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Monitoring in Baltic Coastal Reference Areas 1996

Composition of Fish Communities

Helsinki 1997

RIISTAN- JA KALANTUTKIMUS

Monitoring in Baltic Coastal Reference Areas 1996

Composition of Fish Communities

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KUVAILULEHTI

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Julkaisun nimi

Monitoring in Baltic Coastal Reference Areas 1996 - Composition of Fish Communities

Julkaisun laji	*Toimeksiantaja*	*Toimeksiantopäivämäärä*
Annual report		

Projektin nimi ja numero

Composition of fish communities in Baltic coastal reference areas (204 033)

Tiivistelmä

Six international reference areas for coastal monitoring are established in the Gulf of Bothnia and the Northern Baltic Proper. Cooperation partners are the Estonian Marine Institute, the Fisheries Division at the Provincial Government of Åland, the Finnish Game and Fisheries Research Institute and the Swedish Institute of Coastal Research.

This is the first annual report presenting test fishing results from the reference areas. The test fishing system is directed towards the demersal warm water fish community. The fish communities, temporal trends and catches of cyprinids related to water transparency (Secchi depth) are discussed.

The fish communities found in the areas can be classified into perch dominated and roach dominated. Perch dominated in one subarea (section 1) in Hiiumaa, Brunskär, Finbo and Holmöarna reference areas and roach dominated in Kvädöfjärden, section 2 in Hiiumaa and Råneå reference areas. Demersal warm water species dominated in all areas. Demersal cold water and pelagic species were relatively common in the perch dominated areas and scarce in the roach dominated areas. Roach was in all cases the dominating cyprinid. Other cyprinids were found in noticeable amounts in the roach dominated areas while the catches were insignificant in the perch dominated areas.

Decreasing perch catches in Hiiumaa reference area probably originated from overexploitation and increasing catches in Kvädöfjärden from long-term increase of mean water temperatures. Catches of flounder have increased in the Archipelago Sea and Archipelago of Åland. This may result from successful reproduction of a subspecies with physiological characters more similar to warm water species than to cold water species.

The catches of cyprinids were strongly correlated to water transparency. This indicated that eutrophication was apparent in the roach dominated areas and weak in the perch dominated areas. It can be concluded that the monitoring system gives information on biological effects of eutrophication.

Asiasanat

Coastal monitoring, international reference areas, fish communities, eutrophication, perch, roach

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Seuranta Itämeren vertailualueilla 1996 - Kalayhteisöjen rakenne

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Kalayhteisöjen rakenne Itämeren vertailualueilla (204 033)

Tiivistelmä

Rannikkovesien tilan seurantaa varten on Pohjanlahdelle ja Itämeren pääaltaan pohjoisosaan perustettu kuusi kansainvälistä vertailualuetta. Seurannasta vastaavat yhteistyössä Ahvenanmaan maakuntahallituksen kalataloustoimisto, Eesti Mereinstituut, ruotsalainen Kustlaboratoriet ja Riista- ja kalatalouden tutkimuslaitos.

Tämä on ensimmäinen vertailualueilla tehtävien koekalastusten tuloksia esittelevä vuosiraportti. Koekalastus kohdistuu pohjan tuntumassa eläviin lämmintä vettä suosiviin lajeihin. Raportissa käsitellään kalayhteisöjen rakennetta ja niissä tapahtuneita ajallisia muutoksia sekä särkikalasaaliin suhdetta veden näkösyvyyteen (Secci).

Tutkimusalueiden kalayhteisöt voidaan luokitella ahvenvaltaisiin ja särkivaltaisiin. Ahven oli vallitsevana Hiidenmaan osa-alueella 1, Brunskärissä, Finbossa ja Holmön saaristossa. Särki oli vallitsevana Kvädöfjärdenillä, Hiidenmaan osa-alueella 2 ja Råneåssa. Lämmintä vettä suosivat lajit olivat vallitsevana kaikilla alueilla. Kylmää vettä suosivat pohjakalat ja pelagiset lajit olivat suhteellisen yleisiä ahvenvaltaisilla alueilla ja vähälukuisia särkivaltaisilla alueilla. Särki oli kaikilla alueilla runsain särkikalalaji. Särkivaltaisilla alueilla esiintyi myös muita särkikaloja huomattavassa määrin. Ahvenvaltaisilla alueilla muita särkikaloja oli vähän.

Ahvensaaliit vähenivät tarkastelujakson aikana Hiidenmaan alueella ilmeisesti tehokkaan kalastuksen vuoksi. Kvädöfjärdenin kasvaneiden saaliiden taustalla on todennäköisesti veden keskilämpötilan kohoaminen. Kampelasaaliit kasvoivat Saaristomerellä ja Ahvenanmaan saaristossa, mikä johtunee viime vuosina hyvin onnistuneesta lisääntymisestä. Mainituilla alueilla kampelan fysiologiset ominaisuudet ovat muusta Itämerestä poiketen todennäköisesti lähempänä lämpimän veden lajeja kuin kylmän veden lajeja.

Särkikalasaaliilla on tutkimuksen mukaan selvä yhteys veden näkösyvyyteen. Tämä osoittaa, että särkivaltaiset alueet olivat selvästi rehevöityneempiä kuin ahvenvaltaiset alueet. Seurantajärjestelmä tuottaa näin ollen tietoa rehevöitymisen biologisista vaikutuksista.

Asiasanat

Rannikkovesien seuranta, kansainväliset vertailualueet, kalayhteisöt, rehevöityminen, ahven, särki

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Kustantaja

Riista- ja kalatalouden tutkimuslaitos

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1. Introduction

The lack of reference material in environmental studies and the heterogeneity of methods in fish monitoring in the Baltic coastal areas have lead to the development of an international fish monitoring system. The system involves annual monitoring of biological key variables at fixed areas (coastal reference areas) and stations using standardized methods. The methods were established in Sweden already in the 1960's and 1970's. The international cooperation began in the beginning of the 1980's between Swedish and Finnish fishery research institutes. Estonia joined the cooperation in 1990. Corresponding monitoring started in Latvia and Lithuania in 1992. The Nordic Council of Ministers granted financial support during the development of the system.

The objectives of the monitoring in reference areas are:

- to provide reference material for studies in areas affected by human activities,
- to contribute to the general monitoring of the changes in the Baltic coastal
- to trace large-scale environmental changes,
- to follow the biological development in the unique archipelagoes
- to provide material for prognoses of fish stocks.

Reference areas for coastal fish monitoring have so far been established in the Gulf of Bothnia and the Northern Baltic Proper. There are six international reference areas, which are located in regions with a minimum of human impact (Fig. 1). The system of international reference areas is supported by monitoring in regional reference areas and 'hot spots'. Neuman and Sandström (1996a, 1996b) presented an integrated monitoring programme for coastal fish and the development of the system of Baltic coastal reference areas. The action plan used in the selection of reference areas and stations is described eg. in Ådjers et al. (1995).

The reference areas also fulfil the requirements of monitoring of other trophic levels than fish (vegetation, bottom fauna, birds and mammals). The aim of the system of the reference areas is, according to the proposal of the Nordic Council of Ministers (Nordisk Ministerråd, 1992) to monitor all trophic levels and to use the collected information for common purposes. Other trophic levels are already monitored in varying degrees in the reference areas (Ådjers, 1996). The monitoring in reference areas is coordinated by the "Coordination Organ for Baltic Reference Areas" (COBRA), whose secretary is stationed at the Provincial Government of Åland. The organ consists of members of the participating institutes (the Estonian Marine Institute, the Fisheries Division at the Provincial Government of Åland, the Finnish Game and Fisheries Research Institute and the Swedish Institute of Coastal Research).

Annual reports dealing with various, selected themes based on the material collected within the international reference areas will be published. The theme of this report is species composition. Demersal warm water species are mainly discussed including species composition, temporal trends in abundance of perch and roach, abundance of perch compared with cyprinds, abundance of roach related to water transparency. Catches of demersal cold water species and pelagic species are presented.

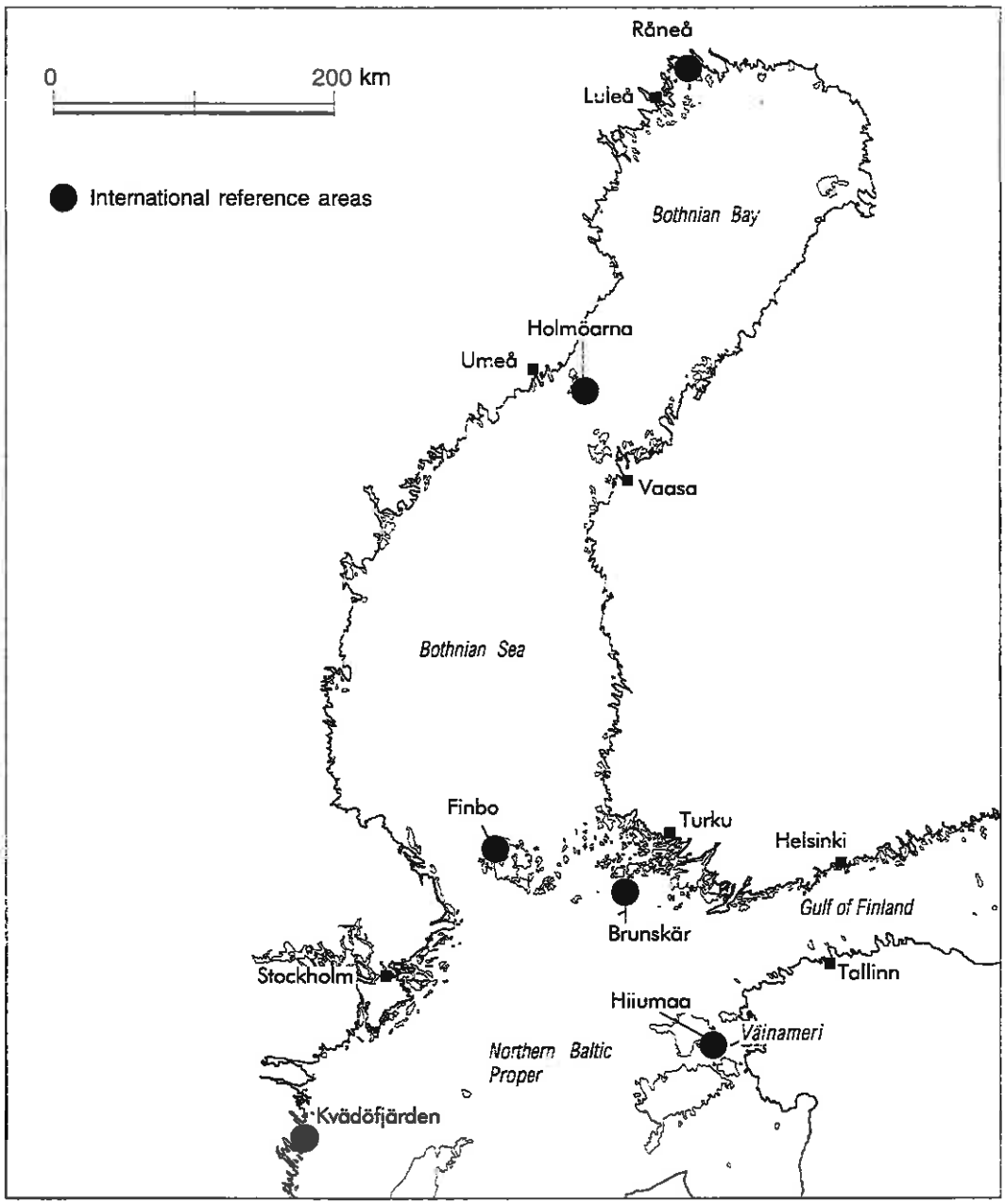

Figure 1. International reference areas in the Baltic Sea.

The monitoring system is under continuous development aiming to increase the monitoring parameters and trophic levels. The purpose is to monitor parameters covering both individual, population and community levels.

The system of reference areas is planned to be expanded to the Gulf of Finland. The archipelago of Haapasaaret has been suggested as a suitable area. Discussions in the matter will continue during 1997.

The viviparous blenny (*Zoarces viviparus*) has been suggested to HELCOM and OSPARCOM as an indicator species for biological effects of toxic substances, which creates a demand for monitoring. Monitoring is already carried out in Kvädöfjärden and Holmöarna and pilot investigations of the occurrence of blenny have been carried out in Brunskär and Finbo reference areas and in Väinameri at a locality southeast of the reference area.

In 1996 COBRA presented a programme for Finbo reference area, based on the recommendations by the Nordic Council of Ministers (Nordisk Ministerråd, 1992). Discussions of which parameters will be given priority in 1997 are taking place. A corresponding programme for Kvädöfjärden will be presented in spring 1997.

2. Material and methods

In the reference areas fishing stations are placed in narrow strata, defined according to depth. In the depth stratum, groups of neighbouring stations with similar environmental conditions form sections. The sections represent different habitats regarding e.g. exposure and bottom type. Among a great number of tested stations five - ten with similar species composition, catch levels and inter-year variations are selected (Ådjers et al. 1995). This report includes results only from the finally selected stations. The stations are regarded as statistically independent of each other.

The test fishing methods are standardized according to Thoresson (1993). Test fishings are carried out annually between July 25 and August 15 in shallow waters between 2 and 5 m. Fishing is repeated six times in every station. The nets are set between 2 and 4 pm and lifted the next day between 7 and 10 am. In the Gulf of Bothnia and Archipelago Sea (Brunskär, Finbo, Holmöarna, Råneå) coastal survey nets are used, which are 35 m long, 3 m deep (2.5 m in water) and composed of five 7 m long parts with mesh sizes 17, 21, 25, 33 and 50 mm from knot to knot. Two linked nets are set in each station. In the southern areas (Kvädöfjärden, Hiiumaa) net links are used, which consist of four 30 m long, 1.8 m deep (1.5 m in water) nets. Each net is made up of a single mesh size (17, 21, 25 and 30 mm). One link is set in each station. The size of a survey net is almost twice the size of a net in the net links. The size of the catches, expressed as catch per unit effort (CPUE; catch in numbers per net and fishing night), can be compared by doubling the figures from Kvädöfjärden and Hiiumaa.

The reason why different nets are used is partly historical. Net series were used when monitoring in Kvädöfjärden began in 1962. Coastal survey nets were developed later but the nets in Kvädöfjärden were not changed due to obvious problems of comparison between the methods. Another important reason is that 120 m long, plain bottoms,

required by net links, are more difficult to find in the north than in the south of the Baltic Sea. Moreover whitefish, regarded as an important target species in the north, is better catchable in survey nets than in net links. It is now established that survey nets are used north and net series south of the 60th latitude.

The season and localities of the test fishings have been selected to catch demersal warm water species, although demersal cold water species and pelagic species were caught to some extent. The fishing methods are regarded as not appropriate for monitoring of pelagic species (Baltic herring, sprat, smelt and vendace) and the catches are only presented. The following species, caught only occasionally, three-spined stickleback (*Gasterosteus aculeatus*), greater sandeel (*Hyperoplus lanceolatus*), black goby (*Gobius niger*), eel (*Anguilla anguilla*), straight-nosed pipefish (*Nerophis ophidion*) and deep-snouted pipefish (*Syngnathus typhle*) are not mentioned in the report, because of insufficient catching in fishing gear. It is unclear if ruffe and flounder belong to the demersal warm water or demersal cold water community. However, in this report ruffe is included in the demersal warm water community and flounder in the cold water community.

Trends in the abundance of selected species were analysed with Mann-Kendall nonparametric trend analysis. The observations used were catch per station and night. 95 % certainty is used in all cases.

3. The study areas

The international reference areas are located in Kvädöfjärden in the Archipelago of Gryt at the Swedish east coast of the Baltic Proper, in Hiiumaa in Väinameri in western Estonia, in Brunskär in the southern Archipelago Sea in southwestern Finland, in Finbo in northwestern Åland, in Holmöarna in the Northern Quark and in Råneå in the northern Bothnian Bay (Fig. 1). The characters of the areas are briefly described below, but more detailed descriptions are found in Ådjers et al. (1996).

3.1. Kvädöfjärden

The reference area of Kvädöfjärden, located about 160 km southwest of Stockholm, belongs to the continuous archipelago off the Swedish east coast (Fig. 1). The surface salinity is in the range of 6-8 ‰. Deep furrows, with depths down to 30 m, allow good water exchange in the inner parts also. Local human impact is insignificant. A few professional fishermen are operating in the area. Fish monitoring started already in 1962. The sections are made up of six stations each (Fig. 2). Section 5 is located in the inner, sheltered archipelago. Section 6 is found in the outer archipelago close to the edge of the open sea.

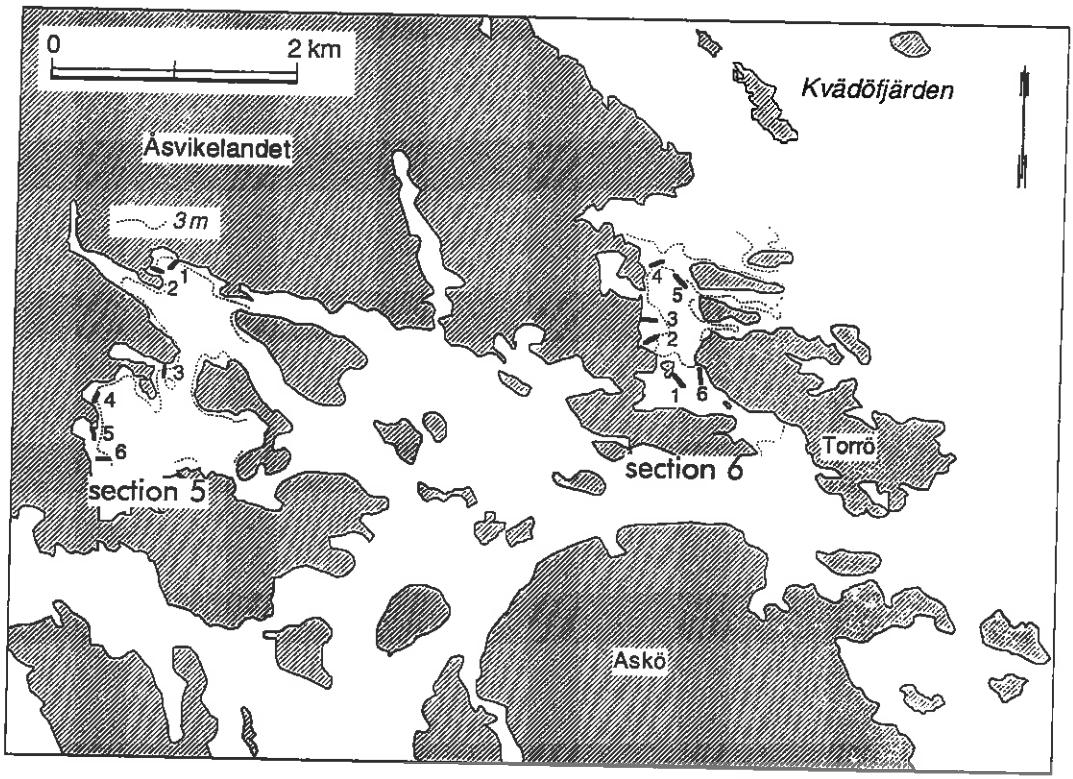

Figure 2. Monitoring stations for coastal fish in Kvädöfjärden reference area. The Secchi depths are measured at station 3 in section 5 and station 5 in section 6.

3.2. Hiiumaa

The Hiiumaa reference area is situated in Väinameri southeast of the island of Hiiumaa (Fig. 1). The area consists of relatively few islands and the water depth is mostly below 4 m (Fig. 3). The mean salinity is 5-6‰. The surrounding land areas are sparsely populated and industries are absent. Commercial fishing in the Väinameri is relatively intensive.

Pilot studies began in 1990 and the fishing programme was established in 1992. The monitoring programme consists of two sections with six stations in each section (Fig. 3). Section 1 is located close to the mainland of Hiiumaa and is sheltered towards most wind directions. Section 2 is open southwards and sheltered in the northeast from the island of Saarnaki. The water depth in the monitoring area is 2 - 3 m.

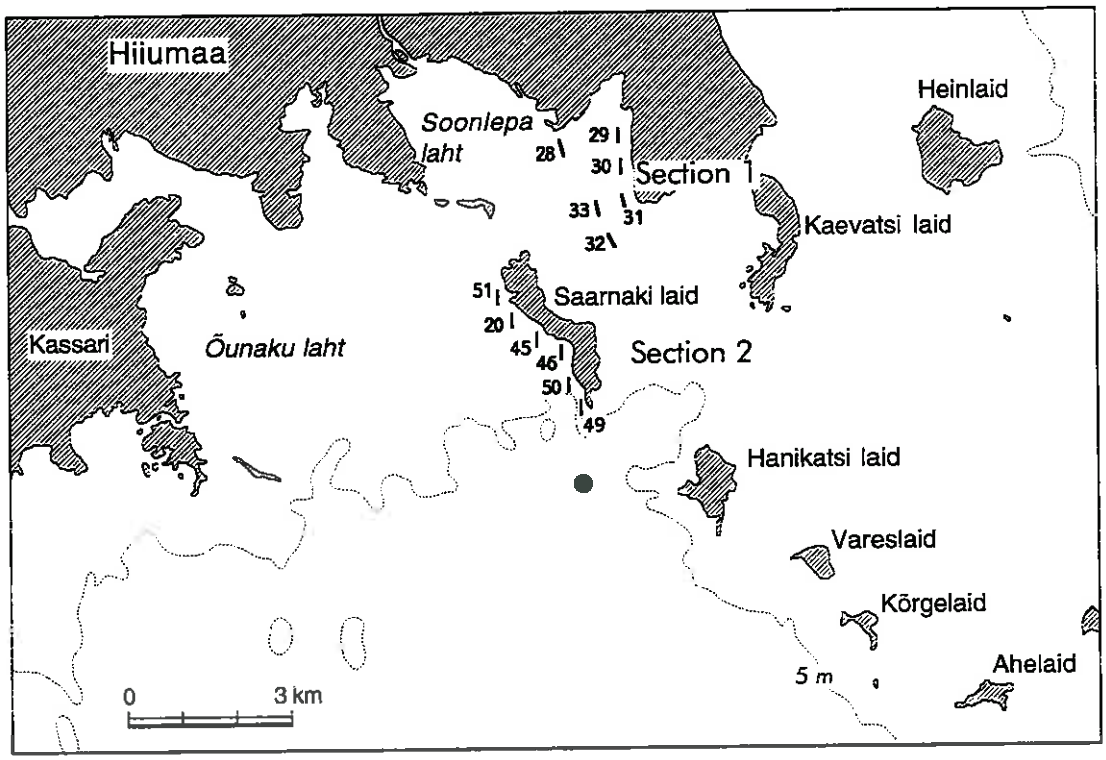

Figure 3. Monitoring stations for coastal fish and locality for Secchi depth measurements (●) in Hiiumaa reference area.

3.3. Brunskär

The reference area of Brunskär is located in the outer archipelago in the southern part of the Archipelago Sea (Fig. 1). The water depth reaches more than 5 m only in narrow, deep ravines, which cut in between the islands. A firth opens south of the area with depths down to 50 m. Islands shelter the area in the north. The salinity of the surface water is 6-7‰. There are no permanent human settlements hence local environmental impacts are small. Only a few fishermen are active in the area today.

Fish monitoring has been carried out since 1991. The results from the first year are excluded from the report due to few replicates. The programme consists of one section with nine stations (Fig. 4), which were each fished three times in 1992 and six times from 1993 and on.

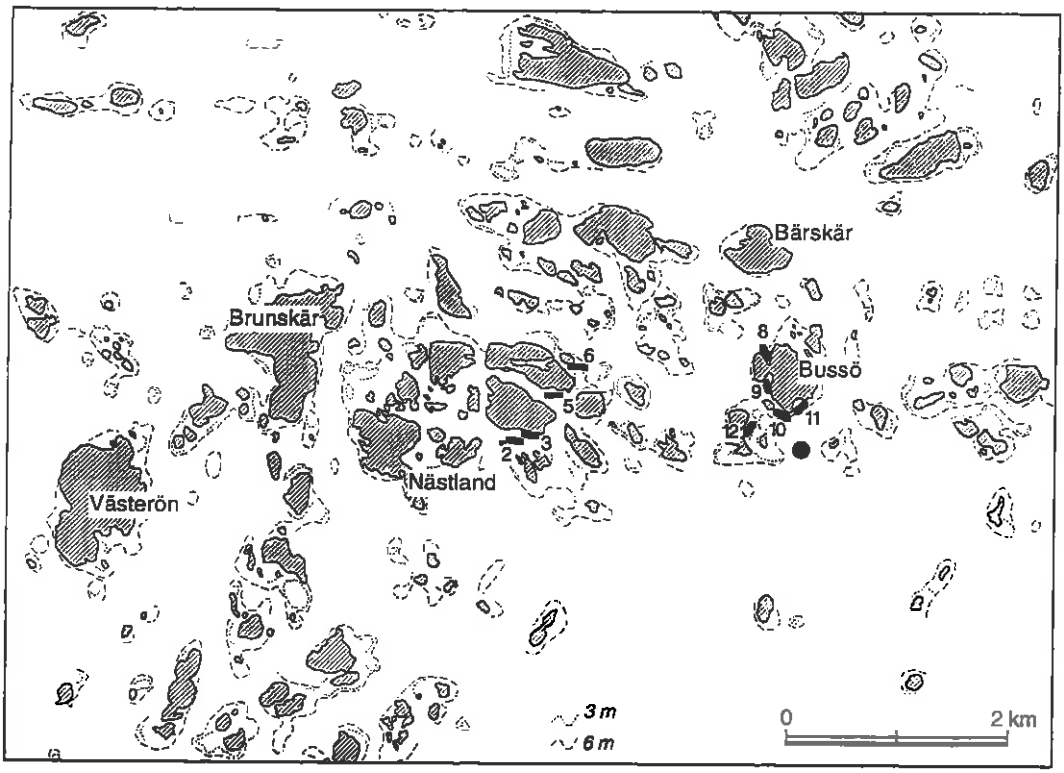

Figure 4. Monitoring stations for coastal fish and locality for Secchi depth measurements (●) in Brunskär reference area.

3.4. Finbo

Finbo reference area is located in the northwestern part of Åland (Fig. 1). The water depth is mostly between 5 and 10 m. The depths in the outer archipelago reach down to 50 m. The salinity of the surface water varies between 6 and 7‰. Commercial fishing of coastal species is carried out only by a few professional fishermen.

Fish monitoring started in 1976. Methods and stations have since then altered and strictly comparable results have been obtained since 1987. The programme consists of eight stations (Fig. 5), which have been visited six times each year, except for 1987 with only four times. The section is located in the middle archipelago zone and is sheltered from most wind directions, but northerly winds may disturb the fishing in some stations.

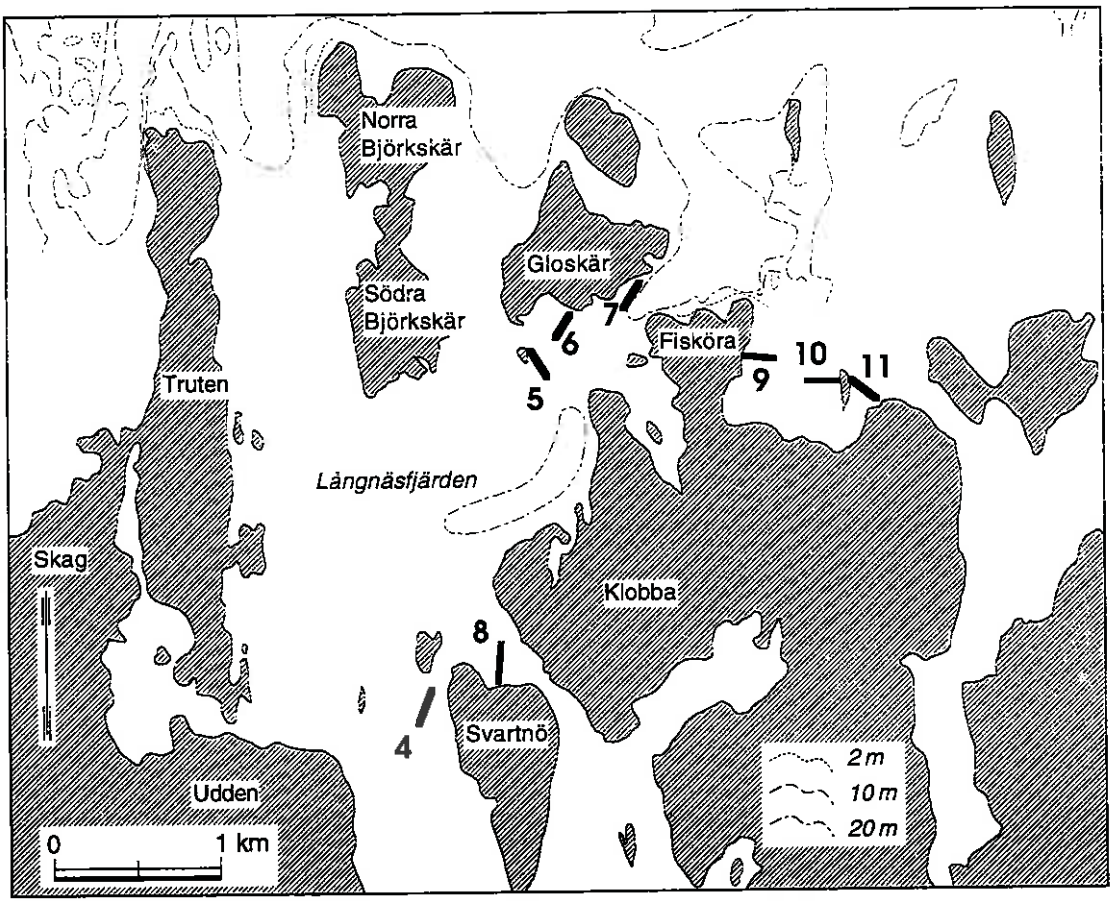

Figure 5. Monitoring stations for coastal fish in Finbo reference area. The Secchi depth is measured at station 6.

3.5. Holmöarna

Holmöarna is located in the Northern Quark about 7 km from the Swedish coast (Fig. 1). The water depth is below 5 m and the salinity of the surface water 3-4‰. There are no permanent human settlements and industries are lacking. Commercial fishing is concentrated on whitefish and salmon.

Fish monitoring started in 1989. The programme consists of two sections with five stations each (Fig. 6). Section 1 is located in a bay at the island of Ängesön. Section 2 is located at the border to the open sea and is exposed to eastern and southeastern winds. The Secchi depth measurements are carried out south of this area, where the water depth reaches 8 m.

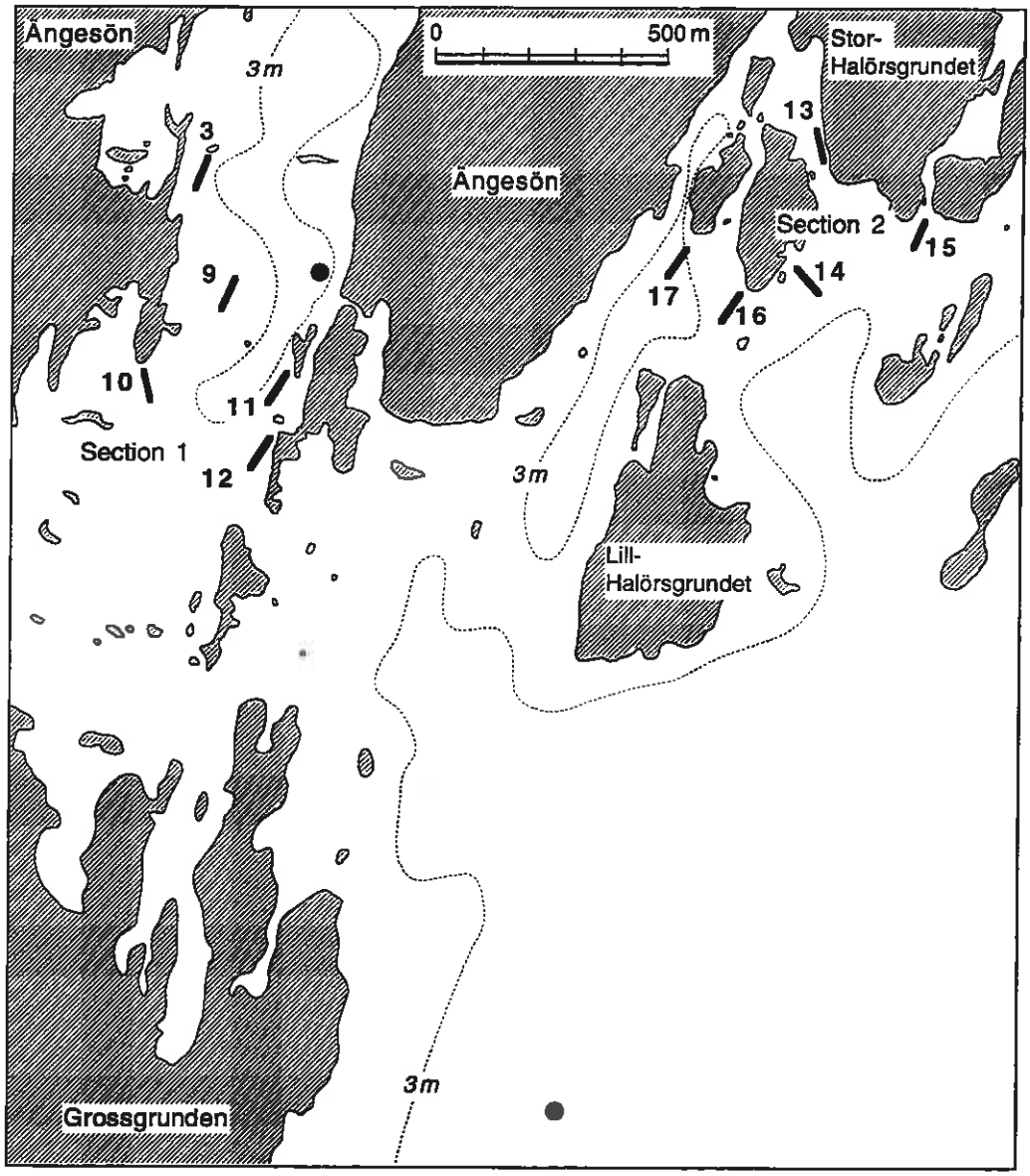

Figure 6. Monitoring stations for coastal fish and locality for Secchi depth measurements (●) in Holmöarna reference area.

3.6. Råneå

The archipelago of Råneå is located in the northern part of the Bothnian Bay (Fig. 1), where the salinity is around 1‰. The depth is mostly below 5 m, but reaches below 8 m south of the island of Laxön. The river Råneälven falling into the bay of Råneå is not influenced by hydroelectric dammings and other human impacts are few. Commercial fishing is directed at whitefish, vendace, salmon and Baltic herring.

Fish monitoring began in 1990. In 1992 and 1993 investigations were not carried out. The programme continued again in 1994 and consists of one section with eight stations (Fig. 7). The test fishing stations are located in the inner part of Råneå archipelago. The stations are exposed to southerly winds.

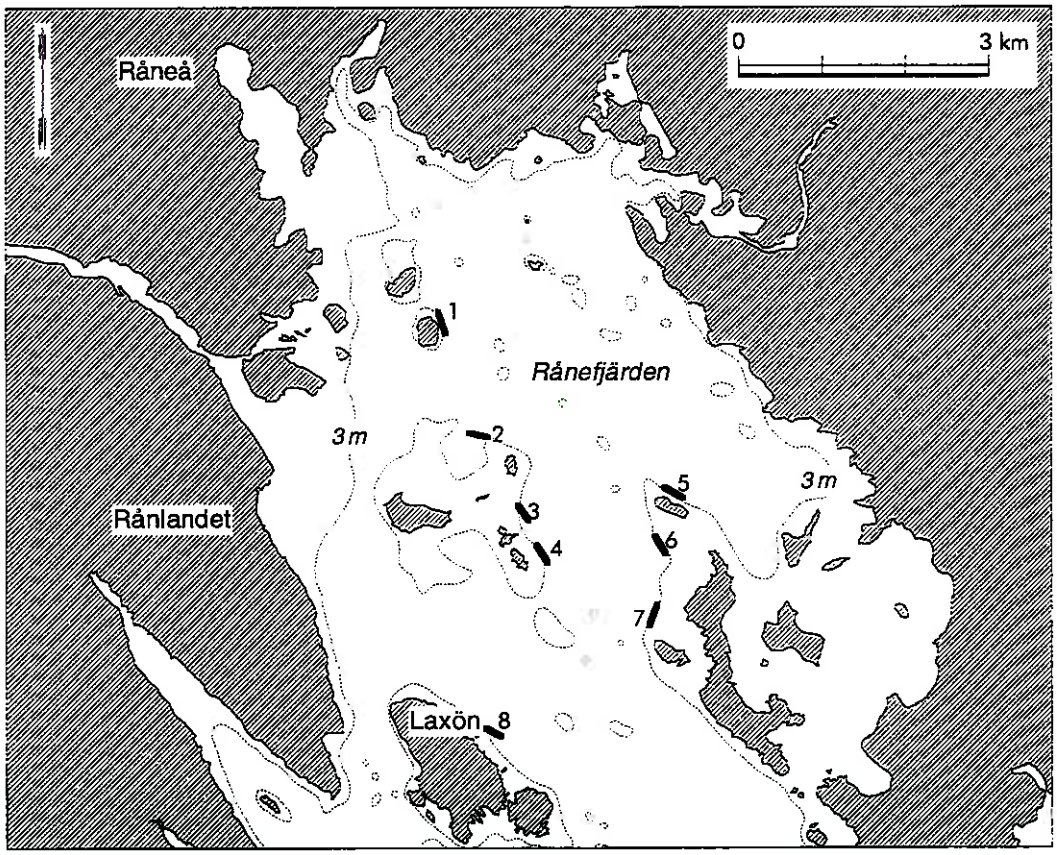

Figure 7. Monitoring stations for coastal fish in Råneå reference area. The Secchi depth is measured at station 4.

4. Results

4.1. Kvädöfjärden

Demersal warm water species dominated the catches in Kvädöfjärden (Table 1). Roach and perch were most abundant. Cyprinids were well represented with eight species. Apart from roach, also silver bream and rudd were relatively abundant. Demersal cold water species were scarce. Only flounder was caught to some extent.

The main differences between the sections were lower abundances of perch and higher abundances of silver bream and rudd in the more sheltered section 5 (Table 1). Ruffe was more abundant in section 6. The abundance of roach was similar in both sections. Pikeperch began to appear regularly in section 5 in 1992, but have not been found in section 6.

The catches of both perch and roach were large in 1994 mainly due to high water temperature (Fig. 8). The increase of the perch catches in section 5 was statistically significant (Mann-Kendall trend analysis), probably because of increased mean temperatures during the period 1962-1995 (Andersson et al., 1996). Higher temperatures have positive effects on the survival of perch fry, which in turn results in larger year-classes and larger populations of catchable size (Karås, 1996a, 1996b). Andersson et al. (1996) also reported that roach catches have increased significantly during the more than 30 years long monitoring period, probably due to higher temperatures and increased eutrophication.

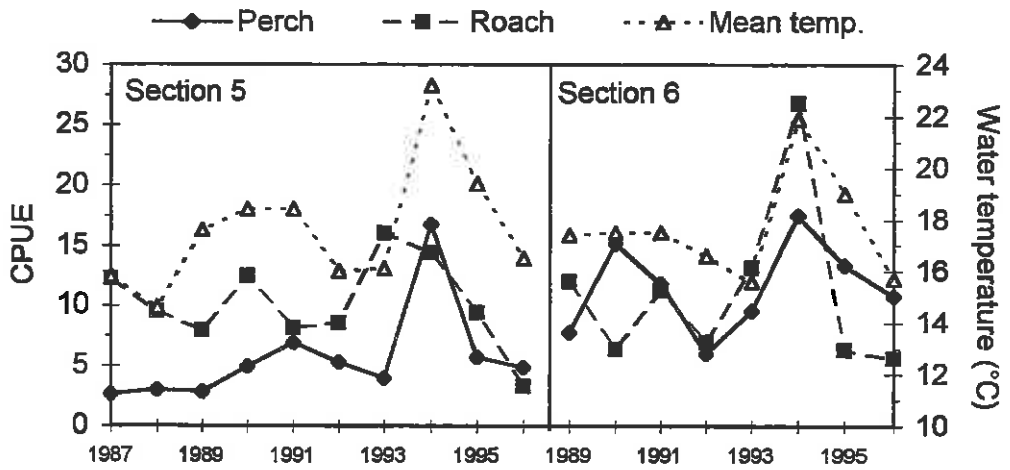

Figure 8. Annual variations of perch and roach catches and mean water temperatures during the fishing in Kvädöfjärden reference area.

Table 1. Mean fish catches (1992 - 1996, RÅ 1994 - 1996), expressed as catch per unit effort (CPUE), in the Baltic reference areas. *different nets have been used and to gain approximatively comparable results between the areas the figures should be doubled. (JM = Kvädöfjärden, HM = Hiiumaa, BS = Brunskär, FB = Finbo, HÖ = Holmöarna, RÅ = Råneå).

Area	JM*		HM*		BS	FB	HÖ		RÅ
Section	5	6	1	2	1	1	1	2	1
Demersal warm water species									
Perch (*Perca fluviatilis*)	7.3	11.4	3.5	4.8	16.7	30.3	30.0	24.0	9.7
Pike (*Esox lucius*)	0.2	0.1	<0.1	<0.1	0	0.2	<0.1	<0.1	0.1
Pikeperch (*Stizostedion lucioperca*)	<0.1	0	<0.1	<0.1	<0.1	0.2	0	0	0
Ruffe (*Gymnocephalus cernuus*)	0.4	1.5	0.4	0.2	<0.1	1.2	2.9	3.1	4.2
Bleak (*Alburnus alburnus*)	0	0	<0.1	<0.1	0	0	<0.1	0.1	<0.1
Bream (*Abramis brama*)	<0.1	<0.1	0	0	0	<0.1	0	0	0.4
Crucian carp (*Carassius carassius*)	<0.1	<0.1	0	0	<0.1	0	0	0	0
Dace (*Leuciscus leuciscus*)	0	0	<0.1	0.1	0	0	0	0	0.2
Ide (*Leuciscus idus*)	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	0	0.2
Roach (*Rutilus rutilus*)	10.3	11.8	1.0	7.6	3.2	4.1	19.7	4.1	33.5
Rudd (*Scardinius erythrophthalmus*)	2.6	0.4	0	0	0	<0.1	0	0	0
Silver bream (*Blicca bjoerkna*)	2.6	0.6	<0.1	0.1	<0.1	<0.1	0	0	0
Tench (*Tinca tinca*)	<0.1	<0.1	0	0	0	0	0	0	0
Vimba bream (*Vimba vimba*)	<0.1	0	<0.1	0.2	0	0	0	0	0
CPUE (SUM)	23.6	25.8	4.9	13.0	19.9	36.0	52.7	31.3	48.3
No. of species	12	10	10	10	7	9	6	5	8
Demersal cold water species									
Arctic char (*Salvelinus alpinus*)	0	0	0	0	0	0	0	0	<0.1
Burbot (*Lota lota*)	0	0	0	<0.1	0	<0.1	0	0	<0.1
Flounder (*Platichthys flesus*)	<0.1	0.1	<0.1	<0.1	1.7	1.5	0	0	0
Fourhorned sculpin (*Myoxocephalus quadricornis*)	0	0	0	0	0	<0.1	0	0	0
Longspined bullhead (*Taurulus bubalis*)	0	0	0	0	<0.1	<0.1	0	0	0
Rainbow trout (*Oncorhynchus mykiss*)	0	<0.1	0	0	0	<0.1	0	0	0
Trout (*Salmo trutta*)	0	0	0	0	0	0	0	0	<0.1
Turbot (*Psetta maxima*)	0	0	0	<0.1	<0.1	<0.1	0	0	0
Viviparous blenny (*Zoarces viviparus*)	0	0	0	<0.1	<0.1	<0.1	0	<0.1	0
Whitefish (*Coregonus lavaretus*)	0	<0.1	0	0	0.5	<0.1	0.3	1.3	0.6
CPUE (SUM)	<0.1	0.1	<0.1	<0.1	2.2	1.6	0.3	1.3	0.6
No. of species	1	3	1	4	5	8	1	2	4
Pelagic species									
Baltic herring (*Clupea harengus*)	0.1	<0.1	0.1	0.8	9.6	9.3	0.6	6.0	1.1
Smelt (*Osmerus eperlanus*)	0	0	0	0	0.1	<0.1	0	0	0
Sprat (*Sprattus sprattus*)	0	0	<0.1	<0.1	<0.1	<0.1	0	0	0
Vendace (*Coregonus albula*)	0	0	0	0	0	0	<0.1	<0.1	<0.1
CPUE (SUM)	0.1	<0.1	0.1	0.8	9.7	9.3	0.6	6.0	1.1
No. of species	1	1	2	2	3	3	2	2	2
Total CPUE	23.7	26.0	5.1	13.8	31.9	46.9	53.6	38.6	50.0
Total no. of species	14	14	13	16	15	20	9	9	14

4.2. Hiiumaa

Sixteen species were caught (Table 1), ten of which belonged to the demersal warm water community. The most common were perch and roach. Demersal cold water and pelagic species were scarce. Only flounder and Baltic herring were found more or less regularly. The total catches, dominated by perch, were low in section 1 (Fig. 9). Ruffe was caught in noticeable numbers. The catches of perch and roach were larger in section 2 than in section 1. Vimba bream was also caught regularly (Table 1).

During 1992 - 1994 perch dominated in section 1, but the catches dropped drastically in 1995 (Fig. 9). Together with a slight increase of the roach catches, the situation altered so that roach dominated the catches in 1996. The perch catches in section 2 showed a similar drop as in section 1 and were very low in 1996 (Fig. 9). The decrease was statistically significant (Mann-Kendall trend analysis) in both sections. Kangur (1996) suggested that the decrease is caused by overexploitation of the perch population in Väinameri. The roach catches in section 2 also decreased but the variations of the catches between the stations were too large to prove it statistically significant. The mean temperature was 2 - 3 °C higher in 1994 compared with the other years, which probably contributed to the high catches of perch (Fig. 9).

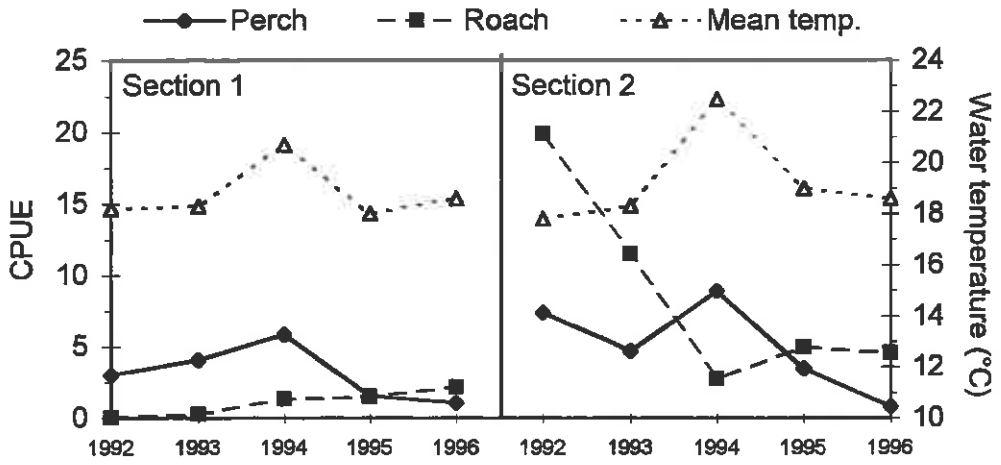

Figure 9. Annual variations of perch and roach catches and mean water temperatures during the fishing in Hiiumaa reference area.

4.3. Brunskär

Totally 15 species were registered. The warm water community consisted mainly of perch and roach, with perch strongly dominating. Other species were found only occasionally. The demersal cold water community was comparatively well represented and dominated by flounder and whitefish. Baltic herring was caught in noticeable amounts in this area (Table 1).

High water temperatures were noted in 1994 and 1995 compared with the other years, which probably contributed to the increased perch catches (Fig. 10). Roach was rare in the beginning of the period, but became successively more common. The increase is statistically significant (Mann-Kendall trend analysis). The roach population consisted mainly of large individuals (17.5 - 25 cm), indicating that the population increase was caused by immigration and that local recruitment is weak.

The catches of flounder have increased significantly during the period (Mann-Kendall trend analysis)in spite of the rather high temperatures. Koli (1990) noted that some subspecies of flounder with different behaviour exist in the Baltic Sea. The subspecies found in this area may have high temperature preference, which may explain the large catches on the shallow areas.

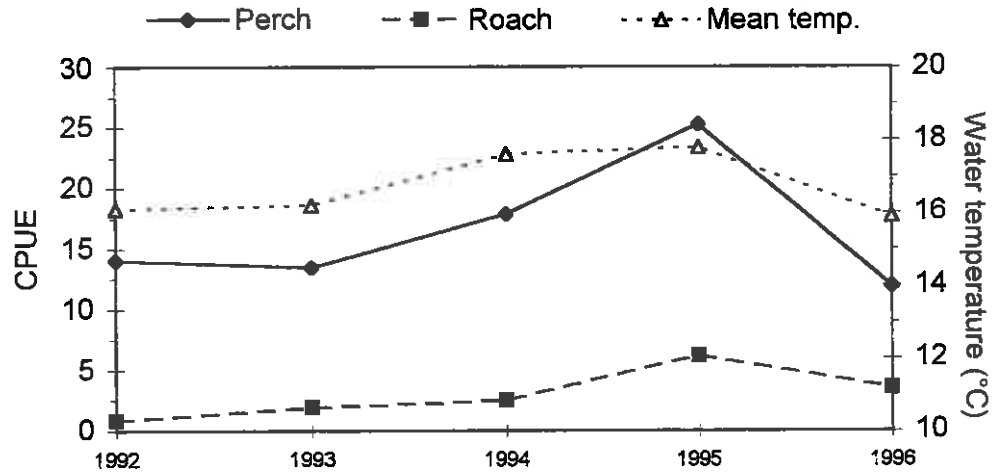

Figure 10. Annual variations of perch and roach catches and mean water temperatures during the fishing in Brunskär reference area.

4.4. Finbo

As many as 20 species have been found since 1992, nine of which were demersal warm water and eight demersal cold water species (Table 1). Baltic herring was also relatively common in the catches. The most common demersal warm water species was perch followed by roach and ruffe. Pikeperch, bream, silver bream and ide were found for the first time in 1991 and have since then been caught more or less regularly. Rudd was found for the first time in 1996. The demersal cold water community was dominated by flounder. Other cold water species have been found only occasionally.

The catches of perch have been relatively stable during the period, except for the large catches in 1994 and 1995 (Fig. 11). The catches of roach have been stable with an exception in 1990, when the catches were large. Flounder was regularly found in low numbers until 1991, but from 1992 and on the catches have been about ten-fold larger. However, this increase could not be proved statistically significant due to large variations of the catches between the stations. The explanation for the surprisingly good catches may be similar to that proposed for the flounder catches in Brunskär. Upwellings of cold water are common in the area, which also probably contribute to the comparatively high catches of demersal cold water and pelagic species (Fig. 11).

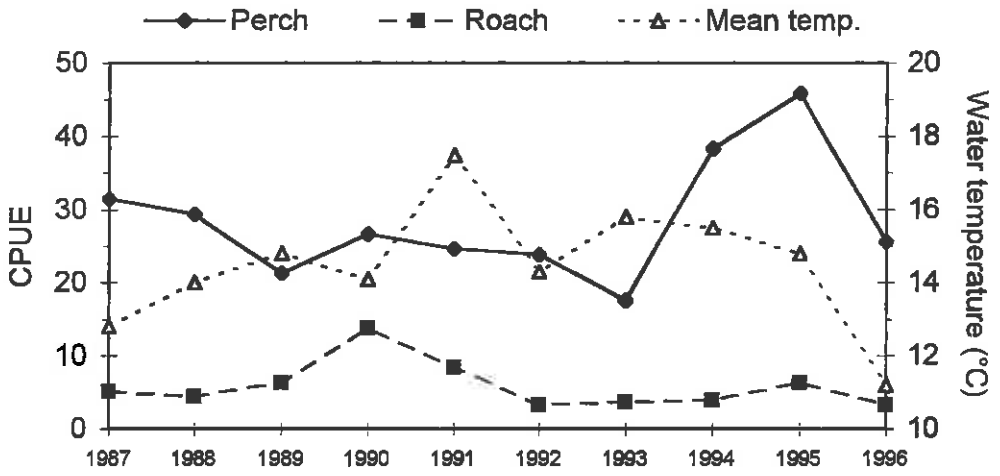

Figure 11. Annual variations of perch and roach catches and mean water temperatures during the fishing in Finbo reference area.

4.5. Holmöarna

The catches were made up of relatively few species. Six species of the demersal warm water and two of the cold water community were noted (Table 1). Perch dominated followed by roach. Ruffe, whitefish and Baltic herring were also relatively abundant. The sections differed from each other mainly in the larger catches of roach in section 1 and larger catches of whitefish in section 2 (Table 1). Perch was slightly more abundant in section 1, although the catches were large in both sections. The catches of ruffe were also similar in both sections.

The abundance of both perch and roach varied strongly between years in section 1 (Fig. 12). The large catches of perch in 1990 and 1991 in both sections (Fig. 12) were probably due to the strong year-class of 1988 (Karås et al., 1997). The perch catches decreased significantly (Mann-Kendall trend analysis) in section 2, probably due to the successive disappearance of year-class 1988.

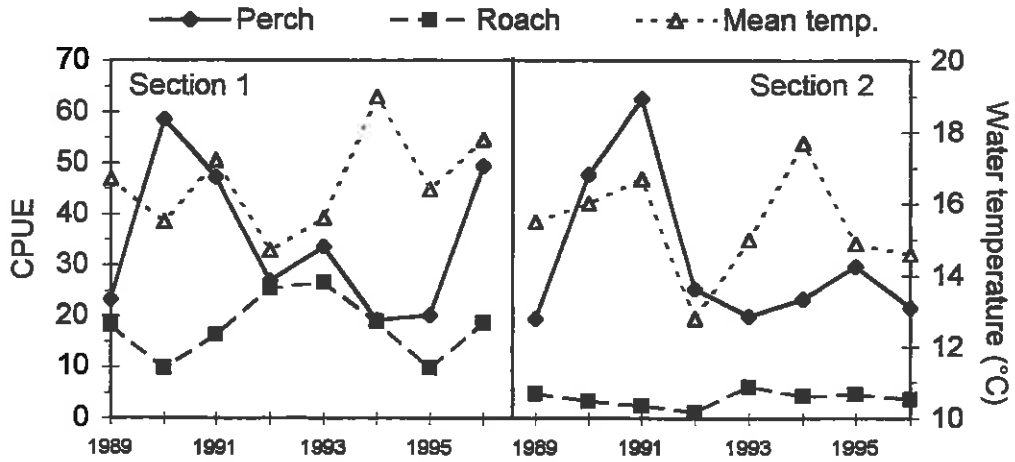

Figure 12. Annual variations of perch and roach catches and mean water temperatures during the fishing in Holmöarna reference area.

4.6. Råneå

The catches consisted of 15 species eight of which belonged to the demersal warm water and four to the demersal cold water community (Table 1). The most common species was roach, but perch and ruffe were also abundant. Bream, dace and ide were found in noticeable amounts. Whitefish dominated the demersal cold water community.

The roach catches varied strongly between years (Fig. 13). For instance, in 1994 the catches were very high, exceeding 60 individuals per unit effort. The perch catches were more stable. The bottom temperatures were remarkably low in 1995 (Fig. 13), which probably contributed to the low catches of roach.

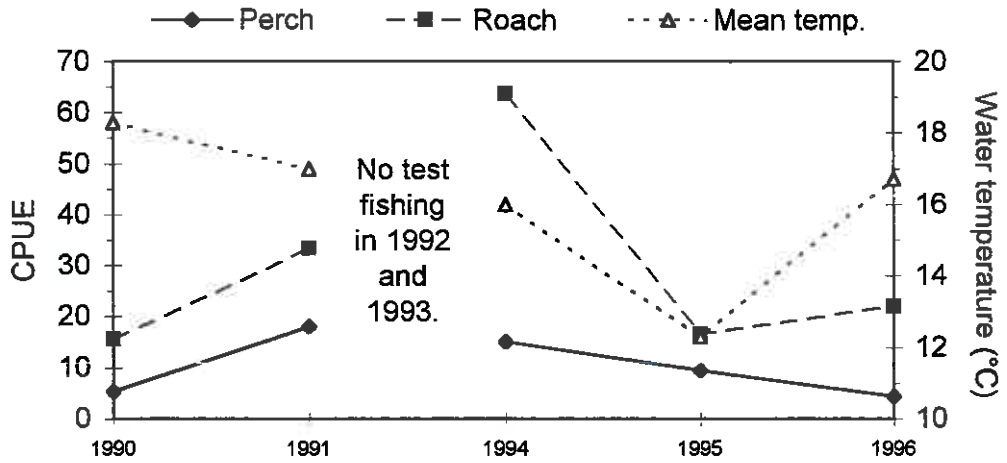

Figure 13. Annual variations of perch and roach catches and mean water temperatures during the fishing in Råneå reference area.

5. Discussion

The test fishings are directed towards demersal warm water species, which also dominated the catches in all areas. Demersal cold water and pelagic species are caught in varying amounts despite this. The distribution of the different fish communities depends on several parameters e.g. the salinity, season and exposure to open waters (Neuman, 1982). The demersal warm water community is totally dominated by freshwater species, mainly perch, ruffe and different cyprinids. Recruitment conditions such as sheltered and warm spawning localities determine to a large extent the abundance of these species. Such localities are often found in inner, sheltered parts of archipelagoes and become more rare towards the open sea. When the basic conditions are available secondary effects of eutrophication e.g. changes in the macrophyte and zooplankton communities influence recruitment success. The effects of eutrophication on fish in the Baltic Sea have been discussed by several authors (e.g. Hansson and Rudstam, 1990) and have recently been reviewed by Tammi (1996). The abundance of cyprinids increases with increasing eutrophication. Also ruffe and pikeperch have been noticed to increase (Lehtonen and Hildén, 1980). For Baltic coastal areas Sandström et al. (1994) showed that decreasing Secchi depths were correlated with increased shares of roach and other cyprinids.

The areas and sections in the monitoring system can be classified into two different groups, perch dominated and cyprinid dominated fish communities (Fig. 14). Section 1 in Hiiumaa, Brunskär, Finbo and Holmöarna belong to the perch dominated group. Section 1 in Holmöarna differed from the others by rather large catches of roach. The numbers of other cyprinids were insignificant in these areas. The fish communities of Brunskär, Finbo and Holmöarna showed similar distribution patterns with significant amounts of demersal cold water and pelagic species. The Secchi depths were also good and it can be concluded that indications of eutrophication were weak in these areas and sections. However, the statistically significant increasing trend of roach catches together with findings of pikeperch in Brunskär and the recent appearence of pikeperch and other cyprinids (bream, silver bream, ide, rudd) in Finbo may indicate increasing eutrophication. Indications of eutrophication in these areas have earlier been reported by several authors (Bonsdorff et al., 1991; Rönnberg 1984; Mäkinen and Aulio, 1986; and Jumppanen and Mattila, 1994). The cyprinid dominated areas and sections were section 2 in Hiiumaa, Kvädöfjärden and Råneå. The dominating cyprinid was in all cases roach, but other cyprinids were also rather common. Indications of eutrophication were hence stronger compared with the perch dominated areas. The catches of demersal cold water and pelagic species were generally low in these areas.

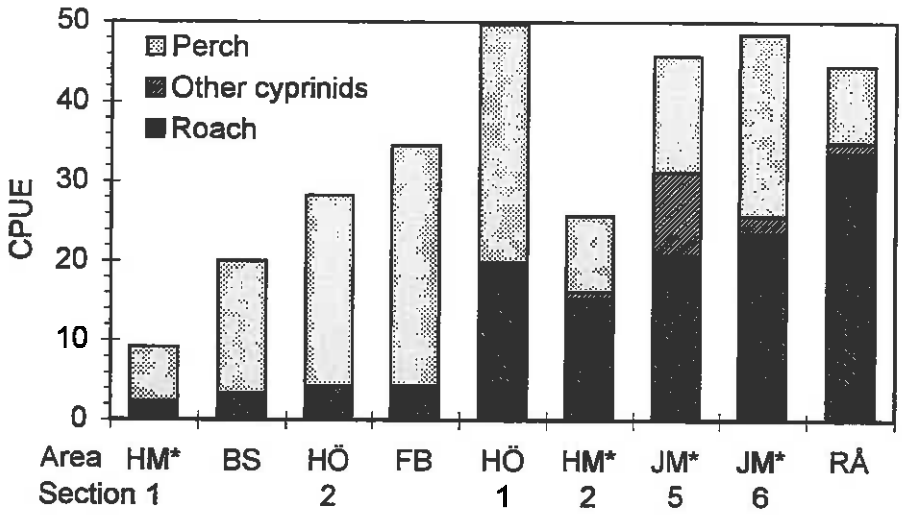

Figure 14. Mean catches (1992 - 1996, RÅ 1994 - 1996) of roach, other cyprinids and perch in the reference areas. *different nets have been used and to gain approximatively comparable results between the areas the figures have been doubled. (JM = Kvädöfjärden, HM = Hiiumaa, BS = Brunskär, FB = Finbo, HÖ = Holmöarna, RÅ = Råneå).

The catches per unit effort of cyprinids were strongly negatively correlated to the Secchi depths (Fig. 15). The seemingly strong dependence of the abundance of cyprinids on the degree of eutrophication is remarkable as it is influenced by many other factors. The two most important are probably the access to shallow, sheltered and warm recruitment areas and the temperature conditions during the fishing. In relation to the Secchi depth, the abundance of roach is surprisingly high in Råneå and low in Finbo. It is likely that Råneå has better recruitment conditions than the other areas (Sandström, 1994), while the catches in Finbo are probably affected by frequent upwellings of cold water rather than any markedly low recruitment capacity. The results of the analysis indicate that the fish monitoring system gives good information on biological effects of eutrophication.

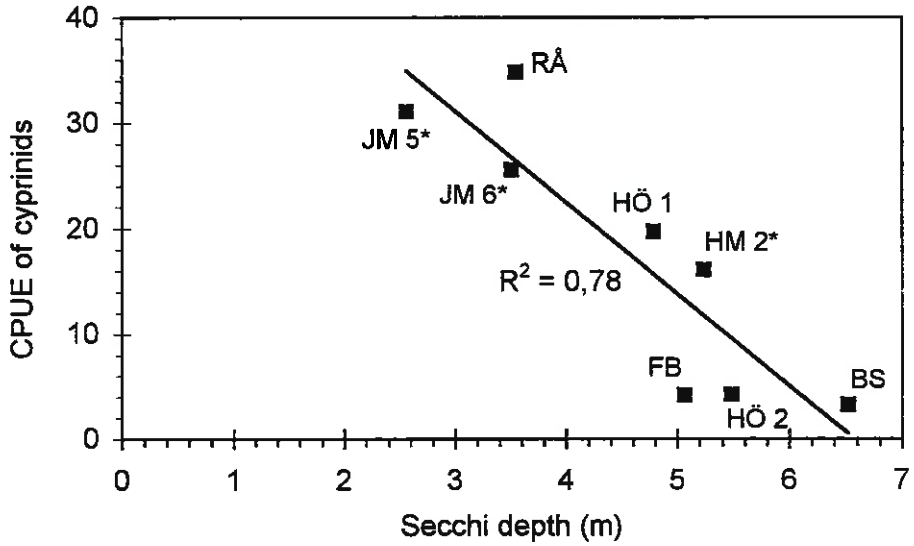

Figure 15. Mean cyprinid catches related to mean Secchi depths (1992 - 1996, RÅ 1994 - 1996) in the reference areas. Section 1 in Hiiumaa was excluded, because the area is too shallow to allow measurements of Secchi depths. *different nets have been used and to gain approximatively comparable results between the areas the figures have been doubled. (JM = Kvädöfjärden, HM = Hiiumaa, BS = Brunskär, FB = Finbo, HÖ = Holmöarna, RÅ = Råneå).

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7. References

Andersson, J., Mo, K., Sandström, O. and Svedäng, H., 1996. Biologiska kontrollundersökningar vid Oskarshamnsverket - Sammanfattning av resultaten t o m 1995. Kustrapport 1996:5. 37 pp (in Swedish).

Bonsdorff, E., Aarnio, K. and Sandberg, E., 1991. Temporal and spatial variability of zoobenthic communities in the archipelago waters of the Northern Baltic Sea - consequences of eutrophication? Int. Revue ges. Hydrobiol. 76. 433-449.

Hansson, S and Rudstam, L.G., 1990. Eutrophication and the Baltic fish communities. Ambio vol. 19 no. 3. 123-125.

Jumppanen, K. and Mattila, J., 1994. The development of the state of the Archipelago Sea and environmental factors affecting it. Lounais-Suomen vesiensuojeluyhdistys r.y. I, Turku (In Finnish with English summary).

Kangur, M., 1996. Coastal fishery and its management in Estonia. Proc. of Polish-Swedish Symposium on Baltic Coastal Fisheries. Resources and Management. Sea Fisheries Institute, Gdynia. 89-92.

Karås, P., 1996a. Basic conditions for production of perch (*Perca fluviatilis* L) young-of-the-year in the Gulf of Bothnia. Ann. Zool. Fennici, 33. 371-381

Karås, P., 1996b. Recruitment of perch (*Perca fluviatilis* L) from Baltic coastal waters. Arch. Hydrobiol. 138. 99-121.

Karås, P, Böhling, P., Järv, L., Lehtonen, H., Makarchouk, A. and Ziliukas, v., 1997. Year-class strength patterns in Baltic perch and pikeperch populations - a base for development of systems for prognoses. Proc. of Polish-Swedish Symposium on Baltic Coastal Fisheries. Resources and Management. Sea Fisheries Institute, Gdynia. 93-105.

Koli, L., 1990. Suomen kalat. WSOY. Porvoo.

Lehtonen, H. and Hildén, M., 1980. The influence of pollution and fish stocks in the Finnish part of the Gulf of Finland. Finnish Mar. Res. 247. 110 - 123.

Mäkinen, A. and Aulio, K., 1986. *Cladophora glomerata* (Chlorophyta) as an indicator of coastal eutrophication. Publ. Water Res. Inst. Finland. 68. 160 - 163.

Neuman, E., 1982. Species composition and seasonal migrations of the coastal fish fauna in the Southern Baltic Sea. In: Coastal Research in the Gulf of Bothnia. Red: K. Müller. Mon. Biol. 45. 317 - 351.

Neuman, E. and Sandström, O., 1996a. Integrated monitoring of coastal fish populations. In: Proc. of the Internat. Meeting on "Baltic Network of Biodiversity and Productivity of Selected Species in Coastal Ecosystems". Editor, R. Volskis. Vilnius, 1996: 28 - 32.

Neuman, E. and Sandström, O., 1996b. Fish monitoring as a tool for assessing the health of Baltic coastal ecosystems. Proc. of Polish-Swedish Symposium on Baltic Coastal Fisheries. Resources and Management. Sea Fisheries Institute, Gdynia. 143-151.

Nordisk Ministerråd, 1992. Integrert økologisk miljøovervåkning i kystzonen. (Integrated Ecological Monitoring in the Coastal Zone). Nord 1992: 39. 47 pp. (In Norwegian with English summary).

Rönnberg, O., 1984. Recent changes in the distribution of *Fucus vesiculosus* L. around the Åland Islands (N Baltic). Ophelia, Suppl. 3: 189-193.

Sandström, O., 1994. Kustfisk och fiske i Bottniska viken. Kustrapport, 1994:1. 61 pp.

Sandström, O., Böhling, P., Mölder, M., Neuman, E., Olsson, M., Pliksh, P., Repecka, R. and Ådjers, K., 1994. Intergrated fish monitoring in Baltic coastal areas. National Board of Fisheries. Institute of Coastal Research. Sweden. (Mimeogr.).

Tammi, J., 1996. The effects of eutrophication on fishes, fish stocks and fisheries - A literature review. Kalatutkimuksia - Fiskundersökningar, 103. 66 pp (in Finnish).

Thoresson, G., 1993. Guidelines for coastal monitoring - fishery biology. Kustrapport, 1993: 1. 35 pp.

Ådjers, K., Andersson, J., Böhling, P., Mölder, M., Neuman, E., and Sandström, O., 1996. Monitoring in coastal reference areas. TemaNord. 1996:627. 38 pp.

Ådjers, K., Böhling, P., Järvik, A., Lehtonen, H., Mölder, M., Neuman, E., Raia, T, and Storå, C., 1995. Coastal fish monitoring in the northern Baltic proper - establishment of reference areas. TemaNord 1995:596. 38 pp.