STOMACH CONTENT OF WHITEFISH, *COREGONUS LAVARETUS* (ACTINOPTERYGII: SALMONIFORMES: SALMONIDAE), OFF THE ÅLAND ISLANDS, BALTIC SEA

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Abstract. The Åland Islands are major feeding grounds for threatened whitefish, *Coregonus lavaretus* (Linnaeus, 1758), in the Gulf of Bothnia, Baltic Sea. Diet of the foraging whitefish, however, has been poorly studied in this area. In the presently reported spot-check study we analysed stomach content of whitefish (n = 88), sampled by gillnets at hard bottom shallows during spring and summer (June–August) 2012. Molluscs and benthic crustaceans were the main prey items, where the rank order of abundance and biomass of food items was *Theodoxus fluviatilis* > *Idotea* spp. > *Gammarus* spp. > *Hydrobia* spp. > *Mytilus trossulus* > *Radix* spp. A shift towards *T. fluviatilis* was observed from June to July–August. The acquired knowledge on the diet composition could help to shed more light on the ecology of whitefish in the Baltic and may serve to indicate food web alterations due to climate variations and long-term change.

Keywords: whitefish, stomach content, prey, Åland Islands, Baltic Sea

European whitefish, *Coregonus lavaretus* (Linnaeus, 1758), are opportunistic generalist epibenthic omnivores, but can show selective feeding behaviour within the available invertebrate prey dietary range (Jacobsen 1982, Tolonen 1997, Verliin et al. 2011). Whitefish are sight-feeding predators with a diurnal or crepuscular feeding activity (Reebs 2002). While the stomach prey composition of whitefish in the Baltic Sea varies among regions and seasons due to prey occurrence, it also differs between populations and individual=fish. Neither consumed nor available prey items of whitefish around the Åland Islands are well studied.

In the Baltic Sea as a whole, a variety of benthic invertebrates and vertebrates in whitefish stomachs were reported, depending on location and season, including polychaetes, insect larvae (Chironomidae), molluscs (gastropods and bivalves), crustaceans (copepods, amphipods, isopods), and vertebrates (fish and fish eggs) (Valtonen 1980, Wiklund and Himberg 1983, Lehtonen and Himberg 1992, Sõrmus and Turovski 2003).

In the northern parts of the Baltic Sea (Gulf of Bothnia), whitefish diet consisted mainly of molluscs and crustaceans. The most important food items were crustaceans (*Monoporeia affinis*) in the north and molluscs (*Mytilus trossulus*) in the south (Valtonen 1980, Wiklund and Himberg 1983, Hansson 1984, Lehtonen and Himberg 1992). No difference in the food items of river- and sea-spawning whitefish was observed (Himberg 1995). A difference, however, in food items due to the location was reported. At the Åland Islands whitefish food (% occurrence) consisted of 60% molluscs, 30% crustaceans (amphipods and isopods), and also fish, fish eggs, and insects (Himberg 1995). In the majority of earlier mentioned studies, whitefish was sampled with gillnets.

Stomach content data of whitefish sampled at the north-east of the Åland Islands during 1960–1980 revealed high proportions (% occurrence) of molluscs and crustaceans, the rank order of species proportions being *Mytilus trossulus* > *Hydrobia* spp. > *Idotea* spp. > *Theodoxus fluviatilis* > *Gammarus* spp. > *Lymnea* spp. = *Pontoporeia affinis* > *Cerastoderma glaucum* (Chironomidae) (Himberg 1995). In June, July, and August 1964 stomachs of whitefish from the northern Åland Islands contained molluscs, insects, and fish eggs with species frequencies strongly varying over the months (Himberg 1995).

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Verliin et al. (2011) investigated the food preferences of whitefish sampled from a hard bottom area in the neighbouring western part of the Gulf of Finland (Neugrund Shallow, Estonia). They found that whitefish is a selective feeder that prefers crustaceans, particularly isopods to other benthic invertebrates. Although highly available, *Mytilus trossulus* had the lowest rank in food preference of *Coregonus lavaretus*.

The Archipelago Sea marks the southern border of the Gulf of Bothnia with the Baltic proper (Fig. 1). The Archipelago Sea, including the Åland Islands, is due to a long growing season major foraging ground for whitefish from the Gulf of Bothnia. Large areas of shallows with benthic and macroalgal invertebrate communities (Saarinen et al. 2017) make the area rich in food for whitefish. Sympatric anadromous river and sea spawning whitefish ecotypes occur in largely similar proportions (Himberg et al. 2015). In the presently reported study we investigated stomach content in adult whitefish sampled in June, July, and August 2012 at shallow hard-bottom reefs at the Kobba Klintar Islands—a sub-archipelago of the Åland Islands. There has been little information on the diet of whitefish in this region. The knowledge acquired on the diet composition could help to shed more light on the ecology of whitefish in the Baltic and may serve to indicate food web alterations due to climate variations and long-term change.

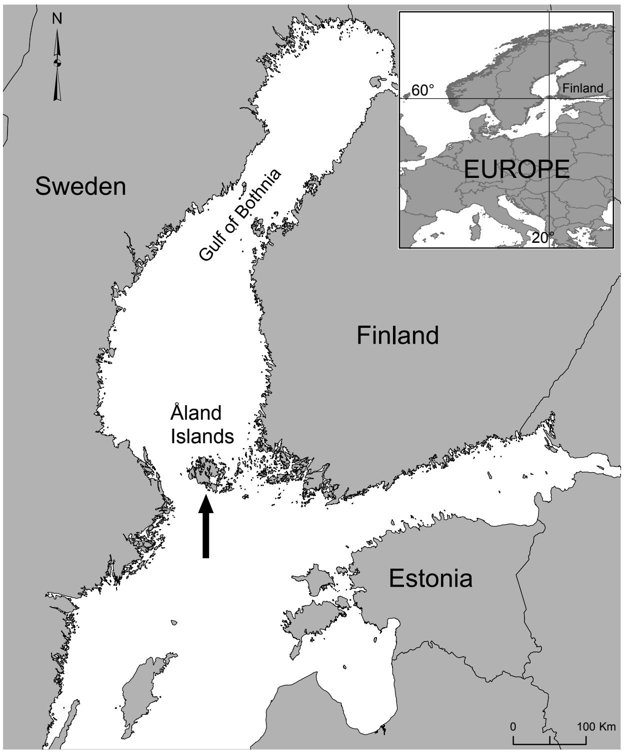

Fig.1. The sampling site of whitefish, *Coregonus lavaretus*, off Kobba Klintar, Mariehamn, Åland Islands (arrow)

The Gulf of Bothnia stretches ~750 km from the Åland Islands in the south, to the Tornio region in the north. In the southern part of the gulf, the Åland Islands and the Archipelago Sea are facing the Baltic proper. Whitefish were sampled at hard bottom granite shallows around the Kobba Klintar Islands (60º1.8′N, 19º53′E) located south of the city of Mariehamn (Fig. 1). The shallows are open to the Baltic Sea proper and therefore are exposed to high wave, strong wind, and ice. The shallows are mainly granite at the top, with patches of sand and stone that increase with depth.

A total of 88 whitefish were caught in June, July, and August 2012 with standard monofilament gillnets (1.8 m deep, 45 mm knot distance, 0.17 mm nylon thread diameter) deployed at 2–5 m depths. Nets were set at the bottom at late evenings or early mornings and lifted after one hour. Four to six samplings were made every month (1–12 June, 11–20 July, and 7–16 August), yielding from anywhere from one to twelve fish. The mean surface water temperature at the Degerby-Föglö weather station located in the sea, 27 km east of the sampling site, the Kobba Klintar Islands (Fig. 1) was 12.9ºC in June, 16.5ºC in July, and 17.6ºC in August 2012 (Finnish Meteorological Institute, Pekka Alenius). Based on the water temperature, samples were divided into two groups: spring (June) and summer (July–August) (Table 1). The fish were adult specimens with the total weight between 0.45 and 1.2 kg. The percentage distribution of female to male was 48% ÷ 52%.

The fish stomachs were dissected, frozen, and subsequently examined in a laboratory. The recovered food items were identified to the lowest possible taxonomic level (species or genus), enumerated, and weighed. We did not attempt to determine relations between the weight and sex of the fish and the stomach content. Previous analyses reported no differences dependant on the weight and sex of stomach food items in the river- and sea-spawning whitefish ecotypes at the Åland Islands (Himberg 1995).

To compare whether the diet composition in terms of the abundance (count of individual prey items in a stomach) and the biomass (mass of prey items (g) in a stomach) differed, the analysis of similarities (ANOSIM) was employed (PRIMER V6*). Individual stomach data were standardized and square root transformed prior to the analyses.

There was moderate but statistically reliable difference in the diet composition structure between the summer and spring whitefish samples (ANOSIM, prey abundance: Global R statistics = 0.28, P = 0.013, n = 88; biomass: R = 0.28, P = 0.017, n = 88). In terms of abundance, the most important prey species were *Theodoxus fluviatilis* (spring mean ± standard deviation = 12.3 ± 8.34); summer mean ± SD = 113.0 ± 122.24; *Idotea* spp. (spring mean ± SD = 12.4 ± 17.3; summer mean ± SD = 14.2 ± 27.10), and gammarids (*Gammarus* spp.) (spring mean ± SD = 20.2 ± 29.61; summer mean ± SD = 12.2 ± 19.55). In terms of biomass, the order of prey items was similar: *T. fluviatilis* (spring mean ± SD = 0.40 ± 0.41; summer mean ± SD = 3.59 ± 3.71); *Idotea* spp. (spring mean ± SD = 0.45 ± 0.76; summer mean ± SD = 0.78 ± 1.31), and gammarids (*Gammarus* spp.) (spring mean ± SD = 0.55 ± 0.78; summer mean ± SD = 0.48 ± 0.94). Less frequent food items consumed by whitefish at the Åland

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Table 1
Principal prevalence and abundance parameters of food items in the diet of whitefish, *Coregonus lavaretus*, collected off Kobba Klintar, Mariehamn, Åland Islands

Food item	Spring (n = 8)			Summer (n = 80)		
	%N	%W	%F	%N	%W	%F
Radix spp.	0.9	0.9	25.0	1.6	1.6	8.8
Theodoxus fluviatilis	20.8	22.2	50.0	79.0	78.0	90.0
Hydrobia spp.	0.0	0.0	0.0	5.6	2.0	41.3
Gastropoda total	21.7	23.1	62.5	86.2	81.6	95.0
Limecola balthica	0.0	0.0	0.0	<0.1	<0.1	6.3
Cerastoderma glaucum	0.0	0.0	0.0	0.1	0.1	1.3
Mytilus trossulus	0.4	0.3	12.5	2.7	1.9	42.5
Bivalvia total	0.4	0.3	12.5	2.8	2.0	45.0
Gammarus spp.	51.5	45.5	75.0	4.8	6.0	51.3
Idotea spp.	26.4	31.1	62.5	6.1	10.3	55.0
Chironomidae larvae	0.0	0.0	0.0	0.1	<0.1	5.0

n = number of fish studied, %N = mean numerical percentage, %W wet weight percentage, %F = occurrence frequency.

Islands were bivalves (*Cerastoderma glaucum*, *Limecola balthica*, *Mytilus trossulus*) and gastropods (*Hydrobia* spp. and *Radix* spp.).

The studied whitefish had primarily fed on molluscs and benthic crustaceans. These results are in line with previous reports from the Åland Islands, where whitefish food (% occurrence) was regarded to consist of about 60% molluscs, 30% crustaceans but also fish, fish eggs, and insects (Himberg 1995). Together these results indicate a stable feeding behaviour over long time periods. A difference in diet composition structure between June and July–August in whitefish samples was observed. One possible explanation for this is that there was a concurrent shift in the availability of prey items. However, we have no data on the prey abundance at the samples sites. Notably, at the Åland Islands as in the Baltic Sea as a whole, food items of whitefish strongly alter over space and time, apparently due to growing habitat and seasonal differences in growth rates of the food species, verifying whitefish being opportunistic generalist omnivore and epibenthic feeder (Verliin et al. 2011). *Mytilus trossulus* was one of the less consumed food items found. Notably, *M. trossulus* had the lowest ranking in *C. lavaretus* food preference at Neugrund Shallow, Gulf of Finland although being highly available (Verliin et al. 2011). Simultaneous analysis of available food items and consumed ones is needed to collect knowledge on whitefish food preferences.

Larger fish are expected to eat larger food items, therefore the larger and fast-growing river-spawning whitefish (Lehtonen 1981) may have an advantage of eating also larger preys. As previously suggested (Verliin et al. 2011) the twilight activity of whitefish and *Idotea* spp. coincide. This may be a partial reason for the rich occurrence of this isopod in whitefish food. Stomach contents of fish relate to prey item abundance, which is in turn highly related to local water temperature, light conditions, and thus food availability of prey. Therefore stomach content of fish may vary considerably during the year.

The abundance of the Baltic Sea whitefish populations have decreased since the middle of the 20th century due to anthropogenic activities such as obstruction of the spawning migration (construction of dams and weirs in rivers), fishing pressure, eutrophication of reproduction habitats, and climate change, therefore the river- and sea-spawning whitefish are listed as endangered and vulnerable, respectively (Anonymous 2013). Knowledge on prey items will help to shed light on the feeding ecology of whitefish in the Baltic Sea. In addition, when followed in different regions over seasons it may serve to indicate food web alterations due to changes in marine ecosystem.

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