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AN EXAMINATION OF THE HEAVY METAL LEVELS IN MUSCLE, KIDNEY AND LIVER OF SAITHE IN RELATION TO YEAR CLASS, AREA OF SAMPLING AND SEASON

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Introduction

No studies appear to have been made of the seasonal variation of heavy metals in either the edible tissue or the internal organs of marine fish. Also, only a few attempts (Portmann, 1973 and Hardisty et al, 1974a,b) have been made to examine the variation of metal levels with year class of fish. In view of the importance of such information to baseline or monitoring programmes set up to identify spatial and temporal trends in metal levels in the sea and to attempt to relate these results to man's industrial activities, it was decided to carry out some research in this field of study.

During 1973 the fish resources team of the Marine Laboratory, Aberdeen had planned to collect samples of saithe from the North Sea and the Firth of Clyde, at approximately monthly intervals, in order to compare age/weight relationship, maturity and fecundity. It was decided to take advantage of this sampling programme by including samples of saithe for heavy metal analyses. Because of the need to limit the number of samples, and analyses, to a manageable level the request for samples was limited to categories of 'small' and 'large' fish from each area.

The selection of organs and tissue for analysis was based on the findings of previous investigations (Holden and Topping, 1971; Windom et al, 1973 and Hardisty et al, 1974a) which had shown that the highest concentrations of heavy metal occurred in the liver and kidney of fish and the results of some recent experimental metal accumulation studies (Saward et al, 1975) which has shown that the level of accumulation of copper in the viscera of young plaice was related to both the level of copper in sea water and the period of exposure to copper.

Methods

Samples of saithe were taken at approximately monthly intervals from commercial landings at Ayr during the period March-December 1973 and at Peterhead during the period May-October 1973. Each monthly sample consisted of 10 small fish and 10 large fish. Small fish samples from the Firth of Clyde consisted of

2 years old and large fish mainly 3-4 years old while small fish from the North Sea consisted of 3-5 years old and large fish 4-9 years old. On arrival at the laboratory the fish were weighed, measured and aged prior to dissection to obtain whole length fillets, kidney and liver. The individual tissues from each group were then bulked and homogenised to provide a suitable sub-sample for chemical analysis.

Samples for copper, zinc, cadmium and lead analysis were wet-ashed with nitric acid at 140°C prior to analysis by flame atomic absorption spectroscopy (Topping 1973). Mercury analysis was carried out using a dry combustion/flameless atomic absorption technique (J Pirie and G Topping, unpublished). The sample was introduced to a silica lined furnace in a silica sample boat and quickly heated to 1000°C. Combustion of the organic matter was assisted by passing oxygen over the sample. The outlet of the furnace was connected to a Dreschel bottle containing an acid-permanganate mixture as a trapping solution for the volatized mercury. The acid permanganate solution was cooled to room temperature and then analysed for mercury by flameless atomic absorption spectroscopy (Topping and Pirie, 1972).

The accuracy of the mercury method was checked by analysing Bowen's Kale (Bowen, 1967); a value of 0.15±0.01 µg/gm was obtained which is in agreement with the accepted mercury value of 0.154 µg/gm.

Results and Discussion

The results of the analyses, together with details of year class, weights, lengths and area of sampling, are given in Table 1.

The request for samples of saithe in rough categories of 'small' and 'large' fish led to two rather different age groups being supplied from the Clyde and from the North Sea. Bearing in mind the limited overlap in the two sets of samples, the analytical data for copper, zinc, cadmium, mercury and lead are discussed below in relation to tissue, year class, sampling area and seasonal changes.

Tissue

As is usual in marine fish the lowest concentration of copper, zinc and cadmium were found in muscle tissue and the highest concentrations in liver; kidney levels fell roughly between halfway. The highest values of mercury were found in muscle tissue except on two occasions when significantly higher values were found in kidney and liver. These analyses show little difference among tissue in respect of lead.

Year Class

In general, muscle levels of mercury and liver levels of copper and zinc increased with year class. There is also a suggestion that muscle levels of copper decreased with year class.

Sampling Area

In general the muscle levels of mercury; kidney levels of cadmium and liver levels of copper and zinc, for similar year class groups, were higher in the samples from the Firth of Clyde.

Seasonal Changes

Although there are significant differences in metal levels in all three tissues throughout the sampling period, it is not easy to identify any consistent trend for any one metal in any of the three tissues.

Summary and Conclusions

One of the objectives behind this exercise was to attempt to identify which tissue of saithe and other fish could be used to monitor spatial trends of heavy metals in the marine environment. Of the metals examined, mercury is the only one to show spatial variation with respect to muscle tissue and the only metal in this tissue that shows a clear increase with year class. There is a strong indication however that the copper and zinc levels in liver reflect the area of sampling and also that they show an increase with year class. In addition there is a remote possibility that cadmium levels in kidney might well be used to show changes in cadmium levels in the marine environment. Bearing in mind the problem of sample contamination and that most of the lead values fall on or near the level of detection the lead levels in muscle, kidney and liver tissue appear to be so uniform that no information could be gained in respect of spatial and temporal variation by monitoring any of these tissues.

Seasonal changes of metal levels in fish tissue are obviously important in the context of baseline investigations or monitoring programmes. The data collected in this survey indicate that there are significant differences in metal levels in all three tissues throughout the sampling period. It is difficult, however to identify any consistent trend for any one metal in any one of the three tissues. In view of this, it is suggested that studies of seasonal variation should be undertaken for all fish species that are selected for monitoring programmes in order to identify the time period when the changes in tissue levels are very small. In this way the differences in metal levels observed for fish from a number of areas may justifiably be attributed to differences in area and not due to differences brought about by physiological factors.

References

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TABLE 1 Heavy Metals in Saithe Tissue (µg/gm wet weight)

FIRTH OF CLYDE

Small Fish

				Muscle					Kidney					Liver				
Date	Length cms	Weight gms	Year Class	Cu	Zn	Cd	Hg	Pb	Cu	Zn	Cd	Hg	Pb	Cu	Zn	Cd	Hg	Pb
13.3.73	33-37	310-488	2	0.41	3.9	0.07	0.11	0.2	1.4	15.6	0.32	0.44	<0.4	4.2	17.8	0.19	0.03	<0.4
12.4.73	33-35	303-390	"	0.56	4.9	0.04	0.06	<0.1	1.5	16.9	0.06	0.06	1.0	6.6	28,2	0.04	0.04	"
17.5.73	33-41	297-544	"	0.21	4.2	0.03	0.04	<0.1	1.0	17.8	<0.02	0.05	0.7	4.9	20.7	0.04	0.06	"
5.7.73	32-36	325-413	"	1.53	7.4	<0.01	0.06	0.05	1.7	19.4	0.06	0.04	<0.05	4.7	22.0	0.09	<0.01	<0.0[illegible]
26.9.73	33-45	301-690	"	0.61	5.1	"	"	0.07	2.4	21.3	0.07	0.03	0.28	6.3	21.6	0.09	"	0.0[illegible]
23.10.73	31-38	301-695	"	0.63	4.3	0.28	0.08	0.10	1.5	15.0	0.07	0.04	<0.05	3.5	19.3	0.18	"	0.1[illegible]
3.12.73	34-44	403-772	"	0.53	10.2	0.02	0.04	0.12	2.4	17.0	0.01	0.03	0.39	5.7	18.5	0.07	"	0.3[illegible]
14.12.73	33-37	317-427	"	0.33	4.8	<0.01	0.14	0.06	2.0	15.4	0.03	0.06	0.34	3.4	17.0	0.09	0.03	<0.0[illegible]
Mean				0.60	5.6	0.06	0.07	-	1.7	17.3	0.08	0.04	-	4.9	20.6	0.10	0.02	-

Large Fish

				Muscle					Kidney					Liver				
Date	Length cms	Weight gms	Year Class	Cu	Zn	Cd	Hg	Pb	Cu	Zn	Cd	Hg	Pb	Cu	Zn	Cd	Hg	Pb
14.3.73	41-53	651-1501	3-4	0.29	3.8	0.03	0.04	0.40	1.1	16.7	0.06	0.09	<0.4	4.6	22.5	<0.02	0.04	0.7
12.4.73	47-53	871-1200	3-4	0.38	4.4	0.04	0.39	"	1.2	19.0	0.04	0.05	"	7.6	30.8	0.10	0.05	<0.4
17.5.73	46-51	825-1305	3-4	-	-	-	-	-	1.2	19.6	0.01	0.06	<0.05	8.9	26.3	0.18	0.30	<0.0[illegible]
5.7.73	42-57	666-1559	3-4	0.70	12.0	<0.01	0.19	0.10	1.6	20.7	0.04	0.04	0.14	6.0	18.4	0.06	0.04	<0.0[illegible]
26.9.73	43-64	641-2325	3-7	0.39	4.9	"	0.11	0.05	1.6	15.0	0.09	0.04	<0.05	9.1	23.6	0.10	<0.01	<0.0[illegible]
3.12.73	46-62	782-2085	3-8	0.63	4.6	"	0.15	0.10	2.9	16.4	0.05	0.03	0.25	8.2	21.5	0.11	0.03	0.1[illegible]
Mean				0.48	5.9	0.01	0.18	-	1.6	17.9	0.05	0.06	-	7.4	23.8	0.10	0.09	

TABLE 1 (cont)

NORTH SEA

Small Fish

Date	Length cms	Weight gms	Year Class	Muscle Cu	Muscle Zn	Muscle Cd	Muscle Hg	Muscle Pb	Kidney Cu	Kidney Zn	Kidney Cd	Kidney Hg	Kidney Pb	Liver Cu	Liver Zn	Liver Cd	Liver Hg	Liver Pb
7.5.73	48-50	915-1195	3-4	0.41	4.4	0.02	0.07	0.19	1.5	13.6	0.03	0.08	<0.4	7.0	30.0	0.16	0.04	1.4
25.6.73	45-55	921-1500	3-5	0.51	5.7	"	0.05	<0.05	2.6	15.6	0.02	0.04	<0.05	3.4	14.9	0.11	0.09	0.10
24.7.73	46-50	893-1248	3-5	0.69	5.1	"	0.03	0.06	1.2	20.1	0.03	0.02	"	3.8	15.0	0.02	<0.01	0.17
1.10.73	44-56	844-1705	3	0.45	5.5	"	"	<0.05	1.6	15.0	0.02	0.04	"	2.7	13.4	0.09	0.02	0.05
	Mean			0.52	5.2	0.02	0.04	-	1.7	16.1	0.02	0.05	-	4.2	18.3	0.09	0.04	-

Large Fish

Date	Length cms	Weight gms	Year Class	Muscle Cu	Muscle Zn	Muscle Cd	Muscle Hg	Muscle Pb	Kidney Cu	Kidney Zn	Kidney Cd	Kidney Hg	Kidney Pb	Liver Cu	Liver Zn	Liver Cd	Liver Hg	Liver Pb
7.5.73	51-60	1155-1860	5-6	0.42	4.1	0.04	0.06	0.40	2.3	20.1	0.03	0.05	<0.4	6.9	22.3	0.06	0.04	<0.4
25.6.73	61-87	2068-4743	4-9	0.49	5.9	0.01	0.08	<0.05	-	-	-	-		5.1	18.1	0.11	0.03	0.1
24.7.73	62-81	2309-4790	4-7	0.41	4.6	"	0.13	"	1.2	16.4	0.06	0.03	<0.05	4.5	16.4	0.15	0.23	<0.05
1.10.73	46-80	1301-4649	4-6	0.32	3.6	"	0.05	"	1.5	15.4	0.08	0.04	"	5.4	17.1	0.10	<0.01	"
	Mean			0.41	4.5	<0.01	0.08	-	1.7	17.4	0.06	0.04	-	5.5	18.4	0.10	0.08	-