Baltic Sea Environment Proceedings No. 103 A

Assessment of Coastal Fish in the Baltic Sea

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Summary

Coastal fish communities are important components of Baltic Sea ecosystems. These communities consist of fish of various origins: marine species, freshwater species, migratory species, and glacial relicts. Representatives of all these categories have different preferences for environmental conditions. For example, marine fish prefer more saline areas, freshwater fish prefer less saline areas, and glacial relicts are more abundant in cold-water layers in deeper areas. The composition of coastal fish communities varies in the different regions of the Baltic Sea in relation to the different habitat characteristics of these regions, with salinity, water temperature, and nutrient availability among the important factors. Other important factors include seabed type for bottom-dwelling fish, and algal and seagrass conditions in shallow waters for near-coastal species.

Monitoring of coastal fish using multi-mesh gillnets and gillnet series has been carried out in fifteen areas in the Baltic Sea. The objectives of this monitoring are to describe and elucidate long-term trends in fish populations and fish community development, and to try to explain the results in relation to natural factors and anthropogenic pressures. This report covers current time series of varying length up to 22 years of annual monitoring. The development of coastal fish stocks has been evaluated using indicators such as species richness, species abundance in terms of numbers and weight, a weight-based ratio between European perch and roach, trophic levels, the abundance of piscivorous fish, and the occurrence of non-indigenous species. A brief summary of the threat status of Baltic fish species is also presented.

Significant increasing trends in European perch and roach catches per unit effort have been observed in the Archipelago region between the southern Gulf of Bothnia and the northern Baltic Proper. A possible reason for these trends is ongoing coastal eutrophication as well as increased temperatures during the past decade. On the other hand, some roach populations in the Baltic Proper have shown decreasing trends in relative abundance. The Curonian lagoon and the river mouth of the Daugava are areas severely affected by anthropogenic impacts, which influence the structure of the local fish community. High fishing pressure during the 1990s in the West-Estonian archipelago, which caused a collapse in the coastal fish stocks, was apparent in the monitoring catches.

The report recommends the inclusion of 34 species considered to be of high priority for conservation, 70 species of medium priority, and 80 species of low priority into the HELCOM Red List of threatened and declining Baltic fish species. Although the spread of non-indigenous species has been suggested to be among the most severe threats to global biodiversity, the significance of most non-indigenous fish species introduced into the Baltic Sea remains of less importance since they have failed to form self-sustaining populations. However, two species, the accidentally introduced round goby (*Neogobius melanostomus*) and the intentionally introduced Prussian carp (*Carassius gibelio*), are exceptions in this respect. In particular, the round goby is spreading, and new records of its occurrence are reported every year.

Introduction

The Baltic Sea ecosystems have undergone dramatic changes during the late 20th century, as a result of both human activities and natural factors. This is also true for the fish communities in coastal areas. Coastal fish are subjected to a number of anthropogenic impacts such as enhanced nutrient loads, contamination by heavy metals, organic toxicants and hormone-like substances, as well as the destruction of recruitment habitats. Changes in mortality rates caused by increased fishing pressure and increased predation by seals and cormorants also influence fish community development. Changes related to the introduction of non-native species may also ultimately represent a substantial threat to the coastal fish fauna.

In an effort to improve the state of the Baltic marine environment, and thus also reduce pressures on the fish community, HELCOM is in the process of developing ecological quality objectives. Some suggested objectives have been presented in the “Discussions and recommendations” section of this report. A number of potential indicators that can be used for assessing ecological quality objectives based on the coastal fish monitoring programme have been discussed in HELCOM workshops (BSRP/HELCOM, 2005). In this assessment, a selected set of indicators has been proposed to describe the status of and temporal trends in the coastal fish fauna in the Baltic Sea. These indicators are: species richness, relative abundance (catch per unit effort) of species, the ratio between functional groups, and the trophic level of fish communities.

Sampling programme used in coastal fish monitoring

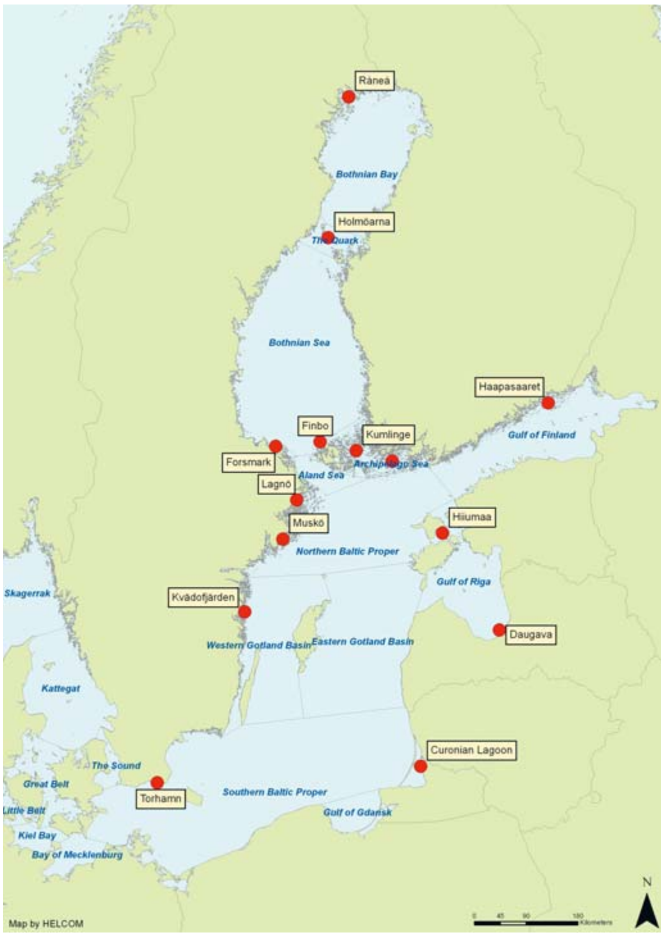


Figure 1. Sampling locations for coastal fish monitoring under the COBRA programme, including the gear used and the first year of sampling.

Coastal fish monitoring in the Baltic Sea 2004		
Area	Gear	Start year
Råneå	Coastal survey nets	1994
Råneå	Nordic coastal nets	2002
Holmöarna	Coastal survey nets	1989
Holmöarna	Nordic coastal nets	2002
Forsmark	Coastal survey nets	1983
Forsmark	Nordic coastal nets	2001
Finbo	Coastal survey nets	1987
Finbo	Nordic coastal nets	2002
Kumlinge	Nordic coastal nets	2003
Brunskär	Coastal survey nets	1991
Brunskär	Nordic coastal nets	2002
Haapasaaret	Nordic coastal nets	2003
Lagnö	Nordic coastal nets	2002
Muskö	Net series	1991
Hiiumaa	Net series	1991
Kvädofjärden	Net series	1987
Kvädofjärden	Nordic coastal nets	2001
Daugava	Net series	1993
Torhamn	Nordic coastal nets	2002
Curonian lagoon	Net series	1991
Polish EEZ waters	Trawl	1996

At present, a network of coastal fish monitoring areas covering large areas of the Baltic Sea is sampled annually. The network comprises monitoring areas in Estonia, Finland, Latvia, Lithuania, Poland, and Sweden. Coastal areas in Denmark, Germany, and Russia are monitored as well, but have not been included in this assessment. This monitoring is coordinated by the "Co-ordination Organ for Baltic Reference Areas" (COBRA), which maintains a database containing coastal fish monitoring results collected from participating monitoring areas. The monitoring programme in 2005 covered fifteen monitoring areas (Figure 1). Four of these include two sub-areas (Curonian lagoon, Hiiumaa, Kvädöfjärden, and Holmöarna) that represent different environmental conditions and, consequently, the fish communities may differ between these sub-areas. The time series cover variable periods, depending on area, up to 22 years of annual monitoring, with the year 2004 being the last year included in the present assessment. Four areas were added to the network in 2004: Torhamn in southern Sweden, Lagnö in the northern archipelago of Stockholm, Haapasaaret in the Gulf of Finland, and Kumlinge in the eastern archipelago of the Åland Islands. As the monitoring method in Poland differs markedly from the others, Polish results have not been included in this report.

The coastal fish monitoring programme is mainly directed towards species of demersal fish (fish living close to the bottom) and benthopelagic fish (fish living both close to the bottom and in the open water) that live in coastal areas during the warm season. The monitoring methods used are not designed to catch pelagic species (fish living in open water) or small fish. Nonetheless, pelagic species such as Baltic herring (*Clupea harengus*), European smelt (*Osmerus eperlanus*), and European sprat (*Sprattus sprattus*) are caught in significant numbers during monitoring (Table 1), but mostly in a random manner, which makes a long-term evaluation of their population development uncertain. Zander (*Sander lucioperca*), also defined as a pelagic species, is caught more regularly in areas with dense populations and its long-term development is possible to evaluate. Small-bodied species such as gobies (Gobiidae), pipefishes (Syngnathidae), sand lances (Ammodytidae), and sticklebacks (Gasterosteidae) are rarely caught and evaluations of their population development are not possible.

Fishing is performed annually in August at fixed stations at 2-m to 5-m water depths using multi-mesh gillnets or gillnet series (Thoresson, 1993). Fishing is repeated at each station over six nights. Gillnets are set between 14.00 hrs and 16.00 hrs and lifted the next day between 07.00 hrs and 10.00 hrs. Coastal survey nets, 35 m long, 3 m deep, and composed of five 7-m long panels with mesh sizes of 17 mm, 21 mm, 25 mm, 33 mm, and 50 mm, knot-to-knot are used in the Archipelago region and the Gulf of Bothnia. Gillnet series are used in the monitoring areas in the Baltic Proper. The net series consists of four 30-m long and 1.8-m deep nets; each net is made up of a single mesh size: 17 mm, 21.5 mm, 25 mm, and 30 mm, respectively. Fish catches at each station are registered in numbers of individuals per species, separated into mesh-size and fish-length (in cm) groups. Weather conditions (wind direction and strength) as well as water temperature and Secchi disc depth are routinely recorded during the fishing period.

A revision of the sampling methods was initiated in 2001 and a new type of sampling gear, termed the Nordic coastal multi-mesh gillnet (or coastal Nordic net), was developed (Appelberg *et al*., 2003). This gillnet is 45 m long, 1.8 m deep, and is composed of nine mesh sizes (10 mm, 12 mm, 15 mm, 19 mm, 24 mm, 30 mm, 38 mm, 47 mm. and 60 mm, knot-to-knot). The sampling strategy is based on depth-stratified random sampling using approximately 45 net stations distributed in different depth strata: 0–3 m, 3–6 m, 6–10 m, and 10–20 m (Söderberg *et al*., 2004). This method has been used in parallel with the former methods in six areas, as well as in the four recently established monitoring areas.

The results have been presented here as indices: catch per unit effort (CPUE) in number of individuals or abundance in terms of weight per unit effort (WPUE). One unit of effort is defined as one fishing night using one gillnet. Although the sampling gears differ between areas in regard to length, depth and mesh-size, no correction for these differences has been made.

The results of coastal fish monitoring in 2004 are presented in Table 1 as CPUE for each fish species according to monitoring area. The fish species have been grouped according to their habitat preference: freshwater, marine, or migratory, and demersal, benthopelagic, or pelagic. A discussion of the factors that are important determinants for the fish populations and communities in the Baltic Sea is provided in the next section of this report.

Length of perches caught in Nordic coastal multi-mesh gillnets are measured. (Foto: Kaj Ådjers)

Table 1.
Mean fish catch per unit effort, in number of individuals, in coastal fish monitoring areas in 2004 (the habitat preference category has been specified according to Fishbase, 2004).

	Net series							
	Curonian lagoon central	Curonian lagoon north	Daugava	Hiiumaa inner	Hiiumaa outer	Kvädöfjärden inner	Kvädöfjärden outer	Muskö
Freshwater species								
Demersal								
Burbot (*Lota lota*)	<0.1							
European perch (*Perca fluviatilis*)	20.7	6.8	14.6	2.1	1.6	6.8	17.7	6.1
Northern pike (*Esox lucius*)				<0.1	<0.1	0.2	0.1	0.2
Ruffe (*Gymnocephalus cernuus*)	16.7	5.9	4.6	0.7	0.9	0.2	0.4	0.5
Tench (*Tinca tinca*)						<0.1	<0.1	<0.1
White bream (*Blicca bjoerkna*)	46.0	3.0	6.1	<0.1	<0.1	0.9	0.3	2.3
Benthopelagic								
Bleak (*Alburnus alburnus*)	0.5	4.3	<0.1	<0.1	0.2			
Common bream (*Abramis brama*)	3.2	<0.1	0.5			0.4		
Common dace (*Leuciscus leuciscus*)								
Gudgeon (*Gobio gobio*)		0.1						
Ide (*Leuciscus idus*)				<0.1			0.1	<0.1
Prussian carp (*Carassius gibelio*)						<0.1		
Roach (*Rutilus rutilus*)	61.0	66.7	2.0	0.9	<0.1	3.8	4.1	11.1
Rudd (*Scardinius erythrophthalmus*)				0.1		0.2	0.1	0.5
Vimba (*Vimba vimba*)	<0.1	2.8	1.5	<0.1	<0.1			
Pelagic								
Vendace (*Coregonus albula*)								
Zander (*Sander lucioperca*)	0.3	0.5	0.6			0.1		<0.1
Ziege (*Pelecus cultratus*)		0.3						
Number of freshwater species	**9**	**10**	**8**	**9**	**7**	**10**	**8**	**9**
Marine species								
Demersal								
Black goby (*Gobius niger*)								<0.1
Flounder (*Platichthys flesus*)		0.5	0.3	<0.1	0.3	<0.1	0.1	<0.1
Fourhorn sculpin (*Triglopsis quadricornis*)								
Great sandeel (*Hyperoplus lanceolatus*)			<0.1					
Small sandeel (*Ammodytes tobianus*)								
Straightnose pipefish (*Nerophis ophidion*)								
Turbot (*Psetta maxima*)					<0.1			
Viviparous blenny (*Zoarces viviparus*)								
Benthopelagic								
Three-spined stickleback (*Gasterosteus aculeatus*)								
Pelagic								
Baltic herring (*Clupea harengus*)			0.5	<0.1	<0.1	0.3	<0.1	<0.1
European sprat (*Sprattus sprattus*)					<0.1			<0.1
Twaite shad (*Alosa fallax*)	0.1	<0.1						
Number of marine species	**1**	**2**	**3**	**2**	**4**	**2**	**2**	**4**
Migratory species								
Demersal								
Common whitefish (*Coregonus lavaretus*)			<0.1					
European eel (*Anguilla anguilla*)								
Benthopelagic								
Atlantic salmon (*Salmo salar*)								
Pelagic								
European smelt (*Osmerus eperlanus*)						<0.1		
Number of migratory species	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**

Coastal survey nets						Nordic coastal multi-mesh gillnets									
Brunskär	Finbo	Forsmark	Holmöarna inner	Holmöarna outer	Råneå	Torhamn	Kvädöfjärden	Lagnö	Brunskär	Haapasaaret	Finbo	Kumlinge	Forsmark	Holmöarna	Råneå
28.4	50.9	29.2	61.8	63.3	13.2	56.6	18.1	24.9	37.5	17.7	34.3	22.2	21.7	37.0	40.8
	0.1		<0.1	<0.1	0.1	0.5	0.2	0.1			<0.1		<0.1	<0.1	0.1
<0.1	2.2	0.7	5.3	5.8	0.8	0.1	3.9	3.4	0.1	0.6	5.0	0.5	4.9	15.5	6.8
							0.3	<0.1							
<0.1	1.1	1.2				0.1	2.9	0.7			1.5	0.1	4.1		
			0.1	0.9	0.3	4.4	5.3	0.6	0.2	0.6	0.4	0.6	0.5	0.2	2.2
	0.2	0.1			8.8		0.7	<0.1		0.2	0.4		0.5		8.1
					<0.1					<0.1					0.1
0.3		<0.1			0.1	0.2	0.3	<0.1	0.7	0.2	<0.1	<0.1			<0.1
							<0.1								
11.2	23.8	9.0	24.1	14.2	25.9	19.3	18.3	9.2	8.8	27.6	28.4	0.3	8.5	3.3	19.9
		1.0				0.7	0.2	<0.1		<0.1	<0.1	2.7			
							<0.1	<0.1		0.4			0.1		
					<0.1					0.1					0.9
0.1	0.6	0.3					0.4	<0.1	0.2	<0.2	0.7	0.4	2.2		
6	**7**	**8**	**5**	**5**	**9**	**8**	**13**	**12**	**6**	**11**	**10**	**8**	**9**	**5**	**9**
						0.1	<0.1	<0.1	<0.1						
0.6	<0.1					0.2	0.6	<0.1	1.5	0.1	0.1	0.3	<0.1		
<0.1								0.3	0.1		<0.1	<0.1			
								<0.1							
	<0.1									<0.1	<0.1				
								0.2		<0.1				<0.1	
			<0.1	0.1									<0.1	8.3	
4.5	4.8	0.2		2.4	<0.1	<0.1	0.8	4.6	1.9	1.1	7.9	2.2	4.7	2.7	0.4
							2.3	1.4	0.1	1.3	0.4	1.5	1.1		
3	**3**	**1**	**1**	**2**	**1**	**3**	**4**	**7**	**5**	**5**	**5**	**4**	**4**	**3**	**1**
0.4	<0.1		0.2	0.1	0.4			0.8	0.1	<0.1	0.1	0.1	<0.1	0.3	0.2
						<0.1									
														<0.1	
<0.1	<0.1						0.3	3.3		0.4	0.2	0.2			<0.1
2	**2**	**0**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**2**	**2**	**2**	**1**	**2**	**2**

Factors influencing the structure of the fish populations and communities in the Baltic Sea

Temperature

Several freshwater fish taxa living in the Baltic Sea (e.g., percids and cyprinids (see Appendix for list of species in these taxa)) prefer warm-water conditions. Temperature has been proved to be an important factor governing the recruitment success, growth, and year-class strength of, for example, European perch (*Perca fluviatilis*) in the Baltic Sea (Böhling *et al.*, 1991; Karås and Thoresson, 1992; Karås, 1996). Measurements of water temperature at five-metre depths at the eastern Åland Islands revealed that the mean temperature during July to September was 0.8 ºC higher during the period 1990–2002 as compared to the period 1979–1989. Short-term changes in water temperature, caused by weather conditions and currents, may have a significant effect on the species composition in open coasts.

Salinity

The distribution of several fish species living in the Baltic Sea (of marine and freshwater origin) is strongly determined by salinity, which decreases towards the north and the east (see salinity contours in Figure 2). Both the number of species and the number of individuals of marine species decline with declining salinity. Flounder *(Platichthys flesus)* is an example of a marine species that is tolerant to lower salinities and it occurs widely over the Baltic Sea (Figure 2). However, it is rare in the low-salinity areas of the Gulf of Bothnia, the Gulf of Finland, and the Curonian lagoon.

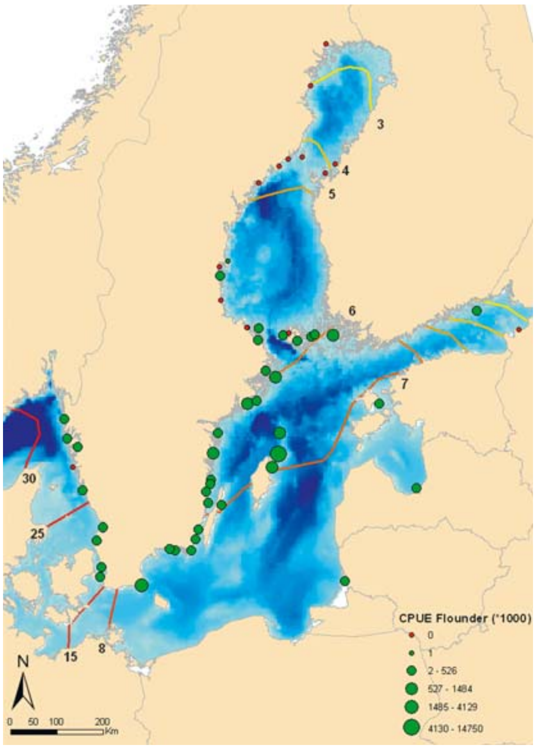


Figure 2.
Distribution of flounder in the Baltic Sea based on catch per unit effort (CPUE) in different monitoring investigations. The contour lines show salinity in Practical Salinity Units (PSU). The low abundance of flounder observed in the coastal areas of western Sweden is a result of using fyke nets instead of the gillnets that are used in the Baltic Sea.

Salinity determines the distribution area of most freshwater species. In higher-salinity areas (>10 PSU), freshwater species appear close to the coast or in the vicinity of river mouths. Vendace *(Coregonus albula)*, being sensitive to higher salinities, is common only in the low-salinity areas of the Gulf of Bothnia and the Gulf of Finland.

Eutrophication

Eutrophication has caused dramatic changes in the Baltic Sea ecosystems at all trophic levels during recent decades (HELCOM, 2002). It is also one of the major factors influencing the composition and long-term development of Baltic fish communities, causing increased production of fish biomass and changes in fish community structure and function (reviewed by Lappalainen, 2002). Investigations in European lakes have shown that a slight increase in nutrients may favour the abundance of percid fish species; however, heavy eutrophication usually favours cyprinid species at the expense of percid and coregonid fish species (Hartmann, 1977). Several authors have noted that cyprinids are more abundant in eutrophic coastal areas compared to less eutrophic areas in the Baltic Sea (Anttila, 1973; Hansson, 1987; Bonsdorff *et al.*, 1997; Lappalainen, 2002). Water transparency, an indicator of the amount of particles in the water and hence also nutrient availability, has decreased in the entire Baltic Sea during the past century (Laamanen *et al.*, 2004). Eutrophication may also have negative effects on threatened and declining species, especially benthic species, owing to habitat loss (see section on "Threatened and declining species", below).

A relationship between trophic state, expressed as Secchi disc depth, and cyprinid fish is suggested by the negative relationship between water transparency and catch per unit effort of roach (*Rutilus rutilus*) and other cyprinids observed in the monitoring areas investigated (Figure 3). The different monitoring methods showed a similar pattern. The smallest Secchi depth (i.e., least water transparency) and largest catches per unit effort of roach and other cyprinid species appeared in the Curonian lagoon, whereas the large Secchi depth and small catches per unit effort of roach and other cyprinid species appeared at Brunskär and Kumlinge.

Among the areas sampled using coastal survey nets, Holmöarna inner and Råneå deviated from the relationship by having larger catches per unit effort of roach and other cyprinids than suggested by the line of best fit (Figure 3b). One reason for the large catches per unit effort of roach in these areas is probably related to temperature, as both areas are shallow, enclosed areas suitable for roach recruitment. The area of Kumlinge also deviated from the line of best fit, by markedly low catches of roach per unit effort (Figure 3c). The catches per unit effort of cyprinid species were of a magnitude suggested by the line of best fit, but dominated by rudd (*Scardinius erythrophthalmus)* and bleak (*Alburnus alburnus*).

The negative correlation between the abundance of roach/cyprinids and Secchi depth indicates that low water transparency, often caused by eutrophic conditions, favours cyprinid species. However, although Secchi depth may often be used as a proxy for eutrophication, there is no direct relationship. For example, in the open, shallow, and turbulent systems of Latvian coastal waters, Secchi depth is more dependent on wind direction and strength rather than on the level of eutrophication. Owing to this, the Latvian area, Daugava, has been excluded from this analysis.

Fisheries

Fishing activity is a major factor influencing the structure of coastal fish communities. In Estonia, coastal fishing intensity increased at the beginning of the 1990s. In the middle of the decade, commercial fishery for European perch (Figure 4a), Northern pike (*Esox lucius*), and zander declined due to overexploitation. The commercial catches of European perch in the West-Estonian archipelago in 1999 were about 1% of the average over the past thirty years (Vetemaa *et al.*, 2000). Catch per unit effort of adult European perch in the coastal fish monitoring programme followed a similar decline (Figure 4a). The significant decrease of zander catch per unit effort that was observed in the Gulf of Riga (Daugava monitoring area) is probably also related to the high fishing pressure (Figure 4b).

Other important factors

Reduced European perch stocks and recruitment failures of European perch and Northern pike have been reported for the coastal areas of the western Baltic Proper (Andersson *et al.*, 2000; Ljunggren *et al.*, 2005). Studies in the Kalmarsund area in 1998–1999 showed low abundances of both young-of-the-year and adult fish of most fish species except sticklebacks. Subsequent studies have confirmed that recruitment disturbances have occurred in most areas in the outer parts of archipelagos on the western side of the Baltic Proper. Similar effects were not detected in the inner Kvädöfjärden area, and it is suggested that this disruption in recruitment is related to ecosys-

Figure 3 a–c. Relationship between Secchi depth and CPUE in terms of numbers of roach and other cyprinids in different monitoring gears. Significant relationships between CPUE and Secchi disc depth were found for both roach (linear regression, p=0.032) and cyprinids (linear regression, p=0.006) in net series and for other cyprinids (linear regression, p=0.025) in Nordic coastal nets. Data included in a) and b) are for the years 1992–2004, and in c) for the years 2002–2004.

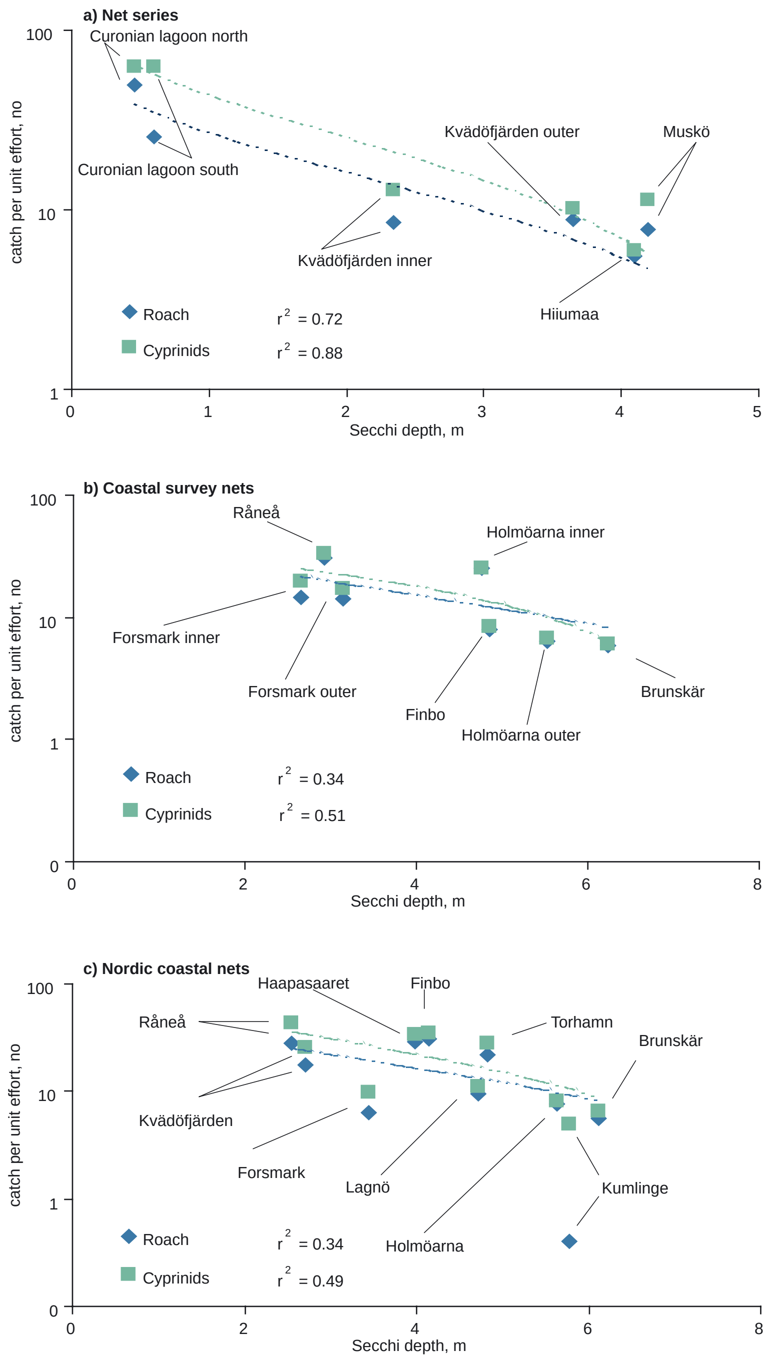
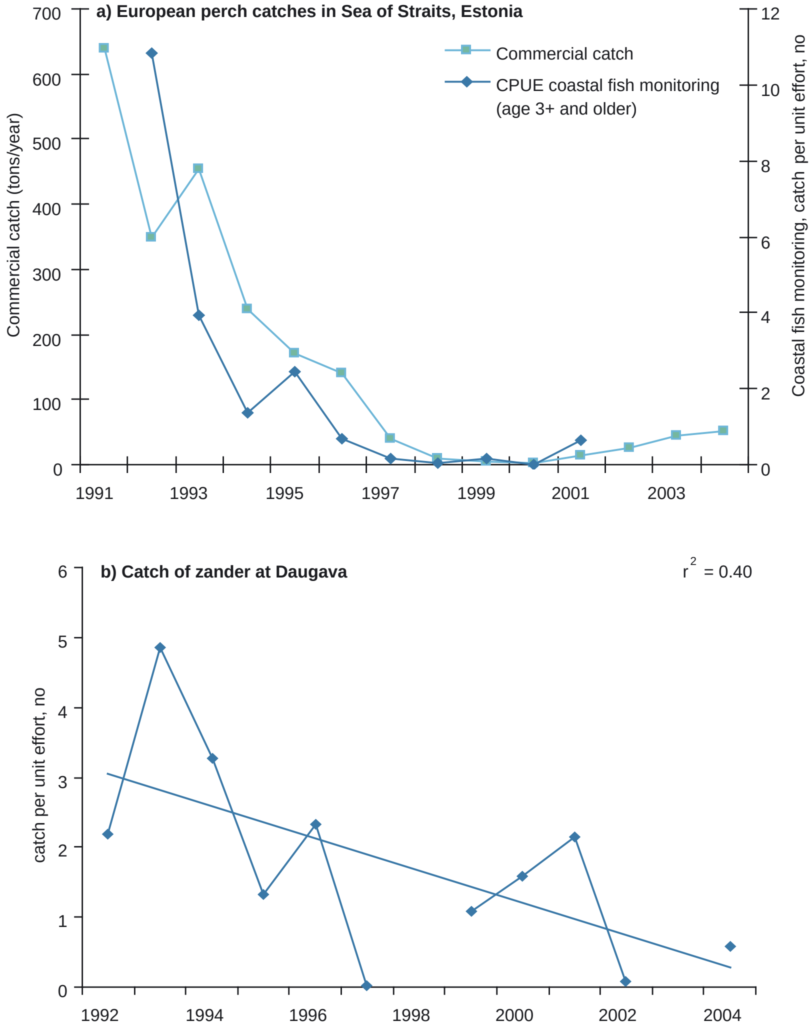


Figure 4.
(a) Commercial catches in tonnes per year (from Vetemaa et al., 2000) and monitoring catches per unit effort of adult European perch in the West-Estonian Archipelago Sea, and (b) zander catch per unit effort in terms of numbers (significant decrease, Mann-Kendall trend analysis, $p<0.05$) in the monitoring area of Daugava, illustrated by the line of best fit.



tem changes in the open sea, which then influence coastal areas subjected to open water exchange (Ljunggren *et al*., 2005).

In pace with the increase in the Baltic seal populations during the past two decades, predation by seals on coastal fish has increased (Lunneryd *et al*., 2004). From a population size of about 100 000 individuals one hundred years ago, the grey seal (*Halichoerus grypus*) population decreased substantially and was estimated at about 4 000 individuals in the late 1970s (Harding and Härkönen, 1999). Since then, the population has increased and was estimated at 17 640 individuals in 2004 (Halkka *et al*., 2005). According to Lundström *et al*. (2005), grey seals prey mostly on Baltic herring, but common whitefish (*Coregonus lavaretus*) and European sprat are also common in their diet. They also consume cyprinids, viviparous blenny (*Zoarces viviparus*), flounder, Atlantic salmon (*Salmo salar*), and sea trout (*Salmo trutta*). Seals interact with commercial fisheries in the northern Baltic Sea, by eating fish caught in passive gears and causing damage to the gears. Despite the growing conflict between increasing seal populations and coastal fisheries, there is still a substantial lack of knowledge concerning the impact of seal populations on coastal fish communities.

The population of cormorants (*Phalacrocorax carbo sinensis*) has increased strongly in the Baltic Sea over the past two decades. As an example, the first breeding colony was established in the West-Estonian Archipelago Sea in 1984, and by 1998 there were 2 675 pairs. Cormorants consumed approximately 463 tonnes of fish in 1998, which was of the same order as the annual commercial catch of coastal species in the area investigated (Eschbaum *et al*., 2003). On the Kattegat and Skagerrak coasts of western Sweden, Alexandersson and Lunneryd (2005) estimated that the amount of cod taken by cormorants was of the same order of magnitude as the by-catch in the eel fishery, and the amount of flatfish taken was considerably larger. This species of seabird is thus expected to have a significant impact on coastal fish populations.

Ecological indicators

The following indicators have been proposed to describe the status and temporal trends of the coastal fish fauna in the Baltic Sea. These potential indicators can therefore be used for assessing the success of measures that have been taken to achieve defined ecological objectives.

Species richness

Species richness (measured here as the number of species caught in gillnets) depends on factors such as habitat heterogeneity, salinity, temperature, and exposure to the open sea of the area sampled. Species richness is also dependent on the number of efforts used in sampling, since the probability to catch a species increases with the number of efforts. The numbers of freshwater species found in 2004 varied between five and ten species in gillnet series and in coastal survey nets (Table 1). More species, between five and thirteen were caught in Nordic coastal nets. The Nordic coastal gillnets contain smaller mesh sizes as compared to the other gears and thus more easily catch small-sized fish species.

The most common freshwater species caught in coastal fish monitoring in 2004 were European perch, roach, and ruffe (*Gymnocephalus cernuus*). These species appeared in all areas/sub-areas, sometimes in high densities. White bream (*Blicca bjoerkna*), zander, Northern pike, and bleak were caught in considerable numbers in most areas. Common bream (*Abramis brama*), ide (*Leuciscus idus*), rudd, common whitefish, and vimba (*Vimba vimba*) were found in noticeable numbers in many areas. Other species were scarce (Table 1).

Marine species were rarely represented in the Curonian lagoon, an almost enclosed freshwater basin, or in the Gulf of Bothnia, where salinity ranges between 1 PSU and 5 PSU. The only marine species caught in 2004 in these basins were Baltic herring, viviparous blenny, and twaite shad (*Alosa fallax*). In the more open areas of the Archipelago region (Finbo, Brunskär), with high habitat heterogeneity and a salinity of about 6 PSU, the contribution of marine species was noticeable in 2004. The most common marine species, in addition to Baltic herring, was flounder. This species was represented in almost all areas, except for the two northernmost monitoring areas in the Bothnian Bay (Holmöarna and Råneå) and the central sub-area of the Curonian lagoon (Figure 2). European sprat was also found in several areas, but other species appeared only occasionally (Table 1).

An excample of catch in Nordic coastal nets, separated in different mesh sizes. (Foto: Kaj Ådjers)

Index of abundance

Species abundance is monitored to assess the population development of economically important species, e.g., European perch and zander, and species of specific environmental interest, e.g., roach. In most of the areas investigated, European perch and roach are the dominant species. Hence, European perch and roach are key indicator species in assessing coastal fish community structure and development in the entire Baltic Sea. In the Curonian lagoon and in Daugava, the abundance of ruffe and white bream are at similar levels to those of European perch and roach.

Significant temporal trends in catch per unit effort were observed for seven species, with European perch and roach being the most common. Trend directions were in some cases similar among several areas in the same geographical region. Perceivable and consistent increasing trends in CPUE of European perch (Figure 5a) and roach (Figure 5b) were observed in the archipelago region between Sweden and Finland (Finbo and Brunskär). A simultaneous significant decrease in water transparency was noted at Finbo. Roach was rare in the early 1990s at Brunskär, but the CPUE has increased considerably since then, from 0.8 in 1992 to 14.9 in 2003. Despite the increased densities of roach at Brunskär, the levels can still be regarded as low. The warm summers during the 1990s may have contributed to the increase in the fish stocks in this area. However, a negative correlation between water transparency and the

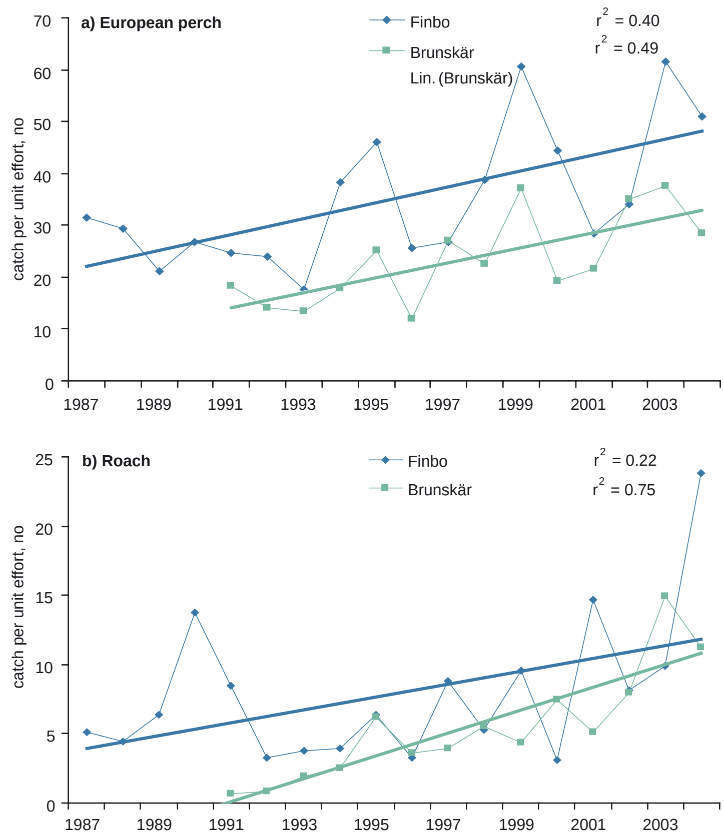


Figure 5.
Significant trends (Mann-Kendall trend analysis, $p<0.05$) in catch per unit effort in terms of numbers of (a) European perch and (b) roach, illustrated by the line of best fit, in the Archipelago Sea and Åland Islands.

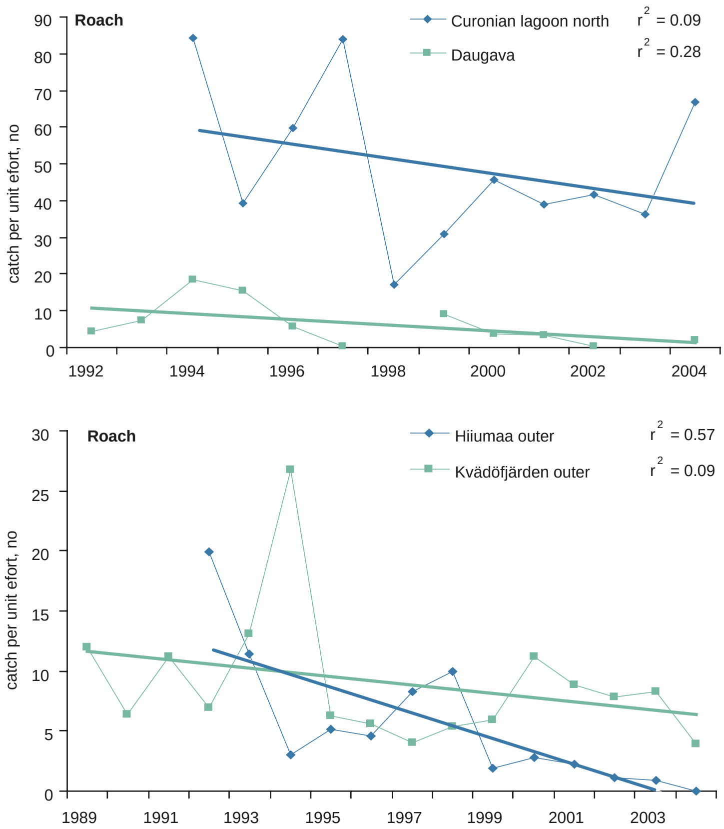


Figure 6.
Significant trends (Mann-Kendall trend analysis, $p<0.05$) in catch per unit effort in terms of numbers of roach along the coasts of the Baltic Proper; trend directions are illustrated by the lines of best fit.

abundance of cyprinids suggests that eutrophication may be a reason for the observed changes in fish communities (Figure 3).

The CPUE of roach demonstrates another consistent development in the Baltic Proper. In four out of a total of eight areas/sub-areas, the CPUE decreased significantly (Figure 6), whereas no trends were noted in the other four areas. This may indicate a decrease in eutrophication in the coastal areas of the Baltic Proper. Intense fishery may also contribute to the decrease, at least in the Curonian lagoon, where commercial roach landings were three to four times higher in 1998–2001 compared to 1992–1994 (Repečka *et al.*, 2002). Despite this decrease, the abundance of roach in the Curonian lagoon remained considerably higher than in the other areas monitored.

Significant trends in CPUE for other species were commonly observed in the eastern Baltic Sea (Curonian lagoon and Daugava). Trends in the CPUE of ruffe showed opposite directions between the sub-areas in the Curonian lagoon, whereas zander decreased in Daugava. Finally, the CPUE of common bream increased in the central Curonian lagoon, vimba increased in Daugava, and white bream increased in the northern Curonian lagoon. In contrast to the other areas, the fish communities in the eastern Baltic Sea were clearly influenced by human impacts. Although anthropogenic discharges to the Curonian lagoon (Stankevicius, 1998) and the Gulf of Riga (Yurkovskis, 2004) have been reduced significantly during recent years, resulting in reduced eutrophication, the Curonian lagoon is still subject to large discharges and a greater level of eutrophication compared to the other areas included in this report. Altered environmental conditions are possibly one factor causing changes in the fish populations. Intense fishery, particularly in the case of zander in Daugava, is also probably one reason for the population decline.

Index of biomass

Weight per unit effort (WPUE) of the fish community may be used as an index of the size of the standing stock, the nutritional conditions, and the production potential of a coastal area. A temporal increase in total WPUE, such as in the archipelago area between southwestern Finland and Sweden (Figure 7a), indicates increased feeding conditions resulting in increased reproductive success and enhanced growth. It is also possible that increased temperatures during the growth season may contribute to the WPUE increase. The decrease in total WPUE noted at Muskö (Figure 7b), also located in the northern Baltic Sea, merely indicates that nutritional conditions rather than temperature caused the temporal changes of total WPUE in the northern Baltic Sea. The decrease in total WPUE at Hiiumaa was probably caused by overexploitation of the fish stocks. Strong year-classes (i.e., fish hatched or born in a given year) of European perch in 1988 and 2001 caused the WPUE peaks in 1991 and 2004 at Holmöarna. It is expected that the WPUE will be high during the next one to two years in this area as a result of the strong year-class of 2001. Although a significant long-term decrease was noted when analysing the period 1989–2004, the situation may change when the influence of this year-class is fully recruited to the sampling gears in 2005.

Ratio between European perch/roach based on weight

The ratio between European perch and roach provides a description of fish community composition, and a declining ratio indicates a development towards a more cyprinid-dominated community. An increase in the abundance of cyprinids could be caused by a set of factors, of which increased amounts of nutrients, reduced water transparency, strong year-classes, and increased water temperatures may be the most important. The area of Kvädöfjärden, both the inner and outer sub-areas (Figure 8a), was the only area showing a development towards a less cyprinid-dominated community. This development, which is an effect of both a slight increase in the CPUE of European perch as well as decreasing roach abundance, may indicate decreased eutrophication (Figure 8). Three areas (Muskö, Brunskär, and Holmöarna outer) showed decreasing ratios (Figure 8b), indicating that the fish communities in these areas have become more cyprinid-dominated. With regard to Brunskär, this change is probably related to more eutrophic conditions, as total WPUE also increased. However, given that total WPUE decreased in both the Muskö area and at Holmöarna outer area, there are probably other causes for the change in the European perch/roach ratio in these two areas. This suggests that the importance of the ratio between European perch and roach should be assessed together with an indicator of abundance or biomass.

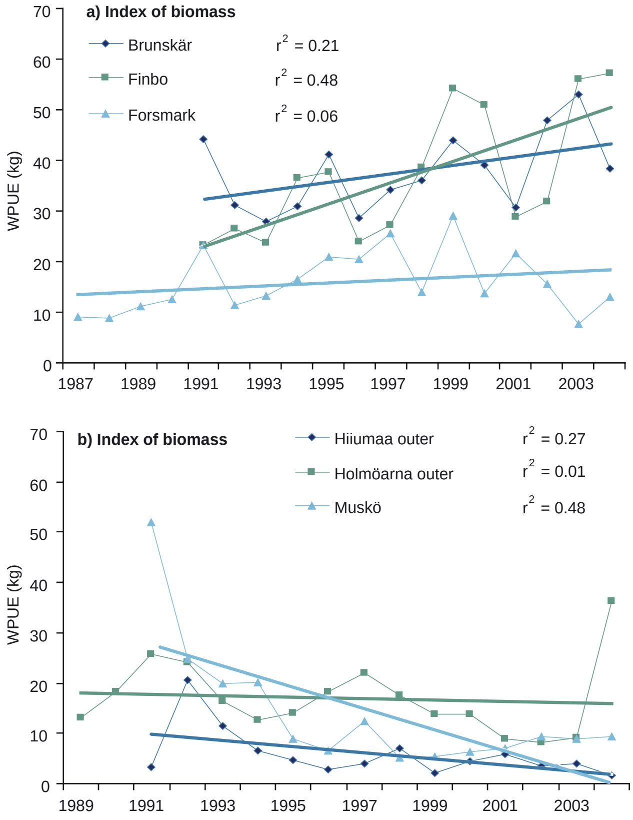


Figure 7 a,b.
Development of total fish weight per unit effort at areas with significant temporal trends (Mann-Kendall trend analysis, $p<0.05$); trend directions are illustrated by the lines of best fit. Total fish weight is calculated from the length distribution.

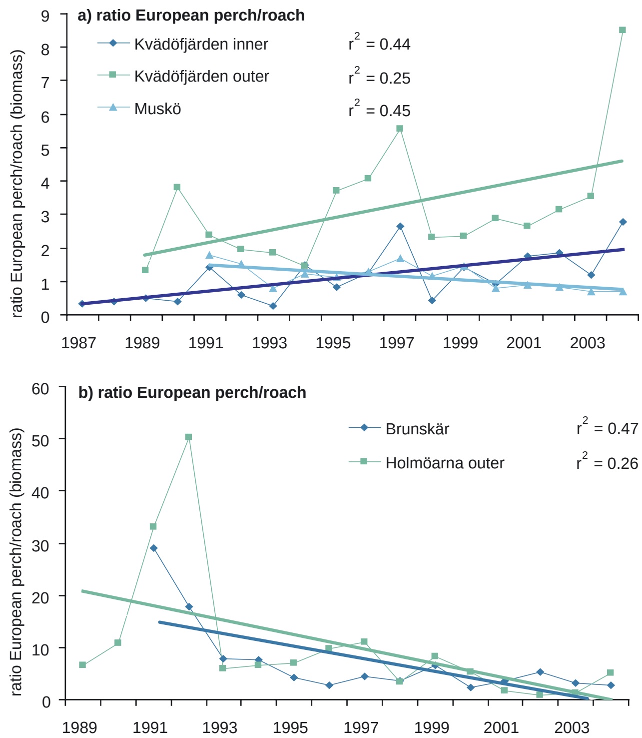


Figure 8 a,b.
Development of the ratio between European perch and roach at areas with significant temporal trends (regression analysis, $p<0.05$); trend directions are indicated by the lines of best fit. Total fish weight was registered at Kvädöfjärden and calculated from the length distribution in the other areas.

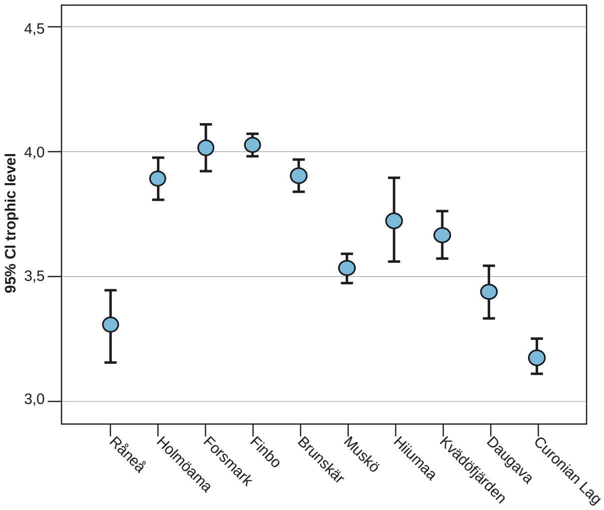


Figure 9. Average trophic level of the fish communities in the areas monitored. The time series for the various areas ranges from 5 to 17 years.

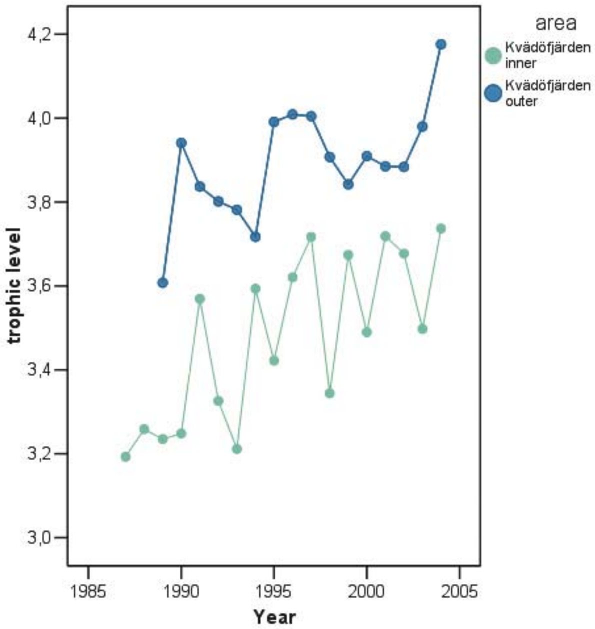


Figure 10. Trophic levels in the inner and outer sections of the Kvädöfjärden area for the years 1987 to 2004 (linear regression, r^2=0.56 and 0.37, respectively, p<0.001).

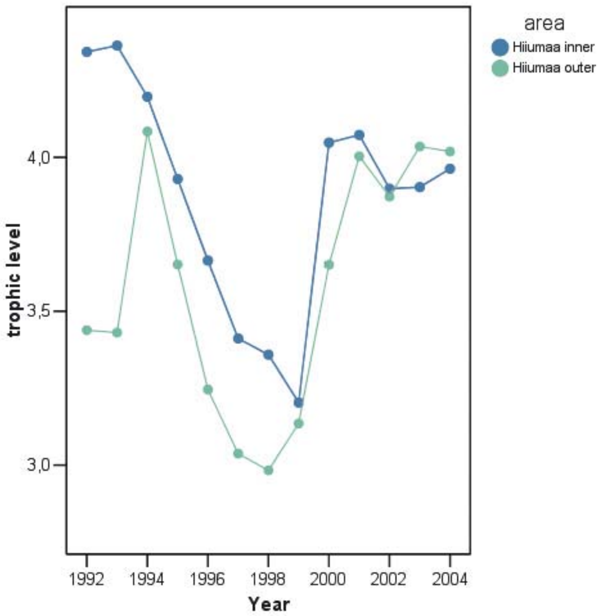


Figure 11. Trophic levels in the inner and outer sections of the Hiiumaa area for the years 1992–2004.

Trophic level of fish communities

The trophic level of a fish community reflects both the fish size structure and the position of fish in the food web, and hence the ecological role of the fish community. The trophic level could therefore be used as a proxy for community structure and function. Low values indicate that the proportion of species at the higher trophic levels of the food web (e.g., piscivorous fish (species of fish that feed on other fish)) is small and that the fish community is largely composed of plankton-feeding and benthos-feeding species. The trophic level also reflects the influence of the various types of environmental and anthropogenic pressures including the fishery, which is suggested to be one of the most important causes of ecosystem change. For example, high fishing pressure has been shown to reduce the trophic level in marine fish communities in the North Atlantic (Pauly *et al.*, 1998).

The trophic level of coastal fish communities was calculated for all areas sampled based on the WPUE for each species adjusted by species-specific values for trophic level according to Fishbase (2004). Mean values for the trophic level of all areas sampled for more than five years varied between 3 and 4 (Figure 9). The highest values (around 4) were found in the Northern Quark and in the archipelago regions of Finland and Sweden. Values around 3.5–3.7 were found on the western and eastern coasts of the Northern Baltic Proper. The lowest values were noted for the northernmost area and the eastern areas of the Baltic Proper (i.e., Råneå in the Bothnian Bay, Daugava in the Gulf of Riga, and the areas in the Curonian lagoon). The Råneå area is affected by runoff from the River Råneå, which influences the abundance of benthic feeders. The fish community in the Curonian lagoon is subjected both to high fishing pressure on predatory fish species, as well as to high nutrient loads. Interestingly, the trends in the two areas sampled in the lagoon (northern and central) were fairly well synchronized until 2003, after which the development diverged substantially. The increasing trend observed in the central area in recent years is not reflected in the northern area, which shows the lowest value since the start of sampling.

Significant trends over time were noted at Kvädöfjärden and Daugava. At Hiiumaa, substantial changes were also observed. At the Kvädöfjärden area, both the inner and the outer areas sampled showed a significant increase in

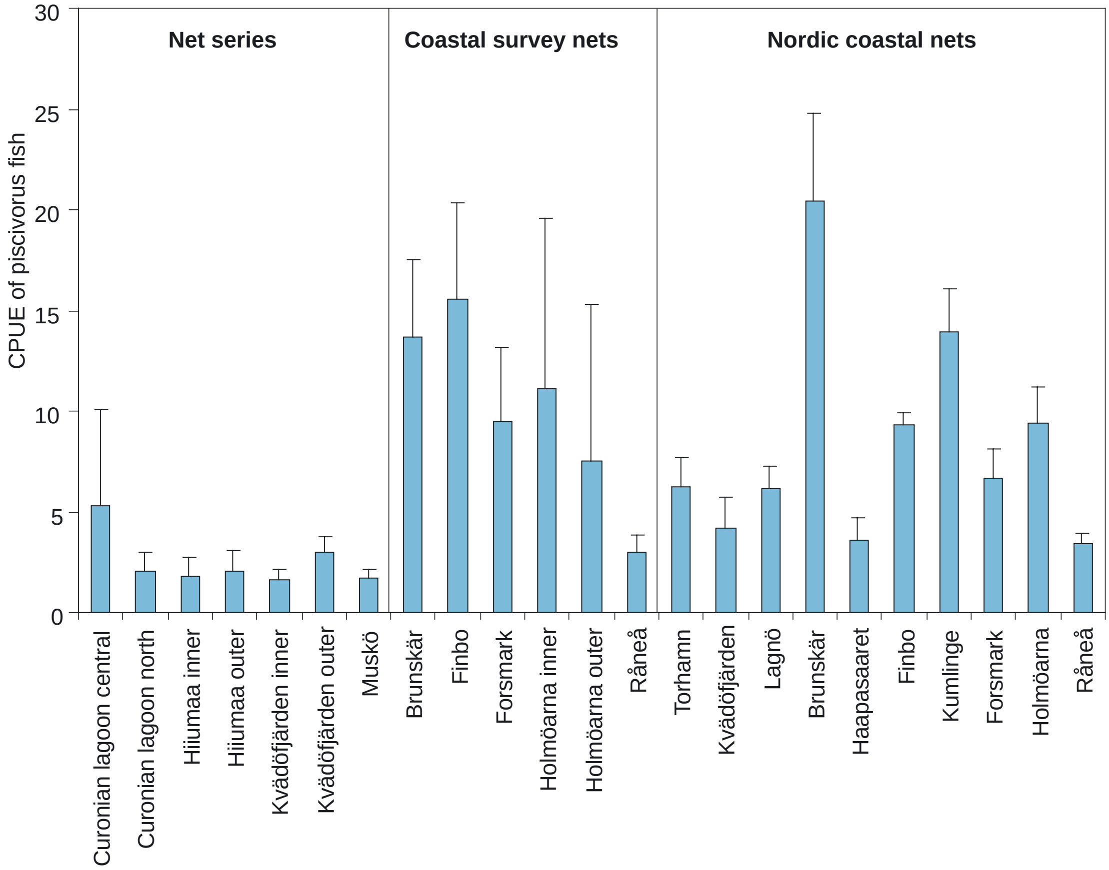


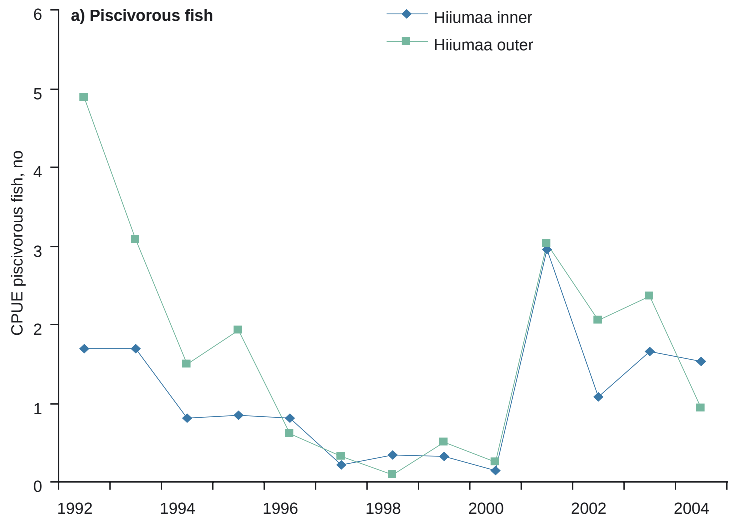
Figure 12.
Catch per unit effort of piscivorous fish at coastal fish monitoring areas, separated according to gear. Values include means from the period 2001–2004.

trophic level over time, indicating an improved environmental situation (Figure 10). A reversed trend was observed at Daugava between the years 1993 and 1997, demonstrating a shift in the fish community from a higher to a lower trophic level. This can partly be explained by a decrease in zander, one of the top predators in the coastal fish community in Daugava, owing to high fishing intensity. It is important to take into consideration that low temperatures in 1997 and 2002 in Daugava resulted in low catches of freshwater fish, which probably affected the analysis. At Hiiumaa, the high exploitation of piscivorous fish in the early 1990s is clearly indicated by a drastic drop in trophic level from above 4 in the outer area down to just above 3, six years later (Figure 11). The situation improved in the late 1990s.

Piscivorous fish

Piscivorous fish are species of fish that prey on other fish. The most common piscivorous fish found in coastal fish monitoring in the Baltic Sea is large European perch (larger than 20 cm), followed by zander and Northern pike. Other species, which are less common but still included in the calculations, are burbot (Lota lota) and turbot (Psetta maxima). The abundance of piscivorous fish caught in coastal fish monitoring showed a possible effect of the sampling gear used (Figure 12). The abundances in net series were in general lower than abundances in the other gears. The only area where both net series and Nordic coastal nets were used was Kvädöfjärden. A significant difference in the annual means of 2001–2004 was found between the gears (t-test; $p=0.038$). High abundances of piscivorous fish during the period 2001–2004 were found in the archipelago region between Sweden and Finland, which mainly were determined by high abundances of large European perch and to some extent also by the abundance of zander. Areas with high abundances of piscivorous fish were similar to those of high trophic levels (see section “Trophic level of fish communities”, above).

Piscivorous fish are often target species in commercial fisheries. Low or decreasing abundances may indicate high fishing pressure, as, for example, at Hiiumaa and the Curonian lagoon. However, it is difficult to separate the gear effect from the effect of high fishing pressure. Time trend comparisons are therefore necessary, and the development of the abundance of piscivorous fish at Hiiumaa (Figure 13a) was similar to the development of trophic levels in that area (Figure 11), with abundances decreasing to low levels, along with decreased trophic levels, during the late 1990s and then rising again thereafter. Increas-



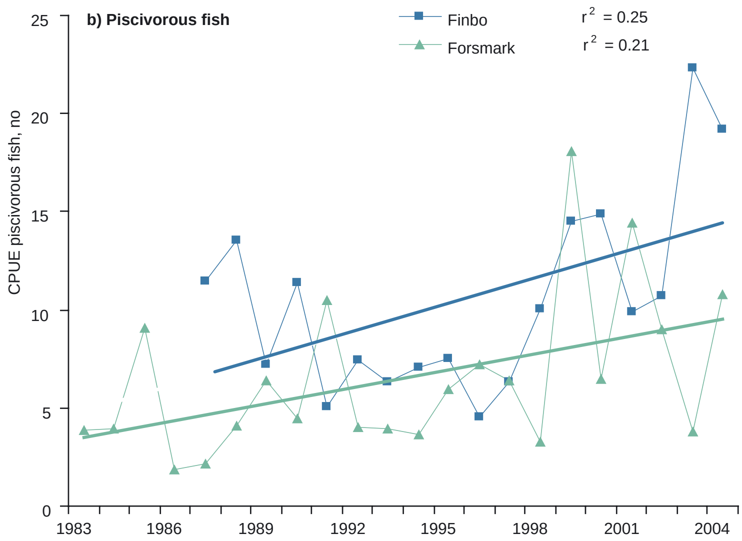


Figure 13.
Abundance of piscivorous fish (a) at Hiiumaa and (b) in areas with significant increasing trends (regression); trend directions are illustrated by the lines of best fit.

ing trends of piscivorous fish were found at Finbo and Forsmark (Figure 13b) and a decreasing trend at Muskö. These increases are to a large degree determined by the increasing abundance of European perch in the region.

Threatened and declining species

The main threats to fish species include the fishery, either as a target species or as by-catch, eutrophication, toxic contaminants, constructions in adjacent waters, aquaculture, and the introduction of non-native species. There are a number of threatened fish species in the Baltic Sea, several of which are either of global importance or of local importance in the HELCOM area.

Habitat loss can have an especially dramatic effect on some fish species; one example is the disappearance of clean sandy bottoms that are needed by many threatened benthic fish species. Eutrophication may lead to the deposition of detritus (dead organic matter) and the development of low oxygen concentrations close to the seabed or in the sand, which is then no longer available as a habitat for fish. Several species also depend on seagrass or higher algae, which may disappear owing to the effects of eutrophication. Proposals have been made for the inclusion of 184 species on the HELCOM priority list of threatened and declining fish species (BSRP/HELCOM, 2005); of these, 34 species (18.5%) are considered to be of high priority, 70 species (38.0%) of medium priority, and 80 species (43.5%) of low priority for conservation.

The COBRA database already includes data on the following threatened and declining species: *Lampetra fluviatilis*, *Anguilla anguilla*, *Alosa fallax*, *Vimba vimba*, *Barbus barbus*, *Pelecus cultratus*, *Coregonus albula*, *Osmerus eperlanomarinus* (*Osmerus eperlanus* part), *Nerophis ophidion*, *Syngnathus typhle*, *Gadus morhua*, *Lota lota*, *Myoxocephalus scorpius, Taurulus bubalis*, and *Triglopsis quadricornis*. The current coastal fish monitoring programme, however, does not yet cover many threatened and declining fish species. Small-bodied species and species living on hard substrates are especially under-represented in this database.

European eel (*Anguilla anguilla*) is an example of a species included in the recommended HELCOM high priority list (BSRP/HELCOM, 2005). It is a species that migrates catadromously and spawns somewhere in the tropical Atlantic between northern Brazil and the Sargasso Sea. European eel larvae follow the Gulf Stream and arrive in Europe as glass eels. The migration towards Europe takes 7–8 months. Arriving in the Bay of Biscay, European eel larvae are regularly collected and introduced into many streams and rivers. Though European eel is still relatively abundant in many areas due to anthropogenic introductions, it is affected by severe threats. European eel is commercially heavily exploited and commercial catches in many areas have decreased considerably owing to decreased eel stocks. European eels on their spawning migration are also caught as by-catch in trawl fisheries. Many eels never reach the ocean on their spawning migration from rivers in northern Europe, as in many rivers they have to pass through power plant turbines and are often injured or killed. European eels are also affected by eutrophication and pollution, as their naked skin is very sensitive to chemicals. Specimens with ulcers are frequently found in the lower reaches of rivers. In recent years, European eels have been seriously affected by parasites, which may reflect general health problems. The European eel is not considered rare at the moment, but is considered to be highly sensitive due to the above-mentioned threats.

Non-indigenous fish

There are several non-indigenous fish species that have been recorded at various times in different parts of the Baltic Sea. Most of them have been introduced intentionally during the 20th century, with the exception of carp *(Cyprinus carpio)*, which was introduced earlier. During the 1940s–1960s, various sturgeon stocks were released into the Gulf of Riga for the enhancement of commercial fish stocks: the sterlet *(Acipenser ruthenus)*, the beluga *(Huso huso)*, the Siberian sturgeon *(A. baeri)*, and the Russian sturgeon *(A. gueldenstaedtii)*. In addition, the chum salmon *(Oncorhynchus keta)* and the pink salmon *(O. gorbusha)* were released in the 1970s (Ojaveer, 1995). In the Gulf of Finland, several non-indigenous fish species such as *Acipenser ruthenus*, *A. baerii*, *A. gueldenstaedtii*, *Oncorhynchus mykiss*, *Coregonus autumnalis migratorius*, *C. nasus*, *C. muksun*, *C. peled*, *Catostomus catostomus*, *Perccottus glenii*, and *Cyprinus carpio* have been recorded as rare findings only (Leppäkoski et al., 2002). *A. ruthenus*, *C. peled*, silver carp *(Hypophthalmichthys molitrix)*, and spotted silver carp *(Aristichthys nobilis)* have been found in the Curonian lagoon (Repečka, 2003). In the Bothnian Bay, in addition to the species of alien fish found in the Gulf of Finland, *Salvelinus* spp. has also been recorded (Leppäkoski, 1984). As probably none of the above-mentioned species have been able to form self-sustaining populations, their ecological impact should be considered as insignificant.

There are, however, two alien fish species of recent concern: the round goby *(Neogobius melanostomus)* and the Prussian carp *(Carassius gibelio)*. The round goby is a eurytherm (i.e., can withstand a wide range of temperatures), euryhaline (i.e., able to live in waters of a wide range of salinities) species, native to the Ponto-Caspian region. Although the fish was first found in the Baltic Sea in 1990 in the Gulf of Gdansk, the species probably invaded the Baltic Sea at the end of the 1980s as a result of unintentional introduction, most likely by means of ships' ballast water (Skora and Stolarski, 1993). At the same time, the species was also discovered in the Great Lakes Basin in North America (Jude *et al*., 1992), where it has become especially widespread (Charlebois *et al*., 1997). The distribution area of the round goby in the Baltic Sea now embraces waters along the north coast of Germany (1999), the Gulf of Gdansk area (1990), various localities along the east coast of the Baltic Proper (2003–2004), the northeast Gulf of Riga (2002), the Archipelago Sea (2005), and the Gulf of Finland (2005) (Shpilev and Ojaveer, 2003; E. Leppäkoski, S. Olenin, K. Skora, and H. Winkler, unpubl.). This species of fish has a great potential to dominate the majority of the coastal zone of the Baltic Sea (Skora and Rzeznik, 2001). In the Gulf of Gdansk, competition for food and the displacement of several native demersal fish species (e.g., flatfishes, viviparous blenny, and black goby (*Gobius niger*)) by the invading round goby is currently an ongoing process. Round gobies have already caused recruitment failure and the subsequent demise of mottled sculpins (*Cottus bairdi*) in the Great Lakes Basin. This has been suggested to occur by three different mechanisms: competition for food resources at small sizes, competition for space at intermediate sizes, and competition for spawning at large sizes (Janssen and Jude, 2001).

The Prussian carp is a sedentary demersal fish originating from Southeast Asia. It was introduced into Germany in the 16th century and into the freshwater lakes of other Baltic countries in the mid-20th century, and has subsequently moved into the Baltic Sea. In recent years, the distribution area of the Prussian carp in the northeast Baltic Sea has expanded remarkably and it even dominates the fish catches in some regions. Prussian carp has received the status of a commercial fish species in the Curonian lagoon and the Gulf of Riga (Repečka, 2003; Vetemaa *et al*., 2005). The recent rapid increase in the abundance of this fish has most likely occurred owing to two simultaneously positively influencing factors: the small number of predators and several consecutive years of warm summers (Vetemaa *et al*., 2005).

Discussion and recommendations

Despite different time spans of sampling between areas, monitoring time periods in this report have been analysed in their entirety. However, owing to the variability of the structuring factors over time, regional comparisons could only be based on similar time periods. Long time periods have to be broken down into shorter periods to identify different development directions and to detect long-term variations. Future work needs to be done to assess the comparability between the methods used for the monitoring of coastal fish, including methods that are not described in this report. There is also a strong need for an assessment of the statistical features and the statistical power of the different methods and indicators used. It is well known that sampling fish with passive gears is influenced by local environmental conditions. Thus, more thorough studies are needed on how environmental variables, such as temperature, wind conditions, and wave exposure, influence the results of fish monitoring.

New perspectives on marine ecosystem management and conservation, including an ecosystem approach to coastal zone management, as well as recent EU directives such as the Water Framework Directive (WFD) and the Habitats Directive, also call for revised objectives in monitoring practices. From originally being focused mainly on detecting the effects of local pollution including toxic substances and eutrophication, coastal fish monitoring should be developed to provide a basis for estimating the ecological status of the coastal fish compartment. For this reason, the following management objectives regarding coastal fish in the Baltic Sea have been identified:

- To restore and maintain the structure and function of coastal fish communities;
- To restore and maintain the species and genetic diversity of coastal fish, including commercial species;
- To restore and maintain healthy fish on an individual level and to ensure healthy fish populations, without causing harm either to other marine biota or to human populations.

These objectives should be assessed on both a Baltic-wide scale, as well as on a sub-regional scale. In order to be able to assess progress towards the achievement of these objectives, the monitoring programme must be able to distinguish between natural variations and variations related to environmental disturbance affecting both coastal fish communities and selected coastal fish species. In addition, the programme needs to produce robust and easily understandable indicators for each of the objectives identified.

Based on the COBRA network, relevant indicators for coastal fish objectives, such as indicators of recruitment based on age analysis and year-class strength as well as indicators for mortality, should be further developed and assessed from both an ecological and a statistical point of view. It is also recommended that indicators obtained from coastal fish monitoring be used for the management of economically important coastal fish stocks and for coastal zone management. Monitoring, as presented here, together with age distributions, can be used, for example, to assess the development of stocks of commercially important coastal species.

Indicators used for the assessment of coastal fish communities in the Baltic Sea should be selected according to the properties of local fish populations. However, the assessment should always include indicators involving the most dominant species such as European perch and roach. Site-specific reference values for indicators also need to be developed and annual indicator fact sheets for each monitoring area should be produced.

Coastal fish monitoring should be integrated with other coastal monitoring programmes, in order to work towards an ecosystem approach to coastal zone management. This means that the coastal fish monitoring programme should be broadened to cover all HELCOM coastal areas, including the southern Baltic Sea and the Kattegat, and coastal fish monitoring data from areas not covered by the COBRA programme should also be included in the COBRA database. Because the present COBRA programme monitors only a fraction of the fish community, it is recommended that monitoring be expanded to sample also small-sized fish and to cover the cold season and deeper waters. In addition, the monitoring of threatened and declining fish species should be improved, especially in NATURA 2000 sites, as required by the EU Habitats Directive. Special monitoring methods need to be developed for threatened species that are not lethal for fish, such as underwater visual censuses.

Due to the profound effect of fisheries on fish community and population development, it is of the utmost importance to analyse the impact of fishing activities on coastal fish communities, including the regional aspects. This analysis should be included in future assessments of coastal fish.

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Appendix 1

Species list by common name

Families of species mentioned in the text are indicated as follows:
*Cyprinid, ‡Percid, †Coregonid.

Atlantic salmon	*Salmo salar*
Arctic cisco†	*Coregonus autumnalis migratorius*
Baltic herring	*Clupea harengus*
Barbel*	*Barbus barbus*
Beluga	*Huso huso*
Black goby	*Gobius niger*
Bleak*	*Alburnus alburnus*
Broad-nosed pipefish	*Syngnathus typhle*
Broad whitefish†	*Coregonus nasus*
Burbot	*Lota lota*
Common bream*	*Abramis brama*
Chinese sleeper	*Perccottus glenii*
Chum salmon	*Oncorhynchus keta*
Cod	*Gadus morhua*
Common carp*	*Cyprinus carpio*
Common dace*	*Leuciscus leuciscus*
Common whitefish†	*Coregonus lavaretus*
Cormorant	*Phalacrocorax carbo sinensis*
European eel	*Anguilla anguilla*
European perch‡	*Perca fluviatilis*
European river lamprey	*Lampetra fluviatilis*
European smelt	*Osmerus eperlanus*
European sprat	*Sprattus sprattus*
Flounder	*Platichthys flesus*
Fourhorn sculpin	*Triglopsis quadricornis*
Great sandeel	*Hyperoplus lanceolatus*
Grey seal	*Halichoerus grypus*
Gudgeon*	*Gobio gobio*
Ide*	*Leuciscus idus*
Longnose sucker	*Catostomus catostomus*
Longspined bullhead	*Taurulus bubalis*
Mottled sculpin	*Cottus bairdi*
Muksun†	*Coregonus muksun*
Northern pike	*Esox lucius*
Peled†	*Coregonus peled*
Pink salmon	*Oncorhynchus gorbusha*
Prussian carp*	*Carassius gibelio*
Rainbow trout	*Oncorhynchus mykiss*
Roach*	*Rutilus rutilus*
Round goby	*Neogobius melanostomus*
Rudd*	*Scardinius erythrophthalmus*
Ruffe‡	*Gymnocephalus cernuus*

Russian sturgeon	*Acipenser gueldenstaedtii*
Sea trout	*Salmo trutta*
Shorthorn sculpin	*Myoxocephalus scorpius*
Siberian sturgeon	*Acipenser baeri*
Silver carp*	*Hypophthalmichthys molitrix*
Small sandeel	*Ammodytes tobianus*
Spotted silver carp*	*Aristichthys nobilis*
Sterlet	*Acipenser ruthenus*
Straightnose pipefish	*Nerophis ophidion*
Tench*	*Tinca tinca*
Three-spined stickleback	*Gasterosteus aculeatus*
Turbot	*Psetta maxima*
Twaite shad	*Alosa fallax*
Vendace†	*Coregonus albula*
Vimba*	*Vimba vimba*
Viviparous blenny	*Zoarces viviparus*
White bream*	*Blicca bjoerkna*
Zander (pikeperch)‡	*Sander lucioperca*
Ziege*	*Pelecus cultratus*

Species list by Latin name

Abramis brama	Common bream
Acipenser baeri	Siberian sturgeon
Acipenser gueldenstaedtii	Russian sturgeon
Acipenser ruthenus	Sterlet
Alburnus alburnus	Bleak
Alosa fallax	Twaite shad
Ammodytes tobianus	Small sandeel
Anguilla anguilla	European eel
Aristichthys nobilis	Spotted silver carp
Barbus barbus	Barbel
Blicca bjoerkna	White bream
Carassius gibelio	Prussian carp
Catostomus catostomus	Longnose sucker
Clupea harengus	Baltic herring
Coregonus albula	Vendace
Coregonus autumnalis migratorius	Arctic cisco
Coregonus lavaretus	Common whitefish
Coregonus muksun	Muksun
Coregonus nasus	Broad whitefish
Coregonus peled	Peled
Cottus bairdi	Mottled sculpin
Cyprinus carpio	Common carp
Esox lucius	Northern pike
Gadus morhua	Cod
Gasterosteus aculeatus	Three-spined stickleback
Gobio gobio	Gudgeon
Gobius niger	Black goby
Gymnocephalus cernuus	Ruffe

Halichoerus grypus	Grey seal
Huso huso	Beluga
Hyperoplus lanceolatus	Great sandeel
Hypophthalmichthys molitrix	Silver carp
Lampetra fluviatilis	European river lamprey
Leuciscus idus	Ide
Leuciscus leuciscus	Common dace
Lota lota	Burbot
Myoxocephalus scorpius	Shorthorn sculpin
Neogobius melanostomus	Round goby
Nerophis ophidion	Straightnose pipefish
Oncorhynchus gorbusha	Pink salmon
Oncorhynchus keta	Chum salmon
Oncorhynchus mykiss	Rainbow trout
Osmerus eperlanus	European smelt
Pelecus cultratus	Ziege
Perca fluviatilis	European perch
Perccottus glenii	Chinese sleeper
Phalacrocorax carbo sinensis	Cormorant
Platichthys flesus	Flounder
Psetta maxima	Turbot
Rutilus rutilus	Roach
Sander lucioperca	Zander
Salmo salar	Atlantic salmon
Salmo trutta	Sea trout
Scardinius erythrophthalmus	Rudd
Sprattus sprattus	European sprat
Syngnathus typhle	Broad-nosed pipefish
Taurulus bubalis	Longspined bullhead
Tinca tinca	Tench
Triglopsis quadricornis	Fourhorn sculpin
Vimba vimba	Vimba
Zoarces viviparus	Viviparous blenny

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