

**Appearance of the ‘visiting’ fish species in the Polish research catches conducted
in the southern Baltic (autumn-winter 1976-2004)**

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ABSTRACT. Temporal-spatial variations in the occurrence and catch per unit effort of ‘visiting’ fishes in the near bottom water layers of the southern Baltic Sea (within the Polish EEZ), during autumn-winter period of 1976 - 2004 were analysed. The geographical, bathymetric and seasonal distributions of the following ‘visiting’ fishes: whiting - *Merlangius merlangus* L., Atlantic mackerel - *Scomber scombrus* L., horse mackerel (=scad) - *Trachurus trachurus* (L.), European anchovy - *Engraulis encrasicolus* [L.], haddock (=paddock) - *Melanogrammus aeglefinus*, common dab - *Limanda limanda* L., striped seasnail (=sea-snail) - *Liparis liparis barbatus* (Stein and Albe 1986), rock gunnel (=butterfish) - *Pholis gunnellus* (L.) and serpent blenny (=snakeblenny) - *Lumpenus lampretæformis* (Walbaum, 1782), which occur periodically, primarily in the Kołobrzeg-Darłowo fishing ground, were considered. One of the most important factors that contributed to the appearance of these species was the periodic increase in seawater salinity, while in the case of European anchovy, it was the increase in seawater temperature. Fish species listed above were recorded as a by-catch in the Polish research catches that had been carried out within the framework of the Baltic International Trawl Surveys Programme. The paper is based on the results of total of 2,528 bottom catches made along the nine research profiles located in the Polish waters within the depths ranging from 10 to 110 m.

Key words: visiting fish species; occurrence, CPUE, southern Baltic.

INTRODUCTION

The Baltic Sea environmental conditions and their variability are strongly linked among others to the hydrological and meteorological processes and their interactions. The climate and hydrology of the Baltic Sea region is influenced by the winter intensity of the North Atlantic Oscillation – NAO (Hänninen et al. 2000, Lehmann et al. 2002). Changes of hydrological conditions in the deep waters of the Baltic Sea are strictly dependent on periodical inflows from the North Sea, which occur irregularly and are a random phenomenon (Matthäus 1975, 1993, 1995, Majewski 1987, Wojewódzki 1991, Dahlin et al. 1993, Matthäus et al. 2000, Grygiel and Grelowski 2003). The inflows, even if not large, play a major role in shaping of the long-term variation in the hydrological regime of the Baltic deep waters and their effects may be very significant to the species distribution and food web changes, fish gonads maturation and spawning and thus, to the abundance of early life stages (Grauman 1973, Westin and Nissling 1991, Nissling and Westin 1991, Wieland and Zuzarte 1991, Waller et al. 1993, Zezera and Zezera 1997, Wieland et al. 2000).

The Baltic Sea biota consists of four types of natural immigrants of different origin: freshwater, marine boreal cold-water, glacial relicts of freshwater and marine origin (Mańkowski 1975, Elmgren 1984). According to Elmgren and Hill (1997) opinion, the Baltic Sea in comparison with other basins is inhabited by few species, thus it is regarded as the unique example of an ecosystem, which functions at a low level of biodiversity.

Segerstråle (1957) based on Ekman’s (1935) work qualified the influence of salinity on number of marine fish species that were to inhabit in the 1950s the waters from Kattegat (75

species) through Danish Straits (55), Arkona Basin (30) after the Bay of Bothnia (22). These coefficients with the time underwent changes with the tendency to increase the number of fishes classified as the marine species, e.g. Skóra in a paper from 1996 listed 71 species, which permanently or temporary in the past and at present time occupied the Gulf of Gdańsk waters, and 70% from this number were local fishes. In the area of the southern Baltic's central coast, appearance of 31 native species and three from the North Sea (twaited shad, mackerel, sole) were confirmed by Heese (1995, 1998) and Trella (1998). Khlopnikov et al. (1998) reported that 48 species of marine fishes occurred in the waters of the Kaliningrad region. From 1998 to 2002, totally of 31 fish species were recorded in Latvian coastal waters (Winkler et al. 2000; Ustups et al. 2003). Finding in the Polish waters of new, not recorded fish species pertain to the rarity (Skóra 1996b, Krzykowski et al. 2001, Grygiel and Wszyński 2007, Lampart-Kałużniacka et al. 2007). The reason of above-mentioned phenomena is not the 'absence' of given species in the Baltic, but the limited financial and technical sources, which determine the effort of work aimed at such fish search.

The effort of the work in ichthyological investigations is not proportionally distributed in reference to all species. According to Jackowski (2002), only a dozen of fish species, from among 57 noted down in the Puck Bay in the last 80 years, was the object of ichthyologists' interest, whose works became published. From the review of titles and abstracts of papers registered in the Aquatic Sciences and Fisheries Abstracts (ASFA), the conclusion may be drawn that in the period 1974-2003 presence of such the fish species as e.g.: rock gunnel, serpent blenny, striped seasnail, European anchovy, swordfish and red gurnard in the Baltic did not find the confirmation in reviewed scientific publications.

The main goal of this paper was to analyse the geographical, bathymetric and annual (1976-2004) variations in the frequency of occurrence and catch per unit effort (CPUE) of 'visiting' fishes in the Polish research catches conducted in autumn-winter (October-March) in the near bottom layers of the inshore- and offshore-waters of the southern Baltic. Possible relationships between the CPUE of this group of fishes and year, depth, location, temperature and salinity in the near bottom Polish waters were also analysed.

MATERIALS AND METHODS

The materials were collected by the authors within the framework of the Polish Young Fish Survey Programme realised by the Sea Fisheries Institute in Gdynia. The main purpose of this program, also known as the Baltic International Trawl Surveys (BITS) was to estimate the spatial distribution and recruiting year-classes abundance of the main commercial fishes in the Baltic Sea. Group of so-called 'visiting' fishes – the main subject of the current study – also appeared in these research catches as by-catch and was monitored regularly.

The material originated from totally of 2,528 bottom trawl research catches (Table 1) sampled in autumn-winter (October - March) from 1976 to 2004 during the BITS surveys conducted in the southern Baltic (within the Polish EEZ). The less selective bottom fishing gears, i.e. the herring trawl type P20/25 with a 6-mm bar length in the cod-end was applied in 1976-2001, and the cod bottom trawl type TV-3#930 with a 10-mm bar length in the cod-end was applied in 1999-2004. Fish samples were collected at the same geographical location of the southern Baltic nine research profiles (Fig. 1).

The effective catch time in the majority of hauls was 30 minutes. Hauls were made only during the day (from sunrise to sunset) at 10-meter isobath intervals in a depth range of 10÷110 m. The number of hauls at a depth of 10 m was limited due to the relatively deep draught of the surveying vessels and the widespread use of set nets (gill-nets) in coastal areas. The number of hauls at a depth of 110 m was restricted by the minimum oxygen content (1.5-2.0 ml/l) in the

bottom layers and by the small, very deep area in the Gdańsk Deep only. In the periods of 1976-1984, 1987-1996 and 2002-2004 area of the Pomeranian Bay was not monitored.

The various fish species that comprised the catch were weighed separately, and then the total mass of an each haul was determined per hour of trawling. The frequency of occurrence of 'visiting' fishes in hauls (expressed as the numerical percentage; Table 2) and their relative share in the mass of catches (Table 3) was analysed in relation to years, areas (profiles) and depths.

Fishing efficiency, i.e. CPUE (kg/h), which is used in this work as a dependent variable, represents 'visiting' fishes spatial and inter-annual (1976-2004) distribution. In the statistical analyses the following hydrological parameters, that potentially determine the CPUE distribution in the southern Baltic, were also considered:

- horizontal maximum of the seawater temperature at bottom trawling areas in the period 2000-2004;
- vertical water temperature in the 2003-2004 period at fish catches locations in the Bornholm Deep, the Słupsk Furrow, and the Gdańsk Deep and at three fixed hydrographic stations representing these areas; the stations are - IBY5 (55°14'N, 15°59'E), RS2 (55°14'N, 17°20'E) and G2 (54°50'N, 19°20'E);
- mean salinity in bottom layers at the above-mentioned hydrographic stations within whole year in the 1975-2004 period;
- salinity in autumn-winter from 1995 to 2004 in bottom layers of the Kołobrzeg-Darłowo profile at depths of 20÷80 m.

Stratified measurements of the water temperature and salinity were taken from the sea surface to the bottom at isobath intervals of 2.5 m with a CTD Neil-Brown probe supplemented with a bathometer rosette. These measurements were conducted at the catch stations location.

In order to stabilize the CPUE variance, all of the values were log-transformed. With regard to the modified dependent variable, all zero values were changed to values of 0.0001 kg/h at the beginning of calculations. Two stages of statistical analysis were applied. In the first stage, one-way analysis of variance was used and a simple model was formulated by taking into consideration the separate, independent inflow of particular factors on the CPUE variation. In the second stage, the multifactor ANOVA (with the first order of interactions) was used and a generalized model was formulated by taking into consideration the common, simultaneous impact of analysed sources of variation (years, study profiles, depths, water temperature and salinity) on the CPUE changes.

RESULTS

Frequency of appearance and mean share of 'visiting' fishes in the research hauls

The nine following 'visiting' fishes were periodically, occasionally, and regionally recorded in the bottom research hauls made in the autumn-winter period from 1976 to 2004 in the Polish seawaters, i.e.: whiting, Atlantic mackerel, horse mackerel, European anchovy, haddock, common dab, striped seasnail, rock gunel and serpent blenny. The listed fishes were 'newcomers' from the North Sea and adjacent regions for limited time and reached the southern Baltic waters in the natural way due to the hydrological regime changes. Many of found specimens from the above-mentioned species were young, sexually immature and not attained the commercial size typical for the North Sea fishes.

The long-term (1976-2004) mean frequency of occurrence of the 'visiting' fishes in hauls conducted in the bottom zone of the southern Baltic was 4.8% (range of 0.1 to 23.3%), and in comparison with other species, it was the highest for whiting at an average of 3.8% (Table 2). The second and third most common species in the hauls were European anchovy (especially in

2003-2004 at Kołobrzeg-Darłowo profile, on the depths 60-80 m) and striped seasnail as well as horse mackerel at 1.1, 0.9 and 0.9% mean frequency of occurrence, respectively. 'Visiting' fishes were not observed in hauls made in 1978, 1981 (except for serpent blenny), 1984, 1986, 1992 (except for striped seasnail) and 1996 (except for whiting). 'Newcomers' were recorded in all investigated profiles, but most frequently in the Kołobrzeg-Darłowo profile (whiting - 22%) and in the Pomeranian Bay (whiting - 12%; Table 2), i.e., in the western parts of the Polish EEZ.

In 1976-2004, the highest average frequency of appearance of 'visiting' fishes in all the investigated areas was recorded at a depth ranging from 50 to 80 m (overall of 11-22%; Table 2). The relatively high frequency of occurrence of 'visiting' fishes in the two above-mentioned areas corresponded fairly well with the share of this fish group in the total mass of catches made in 1976-2004 (Table 3). The average long-term share of all 'visiting' fishes in the catches conducted within the Kołobrzeg-Darłowo profile and the Pomeranian Bay was 4.2 and 0.6‰, respectively. In comparison with all investigated in 1976-2004 areas, 92% of the 'visiting' fishes was caught in these profiles. However, it should be emphasized that only in the Władysławowo profile the full list of 'visiting' fishes was recorded, though haddock was observed in hauls once in 2002. The long-term average share of particular 'visiting' fishes in mass of the Polish research catches varied from 0.001 to 1.74‰, and during the period of 1976-2004 totally, 421.05 kg of the above-mentioned fishes were caught (Table 3).

Temporal-spatial and hydrological sources of the 'visiting' fishes CPUE variation

The CPUE of the 'visiting' fishes increased significantly in subsequent years from 1997 to 2004 (with a decrease in 2002), while in the previous period (1981-1996) fluctuated much less and it remained at even lower level (Fig. 2). In 1978-1980 a temporal, slightly increase of the CPUE was noted. In the 1976-2004 period, the 'visiting' fishes showed a clear preference for the Kołobrzeg-Darłowo area followed by the Pomeranian Bay. However, in the south-eastern regions of the Polish EEZ catches of them were limited to at most approximately dozen individuals per species and profile over a period of many years. In 1976-2004 the mean CPUE of 'visiting' fishes significantly increased in the depths range from 50 to 80 m, with the maximum on the 80-m stratum.

The results of statistical tests (simple model) indicate that each source of variability (year, depth, area), if having been considered separately, had a statistically significant impact on the shaping of the CPUE values of 'visiting' fishes (Fig. 2). The factors of area (profile) and year (1976-2004) had the greatest influence (correlation coefficient $r = 0.395$ and 0.352 ; significance level $p < 0.0001$). The multifactor ANOVA generalized model, which considered the simultaneous impact of area, depth and year, also confirmed the statistical significance between variables ($p < 0.0001$) and enabled 49% of the CPUE variance to be explained.

The statistical model described above was supplemented by the analysis of the impact of the factors of year, depth, and salinity in the near bottom waters (1995-2004) on the CPUE of 'visiting' fishes in their preferred area of Kołobrzeg-Darłowo (Fig. 3). The CPUE increased in 1996-1999, afterwards it decreased slightly and then increased again in 2002-2004. Moreover, the CPUE showed a tendency to increase at the depths of 40 to 80 m (maximum at 60 m) and at a salinity ranging from 9 to 12 PSU; at higher salinity the CPUE was fairly stable.

The results of statistical tests (simple model) indicate that each source of variability, if having been considered separately, had a statistically significant impact on the shaping of the CPUE value of 'visiting' fishes in the Kołobrzeg-Darłowo area, but the salinity factor had the most crucial impact ($r = 0.553$, $p < 0.0001$; Fig. 3). It should be emphasized that the depth factor ($r = 0.516$, $p < 0.0001$), which as this model indicated, also had a large impact, is, in this case, somewhat masked by its autocorrelation with salinity. The values of these variables generally

increase proportionally. The ANOVA generalized model, which considered the simultaneous influence of parameters year and salinity confirmed the statistically significant ($p < 0.0001$), determining impact on the CPUE and enabled 68% of the variance of it to be explained. The variance of the CPUE of 'visiting' fishes also results from the influence of other biotic and environmental factors not considered in the current work.

The next step of study was to analyse the relations between hydrological parameters in the autumn-winter of 2003-2004 and the CPUE of European anchovy geographical and bathymetrical distribution (Figs. 4-6). To date, this species has been registered very rarely in the Polish research catches. In recent years, the European anchovy began to appear in the bottom catches just after the inflow at the beginning of 2003. However, there was the largest by-catch of European anchovy recorded in February 2004 in the Kołobrzeg-Darłowo area (Fig. 4), where, at the depth of 64 m a maximum of 95.2 kg/h of these fish were caught, and their share was 17.3% in the catch mass of all species. In February 2004, the European anchovy occurred in 38% of the hauls (in November 2003 this figure was 48%). The occurrence of European anchovy near the bottom was recorded primarily in the 53-76 m depth zone in areas, which had relatively high water temperatures over 7.0°C (Fig. 5) and average to high salinity in the autumn-winter season. The deepest area, where this species was noted, was at 93 m in the Gdańsk Deep. During the increased by-catches of European anchovy, the hydrological conditions were characterized by an increase in temperature in the upper part of the near-bottom water layers (Figs. 4 and 5).

The preliminary results of statistical modelling of the European anchovy CPUE distribution in the southern Baltic during the autumn-winter season of 2003-2004 are shown in the Figure 6. In the simple model, statistical tests indicated that three of the four considered sources of variability had a significant impact on shaping the dependent variable. The maximum water temperature in the bottom layers followed by that of salinity and area effects had the most statistically significant impact ($r = 0.776, 0.619, 0.588$, respectively; $p < 0.0001$; Fig. 6) on the CPUE of European anchovy. The depth factor was statistically insignificant as the determinant of CPUE. The highest CPUE was noted in the Kołobrzeg-Darłowo profile at increasing salinity of 12 to 15 PSU and increasing water temperature of 8 to 11°C. In the second stage of the analyses, the ANOVA general model indicated that the simultaneous impacts of profile, salinity, and water temperature were statistically significant ($p < 0.0001$) and together they had a determining influence on the CPUE of the European anchovy, which explained 90% of the variation of this variable.

DISCUSSION

The results presented in this paper indicate that in 1976-2004 the appearance of nine above-mentioned 'visiting' fishes in the Polish research catches, conducted in the bottom waters of the southern Baltic, was not abundant and more local comparing with the commercial species, and that was significantly dependent from year, area, depth, water temperature and salinity. The preceding statement was confirmed by the statistical tests (the multifactor ANOVA) and formulated mathematical models, which indicated that the high CPUE of 'visiting' fishes was achieved in the offshore waters of the south-western Baltic, namely in the Kołobrzeg-Darłowo profile followed by the Pomeranian Bay, at depths ranging from 50 to 90 m, with the maximum at 80-m (Figs. 2-4 and 6, Table 2). Moreover, the CPUE of all analysed 'visiting' fishes showed a tendency to increase at a salinity ranging from 9 to 12 PSU; at higher salinity the CPUE was at high level too, however fairly stable (Fig. 3). In 2003-2004 the highest CPUE of European anchovy was noted in the Kołobrzeg-Darłowo profile at the 53-76 m depth, and at increasing both the seawater temperature of 8 to 11°C and salinity of 12 to 15 PSU (Figs. 4 and 6).

The inflows of new water of higher than average temperature and salinity to some regions of the southern Baltic (Figs. 5 and 7) undoubtedly had an impact on the occasional, to date unheard-of increase in the CPUE of ‘newcomers’ in the near-bottom zone of the Polish waters, especially since 1997. For example, the European anchovy was recorded particularly after unusually strong inflow at the beginning of 2003 (Figs. 4 and 6, Tables 2 and 3; Feistel et al. 2003, Grygiel and Grelowski 2003, Grygiel et al. 2004, Łysiak-Pastuszek et al. 2004). The inflows that occurred in the 1980s did not result in significant increases in salinity in the Bornholm Deep, the Słupsk Furrow, and the Gdańsk Deep (Fig. 7). It was, in fact, below the long-term (1975-2004) average. In autumn-winter 2003-2004, seawater with a relatively high temperature (up to 12°C) and salinity (of approximately 11-12 PSU) formed an upper sub-layer of deep waters of the Bornholm Deep and the Kołobrzeg-Darłowo profile with a clearly visible local maximum temperature. Mentioned sub-layer of waters occurred at the 20-40 m above the bottom and remained there for several months. In February 2004 the relatively high abundance of the European anchovy was recorded in the Polish both research and commercial catches, made in the above-mentioned sub-layer of water. The temporary and locally very high by-catch of European anchovy and whiting in the Polish commercial catches of herring and cod, respectively posed a short-term substantial problem in sales of basic fish species in local markets. Popiel (1962) based on the investigation results from the 1950s concluded that the European anchovy never occurred in the Baltic in quantities that could be of commercial interest to fishermen, and reported that single specimens were sighted frequently in the Bornholm Basin, the Gulf of Gdańsk, and occasionally even in the waters near Stockholm. In contrast to the above-cited facts, Whitehead (1984) considered that the European anchovy does not occur in the Baltic.

Few Polish and foreign publications prepared in the 1990s confirmed of almost a similar spectrum of ‘visiting’ fishes analysed in this paper, however mostly in the inshore waters of the southern Baltic, e.g.: Skóra (1993, 1996a), Heese (1995, 1996, 1998), Khlopnikov et al. (1998), Plikšs and Aleksejevs (1998), Psuty-Lipska and Garbacik-Wesołowska (1998), Winkler et al. (2000) and Repečka (2003). Mańkowski (1951) in principally the same type of study as authors of this paper, however regarding the period of 1900-1950 concluded that totally of 12 zooplankton and fish (*Hippoglossoides platessoides limandoides* Bloch 1787, mackerel, horse mackerel, European anchovy, whiting) ‘newcomers’ from the North Sea were temporary recorded in the Polish waters over fifty years, mostly in the bottom zone of the south-western Baltic. According to Jackowski (2002) the Atlantic mackerel, which were once abundant in the Puck Bay, are recently not observed. In the period prior to the Second World War, the average annual commercial catches of mackerel in the Puck Bay were 6.5 tons, and e.g. in 1929 they exceeded 35 tons. At the beginning of the 1950s, annual catches of this species were 4.3 tons, but by the 1960s, this fish disappeared (Romański 1957). According to Demel (1947), small amounts of whiting were caught for commercial purposes near the Peninsula of Hel prior to and following the Second World War. The issue of the temporary increase of the European anchovy by-catch in the autumn of 2003 was also observed in other countries research catches in the Baltic. Hjelm and Rudolphi (2003) reported appearance of a total of 241 specimens of the European anchovy in 21 hauls conducted with a bottom trawl by the Swedish r.v. “Argos”, however only in the ICES Sub-division 25. In the pelagic catches of clupeids conducted by the German r.v. “Solea”, the average European anchovy CPUE decreased as the vessel headed towards the south-east from the ICES Sub-divisions 21 to 24 at 52.2, 24.9, 4.6, and 0.7 kg/h, respectively (Gröhsler and Götze 2004).

According to the current publications of other Polish ichthyologists, in the period 1993-1999 the following representatives of rare and exotic species were recorded as by-catch in the commercial catches conducted in the western part of the Polish EEZ, namely in the Dąbie Lake, at mouth of the Regalica River and in the Międzyodrze: the Siberian sturgeon, paddlefish, yellow

gurnard, twaite shad, allice shad, sabrefish, saithe, swordfish, sea bass and common weever (Krzykawski et al. 2001). The above-mentioned authors concluded that the occurrence of listed fishes in the Baltic results probably from the strong inflows from the North Sea and from the introduction of new species in aquaculture as well as from the petfish-industries. In the neighbouring to the above-mentioned eastern areas, Lampart-Kałużniacka et al. (2007) recorded in 1994-2004 appearance (in many cases single specimens) of following rare 'newcomer' fishes: ballan wrasse, common weever, horse mackerel, red mullet, sea bass, red gurnard, black mullet, European hake, saithe, paddock, whiting, European pollock, mackerel, twaite shad and *Entelerus aequoreus*. Appearance of single specimens of 'visiting' fishes - red gurnard (November 2003) and swordfish (November 1991, 2005) in the Polish and adjacent waters were described by Draganik (2004), Wszyński and Pelczarski (2005), and Bacevičius and Karalius (2005).

The co-dependencies described in this paper between the CPUE of 'visiting' fishes in the southern Baltic in autumn-winter seasons of 1976-2004, and temporal-spatial, as well as hydrological sources of variations, are partially of a local character. However, they can be considered as an important example of inter-annual changes in the ichthyofauna and hydrology regime, and relatively high biodiversity of the Baltic fish community.

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Table 1. List of research bottom hauls conducted during BITS surveys in the I and IV quarters of 1976-2004 in particular research profiles of the southern Baltic (within the Polish EEZ) at the depths strata 10÷110 m; the applied numerical code of research profiles are in parentheses.

Year/ depth [m]	Research profiles									Total
	Krynica Morska (1)	Wisło- ujście (2)	Puck Bay (3)	Włady- sławowo (4)	Gdańsk Deep (5)	Ustka - Łeba (6)	Słupsk Furrow (7)	Kołobrzeg - Darłowo (8)	Pomera- nian Bay (9)	
1976	8	-	7	16	4	-	-	-	-	35
1977	27	-	14	54	-	-	-	16	-	111
1978	42	-	30	53	-	2	17	-	-	144
1979	24	-	8	30	-	-	3	9	-	74
1980	30	-	15	23	3	-	9	-	-	80
1981	25	-	9	14	-	-	-	-	-	48
1982	25	4	16	47	3	5	23	18	-	141
1983	27	1	14	24	-	-	3	6	-	75
1984	19	2	11	28	-	3	-	-	-	63
1985	18	6	7	36	-	2	-	8	2	79
1986	6	-	3	5	-	-	-	9	1	24
1987	23	15	14	55	1	-	1	-	-	109
1988	21	19	12	52	11	9	8	-	-	132
1989	18	11	8	36	2	-	-	-	-	75
1990	26	19	11	52	-	-	-	-	-	108
1991	38	22	16	68	-	-	-	-	-	144
1992	15	10	7	29	-	-	10	-	-	71
1993	24	11	15	39	-	2	7	5	-	103
1994	22	12	10	51	1	-	16	-	-	112
1995	7	6	3	16	-	2	5	7	-	46
1996	17	11	5	27	1	1	12	3	-	77
1997	18	12	6	40	2	6	21	26	8	139
1998	18	12	5	38	-	3	23	16	8	123
1999	14	8	3	30	2	4	13	19	4	97
2000	7	8	2	15	-	3	7	17	3	62
2001	10	10	4	12	3	9	7	17	5	77
2002	12	12	3	11	4	9	3	7	-	61
2003	7	4	2	15	8	7	11	22	-	76
2004	1	1	1	8	2	5	6	18	-	42
10	1	-	-	3	-	5	-	-	2	11
20	66	34	5	103	-	35	4	16	11	274
30	72	36	46	97	-	26	5	35	6	323
40	70	36	70	106	-	6	33	27	6	354
50	67	43	70	108	-	-	36	39	5	368
60	67	36	70	123	-	-	37	50	1	384
70	66	31	-	108	2	-	40	37	-	284
80	55	-	-	102	11	-	31	18	-	217
90	48	-	-	94	26	-	19	1	-	188
100	37	-	-	80	1	-	-	-	-	118
110	-	-	-	-	7	-	-	-	-	7
Total	549	216	261	924	47	72	205	223	31	2528

Table 2. Average (1976-2004) frequency of occurrence (in % of hauls) of ‘visiting’ fishes in bottom hauls conducted in the southern Baltic, according to years, research profiles and depths; note: ‘visiting’ fishes not appeared at the depths of 10 and 110 m.

Year/profile/depth	Atlantic mackerel	horse mackerel	haddock	European anchovy	whiting	common dab	striped seasnail	rock gunnel	serpent blenny
1976	1.56	-	-	1.56	-	-	-	-	-
1977	-	2.31	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	5.11	-	-	-	-
1980	-	-	-	-	6.89	-	-	0.67	-
1981	-	-	-	-	-	-	-	-	1.33
1982	-	-	-	-	1.39	-	-	0.78	0.54
1983	-	5.56	-	-	2.78	-	2.08	0.69	1.19
1984	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	1.79	-	-	9.18	-
1986	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	0.72	-	-	-	1.19
1988	-	-	-	-	-	-	1.91	0.27	3.41
1989	-	-	-	-	-	-	7.25	2.22	5.43
1990	-	-	-	-	-	1.32	0.48	4.55	2.28
1991	0.37	-	-	-	1.14	-	1.03	0.74	0.37
1992	-	-	-	-	-	-	1.38	-	-
1993	0.60	-	-	-	3.59	-	-	-	-
1994	-	-	-	-	1.37	0.33	1.37	3.33	1.99
1995	2.04	-	-	-	2.04	-	4.76	2.04	-
1996	-	-	-	-	0.46	-	-	-	-
1997	-	2.24	-	-	9.77	-	1.85	-	-
1998	1.56	4.21	-	1.32	10.64	-	-	-	-
1999	2.34	-	-	-	10.53	-	0.37	-	-
2000	1.47	3.26	-	1.47	2.21	-	-	-	-
2001	0.65	0.65	-	-	13.57	-	1.58	-	-
2002	-	1.79	1.14	-	2.92	-	-	-	-
2003	1.79	2.27	-	11.79	10.02	-	1.40	-	-
2004	1.39	2.78	-	15.28	23.33	0.69	-	-	-
Krynica Morska (1)	0.64	0.13	-	-	0.93	-	0.42	0.61	0.46
Wisłoujście (2)	-	-	-	-	0.21	0.24	0.83	-	0.89
Puck Bay (3)	-	-	-	-	0.46	-	1.58	2.02	1.84
Władysławowo (4)	0.27	0.19	0.31	0.45	2.05	0.07	1.81	0.69	0.18
Gdańsk Deep (5)	-	-	-	3.57	7.74	-	-	-	-
Ustka-Łeba (6)	-	-	-	1.79	2.14	-	1.04	-	-
Słupsk Furrow (7)	-	1.15	-	1.05	7.99	-	0.31	-	0.22
Kołobrzeg-Darłowo (8)	4.51	8.14	-	7.80	21.72	0.33	0.61	-	-
Pomeranian Bay (9)	-	1.79	-	-	11.79	-	-	7.14	-
20 m	0.12	-	-	1.26	0.19	-	1.16	1.14	-
30 m	-	0.36	-	2.62	1.68	0.35	1.67	0.57	0.27
40 m	0.18	-	-	-	2.96	-	0.71	0.83	0.36
50 m	0.73	4.32	0.13	1.60	16.60	0.50	1.19	0.67	1.70
60 m	2.21	2.50	-	2.29	20.29	-	0.55	0.23	0.45
70 m	1.35	2.86	-	2.25	11.01	-	0.15	0.31	1.11
80 m	0.20	3.05	-	2.87	13.71	-	0.20	-	-
90 m	-	0.21	-	1.82	8.63	-	-	-	-
100 m	-	0.42	-	-	-	-	-	-	-
Mean	0.47	0.86	0.04	1.08	3.80	0.08	0.88	0.84	0.61

Table 3. Sum of catches (kg/h) and average share (‰) of ‘visiting’ fishes in the bottom research catches conducted in the IV and I quarters of 1976-2004, according to research profiles of the southern Baltic; the values of share less than 0.001‰ are marked as 0.000.

Species	Parameter	Krynica Morska (1)	Wiśło-ujście (2)	Puck Bay (3)	Władysławowo (4)	Gdańsk Deep (5)	Ustka – Łeba (6)	Słupsk Furrow (7)	Kołobrzeg - Darłowo (8)	Pomeranian Bay (9)	Total
Atlantic mackerel	catch	0.682	-	-	0.176	-	-	-	29.760	-	30.618
	share	0.005	-	-	0.001	-	-	-	0.232	-	-
horse mackerel	catch	0.040	-	-	0.150	-	-	0.094	39.997	0.018	40.299
	share	0.000	-	-	0.001	-	-	0.001	0.987	0.002	-
haddock	catch	-	-	-	0.642	-	-	-	-	-	0.642
	share	-	-	-	0.006	-	-	-	-	-	-
European anchovy	catch	-	-	-	0.088	0.048	0.546	1.158	139.87	-	141.711
	share	-	-	-	0.001	0.002	0.059	0.013	1.241	-	-
whiting	catch	3.820	0.530	0.700	8.885	3.082	1.360	12.221	168.41	3.240	202.247
	share	0.020	0.005	0.008	0.057	0.110	0.228	0.181	1.741	0.618	-
common dab	catch	-	0.600	-	0.700	-	-	-	0.368	-	1.668
	share	-	0.008	-	0.002	-	-	-	0.002	-	-
striped seasnail	catch	0.050	0.020	0.020	0.272	-	0.010	0.008	0.008	-	0.388
	share	0.000	0.001	0.000	0.001	-	0.008	0.000	0.000	-	-
rock gunnel	catch	0.410	-	0.620	0.340	-	-	-	-	0.030	1.400
	share	0.012	-	0.007	0.002	-	-	-	-	0.015	-
serpent blenny	catch	0.420	0.490	0.998	0.140	-	-	0.030	-	-	2.078
	share	0.005	0.011	0.013	0.001	-	-	0.000	-	-	-

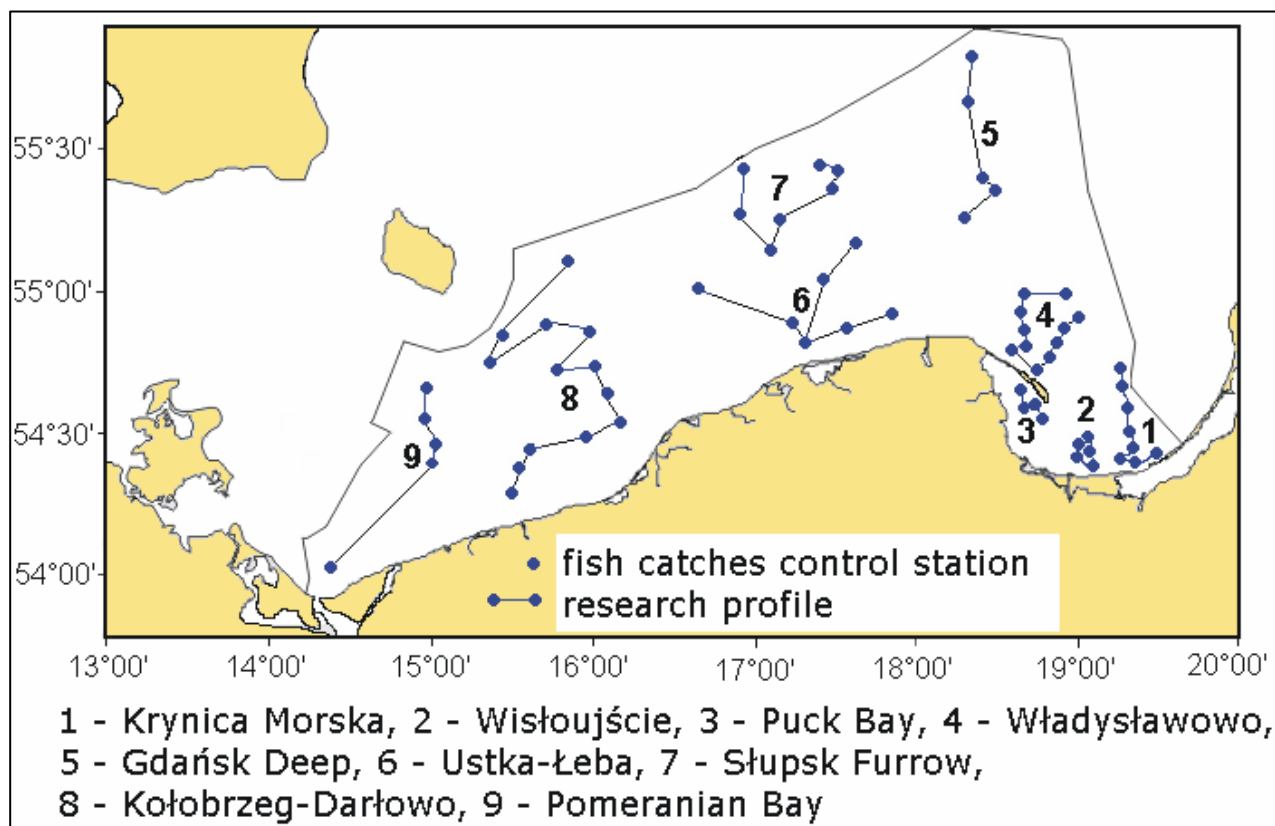


Figure 1. Location of the BITS surveys (1976-2004) research profiles and bottom trawling stations in the southern Baltic (within the Polish EEZ)

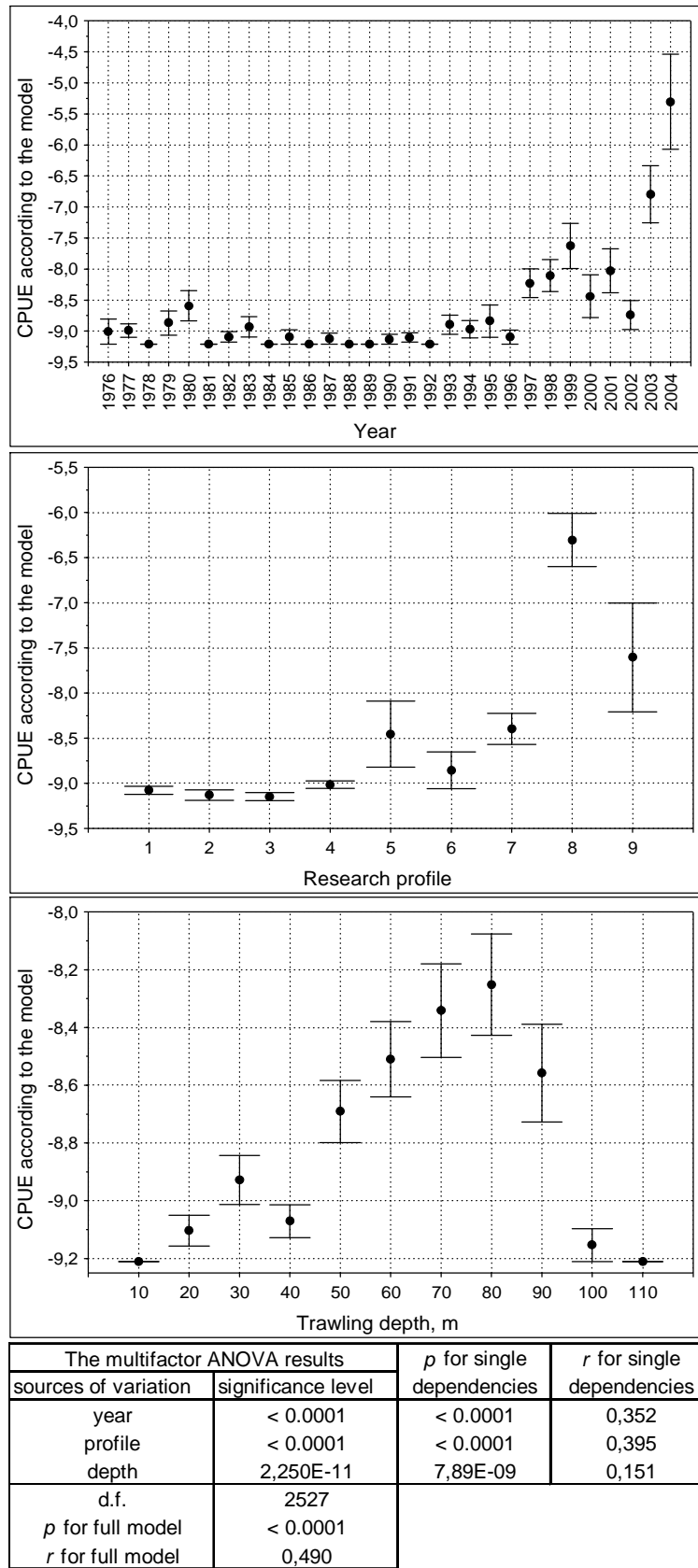


Figure 2. Fishing efficiency (CPUE with standard errors) of ‘visiting’ fishes in the southern Baltic (autumn-winter 1976-2004), according to the multifactor ANOVA model [LOG(y+0.0001 kg/h)] vs. categorized temporal-spatial sources of variation

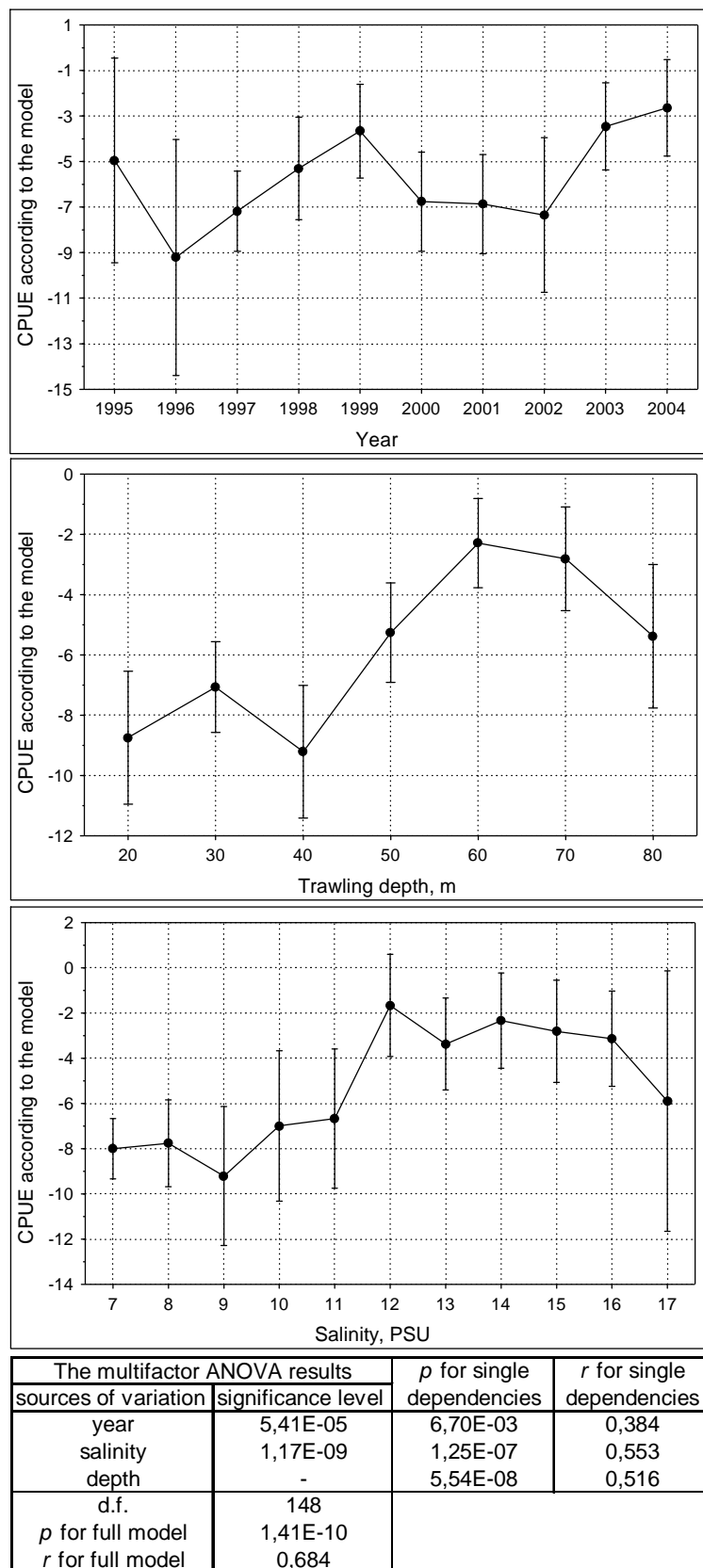


Figure 3. Predicted the marginal averages of 'visiting' fishes CPUE (log-transformed with standard errors marked) in the autumn-winter 1995-2004 vs. year, depth and salinity in the bottom layers of the Kołobrzeg-Darłowo profile, according to the full multifactor ANOVA model

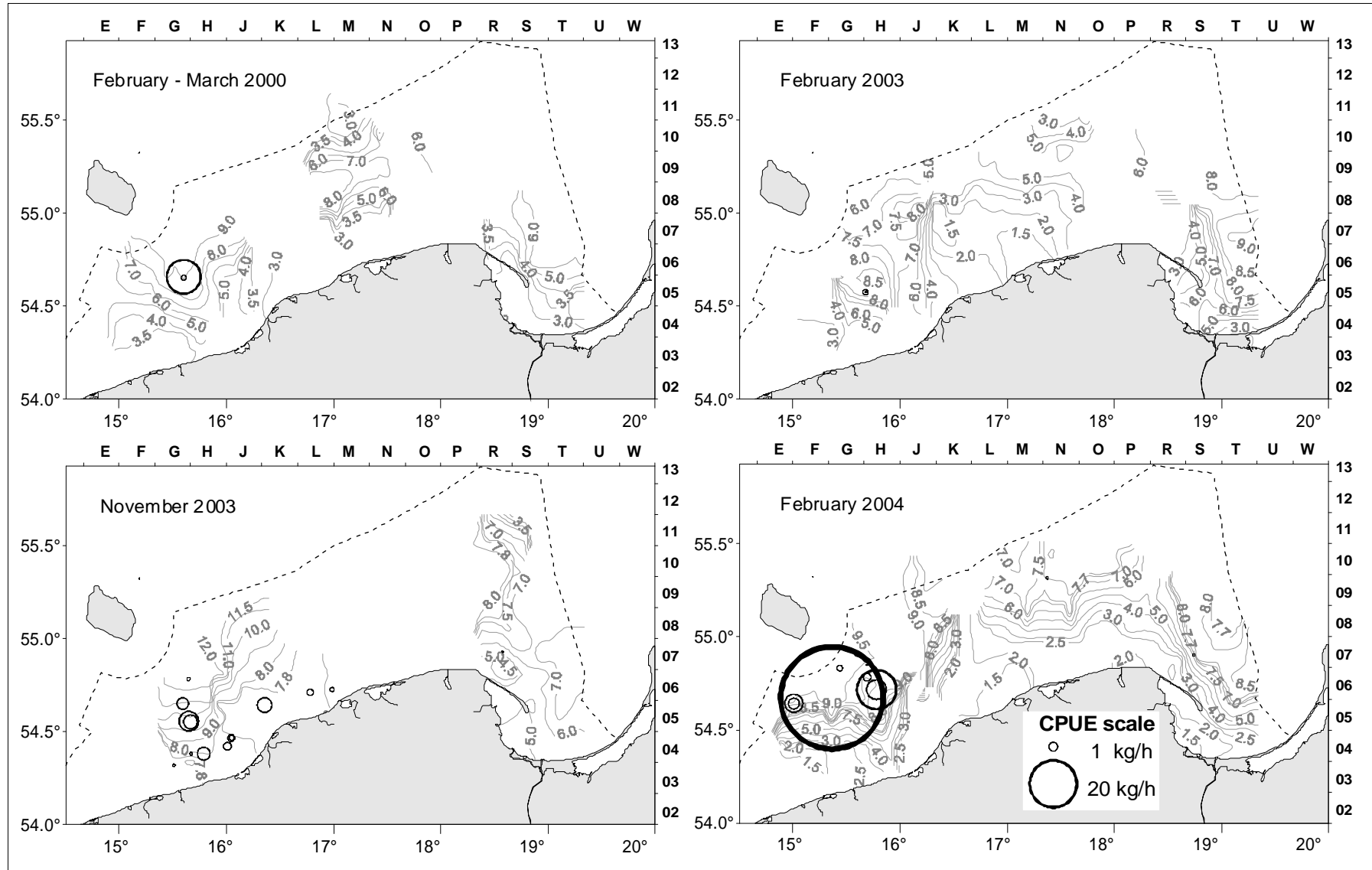


Figure 4. Geographical distribution of European anchovy (*Engraulis encrasicolus* L.) catches (scaled CPUE) within the Polish EEZ in autumn-winter 2000-2004 and the maximum water temperature (isolines; in °C) in the near bottom and bottom layers

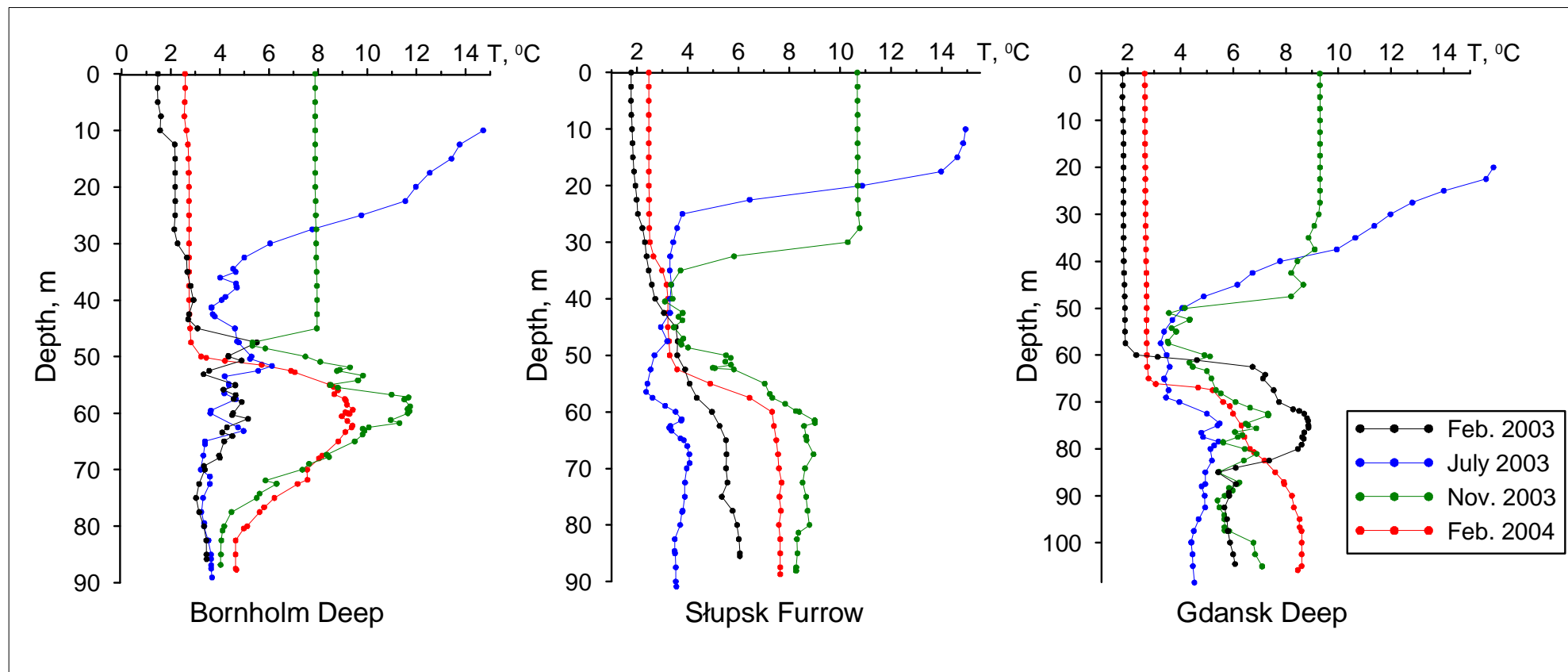


Figure 5. Vertical distribution of the seawater temperature in three areas of the southern Baltic in 2003-2004

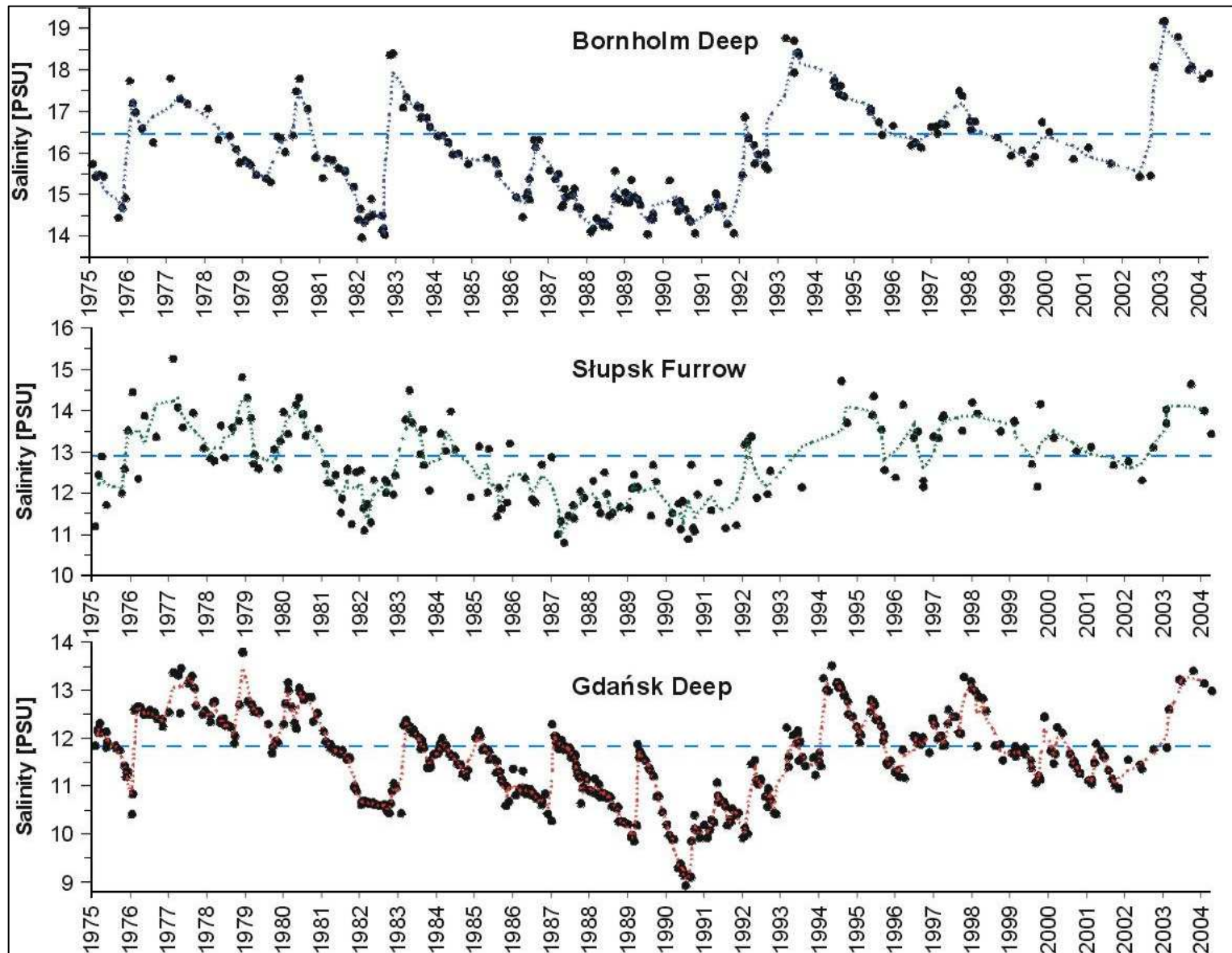


Figure 7. Fluctuations of the mean salinity in the bottom layers of the southern Baltic areas within year over the 1975-2004 period; a dashed (blue) line marks the annual, long-term (1956-2003) mean salinity