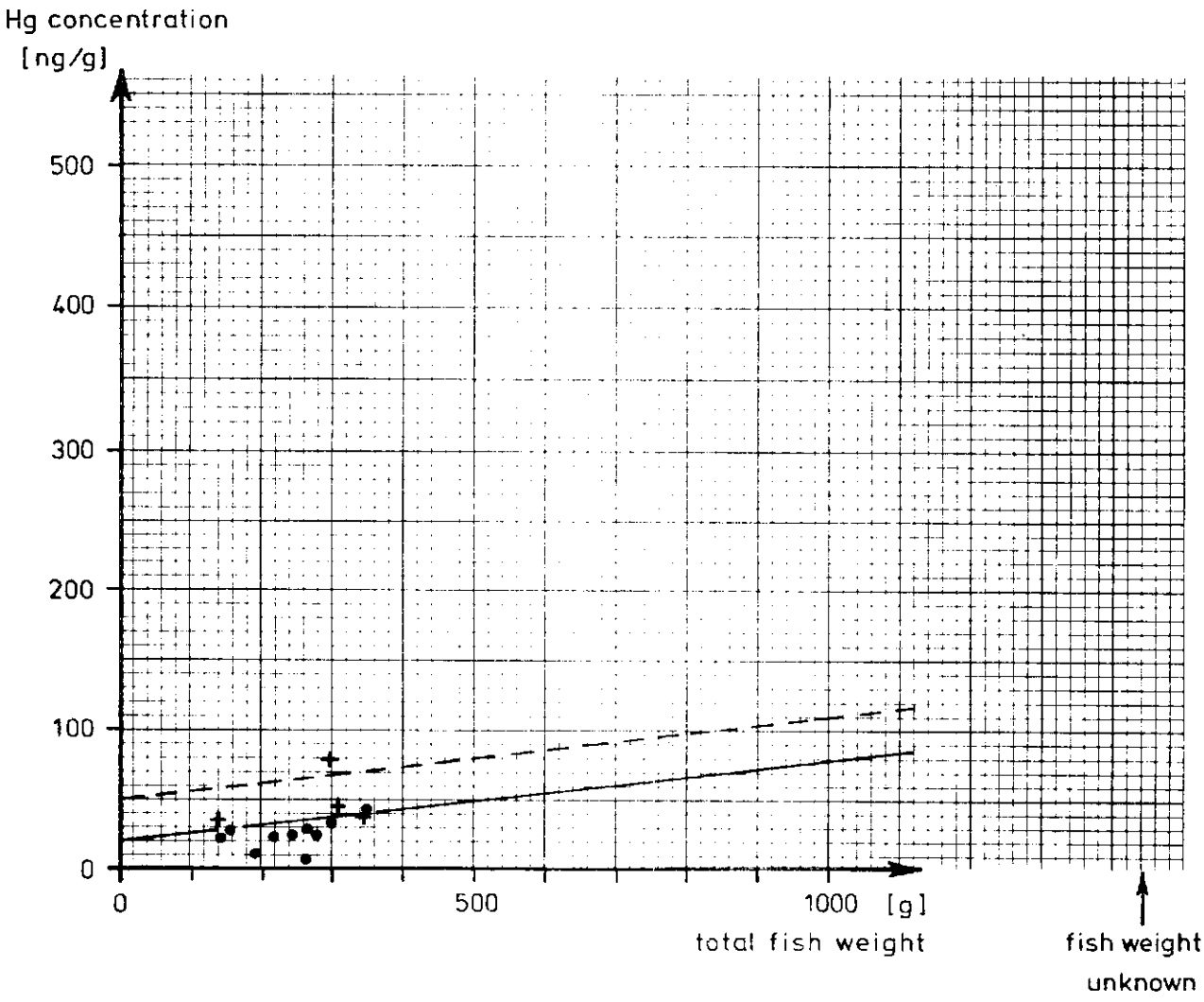
Full line in the diagram indicates the regression line for uncontaminated areas, according to /1/. With 95 % probability the concentration values for uncontaminated samples will be below the dotted line.

PLAICE

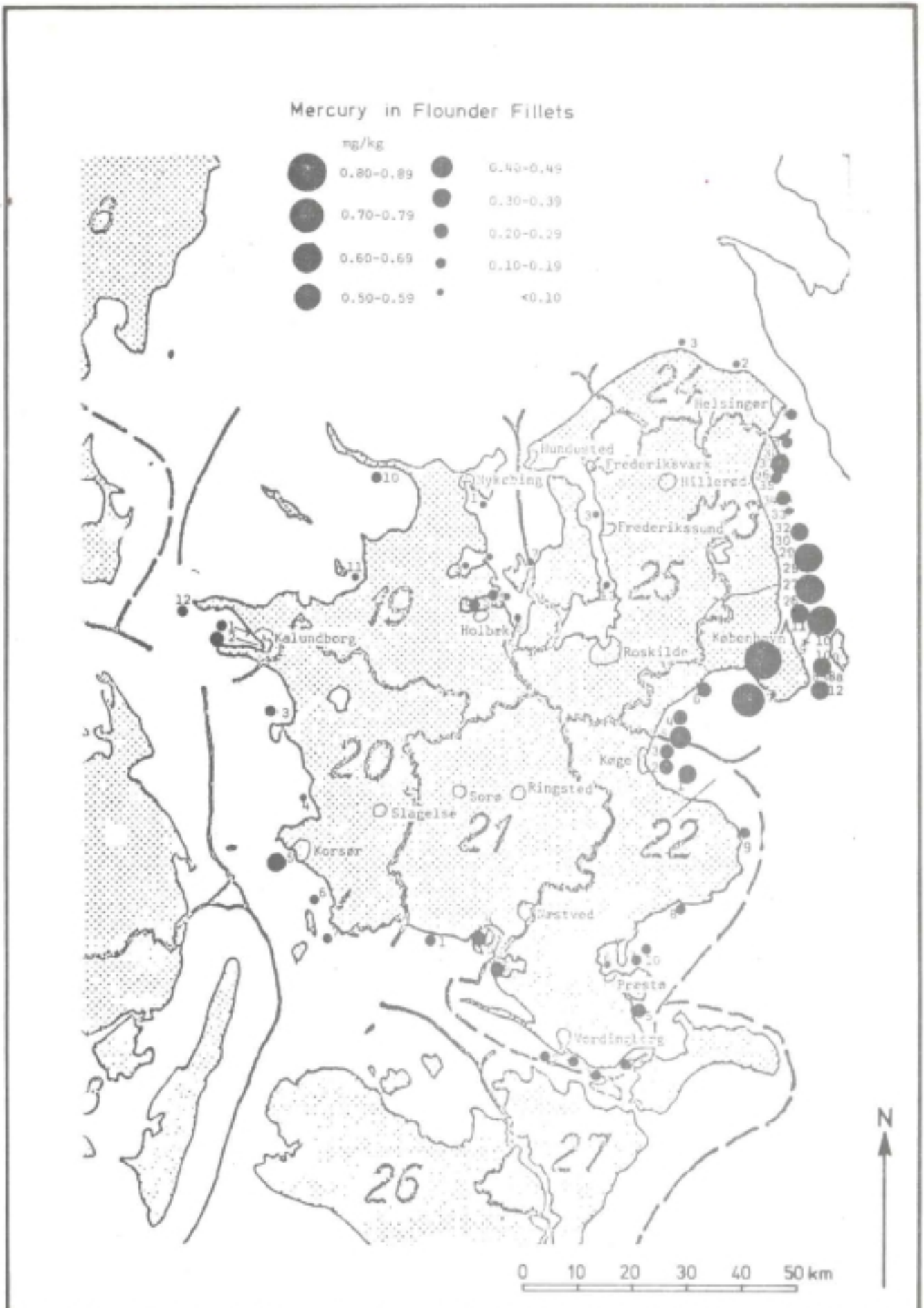
Århus Bay

\+ 1968-72

• 1975



Tegn.:	GK/MF	77o131	ISOTOPCENTRALEN Skelbækgade 2. DK 1717 Kbh. V. Telf. (01) 21 41 31		
Godk.:			Mercury in marine fish 1968-76 Plaice, Århus Bay, 1968-72 and 75	Case no.: 446.70	App.: 53
Rev.:					
Rev.:					
Rev.:					



Tegn.:					
Godk.:					
Rev.:			Mercury Concentration in Flounder Fillets according to NFI /3/.	Case no.: 446.70	App.: 54
Rev.:					
Rev.:					