84 x 119 cm

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Life history inhomogeneity in Baltic Sea whitefish populations revealed by otolith strontium signatures – identification of stocked fish

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Introduction

European whitefish (Fig. 1) occur in two ecotypes in the brackish water (≤7‰) of Gulf of Bothnia, Baltic Sea (Fig. 2); the endangered anadromous river spawning whitefish and the sea spawning whitefish (Lehtonen 1981, Lehtonen & Himberg 1992, Ozerov et a. 2015). The river spawning ecotype undertakes yearlong feeding migrations to the south (Fig. 2). The ecotypes mix in sea outside breeding grounds and season. They are visually similar. To maintain rich whitefish populations and support fishing, massive stocking is undertaken. Stocked fish are raised in freshwater ponds. The ratio of wild-born/stocked adult whitefish in sea remains unknown. Methods to clarify the issue are not well developed. In this pilot study we applied a combination of gill raker (Fig. 3) counting, strontium (Sr) analysis (ICP-OES) of whole otoliths, and analysis (PIXE) of core and edge Sr concentration in polished otoliths (Fig. 4), to shed light on the issue.

Extended background

Gill raker counts differ in river and sea spawning whitefish, being in average below 28 (normally 26-28) in the latter and above 29 (normally 29-31) in the former group (Himberg et al. 2015). Since river spawners naturally hatch in freshwater (rivers) but sea spawners in sea water, a marked difference between Sr concentrations in otolith core and edge may be seen in river spawners but not in sea spawners. The freshwater contains less Sr than sea water which is usually reflected in Sr partition into otoliths (Campana et al. 1999, Engstedt et al. 2012). Moreover, also overall otolith Sr concentration may be lower in river spawners compared to sea spawners. The stocked whitefish are raised in fresh water pounds (several months) and may have particularly low Sr concentrations in the otolith core. To preserve diminishing endangered rivers pawning stocks mainly river spawning whitefish are stocked. River spawners (Kokemäki River) also grow faster in the sea than sea spawners making them more valuable for fishing. However, some freshwater raising and stocking of sea spawners occur as well.

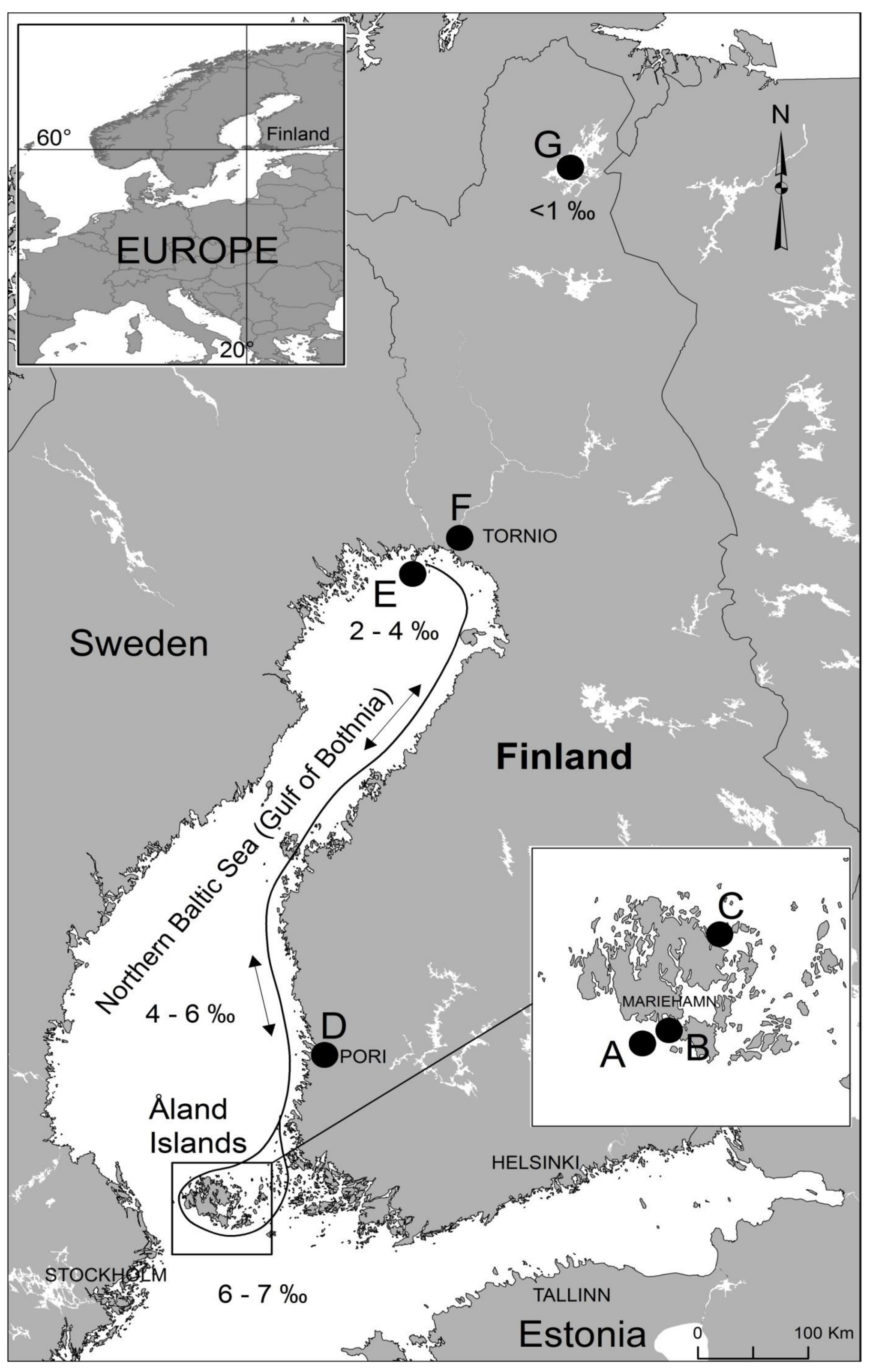

Fig. 2. Whitefish sampling sites in the Gulf of Bothnia (northern Baltic Sea). A, Kobba Klintar Åland (sea); F, Tornio River, Tornio. A schematic migration route for river-spawning whitefish along the Finnish west coast is indicated with black line and arrows. Water salinity (‰) is also indicated.

Materials and Methods

Whitefish were caught in a river (Tornio River, Fig. 2) during spawning (riverspawners, 280-600 g) and at sea (Åland Islands, Fig. 2, 400-900 g) during feeding (mixed ecotypes). In ten fishes from the river gill rakers were counted and otoliths removed. From ten fishes caught in sea, five with 27 gill rakers ("seaspawners") and five with 30 gillrakers ("riverspawners"), otoliths were removed. One otolith from each fish was polished and analyzed for two point (edge/core) PIXE analyses (Lill et al. 2015). The other otolith, or otoliths from fish in the same sample, were dissolved and analyzed with ICP-OES (Hägerstrand et al. 2015).

Fig. 1. Whitefish from the Baltic Sea

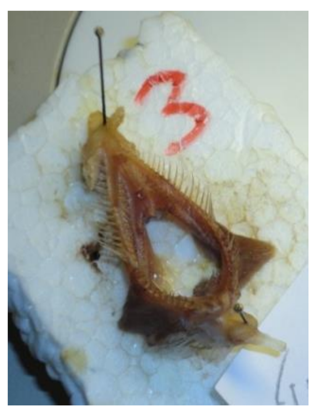

Fig. 3. Gill raker

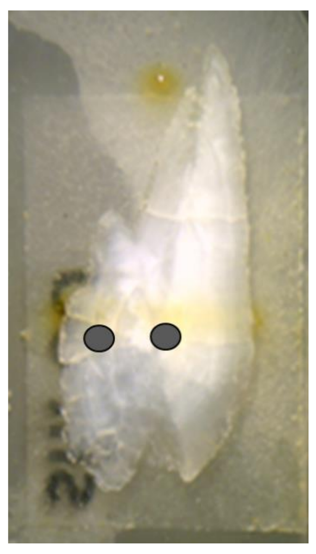

Fig. 4. Polished otolith

Results and Discussion

In the mixed ecotype sample from feeding grounds in the south (Kobba Klintar, Fig 2) one of five (20%) whitefish with 27 gill raker counts (assumably sea spawners) had low core Sr (815 µg/g) and had apparently spent time as juvenile in fresh water (low Sr) and were apparently stocked (Table 1A). The core Sr concentration was similar to that of juvenile sea spawning whitefish raised for stocking in freshwater at Åland Islands, i.e. 831 µg/g ± 18 (n=5, RSD 2%) (unpublished results). Three of five (60%) whitefish with 30 gill raker counts (supposed river spawners) caught at sea showed a fresh water signature (low Sr; 689, 1186 and 1383 µg/g) in the natal core region of the otolith, and were apparently stocked (Table 1A). The low core Sr concentration may not simply be due to river hatching, because the river spawners from Tornio River had much higher otolith core Sr values (Table 1B). Low core Sr further correlated with lower whole otolith Sr concentration in both 27 and 30 gill raker counts whitefish (Table 1A).

In the river spawner population from Tornio River (Fig. 2) the core Sr concentrations (Table 1B) were much higher than the lowest strontium concentrations in otoliths cores from 27 and 30 gill raker count whitefish caught at sea (Kobba Klintar, Table 1A). Thus, it seems that mainly naturally reproduced, not stocked, whitefish were among the examined spawners from Tornio River (Table 1B). Is this a general pattern for Tornio River spawners? Is the homing of stocked whitefish having Tornio River background lost? Notably, river spawners from Tornio river showed somewhat lower edge concentrations than whitefish from feeding grounds in the south (Kobba Klintar). Also their whole otolith Sr concentration was somewhat lower (Table 1A and B). These results should reflect time spent in less saline water.

Until we can tell the juvenile background of high and low gill raker count whitefish, being either naturally reproduced or stocked, they may be categorized as being of either the river or sea spawning "type". Furthermore, naturally reproduced river spawning whitefish may be endangered but not the stocked one.

Table 1. Whitefish were sampled with standing gillnets from feeding grounds at Åland Islands (Kobba Klintar) off spawning season and away from spawning grounds (n=10) 2012 (A), and with dipnets from Tornio River (n=10) during spawning season 2013 (B). Otoliths were polished and analysed for edge and core strontium with point- PIXE as previously described (Lill et al. 2015). Sister otoliths (Åland Islands) or otoliths from fish in the same sample (Tornio River) were analysed for total strontium. For all fishes age, sex (1, male; 2, female) and gill raker counts were determined. Zn was analysed to indicate otolith core where Zn concentration was high compared to the edge.

Code	Age	Sex	Gillraker counts	Sr [µg/g] Core	Sr [µg/g] Edge	Sr [µg/g] Ratio	Zn [µg/g] Core	Zn [µg/g] Edge	Sr [µg/g] Total	Fish weight g	Otolith weight mg
***A**. KobbaKlintar, Åland Islands, mixed population*									Sister otolith	Sample average	
200/4	4	1	**27**	3248	3287	0.99	178	86	3900	x	28
200/7	4	1	**27**	3307	3578	0.92	226	60	3900	x	20
200/8	3	2	**27**	815	3067	0.27	180	36	3100	x	28
201/1	5	1	**27**	2705	3080	0.88	197	59	3800	x	25
201/3	4	2	**27**	3514	3471	1.01	193	61	4200	x	22
207/92	3	2	**30**	689	3662	0.19	181	62	3600	x	37
207/102	4	2	**30**	2999	3570	0.84	123	66	ND	x	25
207/103	4	2	**30**	1186	3055	0.39	137	47	3400	x	26
207/106	4	1	**30**	3634	3900	0.93	165	45	3900	x	30
207/109	5	1	**30**	1383	3982	0.35	208	57	3700	x	23
Average >					3465				3700±300	0.75 kg	26.4±4.8
***B**. Tornio River, Tornio, spawning popula*									Sample average		Sample average
28VS13	7	2	32	2411	3539	0.68	176	50	x	360	x
29VS13	6	2	29	2056	2770	0.74	164	108	x	600	x
30VS13	6	1	31	3077	3593	0.86	173	30	x	375	x
31 VS13	5	2	31	2133	2934	0.73	152	53	x	360	x
32VS13	6	2	28	2433	3214	0.76	148	28	x	310	x
33VS13	6	1	30	1525	3300	0.46	138	42	x	280	x
34VS13	5	1	29	3650	3976	0.92	116	44	x	280	x
35VS13	5	2	30	2418	2957	0.82	128	30	x	300	x
36VS13	6	1	30	1900	3116	0.61	170	55	x	365	x
47VS13	4	1	31	2432	3379	0.72	156	57	x	340	x
Average >			30.1±1.2	2403	3278	0.73			3450±180, n=1	357	28.1±3.6

We raise the following working hypothesis for classifying whitefish in the Gulf of Bothnia into either naturally reproduced or fresh-water-stocked river and sea spawning whitefish:

	Strontium in otoliths Core [µg/g]	Core/Edge [µg/g]	Total [µg/g]	Gill raker number (≥80%)
Sea spawning type:				
Naturally reproduced	>2500	>0.80	>3500	≤28
Stocked (raised in sea water)	>2500	>0.80	>3500	≤28
Stocked (raised in fresh water)	<1500	<0.50	<3500	≤28
River spawning type:				
Naturally reproduced	>1500	>0.60	≤3800	≥29
Stocked (raised in sea water)	>2500	>0.80	>3800	≥29
Stocked (raised in fresh water)	<1500	<0.50	≤3700	≥29

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