Temporal trends in contaminants in Herring in the Baltic Sea in the period 1980-2010

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Key message

The temporal trend analyses of heavy metals showed 20 significant trends (6 upwards and 14 downwards) out of 50 tests. The remarkable upward trends were cadmium (2), zinc (2), and copper (2). The downward trends were cadmium (1), lead (5), mercury (5), copper (2), and zinc (1). The number of significant decreasing trends has increased compared to the last assessment. In the same manner the number of increasing trends has been reduced.

The temporal trend analyses of PCB's (Poly Chlorinated Biphenyls) and Lindane showed 62 significant trends (all downwards) out of 78 tests. The number of significant decreasing trends has increased since the last assessment.

Results and assessment

The temporal trend analyses of heavy metals showed 20 significant trends (6 upwards and 14 downwards) out of 50 tests. For cadmium two areas (Hanöbukt and Gävlebukt) had significant upward trends. For lead five areas showed a downward trend (Kattegat N, Hanöbukt, Stockholm area, Gävlebukt, and Luleå area). Mercury showed significant downward trends in 5 areas (Kattegat N, Hanöbukt, Stockholm area, Gävlebukt, and Luleå area). Zinc showed increasing trends in two areas (Hanöbukt and Outer Gulf of Finland) and a decreasing trend in one area (Stockholm area). Copper showed an increasing trend in two areas (Hanöbukt and Gävlebukt) and a downward trend in two areas (Kattegat N and Stockholm area).

On the spatial scale improvements are most obvious in the Northern Kattegat and in the Stockholm Area (with 11 and 12 significant downward trends) whereas the areas Hanöbukt and Gävlebukt seems to be the most affected by contaminants (3 and 2 upward trends).

Compared with the last update of the indicator in 2010, some improvement can be found in relation to the heavy metals. The number of significant downward trends has increased as well as the number of increasing trends has been reduced. The two significant upwards trends for cadmium is less significant due to decreasing concentrations during the most recent years. Only two trends for zinc is still significant whereas 3 trends which were significant in 2010 has been reversed due to decreasing zinc concentrations in the most recent years.

It should be emphasized that the increasing number of years in a time series in general increase the chance of getting a significant result (the type II error (no significant results, despite the fact there is actual a trend) decreases with the number of years). At the same time lack of data in more recent years from some areas impairs the comparison and the fact that the length of some time series are rather limited makes significant test results less likely. The two significant upwards trends for cadmium and on upward trend for zinc is starting to be reversed by decreasing concentrations during the last years.

The temporal trend analyses of PCB's (Poly Chlorinated Biphenyls) and Lindane showed 62 significant trends (all downwards) out of 78 tests. Compared with the last update of the indicator in 2010 the number of significant trends has increased from 54 to 62.

The trends documented in Table 1 are summarised in the Figures 1-13.

The observed upward trend in the concentration of cadmium in Herring is comparable to observations in other biotic matrices. The temporal trend of cadmium in seawater shows in general a downward trend. This remarkable difference between matrices has so far no clear explanation.

The downward trends of lead in the majority of the areas are probably caused by the reduced atmospheric input of anthropogenic lead due to the removal of lead from the petrol. The causes of the two upward trends in zinc are not clear.

Both copper and zinc are involved in many metabolic processes and carry out specific physiological roles which means that the observed changes can be related to natural variability as well as anthropogenic activities.

The very pronounced reduction in the concentration of PCB's in many areas is probably a result of the regulations and bans in the countries around the Baltic Sea.

The downward trend in the concentration of Lindane in Herring in 8 areas is probably a result of regulations and bans in countries around Baltic Sea leading to a reduced emission of Lindane.

Table 1: The results of the time trend analysis using a non-parametric Mann-Kendall test. For each area and substances the results of the test are given. All the chemical analyses for Heavy metals are done on liver tissue except for Mercury where the analyses are done on muscle tissue. All the chemical analyses for PCB's and Lindane are done on muscle tissue. Upper row (r): the Kendall tau correlation coefficient. Middle row (P): significance level. Lower row (n); number of observations (years) in the time series. The last year in the time series are indicated italic in parentheses. The significant upward trends are indicated by P-values shown in red while significant downward trends are indicated by P-values in green. The significance level of P<0.05 are used.

		Cadmium	Lead	Mercury	Copper	Zinc
		Liver	Liver	Muscle	Liver	Liver
Kattegat N	r	-0.207	-0.686	-0.277	-0.361	0.014
	P	0.139	**<0.0001**	**0.0431**	**0.0124**	0.925
	n	26 (2010)	26 (2010)	27 (2010)	26 (2010)	25 (2010)
Hanöbukt	r	0.33	-0.62	-0.475	0.334	0.361
	P	**0.0183**	**<0.0001**	**0.0004**	**0.0189**	**0.0104**
	n	26 (2010)	26 (2010)	28 (2010)	26 (2010)	26 (2010)
Stockholm area	r	0.03	-0.718	-0.497	-0.293	-0.343
	P	0.833	**<0.0001**	**0.0002**	**0.0437**	**0.0196**
	n	25 (2010)	25 (2010)	28 (2010)	25 (2010)	24 (2010)
Åland	r	0.195	0.356	-0.031	0.429	-0.619
	P	0.543	0.317	0.89	0.177	0.0509
	n	7 (2004)	7 (2004)	12 (2004)	7 (2004)	7 (2004)
Outer Gulf of Finland	r	-0.333	-0.577	0.126	-0.333	0.733
	P	0.348	0.143	0.499	0.348	**0.0388**
	n	6 (2004)	6 (2004)	16 (2004)	6 (2004)	6 (2004)
Inner Gulf of Finland	r	-0.2	0.447	-0.244	0.2	-0.244
	P	0.42	0.117	0.1352	0.421	0.325
	n	10 (2007)	10 (2007)	20 (2007)	10 (2007)	10 (2007)
Gävlebukt	r	0.437	-0.612	-0.638	0.296	0.127
	P	**0.0019**	**<0.0001**	**<0.0001**	**0.0386**	0.374
	n	26 (2010)	26 (2010)	28 (2010)	26 (2010)	25 (2010)
Bothnian Sea	r	0.116	-0.035	-0.309	-0.154	0.026
	P	0.582	0.88	0.0839	0.464	0.9
	n	13 (2010)	13 (2010)	18 (2010)	13 (2010)	13 (2010)
Bothnian Bay	r	-0.485	-0.359	-0.122	0.273	0.394
	P	**0.0282**	0.138	0.389	0.217	0.075
	n	12 (2010)	12 (2010)	26 (2010)	12 (2010)	12 (2010)
Luleå	r	-0.023	-0.702	-0.355	-0.062	0.184
	P	0.867	**<0.0001**	**0.0072**	0.659	0.192
	n	27 (2010)	27 (2010)	29 (2010)	27 (2010)	26 (2010)

Table 1 (continued)

		CB28	CB52	CB101	CB118	CB138	CB153	CB180	HCHG Lindane
Kattegat N	r	-0.384	-0.435	-0.836	-0.836	-0.836	-0.712	-0.619	-0.825
	P	**0.0203**	**0.0056**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
	n	22 (2010)	22 (2010)	22 (2010)	22 (2010)	22 (2010)	22 (2010)	22 (2010)	19 (2010)
Hanöbukt	r	-0.077	-0.486	-0.467	-0.428	-0.204	0.0563	0.117	-0.758
	P	0.628	**0.0021**	**0.0031**	**0.0052**	0.185	0.714	0.4465	**<0.0001**
	n	21 (2010)	21 (2010)	21 (2010)	22 (2010)	22 (2010)	22 (2010)	22 (2010)	20 (2010)
Stockholm area	r	-0.554	-0.57	-0.616	-0.63	-0.659	-0.478	-0.544	-0.886
	P	**0.0002**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.0011**	**0.0002**	**<0.0001**
	n	24 (2010)	24 (2010)	24 (2010)	24 (2010)	24 (2010)	24 (2010)	24 (2010)	21 (2010)
Åland	r		0.195	-0.786	-0.571	-0.786	-0.714	-0.929	-0.143
	P		0.5434	**0.0065**	**0.0478**	**0.0065**	**0.0133**	**0.0013**	0.652
	n	5 (2002)	7 (2002)	8 (2002)	8 (2002)	8 (2002)	8 (2002)	8 (2002)	7 (2002)
Outer Gulf of Finland	r		-0.182	-0.429	-0.429	-0.571	-0.429	-0.5	0.238
	P		0.533	0.138	0.138	**0.0478**	0.138	0.0833	0.453
	n	4 (2002)	8 (2002)	8 (2002)	8 (2002)	8 (2002)	8 (2002)	8 (2002)	7 (2002)
Inner Gulf of Finland	r	-0.36	-0.134	-0.483	-0.483	-0.683	-0.611	-0.7	-0.486
	P	0.151	0.4879	**0.009**	**0.009**	**0.0002**	**0.001**	**0.0002**	**0.0158**
	n	10 (2007)	15 (2007)	16 (2007)	16 (2007)	16 (2007)	16 (2007)	16 (2007)	14 (2007)
Gävlebukt	r	-0.093	-0.105	-0.498	-0.316	-0.498	-0.359	-0.472	-0.883
	P	0.563	0.5164	**0.0012**	**0.0395**	**0.0012**	**0.0193**	**0.0021**	**<0.0001**
	n	21 (2010)	20 (2010)	22 (2010)	22 (2010)	22 (2010)	22 (2010)	22 (2010)	19 (2010)
Bothnian Sea	r	-0.554	-0.5	-0.638	-0.587	-0.746	-0.695	-0.771	-0.53
	P	**0.0131**	**0.0135**	**0.0009**	**0.0025**	**0.0001**	**0.0003**	**<0.0001**	**0.0085**
	n	12 (2010)	14 (2010)	15 (2010)	15 (2010)	15 (2010)	15 (2010)	15 (2010)	14 (2010)
Bothnian Bay	r	-0.489	-0.457	-0.577	-0.511	-0.63	-0.634	-0.529	-0.504
	P	**0.0312**	**0.0116**	**0.0009**	**0.0031**	**0.0003**	**0.0002**	**0.0022**	**0.0068**
	n	12 (2010)	17 (2010)	18 (2010)	18 (2010)	18 (2010)	18 (2010)	18 (2010)	16 (2010)
Luleå	r	-0.385	-0.327	-0.494	-0.455	-0.534	-0.312	-0.399	-0.874
	P	**0.0331**	**0.0467**	**0.001**	**0.0024**	**0.0004**	**0.0369**	**0.0076**	**<0.0001**
	n	21 (2010)	20 (2010)	23 (2010)	23 (2010)	23 (2010)	23 (2010)	23 (2010)	20 (2010)

Metadata

Data on various contaminants (cadmium, lead, mercury, copper, zinc, PCB's and Lindane) in Herring exists from several areas of the Baltic Sea. Based on extractions from the ICES Database on contaminants in biota 10 areas with sufficient temporal coverage were identified. The areas are listed in Table 1 and 2. The length of the time series is rather variable. Some of them extend back to 1980 while others cover only the very recent years. Only time series of more than 5 years are considered in this analysis, and the number of years covered are indicated in the tables. Time series that ended before 2002 are not treated in this analysis.

Time trend analyses were made using the non-parametric Mann-Kendall test using a two-sided test with a significance level of 5%. The analyses revealed some significant trends in various contaminants. The yearly median concentration is uses as a basis for the test. The detailed results of the analyses can be found in Table 1 and 2. In total, 82 (64%) of the 128 trend-tests showed a significant trend. Even though repetitive testing increases the risk of making a Type I error (getting a significant trend when there actually are no trend) the number of significant trends is well over what would be expected (~6-7) from this error. The time frame for this analysis is the period 1980-2010. Data from some years (especially 2003) are lacking in some areas.

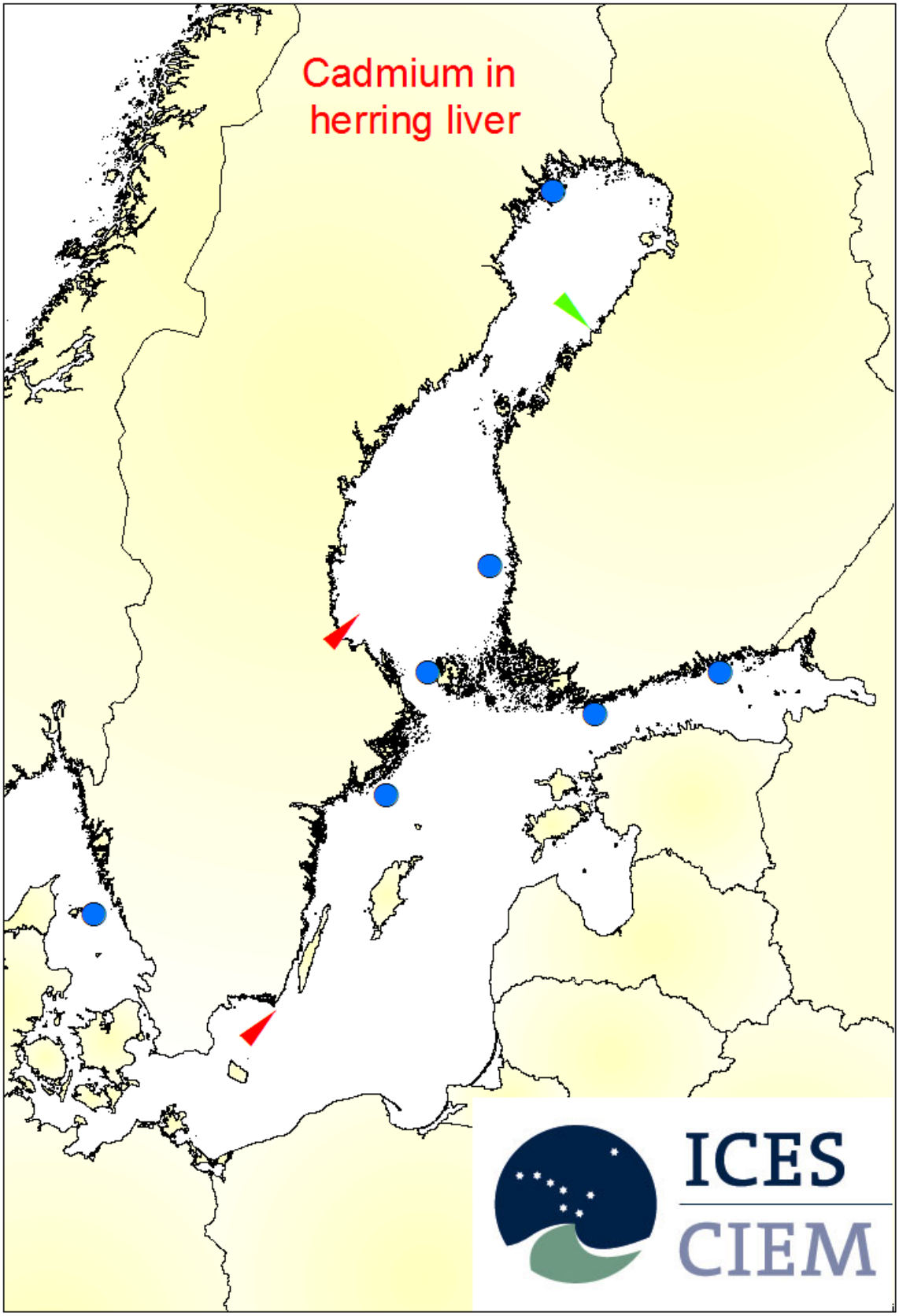

Fig.1. Temporal trends of cadmium in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

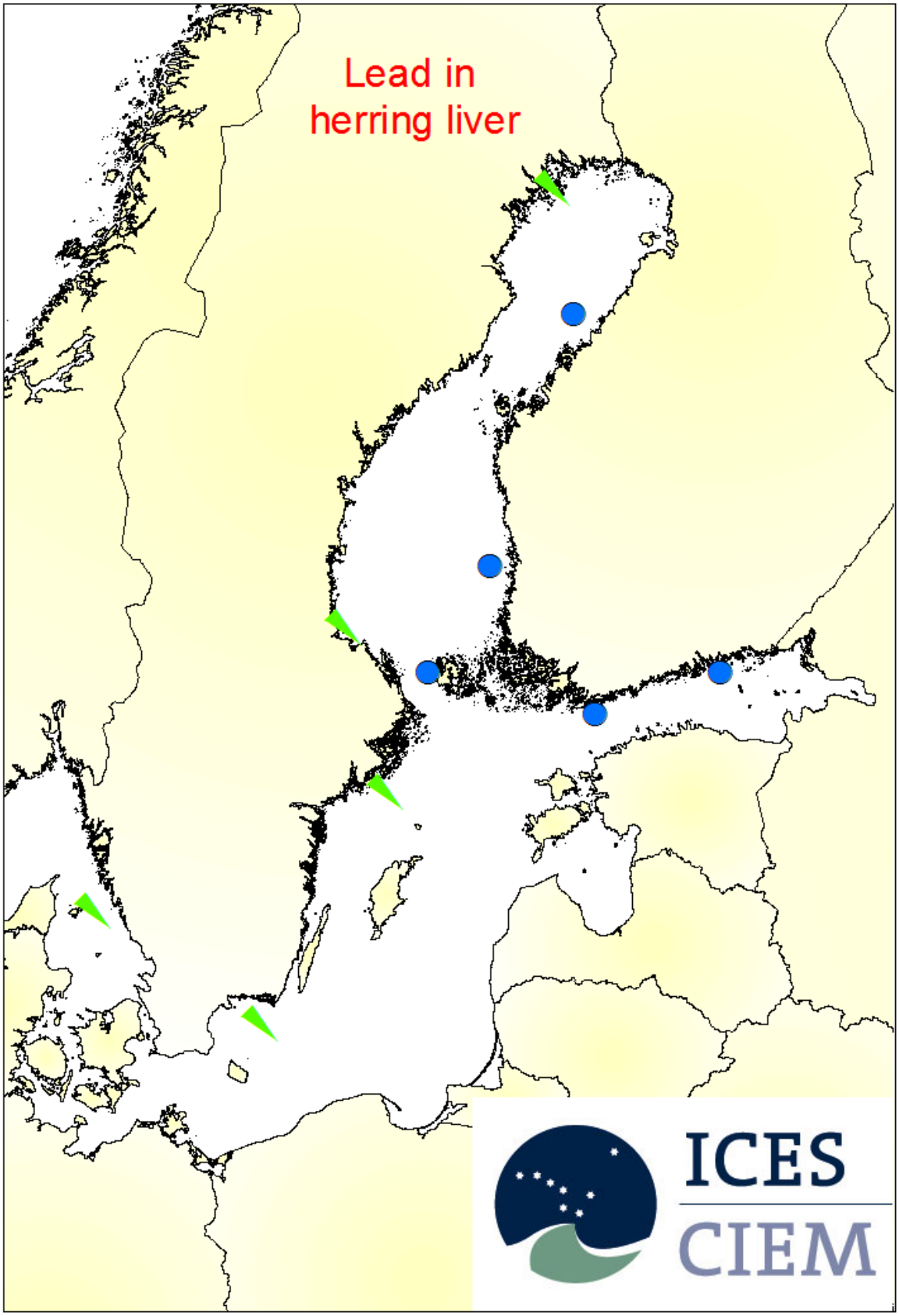

Fig.2. Temporal trends of lead in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

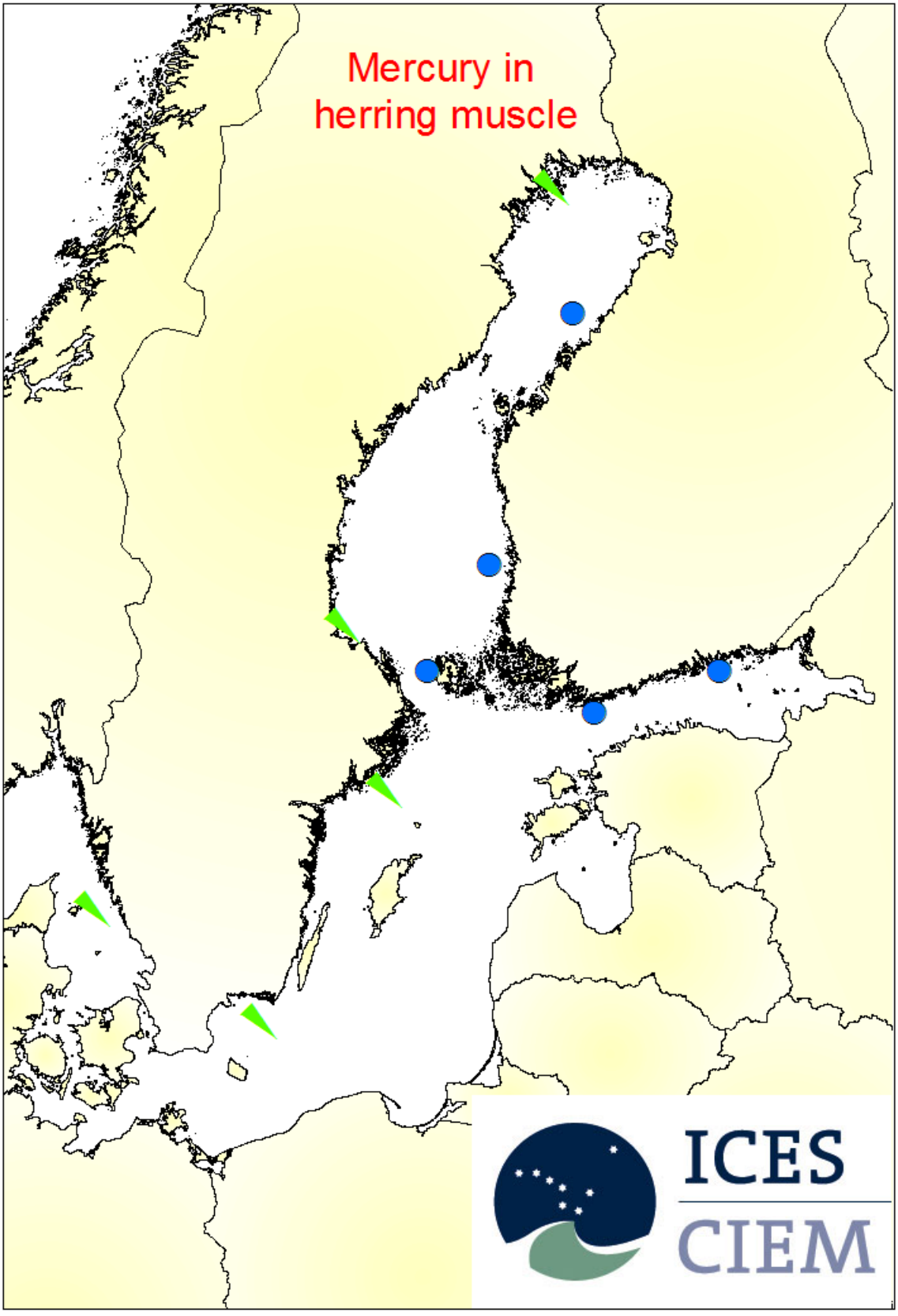

Fig.3. Temporal trends of mercury in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

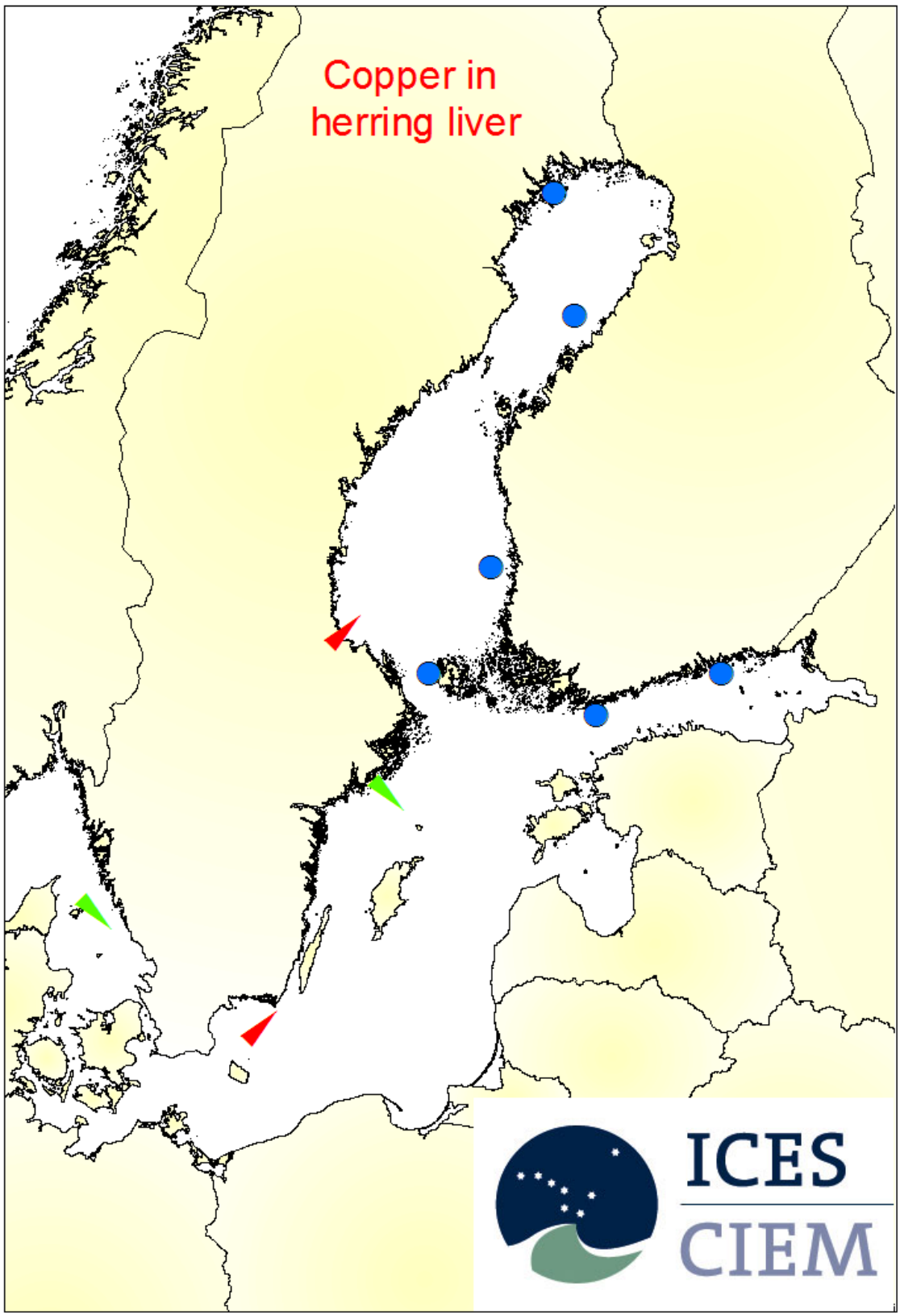

Fig.4. Temporal trends of cupper in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

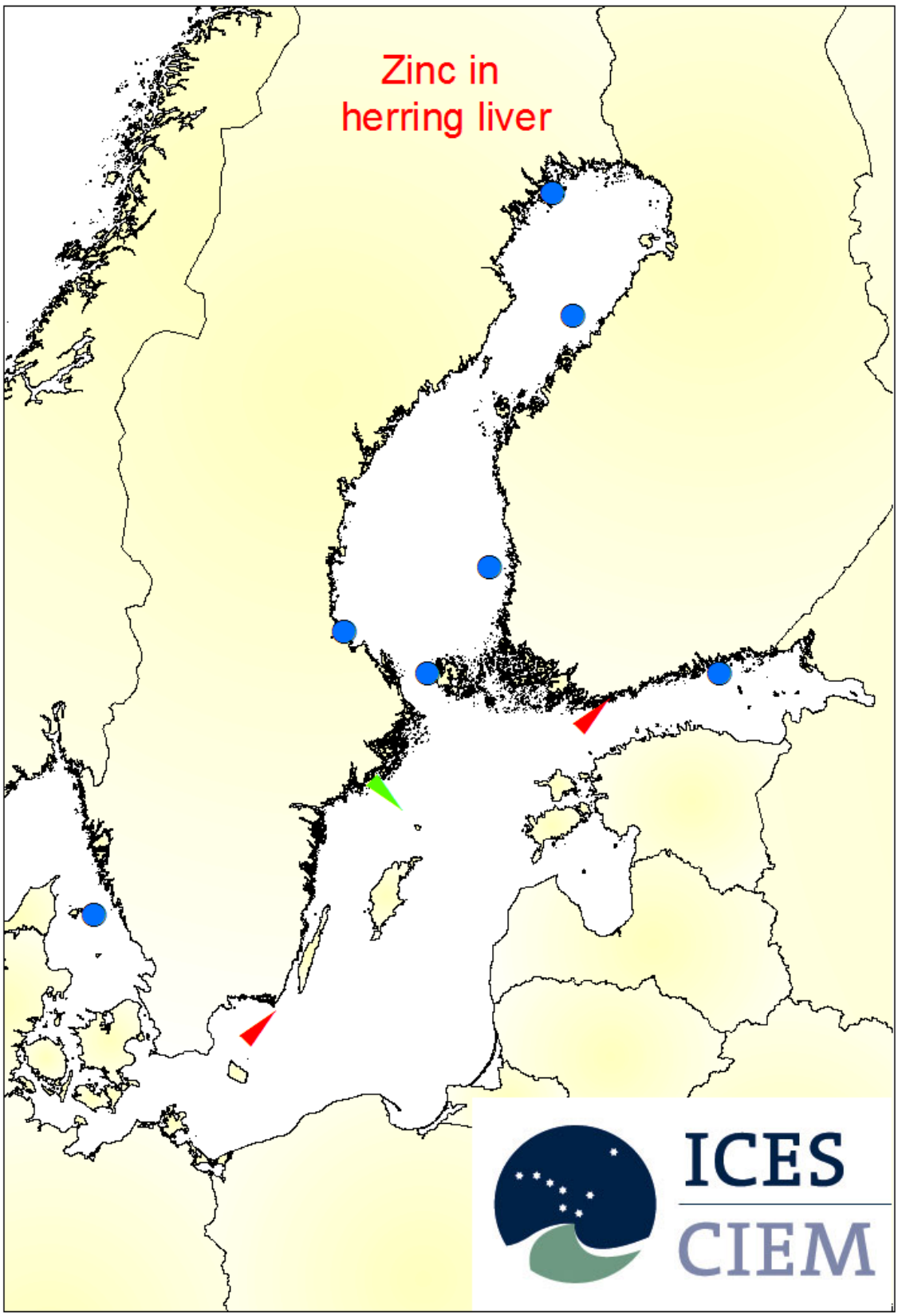

Fig.5. Temporal trends of zinc in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

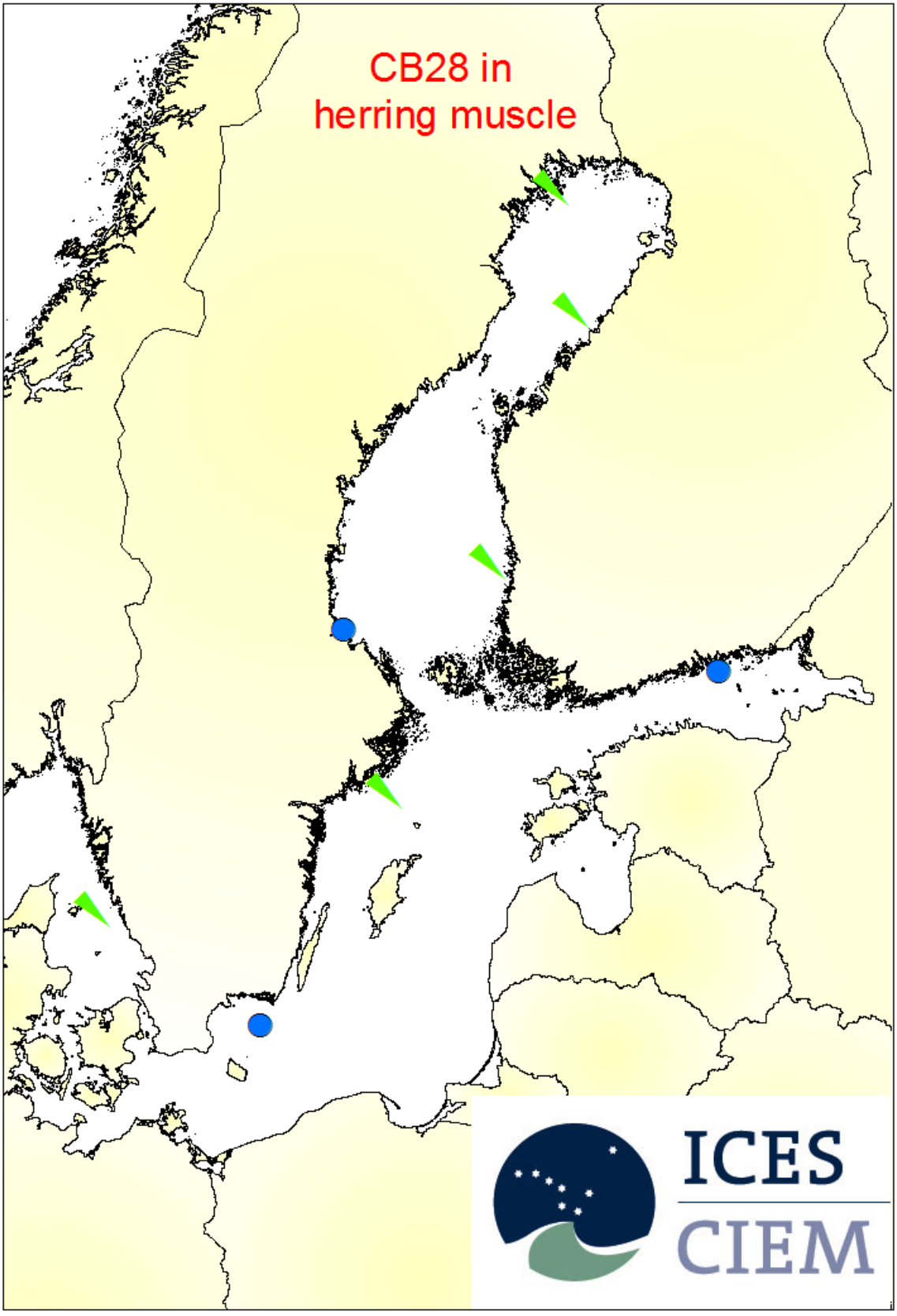

Fig.6. Temporal trends of CB28 in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

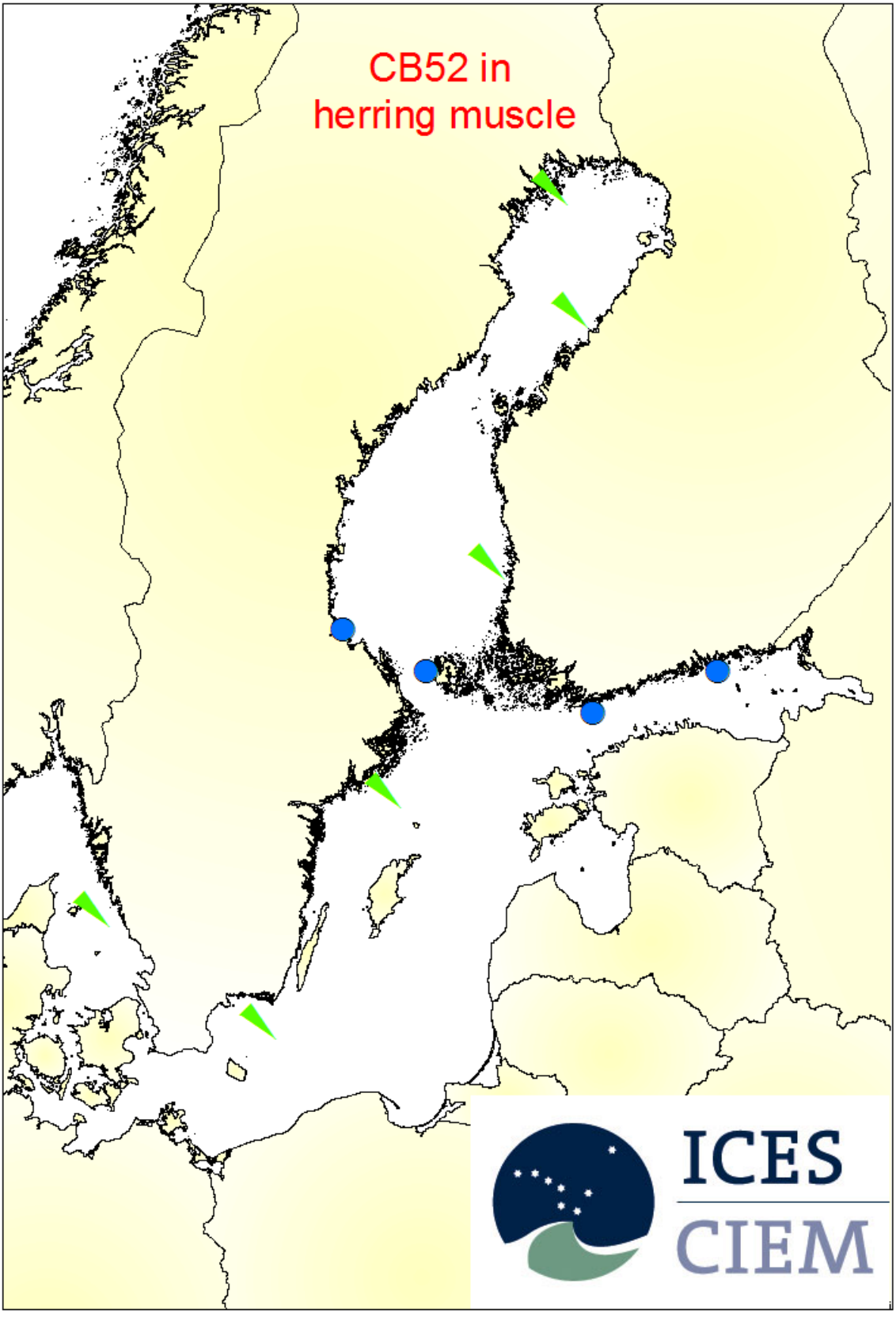

Fig.7. Temporal trends of CB52 in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

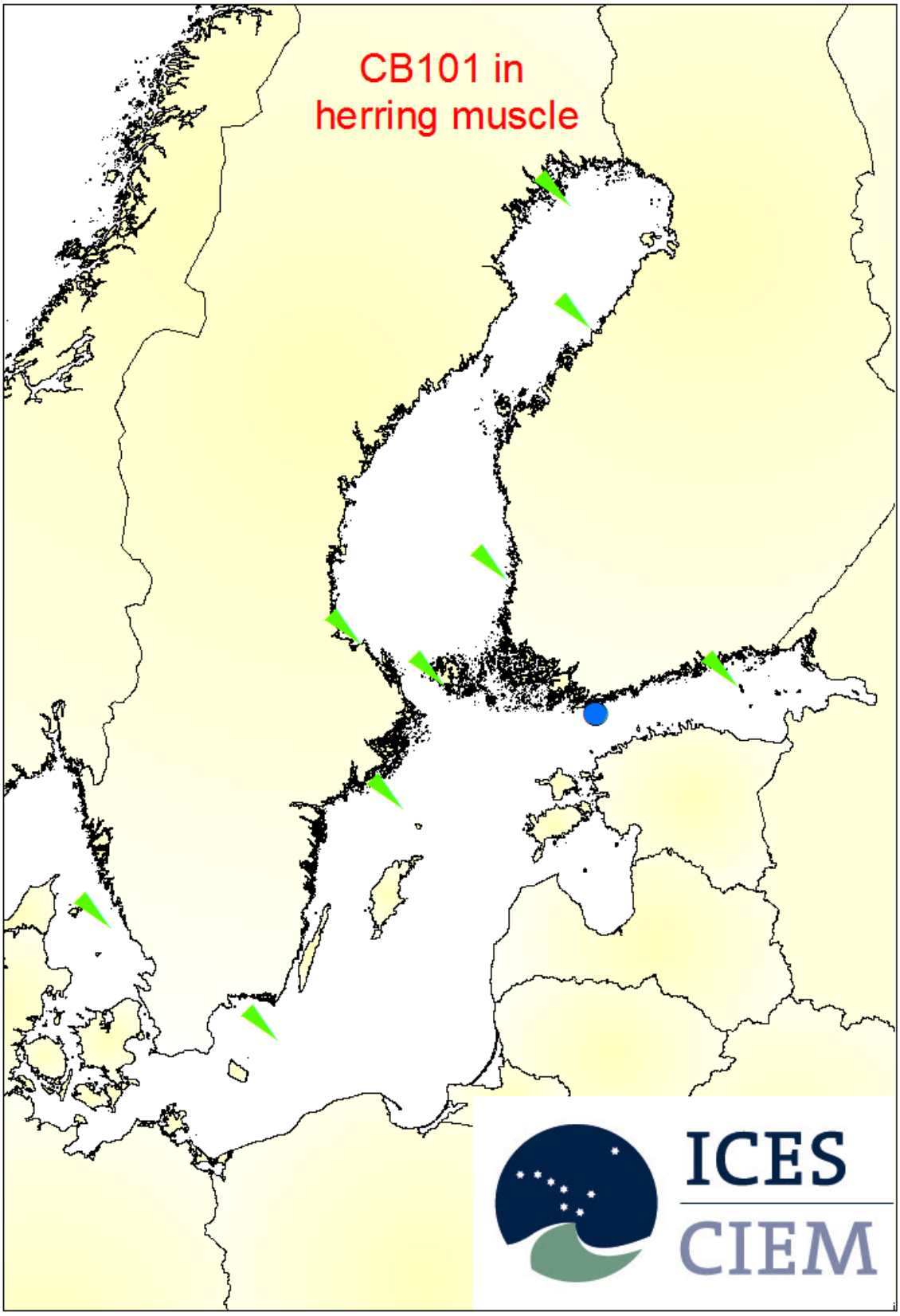

Fig.8. Temporal trends of CB101 in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

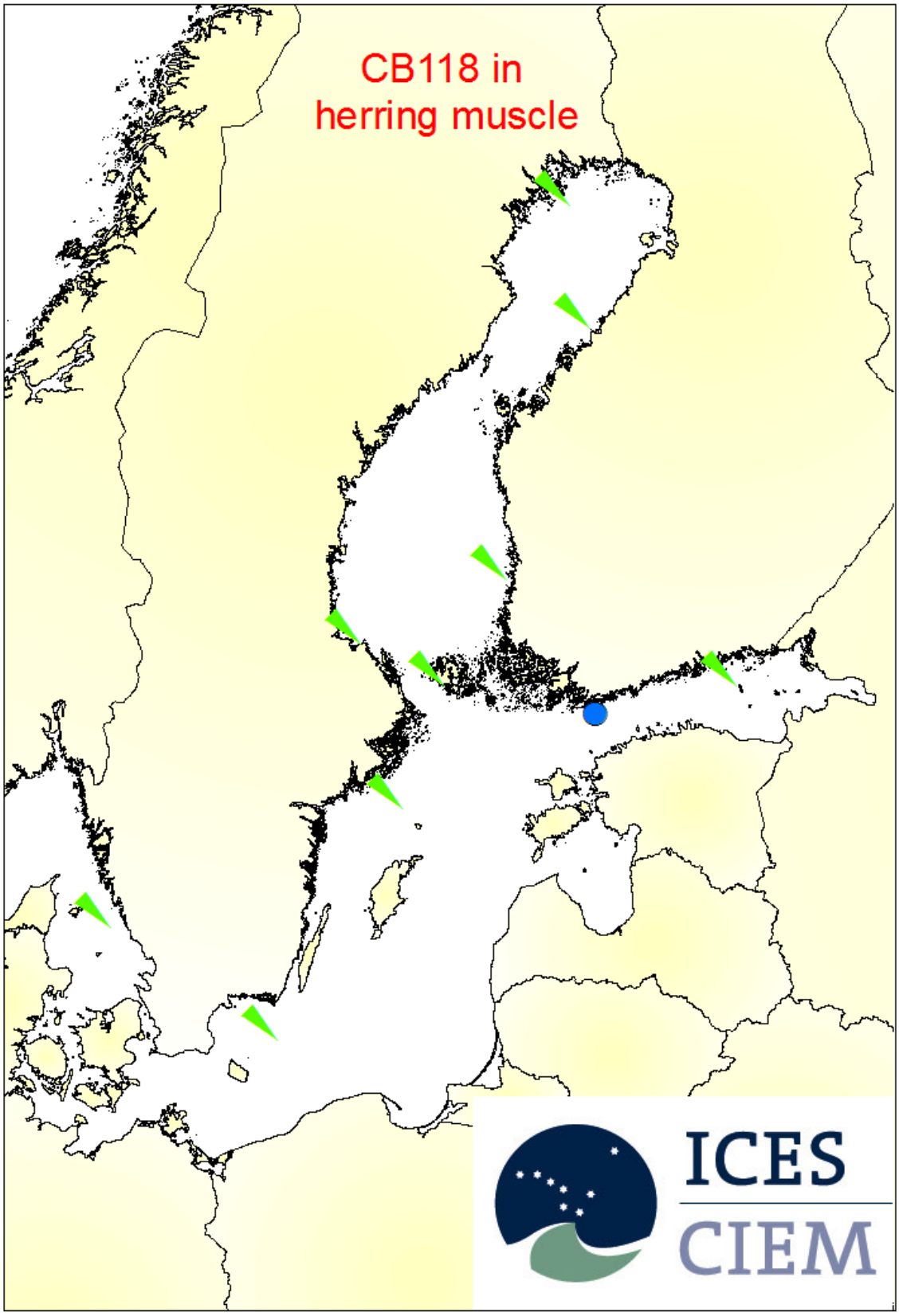

Fig.9. Temporal trends of CB118 in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

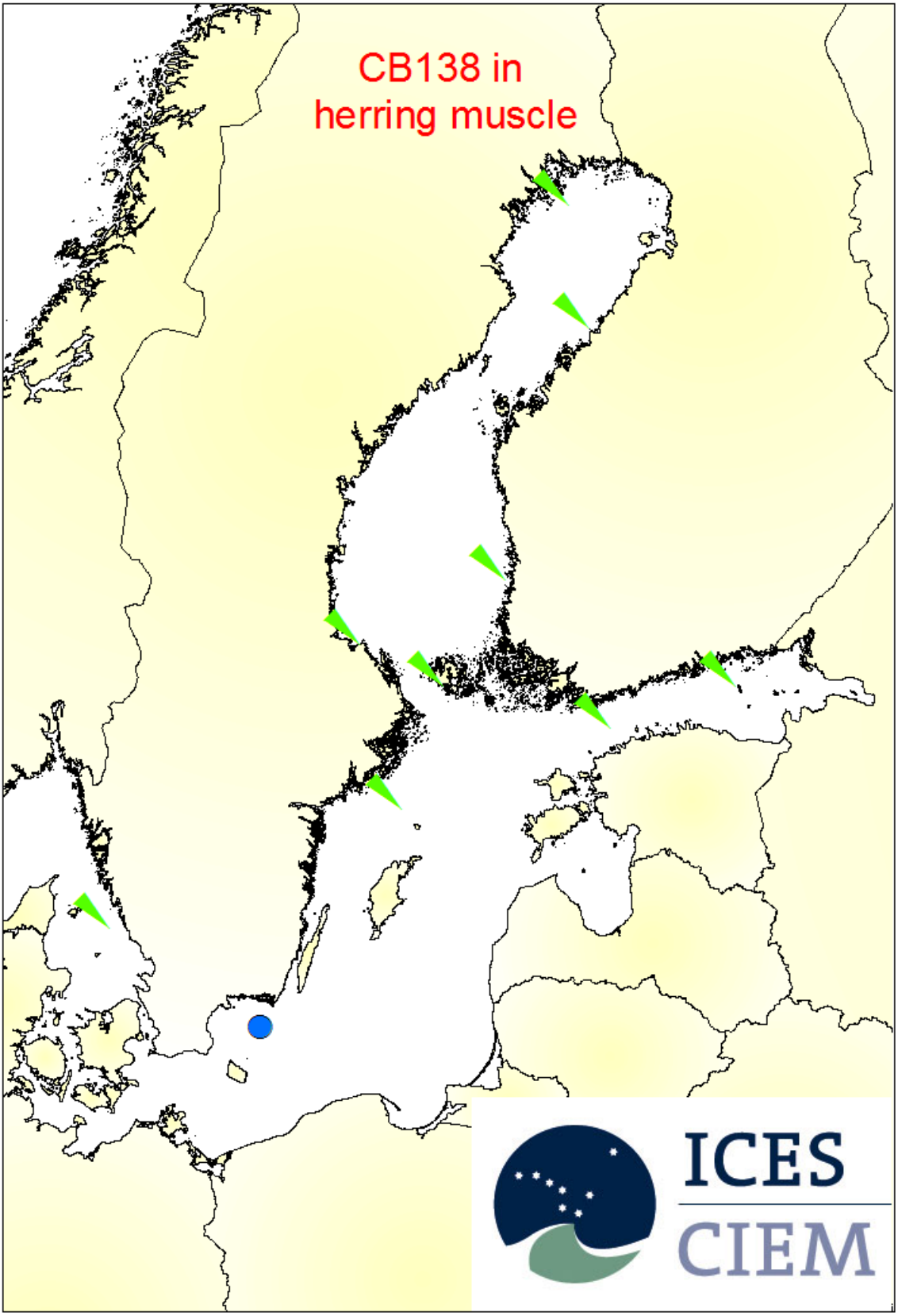

Fig.10. Temporal trends of lead CB138 in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

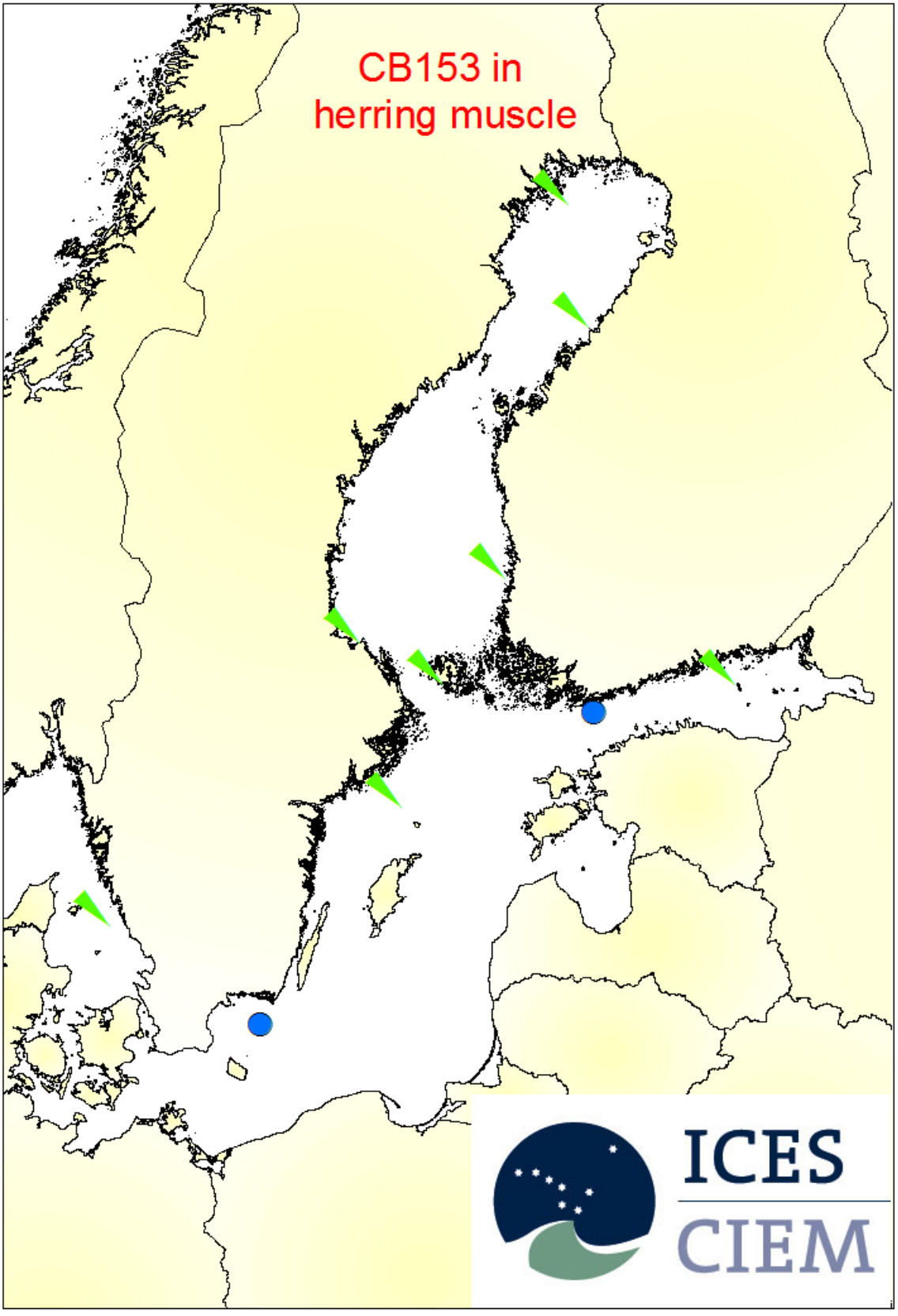

Fig.11. Temporal trends of CB153 in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

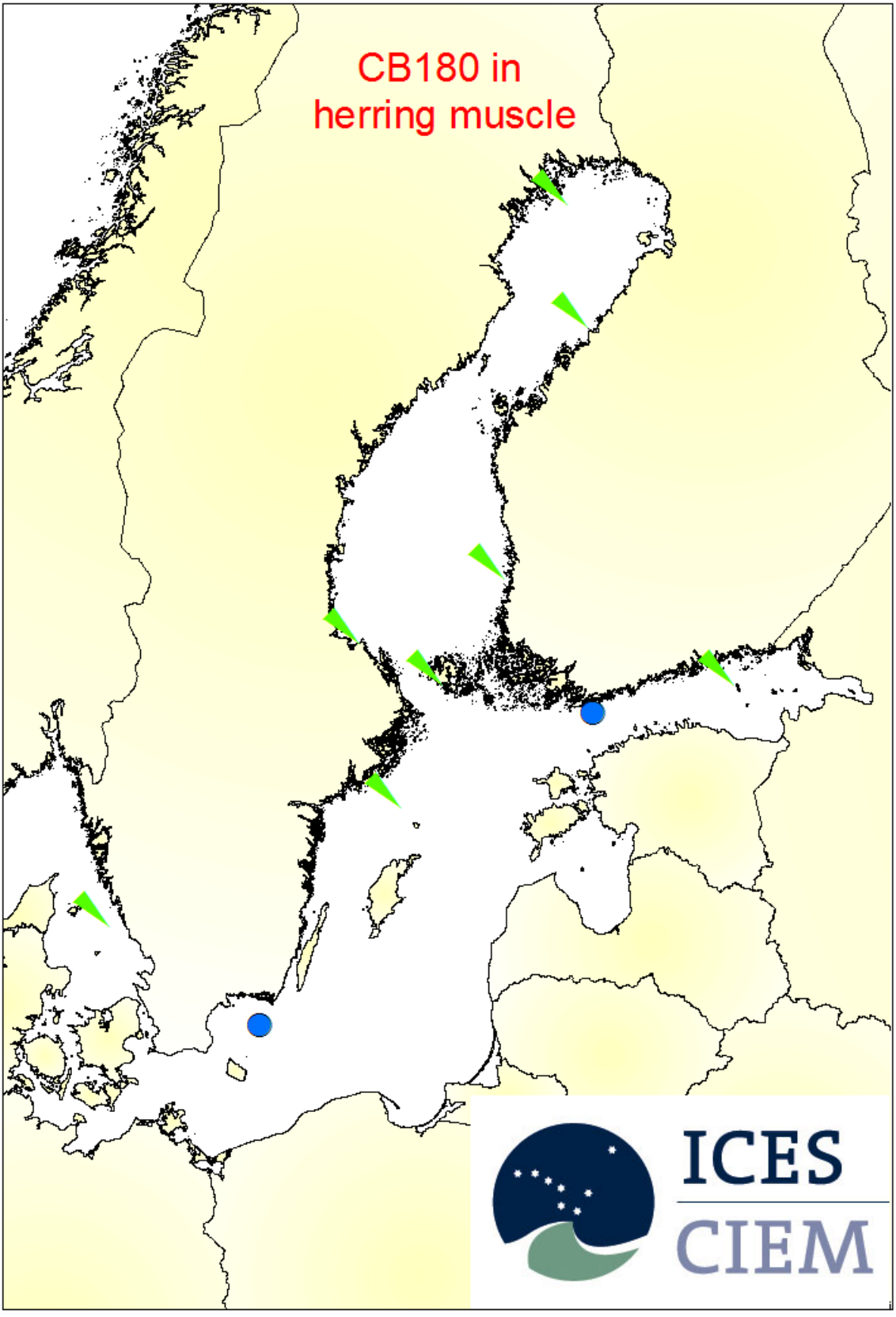

Fig.12. Temporal trends of CB180 in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.

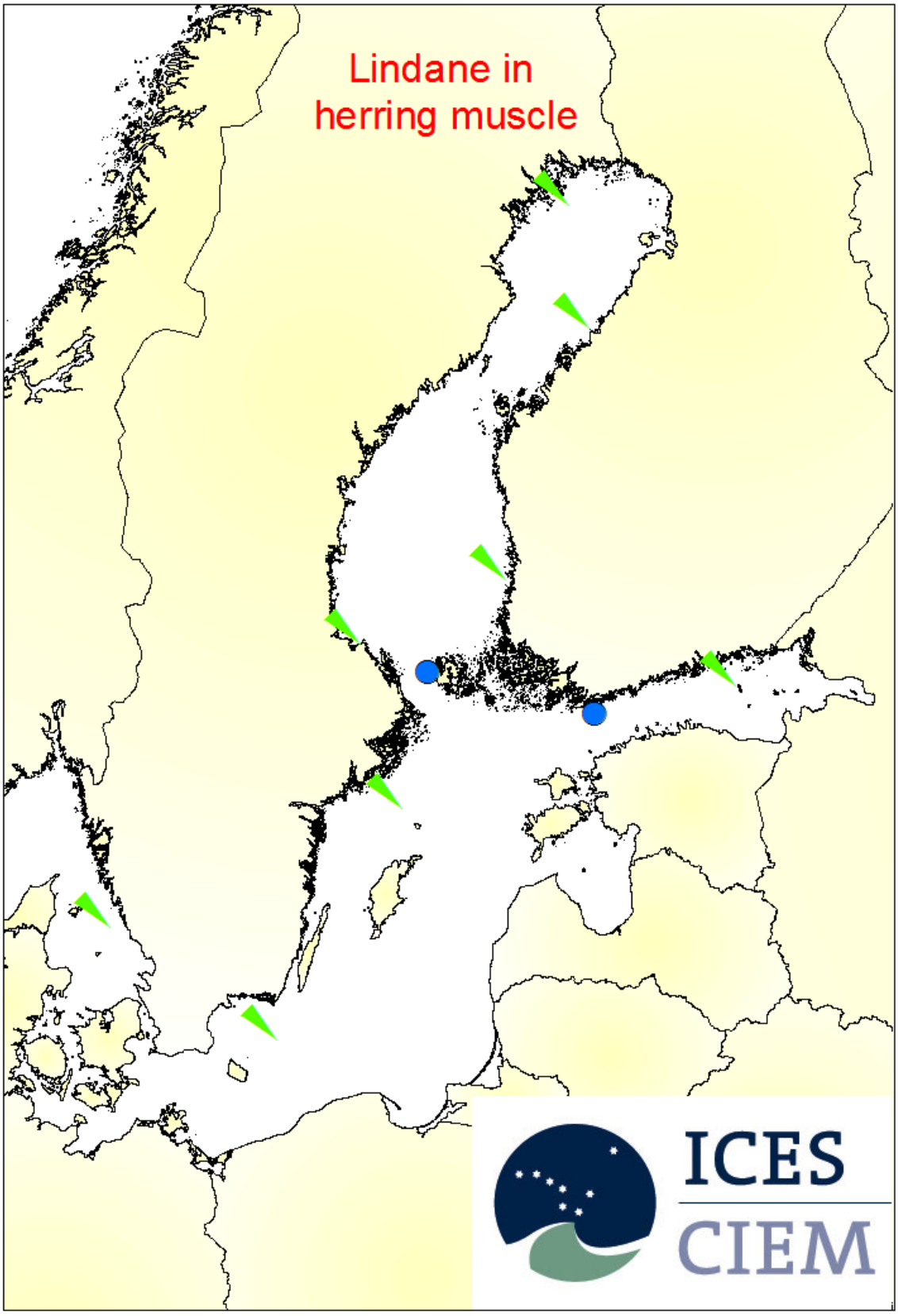

Fig.13. Temporal trends of Lindane in herring livers. Red arrows indicate a significant upward trend. Green arrows indicate a significant downwards trend. Blue dots indicate no significant trend.