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The increase of coincidence in relative year-class strengths of coastal perch (*Perca fluviatilis* L.) stocks in the Baltic Sea

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The year-class strengths of four perch populations (*Perca fluviatilis* L.) in the Northern Quark of the Baltic Sea were compared using a relative year-class strength index. As a result of this it was found that, of the four coastal populations, the three that were reproducing in rivers or estuaries tended to have coinciding year-class fluctuations. Concerning the river and estuary spawning populations, it was discovered that acidification overrules the temperature conditions normally affecting the year-class formation of perch. In the estuaries of the Northern Quark the year-class strengths were more extreme and diverged from the general pattern in the Baltic Sea. In recent years of less acidified conditions, the year-class strength of estuarine perch corresponded more closely to the general pattern in the Baltic Sea.

1. Introduction

Several mass fish kills occurred in estuaries in the Northern Quark in the early 1970s (National board of Waters unpubl., Hildén *et al*. 1982). The mass fish kills were consequences of acidification induced by excavations in the watercourses of rivers running through sulphur rich soils. It was not until the 1980s, i.e. 10–15 years after the worst mass fish kills, that studies of the effects on fish population levels were started in the river Kyrönjoki's estuary. Questions aroused as to how recruitment, population structure and fisheries were affected by the mass fish kills. Furthermore, it was questioned whether missing or scarce year-classes in coastal fish populations are detectable due to the mass fish kills or variating levels of acidification. Studies concerned smelt (*Osmerus eperlanus* (L.)) (Hudd 1985), bream (*Abramis brama* (L.)) (Hudd *et al*. 1986), burbot (*Lota lota* (L.)) (Kjellman *et al*. 1994), whitefish (*Coregonus lavaretus* (L.) s.l.), (Leskelä & Hudd 1993) and perch (*Perca fluviatilis* L.), (Hudd *et al.* 1994). All of the species reproduce in the estuary and are of economic importance to local fishermen (Hudd *et al*. 1984). Other populations of perch in the Northern Quark were included in the

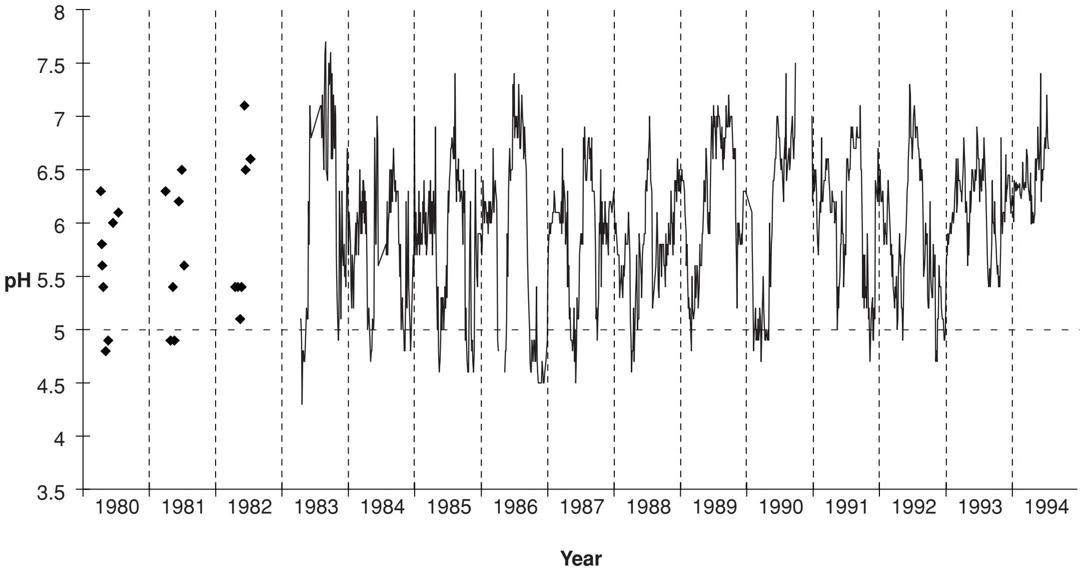

Fig. 1. The pH-levels from the routine measurements in the lower reach (1980–1983) and of the river Kyrönjoki estuary (1983–1994), (West Finland Regional Environmental Centre unpubl.).

monitoring programmes of population structure later in the 1980s.

From the period of mass fish kills in the 1970s there have been changes in the severity and in the annual pattern of the acidification. These changes were especially observed from 1988 onwards. Years with mild and rainy winters led to high water flow in wintertime and the lowest pH-levels were measured earlier in the year than in the beginning of the study period. The lowest pH-levels were normally measured during the late spring flood (Fig. 1). Precipitation during the subsequent summers was also small and some of the summers were relatively warm. In this paper we compared the year-class strengths of coastal perch populations reproducing in acidified estuaries with the general pattern in the Baltic Sea since the late 1970s.

2. Material and methods

In May and the beginning of June, spawning perch were fished with wire traps in the rivers Kyrönjoki (63°14′N, 22°13′E) and Petalax (62°52′N, 21°20′E) estuaries and with a small river trap net in the Malax estuary (62°58′N, 21°30′E) (Table 1). Perch were annually fished between one to several days, until 150–200 fish were caught. Scandinavian survey gill nets (Thoresson 1992) were used in test fishing in the Holmö (63°41′N, 20°53′E) archipelago. All the estuaries have been affected by severe and episodic acidification (e.g. Alasaarela 1983) as all run through areas with sulphur rich soils (Purokoski 1959, Erviö 1975). Their hydrological and meteorological dynamics and conditions are similar although of different size. The Holmö archipelago is a joint reference fishing area for Swedish and Finnish fisheries investigators (Thoresson 1992) and the year-class strengths in the population follow the general pattern in the Baltic Sea (Böhling *et al.* 1991).

Perch were aged from operculum bones and the strength of the year-class was expressed as an index of relative year-

Table 1. Perch samples in the study.

Stock	Time of year	Gear	Years of sampling	Number of age groups in samples	Min.–max. age	Total number of fish
Kyrönjoki	Spawning	Wire trap	1981–1994	4–8	2–11	3 393
Malax	Spawning	Trap net	1981–1983 1985–1994	3–10	2–16	2 297
Petalax	Spawning	Wire trap	1990–1994	3–6	2–7	539
Holmö	Summer	Survey gill nets	1988–1994	4–8	1–8	6 178

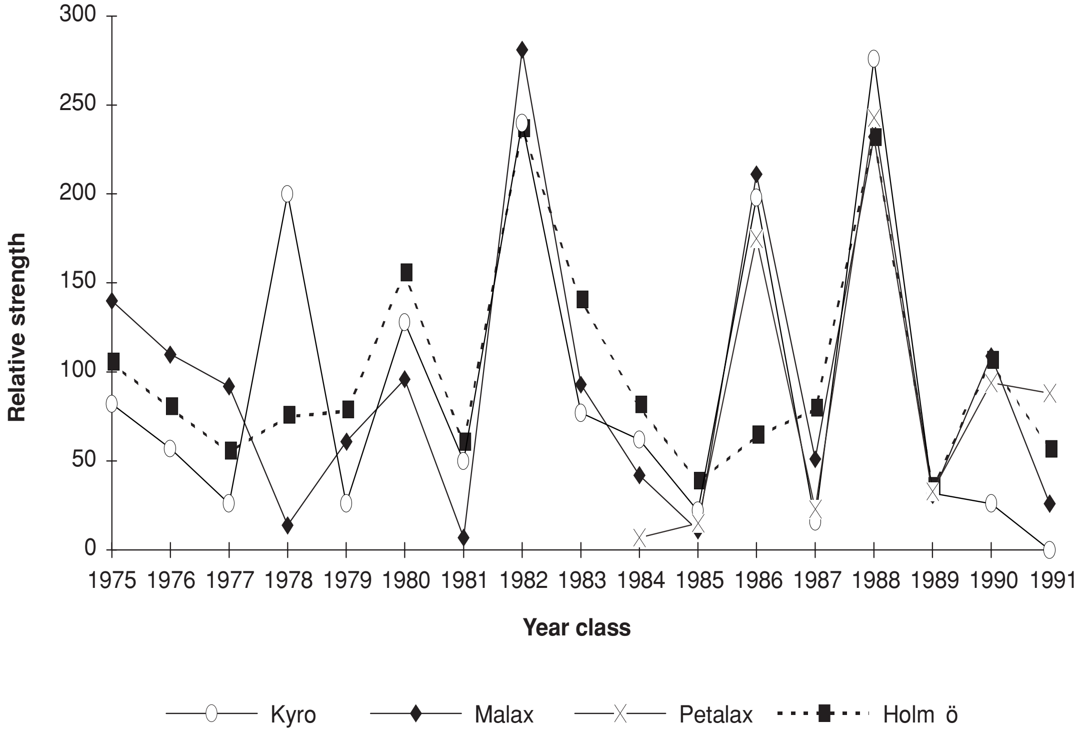

Fig. 2. The relative year-class strengths of the perch populations in the Holmö archipelago and the rivers Kyrönjoki, Malax and Petalax estuaries. In years 1975–1981 the general pattern was drawn according to Böhling *et al.* (1991) and combined to the Holmö values.

class strength (Svärdson 1961, Neuman 1974, Böhling *et al.* 1991). The calculations were done from age groups 3–6 in the estuary spawning stocks and in the Holmö population they were done from age-groups 2–6 according to the smallest coefficient of variation (*c.v.*) (Table 2). Age groups of females and males were combined in all calculations. The year-class strength index of each year-class was thus calculated as the mean of the indicies of a maximum of 4 age groups in the estuary populations and max. 5 age groups in the archipelago population. The general year-class trend of perch in the Baltic Sea was adopted from Böhling *et al.* (1991).

Table 2. The mean of the coefficient of variation with alternative age-groups included in the relative year-class strength calculations in the rivers Kyrönjoki and Malax estuaries and the Holmö archipelago.

	Age-groups included				
	2–6	2–7	3–6	3–7	2–8
Kyrönjoki	0.88	0.94	0.58	0.68	1.15
Malax	1.04	0.73	0.91	1.05	1.33
Holmö	0.41	0.62	0.49	0.70	0.63

3. Results

The relative year-class strengths showed coinciding strengths for the estuary spawning populations and slightly less for the Holmö reference area (Fig. 2). In the rivers Kyrönjoki and rivers Malax populations, year-classes coincided, beginning from 1975, except for the year-class 1978, which was noticeably stronger in the river Kyrönjoki's estuary. Although there were some divergences, especially in 1986, between the estuary populations and the Holmö population, they correlate to each other (Table 3).

Table 3. Spearman rank correlation matrix of the relative year-class strengths of the rivers Kyrönjoki and Malax estuaries and Holmö populations where correlations are compared during two periods.

	1975–1987		1975–1991	
	Kyrönjoki	Malax	Kyrönjoki	Malax
Malax	0.829		0.794	
Holmö	0.543	0.600	0.648	0.818

In the period before 1988 there were 6 year-classes for which the strengths of the populations from the rivers Kyrönjoki, Malax and the Holmö archipelago could be compared. During this period there was a correlation between all the three populations but a much higher correlation existed between the two river spawning populations (Table 3). Compared to the more general pattern in the Baltic Sea before 1982, the variation of the year-class strength was more extreme in the estuarine populations exposed to acidification (Fig. 2).

The youngest and oldest age-groups included in the relative year-class strength calculations were limited by the minimum and maximum age-groups found in the catch samples. As the number of old fish obtained annually was low, the calculations were prone to large errors due to biases in the catch sample, when old fish were included. The same was true when very young fish as pre-recruits were included (Table 2).

4. Discussion

The year-class strength of perch is known to vary synchronously in the Baltic Sea (Neuman 1974). On the eastern side of the Northern Quark, where the largest reproduction areas are situated in the estuaries or in the rivers running through sulphur rich soils (Lehtonen & Hudd 1990), the year-class strengths diverge from the general pattern (Böhling *et al.* 1991, Lehtonen *et al.* 1993). For the stocks in the rivers Kyrönjoki and Malax estuaries, the year-classes until 1987 were generally more extreme than the general pattern of the Baltic Sea. Beginning from the year-class 1988, the populations seem to follow the general pattern ruled by temperature more closely.

In the river Kyrönjoki's estuary, Hudd *et al.* (1994) found that 66% of the year-class strength variation during the years 1975–1988 could be explained by acidification during the spring and early summer. The acidification and temperature together explained 75% of the year-class success. According to the correlation in the year-class strengths of the three studied estuarine populations from the rivers running through sulphur rich soils, it was assumed that the same mechanism controls the year-class strength in the fluvial perch populations of the Northern Quark. The perch catches in the area dropped dramatically in the middle of the 1970s due to recruitment failures (Hildén *et al.* 1982). Similar to perch populations also, for example bream (Hudd *et al.* 1986) and burbot (Kjellman *et al.* 1994) populations suffered. Exceptions in year-class coincidence, like 1978, between the two estuarine populations included in this study may be explained by the differences in timing and severity of acidifications compared to larval and juvenile distribution (Urho *et al.* 1990). All the studied rivers and their estuaries are in a region of highly evolved agriculture, e.g. several waterway clearences and ditching projects have been made in the river Malax and its drainage area in the 1970s (Österholm & Rönn unpubl. data). Detailed water quality measurements are missing and the divergences in the year-class strengths between the rivers can not be evidenced. However, it seems that small actions may cause large divergences in year-class fluctuations. Consequently, if the reproduction areas are restricted to specific environments (Wistbacka unpubl. data) their vulnerability is to be taken into consideration in fisheries management as well as in natural conservation policy.

Unfortunately the wire traps used in this research were selective and may not have given an entirely representative picture of the population, a common problem as with most capture methods. As wire traps are classed as small gear, they should also be more sensitive to bag limits (e.g. Walters 1986). Since 1988, all year-classes have appeared weak in the river Kyrönjoki's estuary (Fig. 2). Between 1991–1994 the wire traps used in the estuary were, however, almost full of perch when emptied and schools tended to be composed of fish of similar size. Perch from a strong year-class may fill small wire traps, thus preventing other fish from being caught. Those samples that contained only one day's catch were therefore prone to inaccuracy.

The mean coefficient of variation for the year-class strengths was the lowest in the estuarine spawning populations when age groups 3–6 were included in the year-class strength calculations. However, the reliability of the year-class strength calculations would generally increase if more age-groups were included. This would have increased the *c.v.* considerably in the trap catch samples, but not in the survey net sample. In fact, the survey net sample showed a similar *c.v.* regardless of the minimum and maximum age groups included. Thereby each year-class is consequently weighted throughout its life span when using survey nets. Accordingly it may be questioned whether the trap samples are representative enough. However, in both the river Kyrönjoki and the river Malax the year-class fluctuations were large, and some year-classes were almost absent. Thereby, the results most likely give a true picture of the year-class variations despite the possible bias in sampling.

Based on the yearly percentual age distributions in samples, the relative year-class strength method (Svärdson 1961, Neuman 1974) can not be used to show long trend increases or decreases in population size. A big population can simply have the same age distribution as a small one. Any long term general trend in population dynamics, like an increase in population, should be shown by other methods, such as VPA. The possible bag limit bias, due to the strong year-class 1988 may affect these calculations as well. We have taken this possibility into consideration and a few years ago also started to collect samples from other sources in order to later evaluate the reliability of the results of the trap samples. However, according to the results of the previous years, with a lower population size, the method of relative year-class strength indexing seems to be useful enabling us to detect discrepancies from the normal variability in reproduction.

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