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Sammanfattning

Livskraftiga bestånd och fisksamhällen längs våra kuster utgör ett viktigt mål inom det internationella miljömålsarbetet som till exempel Havsmiljödirektivet och Aktionsplanen för Östersjön. En viktig del i arbetet med att följa upp om dessa mål uppnås är att utföra en statusklassning av kustfisksamhällen och att nå God miljöstatus (GES) innan 2020.

Många fiskarter i Östersjöns kustområden har en lokalt och begränsad utbredning. Trots att det finns ett välutvecklat miljöövervakningsprogram för kustfisk i Sverige saknas geografisk täckning i övervakningen längs flera kuststräckor. Detta i sin tur leder till att vi inte kan ge en heltäckande bild av miljöstatusen hos kustfisksamhällena.

Inom det kommersiella fisket måste alla fiskare rapportera sina fångster och med vilken ansträngning de fiskat till EU-kommissionen via dagliga loggböcker. För det småskaliga kustnära fisket har denna information än så länge inte använts för att klassa miljöstatus hos kustnära fisksamhällen. I den här rapporten använder vi information som samlas in i loggböckerna från det småskaliga kustfisket för att: 1) undersöka vilka arter som fångas och med vilka redskap, 2) jämföra utvecklingen över tid för indikatorer som tagits fram från den fiskerioberoende miljöövervakningen respektive det småskaliga yrkesfiskets loggböcker, och 3) jämföra statusklassning för kustfisk på basen av data från den fiskerioberoende miljöövervakningen respektive det småskaliga yrkesfiskets loggböcker.

Resultaten visar att det småskaliga kustfisket längs Sveriges ostkust främst är inriktat på torsk, strömming, sik, skrubbskädda och abborre, men även gädda och gös fångas i relativt stor omfattning. Man fångar dessa arter främst med olika typer av bottensatta nät eller ryssjor. Fångsterna av arter av litet kommersiellt värde, som karpfiskar (mört och braxen), fångas eller registreras inte i loggböckerna, och informationen från yrkesfisket är således begränsat till ett fåtal arter av kommersiellt värde.

När vi jämförde data från miljöövervakningen med motsvarande från yrkesfisket var kopplingen generellt svag mellan de undersökta indikatorerna. Ett undantag var dock *Abundans av stor abborre* (abborre över 25 cm), där det fanns en ganska god samstämmighet mellan fångster i provfisken och i yrkesfisket.

Statusklassningen visade överlag en ganska bra överensstämmelse mellan data från miljöövervakningen och yrkesfisket för indikatorerna *Abundans av*

abborre, Abundans av stor abborre och *Abundans av rovfisk.* Starkast koppling fanns mellan dessa och estimat över fångst-per-ansträngning från yrkesfisket.

Resultaten i denna rapport visar att data över fångst-per-ansträngning från det småskaliga svenska yrkesfisket skulle kunna användas som ett komplement och stöd för statusklassningar av kustfisk. Detta gäller främst för abundansen av stor abborre. Eftersom ingen information för storleken på den fångade fisken finns att tillgå från yrkesfisket, är informationen som kan erhållas från yrkesfiskets loggböcker begränsad med avseende på storleksstrukturen i fisksamhället och förekomsten av viktiga funktionella grupper som karpfisk. Loggböckerna innehåller många potentiella felkällor, men en väg framåt för att öka användandet av data från loggböckerna är att kontraktera ett antal journalförande yrkesfiskare som för en mer detaljerad och uttömmande registrering av fångsterna. Detta skulle till exempel kunna inkludera notering av bifångst (oönskade arter och storlekar), stickprov av storleksfördelningen i fångsten, och högre upplösning över var fisken är fångad och med vilken fiskeansträngning. Detta skulle vara väldigt värdefulla uppgifter för arter som inte fångas i någon större utsträckning inom miljöövervakningen som sik, gös, gädda och plattfiskar.

Summary

Healthy coastal fish stocks and communities comprise an important part of the environmental targets of the Marine Strategy Framework Directive and Baltic Sea Action Plan, both in Sweden and the Baltic Sea as a whole. As such, the status of fish communities along our coasts should be assessed and Good Environmental Status (GES) should be achieved in 2020 by using a suite of selected indicators.

Many coastal fish stocks in the Baltic Sea are typically local in their appearance and response to environmental conditions. In spite of a well-developed coastal fish monitoring program in Sweden, there are still spatial gaps in its coverage limiting the potential for a full comprehensive status assessment of coastal fish.

Within the commercial fishery, all fishermen are obliged to report the catches and effort of their fishery to the European Commission via daily logbooks. To date, however, the information gathered from the small-scale coastal fisheries has not been used to assess the status and development of coastal fish stocks and communities. In this report we assess the potential for using data collected within the small-scale coastal fishery for indicator development and status assessments of coastal fish by 1) screening the species targeted and gears used in the commercial fishery, 2) comparing the temporal development of indicators derived from the commercial fishery and fishery independent coastal fish monitoring, and 3) comparing the outcome of status assessments derived from indicators developed using the two sources of data.

Our results show that the commercial coastal fishery in Sweden is mainly targeting cod, herring, whitefish, flounder and perch, and to a minor extent also pike and pike-perch. These species are mainly caught using gillnets, but in some areas traps or trap-nets are of importance. Catches of species of non-commercial value as roach and breams and other members of the carp family are very low or not registered, and the data is hence limited to a few species of commercial importance.

We found an overall weak match and substantial variation across coastal areas between indicators derived from the commercial fishery and fisheries independent monitoring data. There was, however, a reasonable concordance between the *Abundance of large perch* (above 25 cm) from monitoring data and catch-per-unit-effort (CPUE) of perch in the commercial fishery.

When assessing the environmental status of the fish communities based on indicators derived from the two sources of data, there was a rather good overall match in GES for the indicators *Abundance of perch*, *Abundance of large perch* and *Abundance of piscivores* and CPUE based indicators from the commercial fishery. The match was lower for the indicator *Abundance of large piscivores* and indicators ignoring effort data in the commercial fishery.

Our results suggest that CPUE data from the coastal commercial fishery could potentially be used as a complement and give additional support for status assessments of coastal fish in Sweden, particularly for the indicator *Abundance of large perch*. Since no information on size structure or the abundance of species of low commercial value could be obtained from the coastal commercial fisheries statistics, the data reported is in its current form of limited use for more detailed assessments of coastal fish communities. This regards important parameters such as size structure and the abundance of important functional groups as carp fishes. The fisheries statistics includes many sources for potential errors, but there are some means that can be used to increase the value of this data for assessments. The quality of the reporting can be improved, a selected number of coastal fishermen can be contracted for more detailed self-reporting of their catches and efforts. It is especially important to focus on registration of by-catch (both undersized fish of focal species and species of non-commercial value), subsampling for length and age estimates, and improved resolution of the effort and fishing location. This would be especially valid for those species and stocks that we have limited information on in the fishery independent gillnet monitoring programs as for example whitefish, pike-perch, pike and flatfishes.

Innehållsförteckning

1 Introduction

1.1 Contents and aim

This report contains analyses on the match of data for status assessments of coastal fish from fisheries independent gillnet monitoring programs and commercial catch statistics. The report also summarizes general patterns in the small-scale commercial fishery along the Swedish east coast, and provides a number of recommendations by which the data from the commercial fishery could be improved to also serve the needs for status assessments within internationals agreements and legislative acts. More specifically, the objectives of the report are:

1) to review the general patterns and target species of the small-scale coastal fishery along the Swedish Baltic Sea coast,

2) to assess how well trends in the small-scale coastal commercial fishery match those observed in fishery independent monitoring, when focusing on proposed indicators for coastal fish,

3) to evaluate how well status assessments for coastal fish based on data from the small-scale coastal commercial fishery matches assessments based on fishery independent monitoring data

1.2 Background

In 2008, the European Commission launched the Marine Strategy Framework Directive (MSFD; European Commission, 2008), which calls for the environmental status of all European marine waters to be assessed. For those waters classified as being of poor status, measures to achieve good environmental status (GES) should be implemented. Concurrently the states around the Baltic Sea agreed to improve the status of the Baltic Sea ecosystem via the HELCOM Baltic Sea Action Plan (BSAP; HELCOM 2007). In both the MSFD and BSAP, targets are set for different segments of the ecosystem, through 12 ecological objectives (BSAP) and 11 descriptors (MSFD), for which the status should be assessed. Concerning fish stocks and communties, this division includes for example the BSAP objectives *Natural distribution and occurrence of plants and animals*, and *Viable populations of species*, and the MSFD descriptors *Biodiversity* (descriptor 1) and *Commercially exploited fish and shellfish* (descriptor 3). Since each of the ecological objectives and descriptors are broadly defined, a suite of indicators representing different features of the ecosystem has been proposed to assess the status and to evaluate measures taken within the BSAP and MSFD.

In the Baltic Sea, targets for coastal fish are included in both the Marine Strategy Framework Directive and the Baltic Sea Action Plan (HELCOM 2013). At an international level, two indicators for coastal fish have so far been accepted as Baltic Sea wide within HELCOM (HELCOM 2013), and in the Swedish implementation of the MSFD, three additional coastal fish indicators have been suggested (HVMFS 2012; SWaM 2012; Bergström & Olsson 2014). The status of the proposed indicators is to be assessed using data from national and/or international environmental monitoring programs.

Coastal fish monitoring in the Baltic Sea has a long tradition (Olsson & Andersson 2012), and is currently undertaken in some form in all Baltic countries (HELCOM 2015). In Sweden as well as in the majority of the other Baltic Sea countries, status assessments for the proposed indicators are derived from fishery independent multi-mesh gillnet or fyke net monitoring (SWaM 2014; HELCOM 2015). In other countries, data from small-scale coastal fisheries or recreational fishing surveys serves as the basis for indicator-based status assessments due to a lack of monitoring programs (HELCOM 2015).

Coastal fish communities in the Baltic Sea are usually local in their appearance and response to environmental conditions (reviewed in Olsson et al. 2012). Their status should hence be assessed on a local geographical scale (SWaM 2012). Despite the extensive coastal fish monitoring program in Sweden, there are thus still gaps in the geographical coverage of the program (Fredriksson 2013; Bergström & Olsson 2014).

All commercial fishermen are, according to the EU legislation, obliged to report their catches of fish to national authorities (EU laws on fisheries 286/1982 and 1116/1982). The catches are typically reported by ICES rectangle (55 by 55–60 km, Figure 1), where every fishing vessel has to document the catches per species and gear type used (including mesh size), the fishing effort, and fishing location (Lappalainen 2015). This information is thus available for all coastal areas where commercial fishery is undertaken in EU. The extent of this information does, however, differ across countries in the Baltic Sea (Lappalainen 2015).

For coastal fish, data from the commercial fishery has so far mainly been used to assess fishing practices and total landings in the fishery. However, since the fishing effort of each vessel and day is also registered, the information collected might serve as an additional source of data for monitoring the status of coastal fish stocks and communities, as currently undertaken in for example Finland (HELCOM 2015). The quality and reliability of the data collected has, however, been questioned (Lappalainen 2015), and no evaluation of its usefulness for environmental status assessments has previously been carried out. Sweden offers a unique opportunity for such evaluations with a rather extensive coast that covers wide environmental gradients in salinity, temperature and nutrient concentration. Accompanied with a well developed fisheries independent coastal fish monitoring program covering a number of coastal areas (Bergström & Olsson 2014, Figure 1), this allows for a comparison of data collected within the commercial fishery and fisheries independent monitoring programs over substantial environmental gradients.

2 Methods

2.1 Commercial fishery data

The data used representing the commercial fishery was derived from Swedish logbooks. In these, every commercial fishing vessel is obliged to report on a daily basis e.g. the fishing location and dates, the amount of fish landed, the gears used, and the fishing effort. The landings are typically reported as the total weight (in kg) of the catch per species, and the effort as the number of fishing days and length of the gear, or number of gears used. In many instances, however, only the summed effort per fishing journey is provided by the fishermen. Anyhow, based on this data, information on catch per unit effort can be extracted per fishing vessel, fishing journey and ICES rectangle (Figure 1).

In this report, we first summarized the species caught using different gears in the Swedish commercial coastal fishery. We then extracted information on the total landings per ICES rectangle and years across gears to screen the nature of the commercial fishery in each area. The analyses were confined to different types of gillnets, since the catches of coastal species in the different areas were mainly attributable to gillnet catches (see results below). To calculate the four indicators assessed in this report (see below) for landings and CPUE estimates in the commercial fishery, we extracted data per gear and ICES rectangle for the species included in the indicators perch (*Perca fluviatilis*), pike (*Esox lucius*), burbot (*Lota lota*), pikeperch (*Zander lucioperca*), cod (*Gadus morhua*), and turbot (*Psetta maxima*). Of these, perch was included in all four indicators, whereas the others in the two piscivore indicators only.

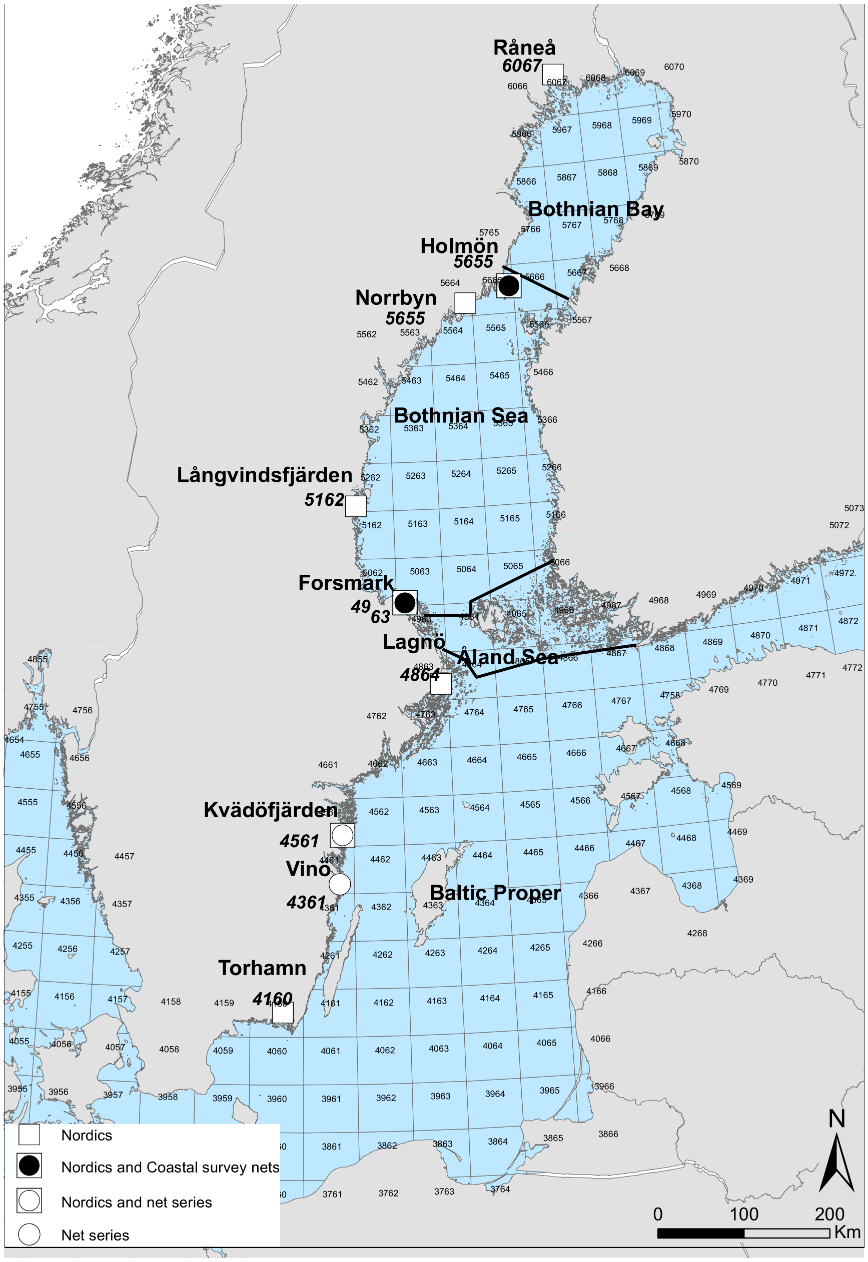


Figure 1. Location of the monitoring areas included in the analyses. Given is also the ICES rectangles by which the commercial fishery is reported and the sub-basins discussed in this report.

We also assessed the landings and effort data per vessel for those fishermen landing the majority of fish within each rectangle. In further analyses we used the most robust source of data from each rectangle to get comparable estimtes over time (Table 1). More specifically, the quality of data with respect to landings and effort was assesed. We based the quality assessment on the size and time-coverage of landings and efforts across gears. Only those gears including the majority of landings and efforts, and that exhibited relatively little interannual fluctuations was selected for further analyses in each rectangle. If there were no major differences across gear types used, we summed the catches for all gears (Table 1). Since reliable effort data for the Swedish coastal commercial fishery is only available since 1999, data covering the time-period 1999-2013 was used in this report.

The CPUE from the commercial fishery was calculated as the landings per year and gear for the focal species, divided by the effort for that year and gear. In contrast to the gillnet monitoring which is mainly confined to the late summer, the commercial fishery is undertaken year around. The focal periods for the coastal fishery targeting the species in focus in this report was late spring, summer and early autumn, but landings from early spring and late autumn also exist in some areas and are included in the analyses. Despite that data are collected on a daily basis, data per rectangle was pooled to annual means in our analyses to minimize the influence of day to day variation in the material and to be comparable to the gillnet monitoring data.

Table 1. *Overview of the gears used per ICES rectangle to estimate total landings and CPUE from the commercial catch data. For the monitoring areas of Norrbyn and Lagnö, data from the commercial fishery in the nearest ICES rectangle was used due to data limitations.*

ICES rectangle	Monitoring area	Landings perch	CPUE perch	Landings piscivores	CPUE piscivores
6067	Råneå	All nets*	All nets*	Whitefish nets	Whitefish nets
5665	Holmön	Perch nets	Whitefish nets	Perch nets	Whitefish nets
5665	Norrbyn	Perch nets	Whitefish nets	Perch nets	Whitefish nets
5162	Långvindsfjärden	Perch nets	Whitefish nets	Perch nets	Whitefish nets
4963	Forsmark	Whitefish nets	Whitefish nets	Whitefish nets	Whitefish nets
4864	Lagnö	Perch nets	Perch nets	Perch nets	Perch nets
4561	Kvädöfjärden	Whitefish nets	Whitefish nets	Whitefish nets	Whitefish nets
4361	Vinö	All nets*	All nets*	All nets*	All nets
4160	Torhamn	All nets*	All nets*	All nets*	All nets

* Includes perch nets, whitefish nets, and pike nets

2.2 Gillnet monitoring data

The coastal fish monitoring program along the Swedish east coast is rather well developed with a good geographical coverage (Bergström & Olsson 2014, Figure 1). In a few areas, monitoring dates back to the 1960s or late 1980s, but in the majority of areas monitoring was initiated in the early/mid 2000s. Whereas the monitoring programs initiated in the 1970s and 1980s are carried out using coastal survey nets (Gulf of Bothnia) and net series (Baltic Proper), the more recently established monitoring programs use Nordic coastal multimesh gillnets (Nordic nets, HELCOM 2015). The different gears are not fully comparable with respect to fishing performance and strategy (HELCOM 2012), and the Nordic nets catch a wider range of size classes than the other gears used (Appelberg et al. 2003). For a more detailed description of the different gears used see HELCOM 2015.

Since reliable effort data from the commercial fishery is only available since 1999, the analyses were confined to monitoring data covering 1999-2013. To that end, we used data sets from four monitoring areas covering years before 2002, and another eigth data sets covering the years after 2002 (Table 2).

Coastal fish monitoring in Sweden is usually conducted in late summer (August) when many coastal fish species such as perch and those from the carp family (Cyprinidae) are most active and thus susceptible to passive gears (HELCOM 2015). In a few areas, monitoring is also undertaken during spring or fall (Olsson and Andersson 2012) when cold-water species, including marine fish, are more abundant in the catch (Olsson et al 2012). In this report, however, we confine the analyses to those areas in which monitoring is conducted in the summer since the current suite of indicators used in the MSFD and BSAP is mainly developed for these data (HELCOM 2012).

For each monitoring area and data set, a mean indicator value over all stations per year was calculated (based on abundance and effort). For the Nordic nets, only fish larger than 12 cm (total length, TL) was included in the analyses since fish smaller than this size are not representatively sampled by the gear (HELCOM 2012). The analyses were further confined to using data from the depth strata 0-3, 3-6 and 6-10 m. Corresponding cut-off in size is 14 cm TL for coastal survey nets and net series (HELCOM 2012). The indicator values from all three gears were based on number of individuals (relative abundance) per species and the related fishing effort (the number of nets and nights).

Table 2. *Overview of the monitoring areas considered in this report, including time coverage of the monitoring program, the time-period considered in this report, the gears used and the corresponding ICES square rectangle for the commercial fisheries data. See Figure 1 for location of the monitoring areas and ICES rectangles.*

Area	**Time coverage**	**Time period considered**	**Gear used in monitoring**	**ICES rectangle**
Råneå	2002-	2002-2013	Nordic nets	6067
Holmön	2002-	2002-2013	Nordic nets	5665
Holmön	1989-	1999-2013	Coastal survey nets	5665
Norrbyn	2002-	2002-2013	Nordic nets	5665
Långvindsfjärden	2002-	2002-2013	Nordic nets	5162
Forsmark	2002-	2002-2013	Nordic nets	4963
Forsmark	1989-	1999-2013	Coastal survey nets	4963
Lagnö	2002-	2002-2013	Nordic nets	4864
Kvädöfjärden	2002-	2002-2013	Nordic nets	4561
Kvädöfjärden	1971-	1999-2013	Net series	4561
Vinö	1995-	1999-2013	Net series	4361
Torhamn	2002-	2002-2013	Nordic nets	4160

2.3 Indicators assessed

The five indicators suggested for coastal fish in Sweden and HELCOM are 1) Abundance of key species, 2) Abundance of key functional groups, 3) Size structure of key species, 4) Size structure in the fish community, and 5) Trophic level in the fish community (SwaM 2012), where two (Abundance of key species and Abundance of key functional groups) are also used Baltic wide by HELCOM (HELCOM 2013). As key species, perch is used, and as key functional groups both the abundance of piscivorous fish (species with a trophic level above four according to FishBase) and cyprinids (species of the *Cyprinidae* family) are included (SWam 2012; HELCOM 2013). In this study piscivorous fish was represented by perch, pikeperch, pike, burbot, cod and turbot. In the monitoring catches perch comprised the vast majority of the piscivore catches, whereas in the commercial catches a wider range of piscivorous species was included. This in turn influenced the correspondence between the piscivore indicators across data sources. The size structure of key species are defined as the abundance of all perch above 25 cm TL, and for the size structure of the fish community all piscivorous fish above 30 cm TL is used (Bergström & Olsson 2014). The trophic level of the fish community is commonly calculated as the abundance weighted mean trophic level of the fish in the monitoring catch (HELCOM 2012).

In this report we focus the work on four of the indicators (Table 3): Abundance of key species (perch), Size structure of key species (abundance of perch larger than 25 cm TL), Abundance of key functional groups (piscivores), and Size structure in the fish community (abundance of piscivores larger than 30 cm), as reliable data from the commercial fishery are only available for a few targeted commercial species.

Table 3. *Overview of the indicators suggested within the MSFD (SWaM 2012) assessed in this study, and their representatives in the gillnet monitoring and commercial fishery data.*

Indicator in MSFD	**Indicator used in this report**	**Indicator based on gillnet monitoring data**	**Indicator based on commercial fishery data**
Abundance of key species	Abundance of perch	*Abundance of perch* (CPUE of perch)	*Landings of perch, CPUE of perch*
Size structure of key species	Abundance of large perch	*Abundance of large perch* (CPUE of perch > 25 cm)	*Landings of perch, CPUE of perch*
Abundance of key functional groups	Abundance of piscivores	*Abundance of piscivores* (CPUE of piscivores)	*Landings of piscivores, CPUE of piscivores*
Size structure of fish community	Abundance of large piscivores	*Abundance of large piscivores* (CPUE of piscivores > 30 cm)	*Landings of piscivores, CPUE of piscivores*

2.4 Analyses

To assess the match between data from the coastal fish monitoring programs and commercial catch statistics three types of analyses were performed:

1) correlations between the two data sources *including all* monitoring areas and corresponding ICES rectangles across all years

2) correlations between the two data sources *within* each monitoring area and corresponding ICES rectangle

3) the match between the outcome of status assessment (GES or subGES) across data sources in each monitoring area and corresponding ICES rectangle.

2.4.1 Correlations across all areas and years

To perform this analysis, for each indicator, a correlation between the annual values based on the two sources of data (Table 3) was analysed for all years and areas. Hence, a separate correlation analysis was performed e.g. between Abundance of perch based on gillnet monitoring data and Landings of perch and CPUE of perch as derived from commercial fishery data. Prior to analyses, all data were z-transformed (i.e. mean = 0, standard deviation ±1) within each of the areas/ICES rectangles. We assessed the strenght of the correlations on the correlation coeffcient, R, and the associated p-values using the BRODGAR software.

2.4.2 Strength of correlations within areas

To further assess the match between the two data sources, corresponding correlation between each pair of indicators was defined within each monitoring area - ICES rectangle pair (Tables 2 and 3). The strength of the correlation was assessed as the correlation coefficient, R, using ln transformed data for both data types.

2.4.3 Assessment of environmental status

The third analysis performed was to compare assessments of environmental status as dervied from the two sources of data. The proposed approach for an indicator-based assessment of the status of coastal fish communities is to either evaluate the deviation from a reference period (data covering > 15 years), or by using a trend-based approach (data covering <15 years; Bergström & Olsson 2014). In this study, the data usually covered 12-15 years in the gillnet monitoring program, and the trend-based approach was hence used. In this approach, good environmental status (GES; Olsson et al., unpublished) is achieved when the slope of the correlation over time for the indicators evaluated in this report are not negative (at $p < 0.1$). As such, we calculated the slope of the indicators derived from the two sources of data, and compared their coherence. This analysis is hence the least sensitive of the three used to assess the match between the data sources in this report in only comparing the slope of the temporal development between data sources.

3 Results and discussion

3.1 Species targeted in the coastal fishery

The major target species in the coastal commercial gillnet fishery along the Swedish east coast are cod and herring (*Clupea harengus,* Figure 2). When excluding these two species, focusing on the species that exclusively are targeted by the small-scale coastal fishery, the main target species are whitefish (*Coregonus maraena*), perch and flounder (*Platichthys flesus*). The importance of the species varies across regions, and in the Gulf of Bothnia the main target species are herring, whitefish and perch, whereas in the Baltic Proper cod, herring and flounder are of increasing importance.

In the fisheries independent coastal gillnet monitoring program, species of a freshwater origin such as perch and carp fishes, are dominating the catches. According to the logbooks of the commercial fishery, carp fishes such as roach (*Rutilus rutilus*) and breams (*Abramis spp.*) are rarely reported, since these species are of low commercial value in Sweden. Indicators addressing aspects of the structure of the fish community that includes non-commercial species can hence not be derived from this source of data. Moreover, despite that whitefish and flounder are species targeted in the commercial fishery, they are, together with other cold-water species, underrepresented in the gillnet monitoring programs. This limits the comparisons of the catches of the two species in the data sources assessed in this report. Furthermore, as highlighted previously perch comprise the ablsoute majority of pisciovres in the monitoring catches. This limits the potential for coherence of the piscivore indicators across data sources.

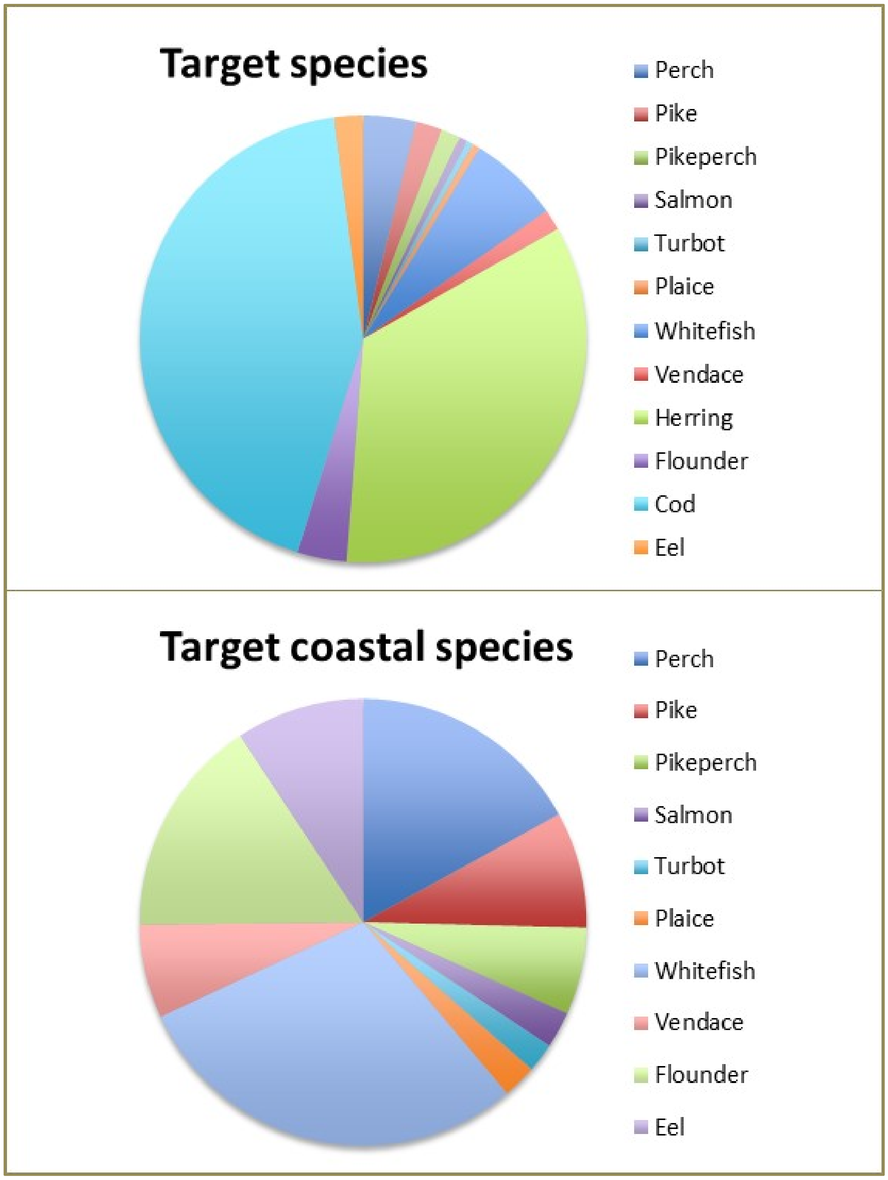
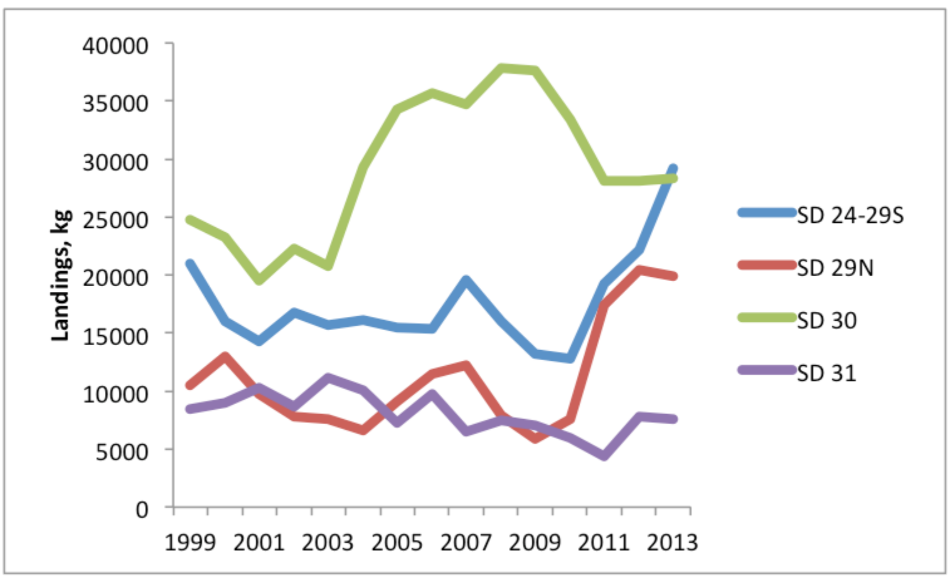


Figure 2. Share of total landings across species in the gillnet fishery along the Swedish Baltic Sea coast during 1994-2013. The most common species are displayed in the top panel, whereas the most common species excluding cod and herring are showed in the bottom panel.

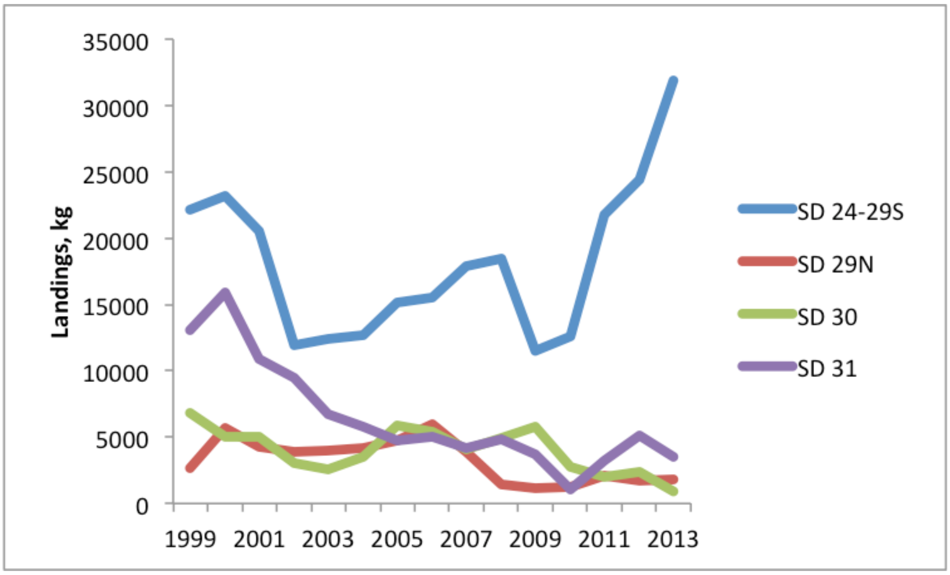
The landings over time for the four piscivorous fish species mainly targeted in the commercial fishery using gillnets are presented in figure 3. The landings of perch has been stable or slightly increasing since 1999 for the three southernmost subdivisions, but have decreased in the Bothnian Bay (Figure 3a). For pike there is a decreasing trend over time in the Åland Sea, Bothnian Sea and Bothnian Bay, whereas in the Baltic Proper the landings have been the highest during the three most recent years (Figure 3b). Pikeperch is only targeted in the Bothnian Sea, Åland Sea and Baltic Proper. In both the Bothnian Sea and Åland Sea the landings have varied across years, but in the Baltic Proper there has been a decreasing trend over time (Figure 3c). Cod is almost exclusively caught in the Baltic Proper, and decreasing landings are seen in all subdivisions (Figure 3d).

In conclusion, the size of the landings of the species varies across regions, as does the temporal development of the landings. Perch is mainly caught in the Bothnian Sea and Baltic Proper, and pike in the Baltic Proper. The landings of pikeperch are higher in the southern and middle parts of the Swedish Baltic coast, whereas cod is almost exclusively caught in the Baltic Proper. Whereas the landings of perch has been rather stable between the years 1999-2013, there has been sharp decreases in some regions for pike, pikeperch and cod. This likely reflects a combination of changes in stock abundances (mainly cod and pikeperch), decreased commercial value of the species (pike), and a decrease in the number of fishermen and hence fishing effort (all species).

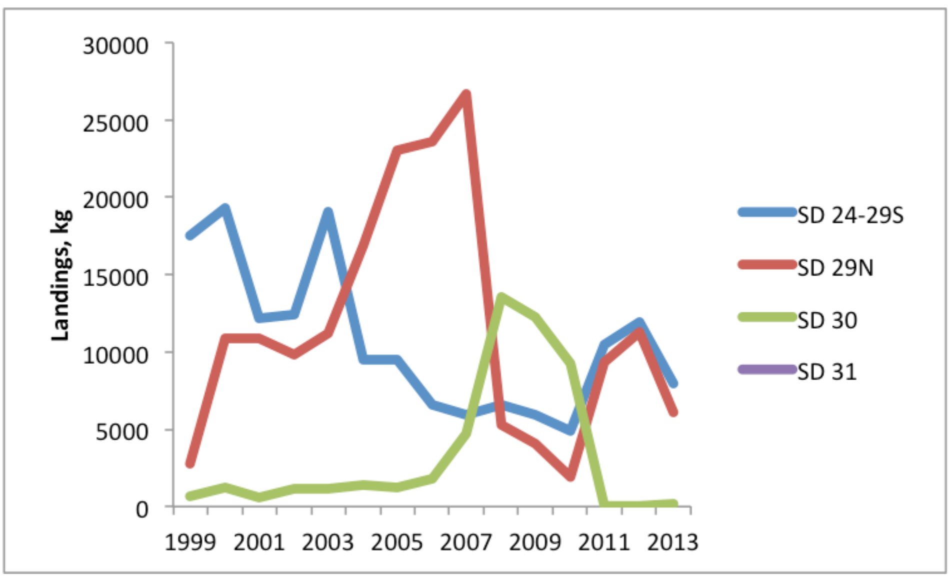
A)



B)


Landings, kg
35000
30000
25000
20000
15000
10000
5000
0
1999
2001
2003
2005
2007
2009
2011
2013
SD 24-29S
SD 29N
SD 30
SD 31

C)


Landings, kg
30000
25000
20000
15000
10000
5000
0
1999
2001
2003
2005
2007
2009
2011
2013
SD 24-29S
SD 29N
SD 30
SD 31

D)

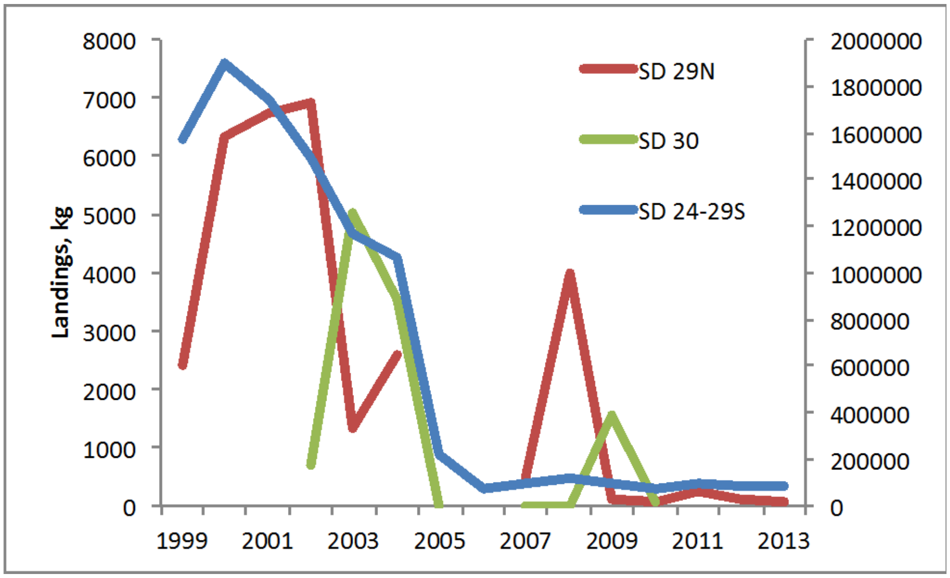


Figure 3. Landings (kg) of perch (A), pike (B), pikeperch (C) and cod (D) in the commercial coastal gillnet fishery divided into ICES subdivisions, SD24-29S (Baltic Proper), SD29N (Åland Sea), SD30 (Bothnian Sea) and SD31 (Bothnian Bay). For cod, landings in SD24-29S are given at the right y-axis.

3.2 Indicator development

The temporal development of the indicators assessed based on the both data sources is summarised in tables 4 and 5. A more detailed presentation is provided in the Appendix. In the majority of areas considered the landings and CPUE of perch in the commercial fishery has been stable or increasing (Table 4), and only in Lagnö (CPUE since 2002) a significant decrease is observed. There was a rather good concordance between perch landings and perch CPUE in nine of 12 comparisons, suggesting that the CPUE estimates provides some additional information about the stock status than that given by landings alone.

In the gillnet monitoring data, a negative development is found in two of nine areas for the indicator *Abundance of perch*, and in one area for *Abundance of large perch*. Overall there was a good match in the temporal development be tween *Abundance of large perch* and commerical fishery data (9/12 comparisons for *CPUE of perch* and 8/12 comparisons for *Landings of perch*). For *Abundance* *of perch* the correspondence was lower (8/12 comparisons for *Landings of perch* and 5/12 comparisons for *CPUE of perch*).

Table 4. *The temporal development of the four indicators assessed for perch in the different ICES rectangles/monitoring areas (based on the Pearson correlation coefficient, R). Landings of perch and CPUE of perch are derived from commercial catches; whereas Abundance of perch and Abundance of large perch are derived from gillnet monitoring data. The gear assessed for the indicators in the commercial fishery is given in Table 1, and the details for each indicator are presented in the Appendix*

ICES rectangle	**Monitoring area**	**Gear type in gillnet monitoring**	***Landings of perch***	***CPUE of perch***	***Abundance of perch***	***Abundance of large perch***
6067	Råneå	Nordic nets	0.74**	0.68*	0.29	0.89***
5665	Holmön	Nordic nets	0.50	0.23	-0.27	0.03
5665	Holmön	Survey nets	-0.09	0.17	0.33	0.47
5665	Norrbyn	Nordic nets	0.50	0.23	-0.71**	-0.58*
5162	Långvindsfjärden	Nordic nets	0.34	0.35	-0.28	0.17
4963	Forsmark	Nordic nets	0.63*	0.90***	0.37	0.74**
4963	Forsmark	Survey nets	-0.10	0.79***	0.07	0.51*
4864	Lagnö	Nordic nets	-0.50	-0.81**	0.19	-0.56
4561	Kvädöfjärden	Nordic nets	0.05	0.12	-0.35	-0.09
4561	Kvädöfjärden	Net sets	0.22	-0.12	-0.24	0.20
4361	Vinö	Net sets	0.70**	0.42	-0.54*	0.02
4160	Torhamn	Nordic nets	0.94***	0.89***	-0.29	0.15

* equals a linear trend at $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

For the piscivore indicators, there have been decreasing landings over time in one area (Torhamn), increasing landings in one area (Råneå), and in the other areas stable landings (Table 5). For CPUE in the commercial fishery a decrease is observed in Lagnö. For all the other areas there have been increases or stable developments over the time period considered. There are striking differences in Torhamn with decreasing landings but increasing CPUE (Table 5). The decreasing landings are the result of a dominance of cod that has declined in the catches. The landings of perch and pike, the other two piscivores caught in this rectangle, have increased (perch) or been stable (pike). The increase in CPUE in the commercial fishery in Torhamn is the result of increasing CPUEs for both perch and pike. The CPUE of cod has, however, decreased over time.

In the gillnet monitoring data, *Abundance of piscivores* has been stable in all areas excluding Norrbyn and Vinö. For *Abundance of large piscivores* a negative development is only observed in Norrbyn, and a positive development in Råneå and Forsmark.

The match between *Landings of piscivores* and *CPUE of piscivores* in the commercial fishery data was lower than that for perch, suggesting that also for piscivores CPUE estimates provides additional information about the stock status compared to that of only landings data. There was a reasonable match between *Abundance of large piscivores* and the fishery data (8/12 comparisons for *Landings of piscivores*, and 6/12 comparisons for *CPUE of piscivores*), and for *Abundance of piscivores* (7/12 comparisons for *CPUE of piscivores* and 7/12 comparisons for *Landings of piscivores*).

Table 5. *The temporal development of the four indicators assessed for piscivores in the different ICES rectangles/monitoring areas (based on the Pearson correlation coefficient, R). Landings of piscivores and CPUE of piscivores are derived from commercial catches, whereas Abundance of piscivores and Abundance of large piscivores are derived from gillnet monitoring data. The gear assessed for the indicators in the commercial fishery is given in Table 1, and the details for each indicator are presented in the Appendix.*

ICES rectangle	**Monitoring area**	**Gear type gill-net monitoring**	***Landings of piscivores***	***CPUE of piscivores***	***Abundance of piscivores***	***Abundance of large piscivores***
6067	Råneå	Nordic nets	0.71*	0.43	0.29	0.85**
5665	Holmön	Nordic nets	0.49	0.23	-0.27	0.16
5665	Holmön	Survey nets	-0.09	0.17	0.33	0.14
5665	Norrbyn	Nordic nets	0.50	0.23	-0.71**	0.47
5162	Långvindsfjärden	Nordic nets	0.35	0.34	-0.29	-0.75**
4963	Forsmark	Nordic nets	-0.56	-0.74**	0.33	-0.14
4963	Forsmark	Survey nets	-0.39	-0.01	-0.04	0.20
4864	Lagnö	Nordic nets	-0.51	-0.81**	0.19	-0.58
4561	Kvädöfjärden	Nordic nets	0.02	-0.17	-0.31	0.19
4561	Kvädöfjärden	Net sets	0.01	-0.26	-0.20	0.67**
4361	Vinö	Net sets	0.55*	0.38	-0.55*	-0.50
4160	Torhamn	Nordic nets	-0.62*	0.63*	-0.29	0.28

* equals a linear trend at $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In four of the areas (Holmön, Norrbyn, Långvind and Lagnö) perch is almost exclusively the only piscivorous species caught in the commercial fishery (see Appendix), whereas in three other areas (Råneå, Forsmark and Kvädöfjärden) also pike (all three areas), pikeperch (Forsmark and Kvädöfjärden) and burbot (Råneå and Forsmark) are caught. In two of the southernmost areas

(Kvädöfjärden and Torhamn) also cod and turbot were caught, and in Torhamn cod dominated the catches. In all areas but two, the piscivorous fish species targeted are caught using some sort of gillnets. In Råneå and Långvind, perch is also caught using traps. There are hence differences across the areas in piscivorous species targeted by the commercial fishery, although perch is represented in all areas. That perch comprise the absolute majority of the piscivores in the monitoring catches hence is likely explains the slightly worse match between the piscivore indicators compared to the perch indicators.

3.3 Correlations across all areas and years

The analyses over all the data (all areas-ICES rectangles and years) showed that there were weak but significant correlations between *Abundance of perch* as derived from fishery independent monitoring data (Nordic nets) and *Landings of perch* in the commercial fishery (R^2 = 0.05, p = 0.023; Figure 4), and between *Abundance of perch* and *CPUE of perch* (R^2 = 0.06, p = 0.028; Figure 4).

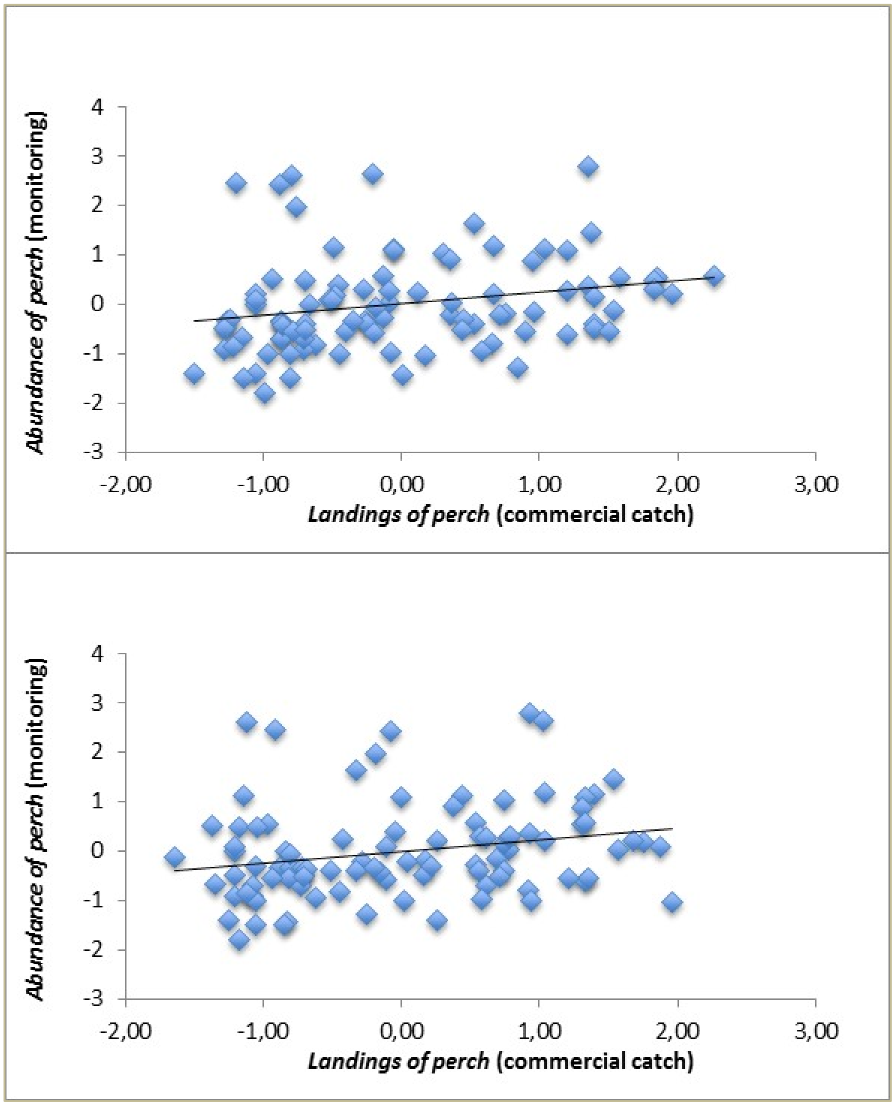


Figure 4. Correlations between *Abundance of perch* from fishery independent gillnet monitoring and (top) *Landings of perch* in the commercial fishery and (bottom) *CPUE of perch* in the commercial fishery. The correlations were based on z-transformed values from each area and year.

The correlations between monitoring data and commercial catch data were stronger for the indicator *Abundance of large perch* (Figure 5). For *Landings of perch* the correlation had a $R^2 = 0.13$ ($p < 0.001$), and for *CPUE of perch* $R^2 = 0.19$ ($p < 0.001$).

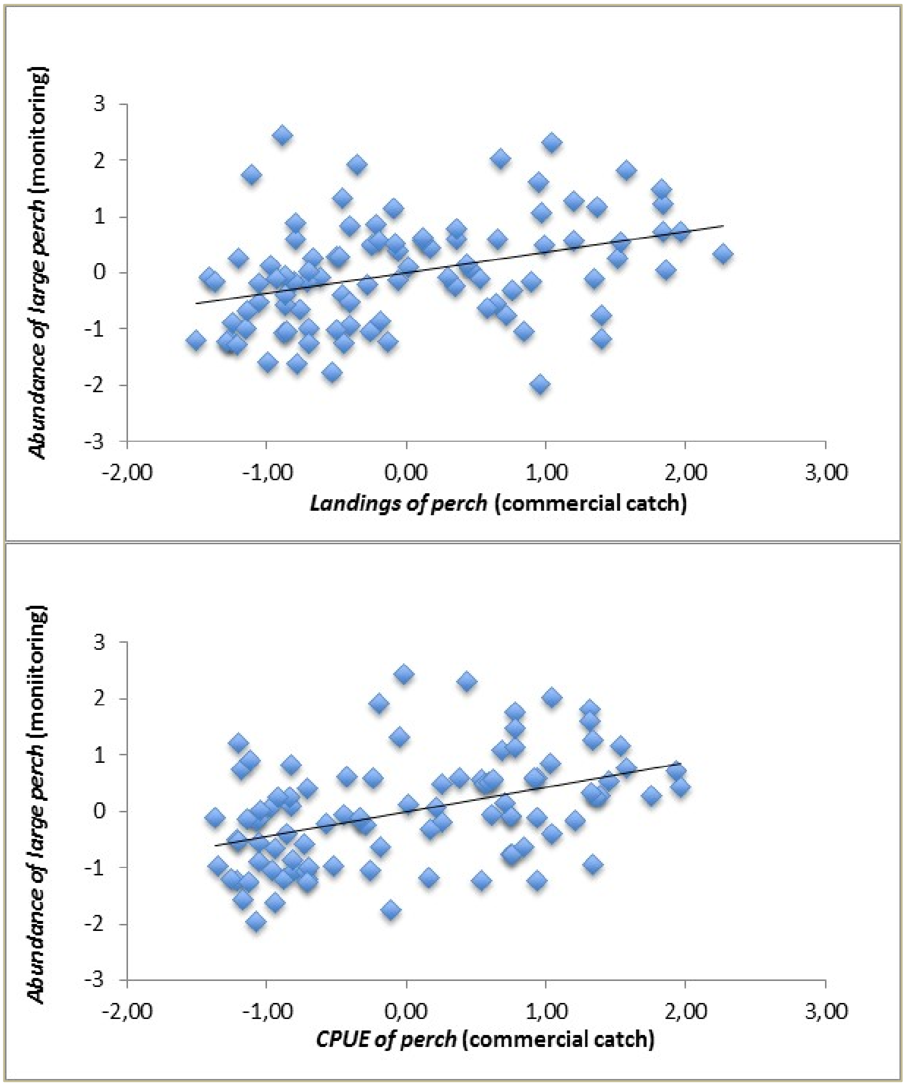


Figure 5. Correlation between *Abundance of large perch* from fishery independent gillnet monitoring and (top) *Landings of perch* in the commercial fishery and (bottom) *CPUE of perch* in the commercial fishery. The correlations were based on z-transformed values from each area and year.

For the indicators related to the abundance of piscivores the correlations with the commercial catch data was rather weak. *The Abundance of piscivores* exhibited a slightly higher correlation with *Landings of piscivores* (R^2 = 0.05, p = 0.034) than with *CPUE of piscivores* (R^2 = 0.03, p = 0.098), whereas the *Abundance of large piscivores* exhibited the highest correlation with *CPUE of piscivores* (R^2 =

0.05, p = 0.027 for *Landings of piscivores*, and $R^2 = 0.07$, $p < 0.01$ for *CPUE of piscivores*).

When performing the same analysis only using data from the four areas monitored using coastal survey nets and net series, the match between the indicators from the two sources of data was even poorer than for the Nordic nets (results not shown).

In all, the only reasonable match in this analysis was found between the *Abundance of large perch* and *CPUE of perch* in the commercial fishery ($R^2 = 0.19$). For the other indicators there was a low degree of correlation.

3.4 Strength of correlations within areas

When assessing the degree of the correlation between indicators derived from the two sources of data within (untransformed data) instead of across areas as above, there was a substantial variation across areas and indicators for the Nordic nets (Figure 6). For *Abundance of perch* (monitoring data) the mean R-value was 0.28 when related to *Landings of perch*, and 0.26 when related to *CPUE of perch* with a highest correlation of 0.72 and the lowest of 0.03 (both with *Landings of perch*). For *Abundance of large perch* the highest correlation across all comparisons was observed (0.39 with *Landings of perch* and 0.43 with *CPUE of perch*), but also here there was a substantial variation across areas (highest value = 0.69, with *CPUE of perch*, and lowest value = 0.07, with *Landings of perch*; Figure 6). The mean R-values for *Abundance of piscivores* and *Abundance of large piscivores* were comparable to those obtained for *Abundance of perch* (*Abundance of piscivores : Landings of piscivores* = 0.25 : *CPUE of piscivores* = 0.20; *Abundance of large piscivores* : *Landings of piscivores* = 0.24 : *CPUE of piscivores* = 0.28), with substantial variation across areas (Figure 6). In some areas, the correlation was even negative, suggesting that a contradictive message is conveyed by the different sources of data.

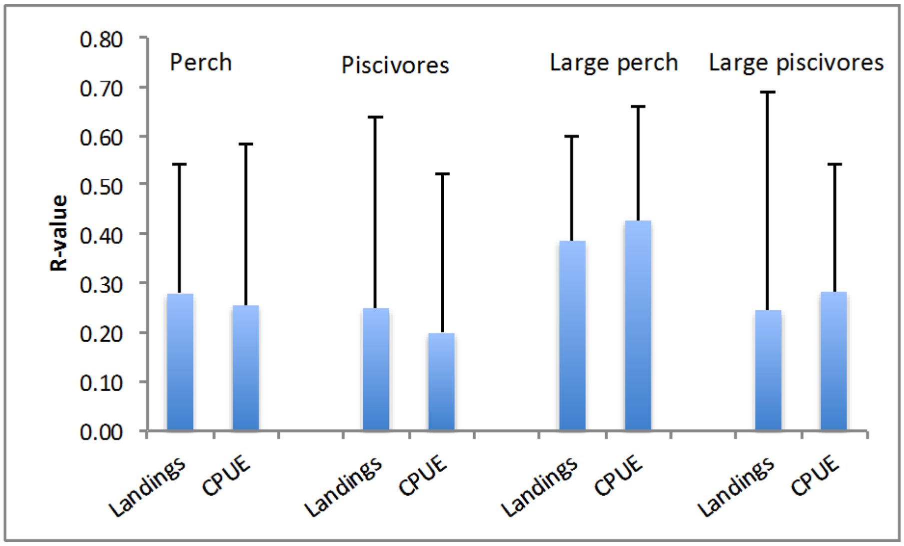


Figure 6. Correlations (mean R-values and standard deviation) between the indicators obtained from the two data sources within each monitoring area/ICES rectangle. Perch = Abundance of perch, Piscivores = Abundance of piscivores, Large perch = Abundance of large perch, and Large piscivores = Abundance of large piscivores.

To further address whether there were some differences in the correspondence with the commercial catch data across gear types used in monitoring, data for the three areas in which parallel gears are used was selected (Holmön, Forsmark and Kvädöfjärden). For *Abundance of perch* and *Abundance of large piscivores* there was always a better match between indicators from the two data sources (monitoring and commercial catch statistics) when derived from the Nordic nets (Figure 7). For the *Abundance of piscivores* the best match was obtained when data was dervied from the coastal survey nets/net series. The indicator *Abundance of large perch* exhibited the highest correlation with respect to landings for coastal survey nets and net series, and for *CPUE of perch* with the Nordic nets (Figure 7). The variation across areas in the strength of the correlations varied substantially making the differences across gear types rather weak. This is likely the result of the proportion of perch in the commercial catches and differences in what species that were included in the piscivore indicators.

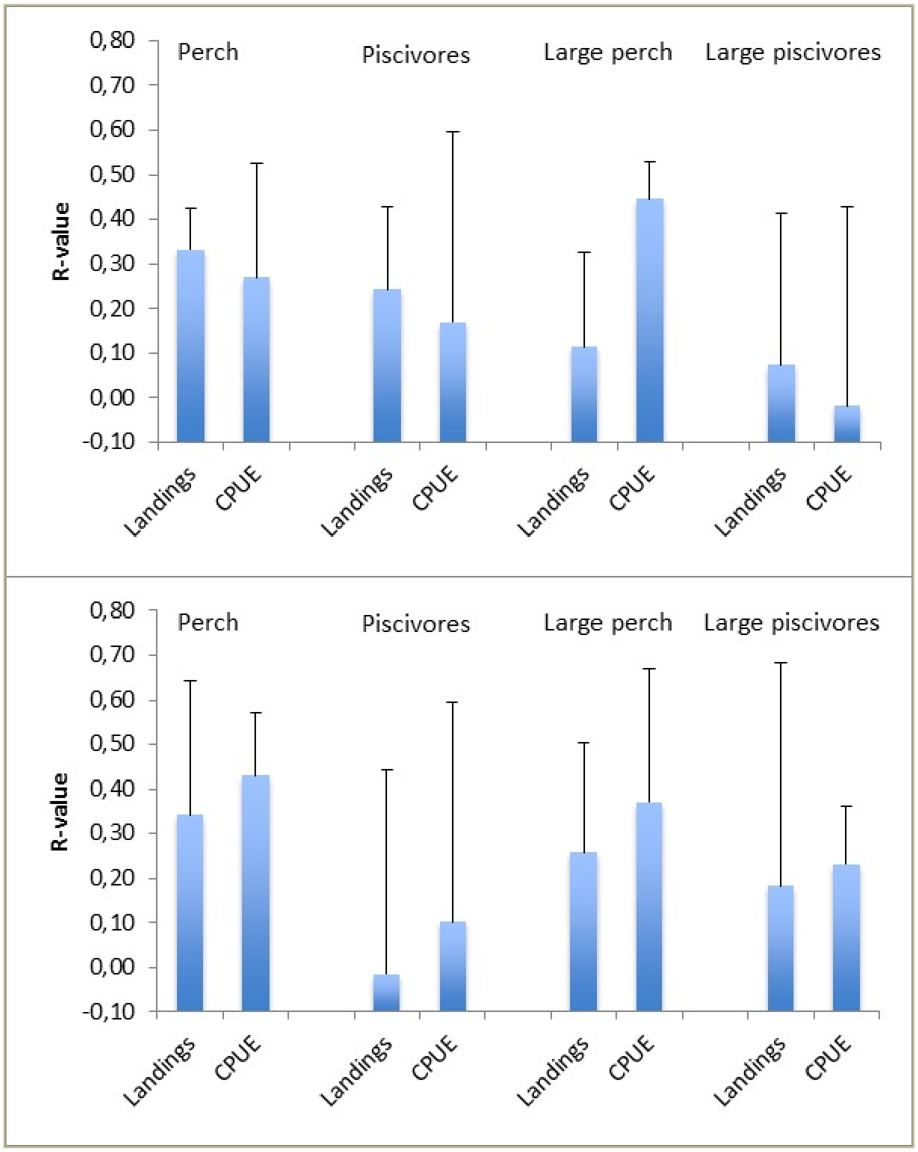


Figure 7. Correlations (mean R-values and standard deviation) between the indicators obtained from the two data sources within the Holmön, Forsmark and Kvädöfjärden monitoring area/ICES rectangles. The top panel represents coastal survey nets and sets of nets, and the lower panel represents Nordic nets. Perch = *Abundance of perch*, Piscivores = *Abundance of piscivores*, Large perch = *Abundance of large perch*, and Large piscivores = *Abundance of large piscivores.*

Since the commercial catch data potentially holds errors with respect to correctly registered catch and effort data, we also performed the correlations as described above using a filtered data set for the commercial catch data. In this data set all observations were included and a z-value for each of the CPUE observations was calculated. Following this, the observations having an absolute z-value > 2 was removed. The data set used in these analyses only covered the years 1994-2010, and was only performed for the indicators *Abundance of perch* and *Abundance of large perch*. In two of the in total eight areas assessed, the match of the indicators between monitoring data and commercial catch data was improved when using this filtered data set. In one area, however, the match was poorer when using the filtered data, and in five areas there was no change in the strength of the match.

3.5 Assessment of environmental status

The third approach undertaken to analyse the concordance between the two data sources, was to assess the environmental status (ES, either GES or subGES) within each monitoring area and ICES rectangle. ES was derived by assessing the slope (at $p < 0.1$) of the temporal development of indicators from the two sources of data.

For perch, the assessment of ES did only depart in one (Lagnö) of the eight comparisons with respect to the indicators *Abundance of perch* (monitoring data from Nordic nets) and *CPUE of perch* (commercial fishery data, Table 6). For the comparison with *Landings of perch* (commercial fishery data), a different ES was observed in three comparisons. For the coastal survey nets and net series corresponding figures were one of four departing comparisons for *CPUE of perch*, and three of four departing comparisons for *Landings of perch*.

For large perch, ES departed in two areas (Lagnö and Kvädöfjärden as well as Holmön and Lagnö, respectively; Table 6) with respect to *Abundance of large perch* (monitoring data from Nordic nets) and *Landings of perch* as well as to *CPUE of perch* (both commercial fishery data). For the coastal survey nets and net series, ES did not differ with respect to *CPUE of perch* in any comparison, but in two comparisons for *Landings of perch*.

Table 6. *Assessments of environmental status using the data from gillnet monitoring (Abundance of perch and Abundance of large perch) and commercial catch statistics (Landings of perch and CPUE of perch) for indicators related to the abundance of perch. GES denotes Good environmental status, and subGES represent an undesirable state. Shaded cells indicate divergent ES across data sources.*

	Gillnet monitoring	**Commercial fishery**		**Gillnet monitoring**	**Commercial fishery**	
Area	*Abundance of perch*	*Landings*	*CPUE*	*Abundance of large perch*	*Landings*	*CPUE*
Nordic nets						
Råneå	GES	GES	GES	GES	GES	GES
Holmön	GES	subGES	GES	GES	subGES	GES
Norrbyn	subGES	subGES	subGES	subGES	subGES	subGES
Långvind	GES	GES	GES	GES	GES	GES
Forsmark	GES	GES	GES	GES	GES	GES
Lagnö	GES	subGES	subGES	GES	subGES	subGES
Kvädö	subGES	GES	subGES	GES	GES	subGES
Torhamn	GES	GES	GES	GES	GES	GES
Coastal survey nets/net series						
Holmön	GES	subGES	GES	GES	subGES	GES
Forsmark	GES	GES	GES	GES	GES	GES
Kvädö	subGES	GES	GES	GES	GES	GES
Vinö	subGES	GES	subGES	subGES	GES	subGES

For the piscivore indicators, the match of ES across data sources was somewhat poorer compared to the perch related indicators (Table 7). For the *Abundance of piscivores* as derived from gillnet monitoring (Nordic nets), ES departed in three comparisons with respect to *Landings of piscivores* (commercial fishery data) and in two cases with respect to *CPUE of piscivores* (commercial fishery data). For coastal survey nets and net series departing ES was observed in three comparisons for *Landings of piscivores* and in one case for *CPUE of piscivores.*

Concerning large piscivores, the *Abundance of large piscivores* (gillnet monitoring, Nordic nets) was the only indicator exhibiting a better match with landings in the commercial fishery compared to CPUE estimates. Departing ES were observed in four (*CPUE of piscivores*) and three (*Landings of piscivores*) comparisons respectively. For coastal survey nets and net series the match in ES was identical to that of *Abundance of large perch* with respect to *Landings of piscivores*, whereas no departing ES was observed for *CPUE of pis*civores.

To summarize, the results of this analysis suggest that there is a rather good match of environmental status assessments results for the indicators *Abundance of perch*, *Abundance of large perch* and *Abundance of piscivores* (all derived from gillnet monitoring data), and corresponding CPUE estimates from the commercial fishery data. The concordance of ES in the four areas monitored using coastal survey nets and net series was generally poorer with respect to data on landings in the commercial fishery.

Table 7. *Assessment of environmental status using the data from gillnet monitoring (Abundance of piscivores and Abundance of large piscivores) and commercial catch statistics (Landings of piscivores and CPUE of piscivores) for indicators related to the abundance of piscivores. GES denotes Good environmental status, and subGES represent an undesirable state. Shaded cells indicate divergent assessments across data sources.*

	Gillnet monitoring	**Commercial fishery**		**Gillnet monitoring**	**Commercial fishery**	
Area	*Abundance of piscivores*	*Landings*	*CPUE*	*Abundance of large piscivores*	*Landings*	*CPUE*
Nordic nets						
Råneå	GES	GES	GES	GES	GES	GES
Holmön	GES	subGES	GES	GES	subGES	GES
Norrbyn	subGES	subGES	subGES	GES	subGES	subGES
Långvind	GES	GES	GES	subGES	GES	GES
Forsmark	GES	GES	subGES	GES	GES	subGES
Lagnö	GES	subGES	subGES	subGES	subGES	subGES
Kvädö	subGES	GES	subGES	GES	GES	subGES
Torhamn	GES	GES	GES	GES	GES	GES
Coastal survey nets/net series						
Holmön	GES	subGES	GES	GES	subGES	GES
Forsmark	GES	GES	GES	GES	GES	GES
Kvädö	subGES	GES	GES	GES	GES	GES
Vinö	subGES	GES	subGES	subGES	GES	subGES

4 Summary and conclusions

The small-scale commercial coastal fishery using passive gears, as different types of gillnets, along the Swedish Baltic Sea coast resembles the offshore fishery in mainly targeting cod and herring. The relative importance of the species in the coastal fishery does, however, change with latitude. Herring is becoming increasingly important in the northern parts whereas cod shows the opposite pattern. Among the fish species exclusively targeted in the coastal fishery, whitefish, perch and flounder dominates the catches. Perch and whitefish is mainly landed in the northern and flounder in the southern coastal areas. Species from the carp family are usually abundant in coastal areas (HELCOM 2012), and represent an important part of coastal fish communities in the Baltic Sea (HELCOM 2013). These species are, however, not targeted by the small-scale coastal fishery in Sweden, likely due to a very limited market. The use of data from the coastal commercial fishery in Sweden for indicator development and status assessments is hence confined to a few target species of commercial value. The data can hence in its current form not be used for information on the size structure in the community and for asssessing the status of important functional groups of fish of non-commercial value as cyprinids.

In general, the landings of perch, pike, pikeperch and cod in the commercial fishery have varied over time and across basins. Since the late 1990s the landings of perch have been stable or slightly increasing for the three southernmost subdivisions in the Baltic Sea, but have decreased in Bothnian Bay. For pike, decreasing trends over time is observed for the Åland Sea, Bothnian Sea and Bothnian Bay. Interestingly, the landings of pike during the three most recent years in the Baltic Proper have been the highest observed during the time-period studied. This is promising since earlier studies have reported drastic declines in the stocks of pike in this region (Ljunggren et al. 2010). Pikeperch is landed only in the Bothnian Sea, Åland Sea and Baltic Proper, and in the Baltic Proper a change over time with declining landings is observed. The landings of cod, which is almost exclusively caught in the Baltic Proper, have decreased in all sub-basins since the late 1990s. The size and change over time in landings for these species in the commercial fishery is influenced by a range of factors including changes in fishing regulations, the market value of the fish, and the number of fishermen. A change over time in the landings does as a result not neccessary reflect a change in the stock status. Of the four species analysed here, cod is the only one with national quotas. The quotas for cod have changed over the study period, as have the stock status (ICES 2014), something influencing the size of the landings over time. For perch, pike and pikeperch the market value have been rather stable, but the number of fishermen have decreased over the study period (http://www.miljomal.se/Miljomalen/Alla-indikatorer/Indikatorsida/?iid=219&pl=1).

The match between indicators derived from the two sources of data was generally poor when comparing all data across all areas in one analysis. This is not surprising given the differences in the gear and fishing methods used across data sources, as well as the local stock structure of the species assessed. In the fisheries independent gillnet monitoring programs, a multi-mesh gillnet with mesh sizes down to 10 mm is used, hence catching individuals of a wide size spectrum in the targeted fish communities (HELCOM 2015). Monitoring is also undertaken during one week in August and fixed stations are repeatedly fished over years. In the commercial fishery as a contrast, only gillnets of larger mesh sizes (40-60 mm) are used, targeting mainly fish over 20 cm and those species of a commercial value. Fishing is also undertaken all year around, and the locations likely change depending on season and the fish abundance. Hence, since there are differences in activity and migration patterns of the typical coastal fish species, the two data sources are hence not directly comparable. Moreover, the spatial overlap between gillnet monitoring stations and the locations for the commercial fishery might be poor. Since coastal fish populations are local in their appearance (Saulamo & Neumann 2002), the two sources of data might to some extent target different segments of the coastal fish communities. To that end, commercial fishermen try to focus their fishing effort to sites where the targeted species are abundant (i.e. hot-spots). Status assessments based on commercial catch data is hence rather insensitive to local changes in the status of the targeted stocks since a change in population and stock status is most likely to first be manifested at marginal areas of the distribution of the population (Lawton 1994).

The overall match between the two sources of data was improved when assessing correlations within areas. In some areas (i.e. the pairs of sampling sites and the corresponding ICES rectangles) the concordance (R-value) between indicators derived from the two sources of data was as high as 0.7. In others, however, there was a negative correlation between indicators. In spite of the large differences across rectangles, the best match was again obtained for *Abundance of large perch*. For the different gear types used in fisheries independent monitoring, there seems to be a slightly better match for the Nordic nets. This is likely explained by that the mesh sizes of this specific gear capture larger fish better than the other two fishery independent monitoring gears currently used.

Despite the differences in fishing methods and potential mismatch in spatial overlap between the two data sources, we found a rather good match for the indicators representing abundance of large perch. This might not come as a surprise since perch above 20-25 cm is within the target size for the commercial fishery. This suggests that data from the coastal fishery could be used at least for assessing the status of large perch in coastal areas. Information of the status of large perch is of key importance since large predatory fish species, as perch, have been proven to be significant for ecosystem functioning in controlling lower trophic levels (Eriksson et al. 2009, 2011). In areas with weak stocks of large predatory fish, mesopredatory fish are released from predation and occur in high numbers in turn promoting blooms of ephemeral algae (i.e. promotion of eutrophication symptoms) via a trophic cascade (Eriksson et al. 2011).

When assessing the environmental status (based only on the slope of the indicator) within rectangles across the two data sets, there was a rather good match for the two perch related indicators. The indicator *Abundance of perch* did, however, exhibit a slightly better match than that of *Abundance of large perch*. For the piscivore related indicators the match was somewhat poorer, but there seems to be a slightly better concordance between the data sources for *Abundance of piscivores* compared to *Abundance of large piscivores*. That the perch related indicators exhibited a better concordance, is likely explained by differences in species included in the piscivore related indicators across data sources. In the gillnet monitoring for example, perch is the dominating piscivore, whereas in the commercial fishery data also pike, pikeperch, burbot and to some extent turbot and cod are included. The better match of ES compared to the other two approaches in this report is not surprising, since this approach is much coarser. In only comparing whether the slopes of regressions over time in the different data sets is significant or not, any two slopes could be different but still on the same side of the significance level. The other two approaches instead assess the strength of the correlation between data sets. In all, the results presented in this report suggest that CPUE estimates from the small-scale commercial fishery could potentially serve as a complement to fisheries independent monitoring for assessing the environmental status as required within the Marine Strategy Framework Directive in the Baltic Sea (European Commission, 2008). With the exception for the *Abundance of large perch*, the potential for more detailed assessments is, however, substantially lower.

Both types of data assessed in this report have their pros and cons. As highlighted above, the commercial fishery has a superior effort and a wider coverage over the year. The spatial coverage of the commercial fishery is also much more extensive and dynamic compared to gillnet monitoring. Moreover, important coastal species such as pike, whitefish, cod, flounder and turbot are not sampled representatively in the current coastal fish monitoring program. If proven trustful, however, data for these species from the commercial coastal fishery could hence be of use in future assessments.

The data collected in the commercial fishery is at a low cost in comparison to fishery independent surveys, since every commercial coastal fisherman is obliged to report his or hers catches and efforts. One important aspect here is, however, that the number of coastal fishermen in Sweden is constantly decreasing as a result of low recruitment of young fishermen and low profitability in the sector. As such, the future of the data collected in the commercial fishery is hence far from secured and highly dependent on the willingness of younger people to engage in the sector. Disadvantages with commercial catch data include an exclusive focus on species of a commercial value, a sometimes questionable reliability of data (e.g. misreporting), opportunistic fishing strategies that are not conservative in space and change over time with invention of novel gears and methods, and a lack of monitoring of size structure of targeted species (Wise et al. 2012). As such, reliable data for the fish community composition and its size structure, which are standard parameters in fisheries independent surveys, are not collected. Many coastal species are also by-catch species in other fisheries, and the low number of fish caught leads to a lowered confidence of the status of the species.

There are, however, several potential means by which the quality and reliability of the data collected within the commercial fishery could be increased. One crucial aspect here is to increase the quality of the data that is reported. This includes both the qulaity of the actual catches per species and the geographic positioning of the catches. Foremost, however, an improved quality and resolution of the fishing effort is needed. Today each commercial fishing vessel are only required to register the number of net meters and days when fishing. This is not a very detailed measure of effort, since the number of hours that a net is in the water greatly affects the catches in the net. For example, the increased abundance of seals in the Baltic Sea has lead to an elevated conflict between fishermen and seals (Havs- och Vattenmyndigheten 2014). Many fishermen along the Bothnian Sea and Bothnian Bay coast have hence due to increased disturbances during fishing from seals, completely changed their fishing strategy. Instead of setting the nets at night and lifting them the next day, many fishermen nowadays only leave the nets in the water for a couple of hours. Independent of whether the nets are in the water for a few hours or for a full night, the current smallest unit for effort reporting is one day. Furthermore, the catches that are registered today most likely only includes the fish that is sold. The catch used for personal consumption as well as the catch that is released/thrown back to sea is for example seldom registered. The true and the registered catch hence do not necessary always match. This is a problem that most likely is more pronounced for species with lower commercial value such as pike and flounder.

One way to make more efficient use of the data collected is to improve fishermen sampling. Today suggestions on methods and tools for how to facilitate this is a growing and developing field. In Sweden, a first step would be to contract a number of focal fishermen along different parts of the coast for a more detailed reporting of their catches and efforts. The detailed reporting should include registration of the whole catch (including by-catch of fish of undersized focal species and species of non-commercial value), registration of size (lenght) for a a subsample of the individuals in the catch, subsampling for age analysis, as well as a higher resolution of the fishing effort and fishing location. Such a program would be of substantial significance especially for those species that are not representatively sampled by the current fishery independent gillnet monitoring program. This set-up also likely offers a cost-efficient complement to the current coastal fish monitoring program. A similar approach has been used locally in Sweden by the former Swedish Board of Fisheries and is used in Sweden and other countries within the Data Collection Framework for certain species. In Denmark, a similar program is undertaken, where recreational fishermen are instructed to collect data on coastal fish communities (Kristensen et al. 2014). This procedure has been used locally at a small scale also in Sweden to collect data on pike (the ”*Pikereg*” project). A tighter and closer cooperation regarding data collection and status assessments between commercial fisheries, researchers and authorities would favour all three parties, and is something that is requested by the European commission via the European Fisheries Fund (EC 1198/2006). Finally, the majority of the landings of coastal fish along the Swedish Baltic Sea coast are taken by the recreational fishery sector. For most species between 50-90 % of the total landings are taken by the recreational fishery (Karlsson et al 2014). In order to obtain a sounder estimate of the status of coastal fish, better information and registration of the catches and efforts of the recreational fishery sector is hence needed. Especially so for species that are of great importance for the recreational fishery such as whitefish, pike, pikeperch and perch.

5 Acknowledgements

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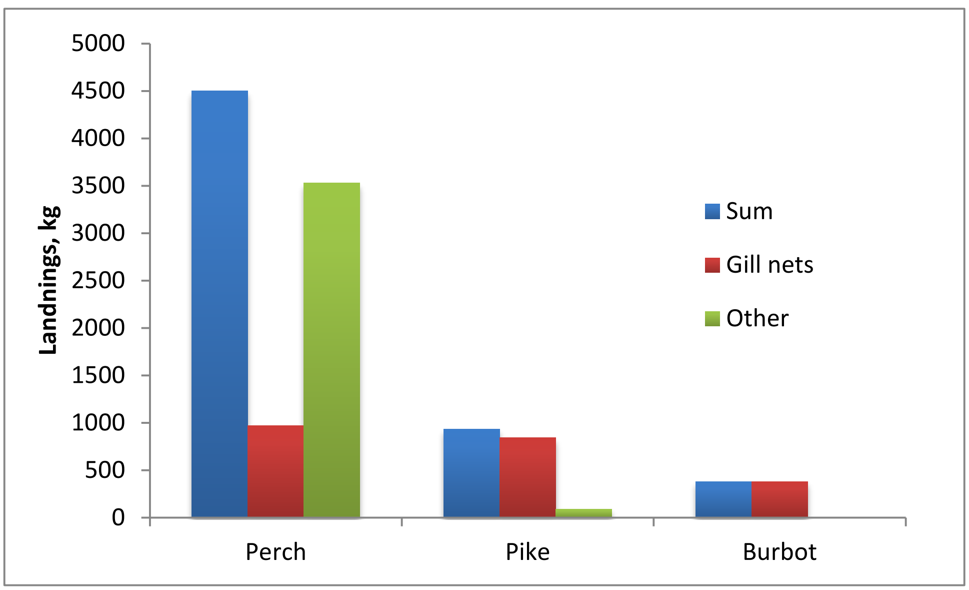
7 Appendix

In this appendix a summary of the catches in the commercial fishery and in the gillnet monitoring of perch and other piscivores in the different monitoring areas and corresponding ICES rectangles are presented. The data covers the years 2002-2013. In the bar charts the summed landings per species are and gears for the years 2011-2013 are presented. Only the data for Nordics nets are displayed, and only data for the gear selected in the commercial fishery are displayed in the figures describing the development over time (see table 1).

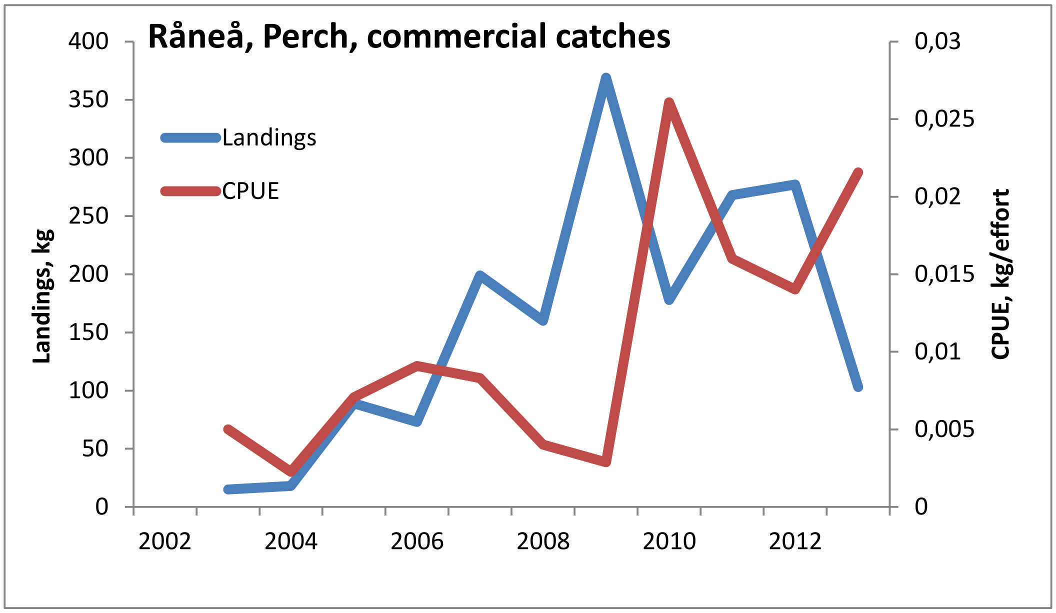
7.1 Råneå (ICES rectangle 6067)

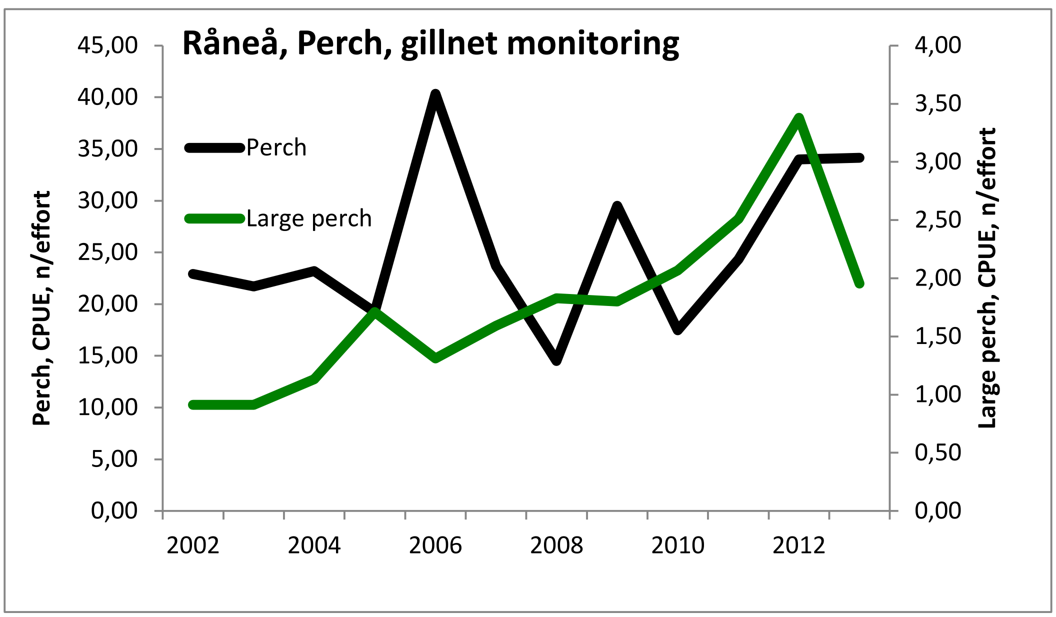
In Råneå, three piscivorous species are caught in the fishery, perch, pike and burbot.



The largest catches are found in gears other than gill net, mainly different types of traps.

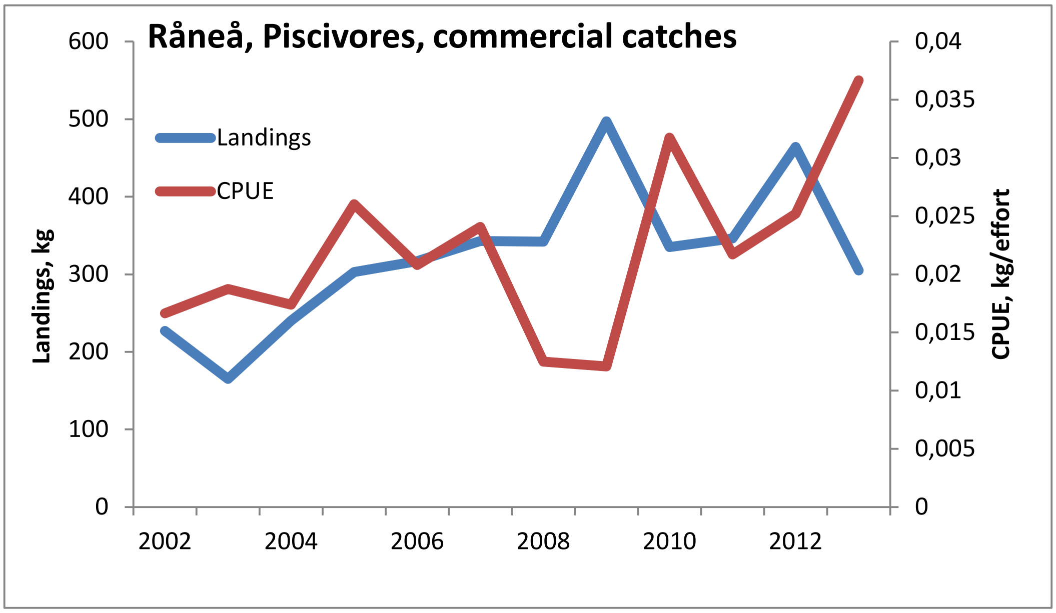
Both the landnings and CPUE in gill nets of perch has increased over time, as have the abundance of large perch in the gill net monitoring program in the area.

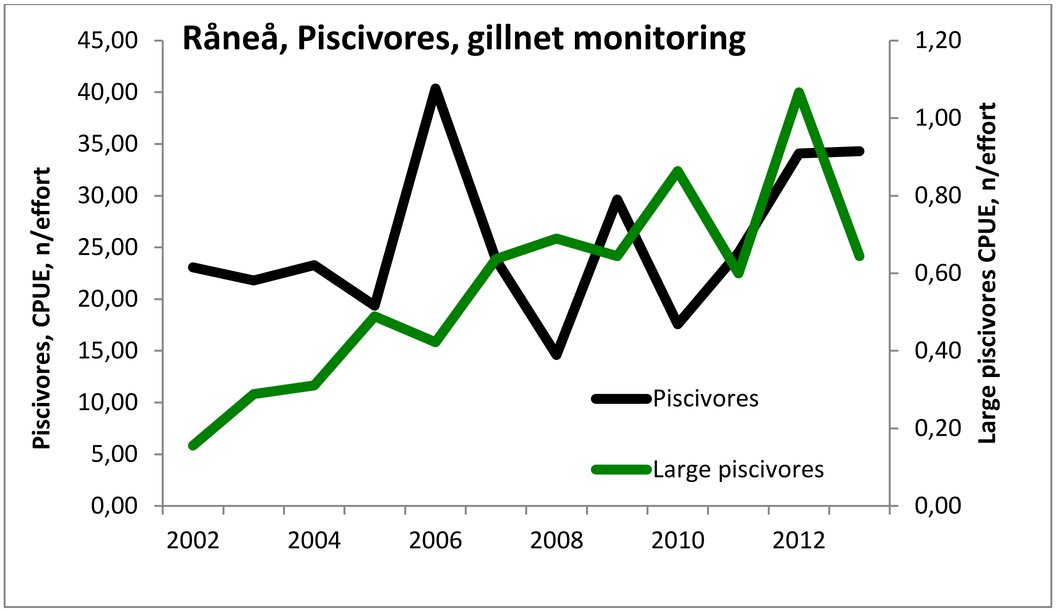




There was a rather good match between commercial landings and effort (R^2 = 0.51), and the strongest relationship was found between landings and large perch (R = 0.68).

Also the landings and CPUE in gill nets of all piscivores have increased over time. The abundance of piscivores has been stable, whereas the abundance of large piscivores has increased over time in the gill net monitoring program in the area.

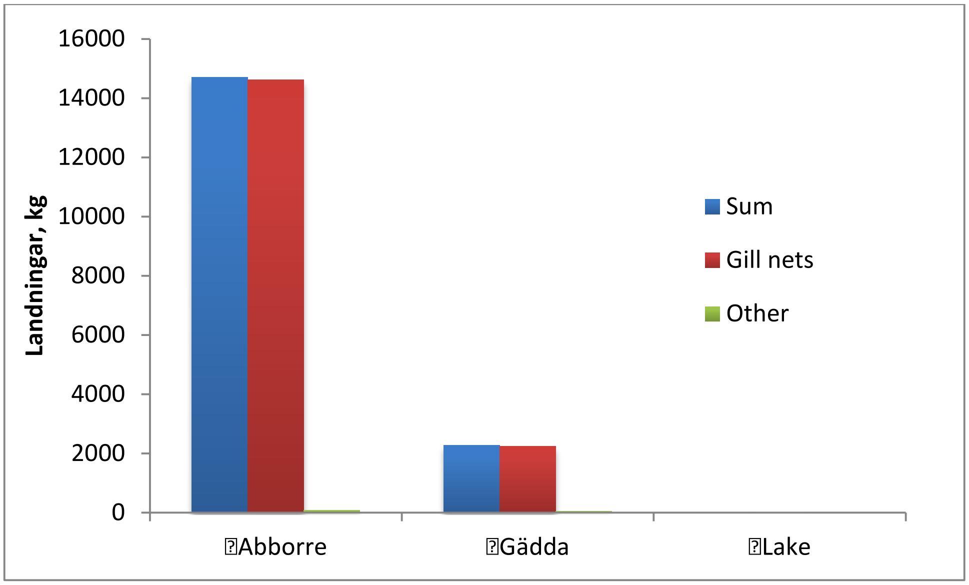




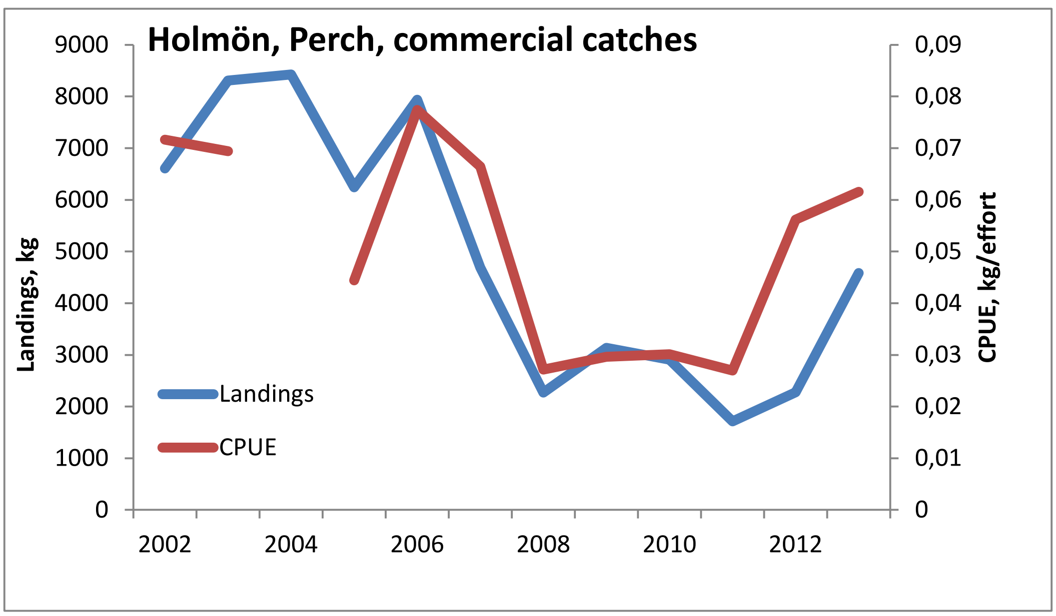
There was a rather weak relationship between landings and effort for piscivores (R2 = 0.11), and the strongest relationship was found between landings and large piscivores (R = 0.77).

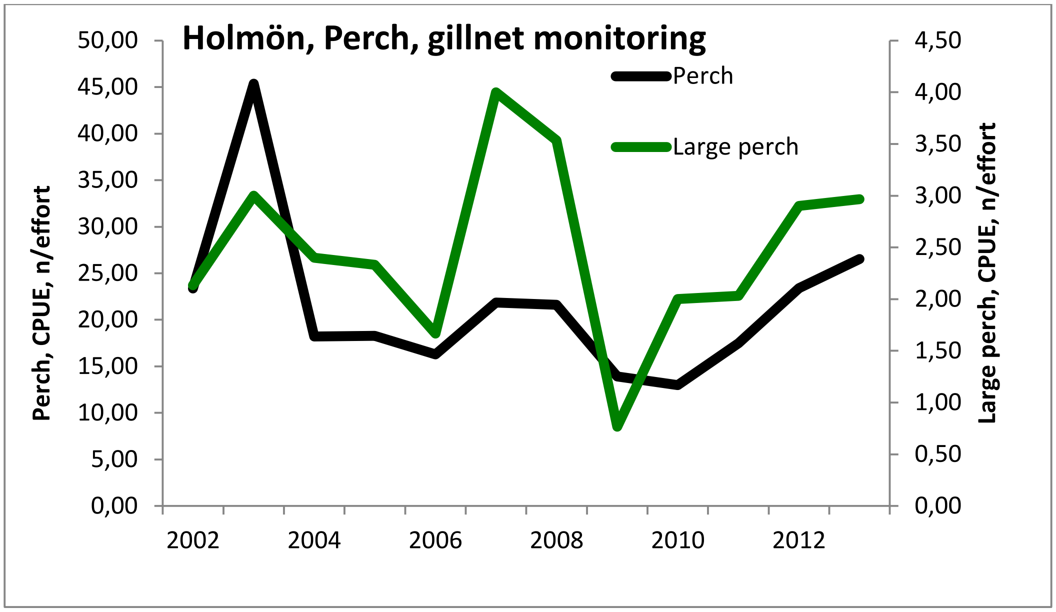
7.2 Holmön (ICES rectangle 5665)

In Holmön, three piscivorous species are caught in the fishery, perch, pike and burbot. The catch of piscivores in gillnets is almost exclusively perch, and only perch was hence considered in further analyses.



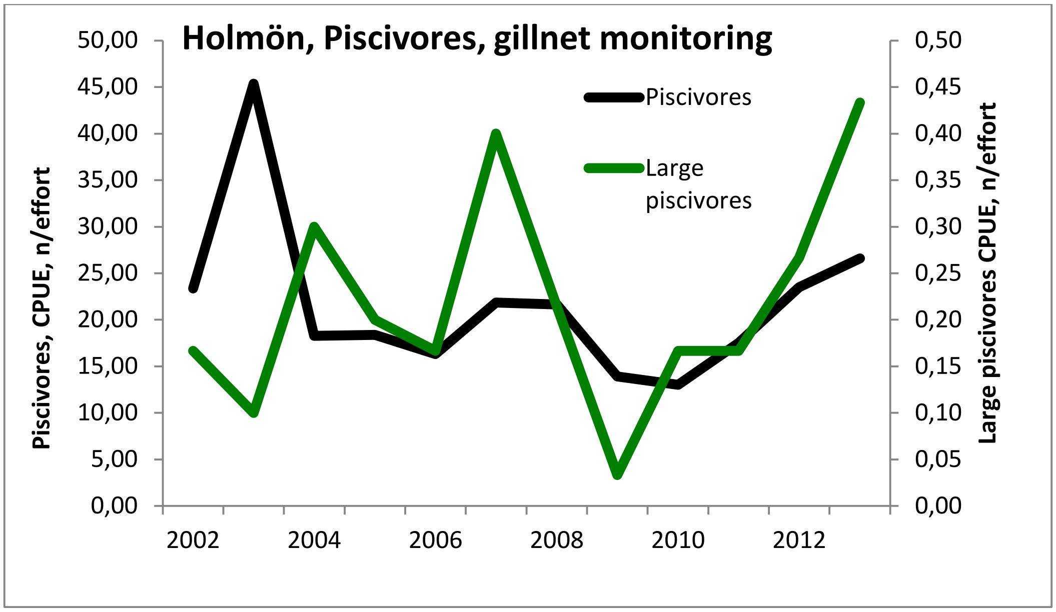
Both the landnings and CPUE in gill nets of perch has decreased over time, and there is a tendency for a similar pattern in the abundance of perch in the gill net monitoring program in the area.





There was a good match between commercial landings and effort ($R^2 = 0.78$), and the strongest relationship was found between CPUE and perch (R = 0.49).

Since only perch where considered in this area, the data for landings and CPUE in gill nets of piscivores are the same as for fig. The abundance of piscivores in the gill net monitoring program in the area show a slight decrease, whereas the abundance of large piscivores has been stable over time.

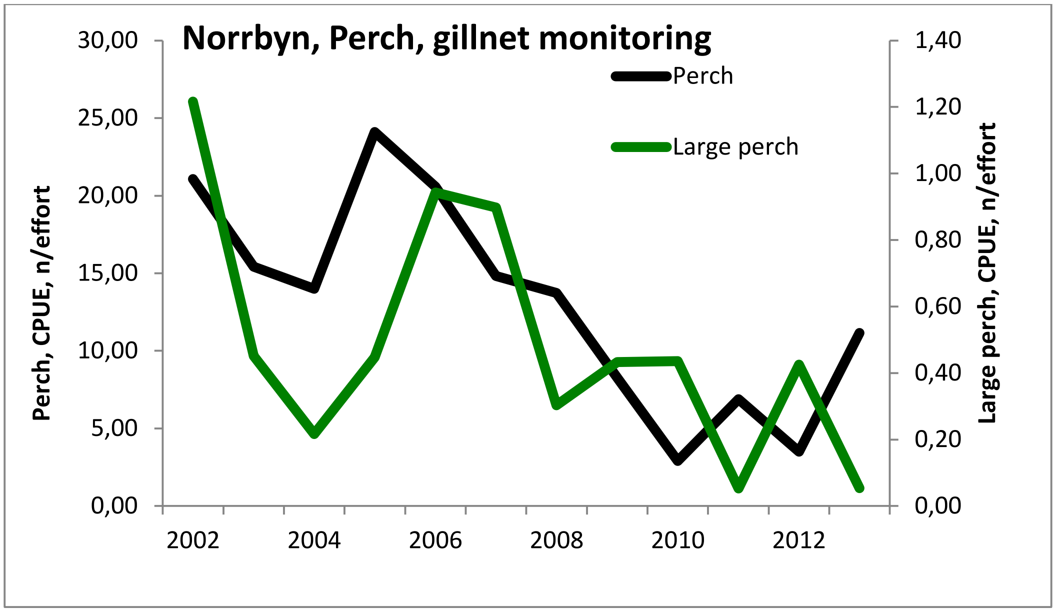


There was a good match between commercial landings and effort ($R^2 = 0.78$), and the strongest relationship was found between CPUE and perch (R = 0.49).

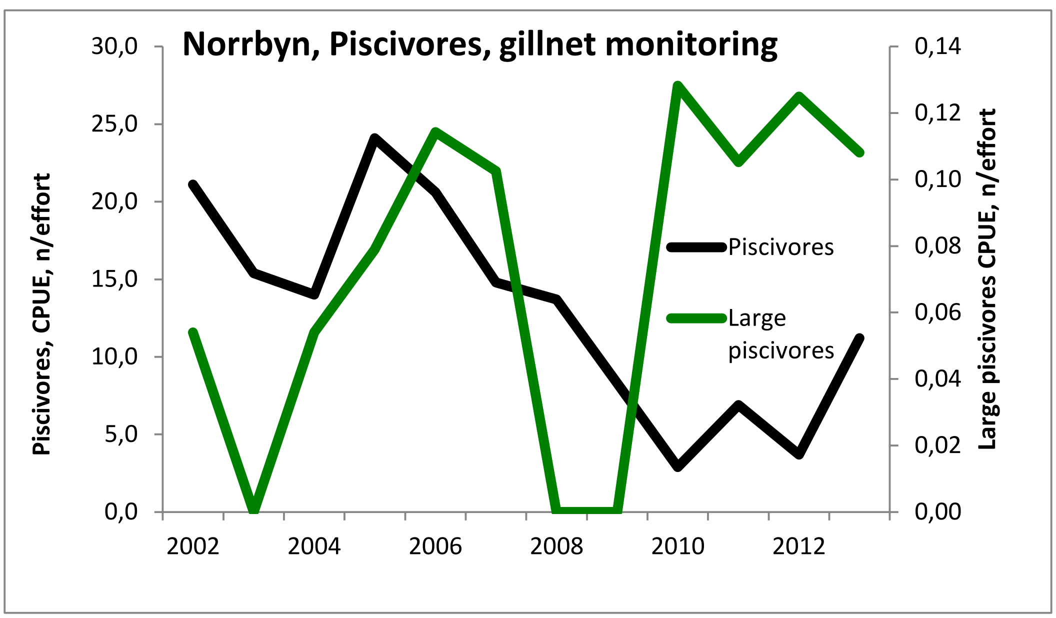
7.3 Norrbyn (ICES rectangle 5665)

Norrbyn is situated close to Holmön, and the same data from the commercial catch statistics were used in both areas.

There is a decrease in the abundance of perch and large perch in the area. The strongest relationship was found between landings and perch abundance (0.72).



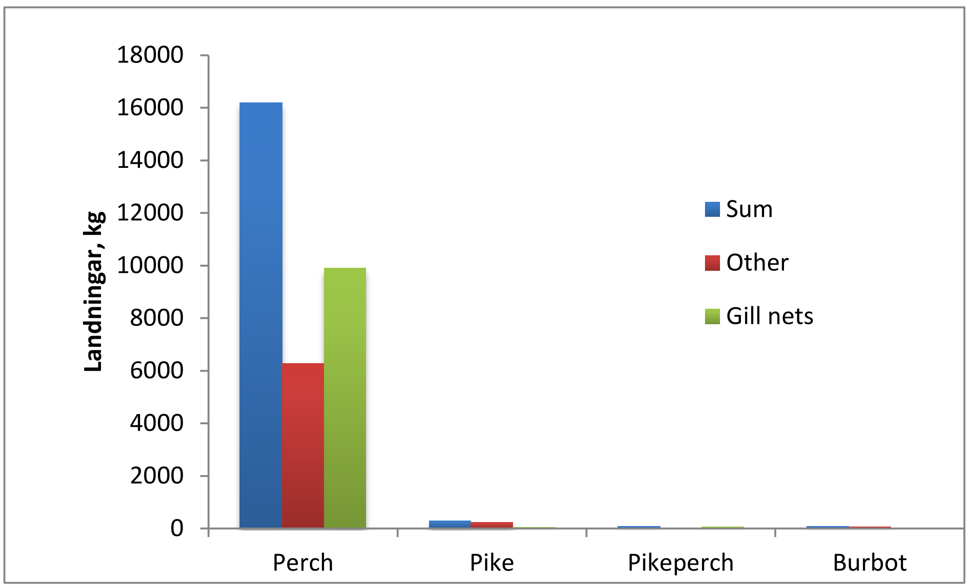
Also the abundance of piscivores has decreased over time, but no trend is discernable for the abundance of large piscivores. The strongest link was found between landings and piscivore abundance (0.72).



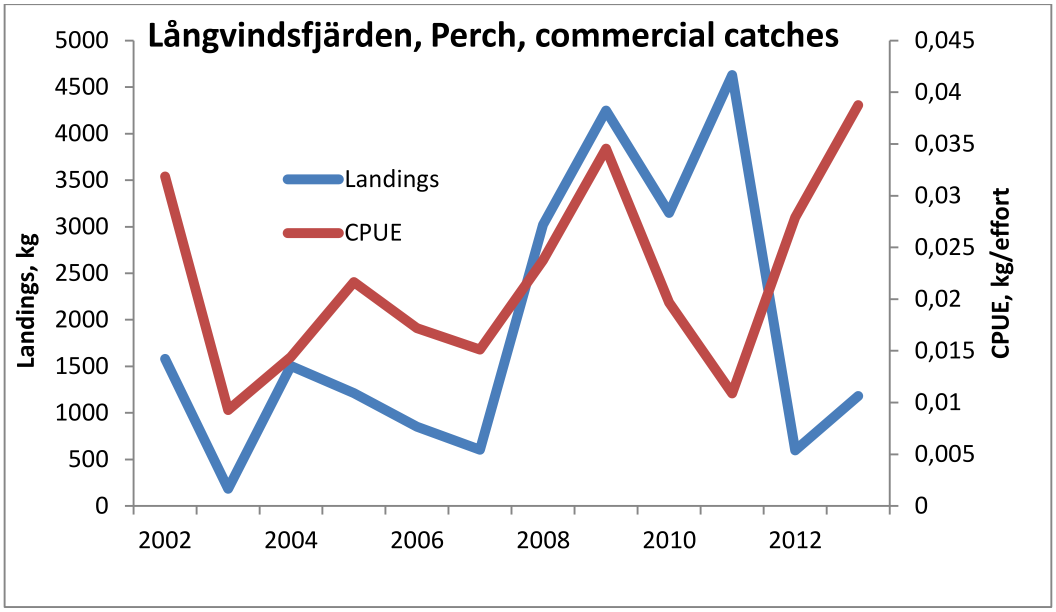
There was a rather weak relationship between landings and effort for piscivores ($R^2 = 0.11$), and the strongest relationship was found between landings and large piscivores ($R = 0.77$).

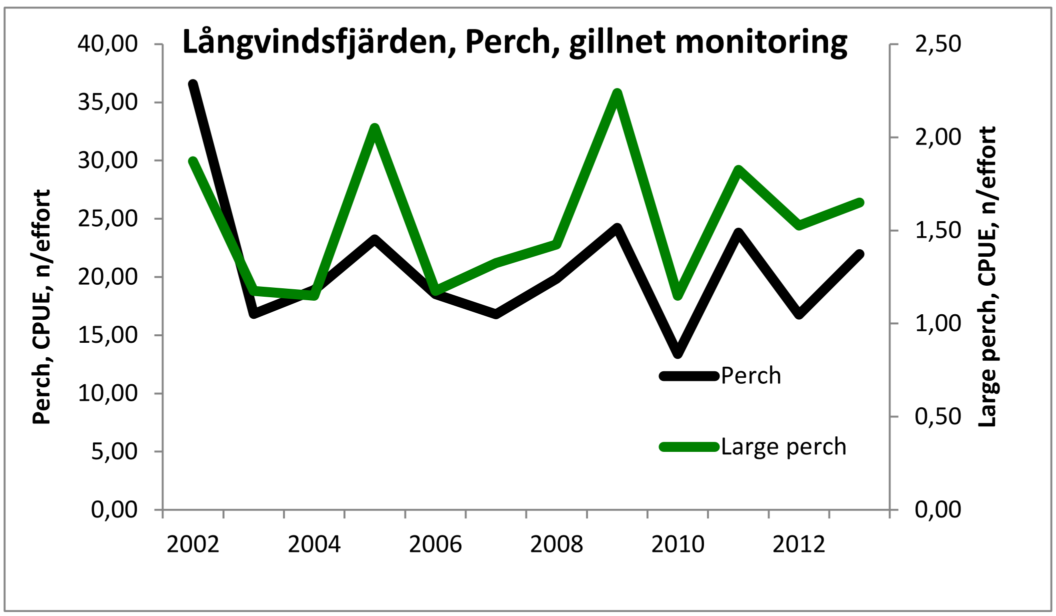
7.4 Långvindsfjärden (ICES rectangle 5162)

In Långvindsfjärden, perch is the absolute dominant piscivorous species. The majority of catches are derived using gillnets, but a substantial part are caught using other gears as trap nets. We base the following analyses solely on perch in gill nets.



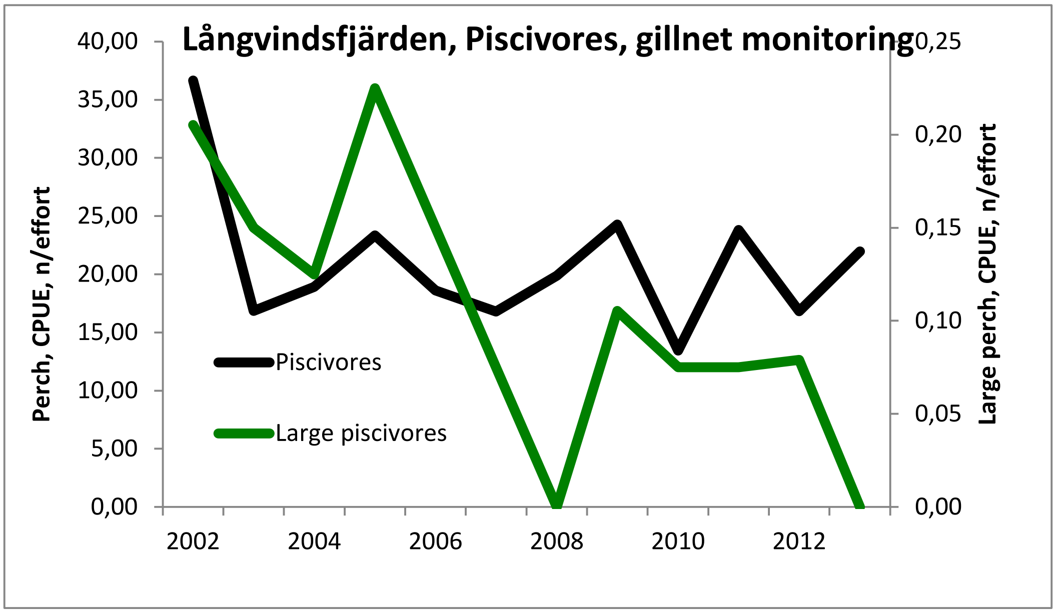
The landings of perch have fluctuated substantially over time, and the CPUE of perch has decreased over time. The abundance of perch in the gill net monitoring program in the area does not exhibit any trend.





There was a good match between commercial landings and effort ($R^2 = 0.71$), and the strongest relationship was found between CPUE and the abundance of large perch ($R = 0.56$).

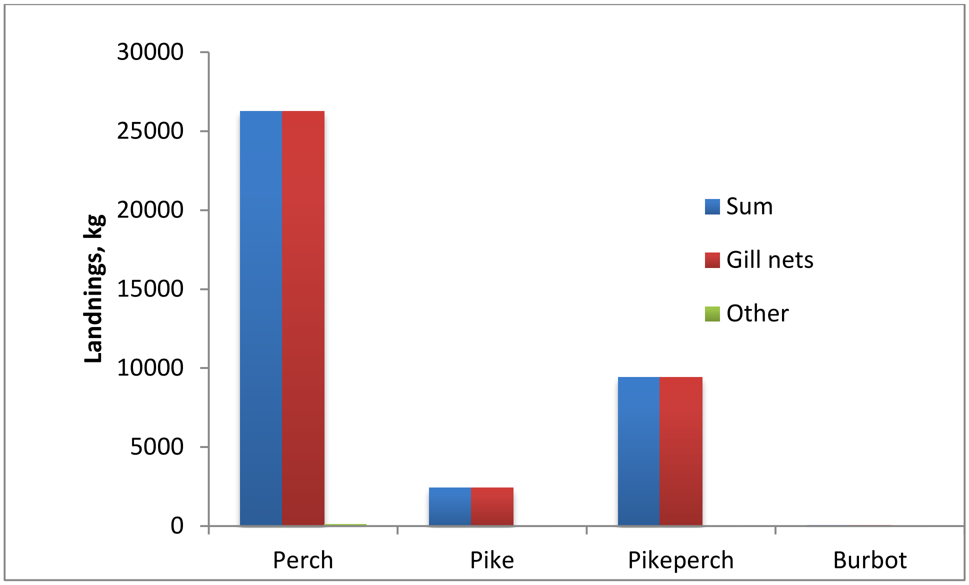
The data for piscivores are the same as for perch with regards to the data from the commercial fishery. In the gill net monitoring in the area, the abundance of piscivores has been stable over time, but there is a tendency for a decrease in large piscivores.



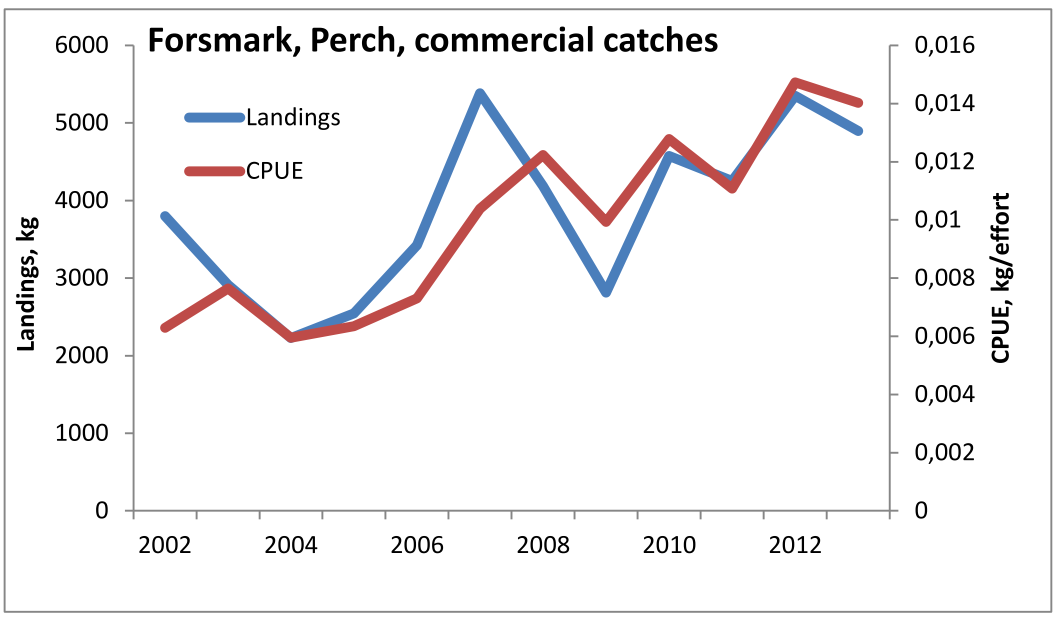
The best match was found between landings and large piscivores ($R^2 = 0.64$).

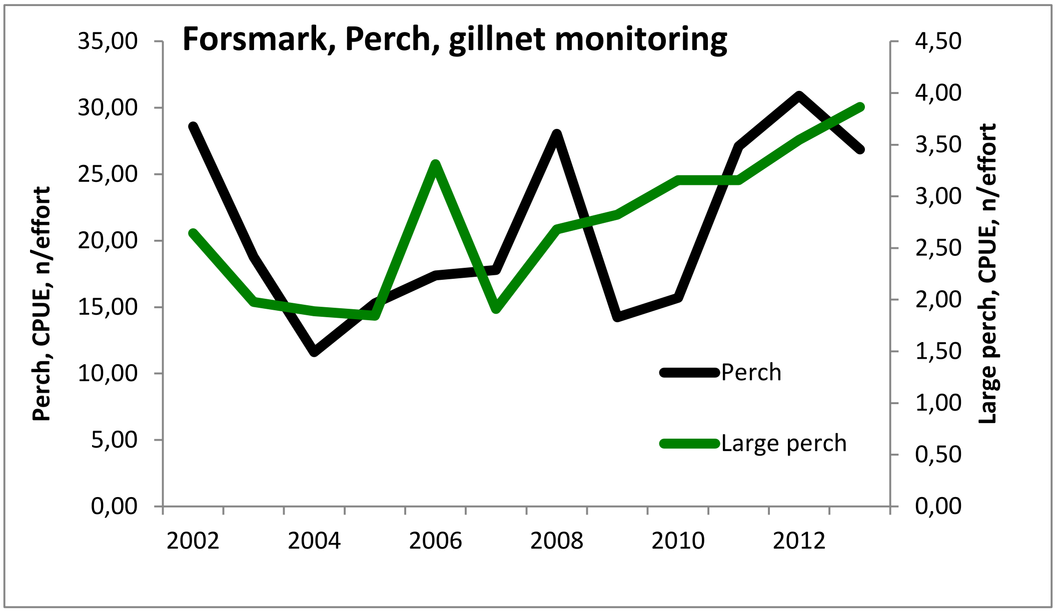
7.5 Forsmark (ICES rectangle 4963)

Fishing in the statistical rectangle in which Forsmark is situated is mainly carried out using gill nets. Perch constitutes the bulk of the landings, but also pike and pikeperch, and to a lesser extent burbot is landed.



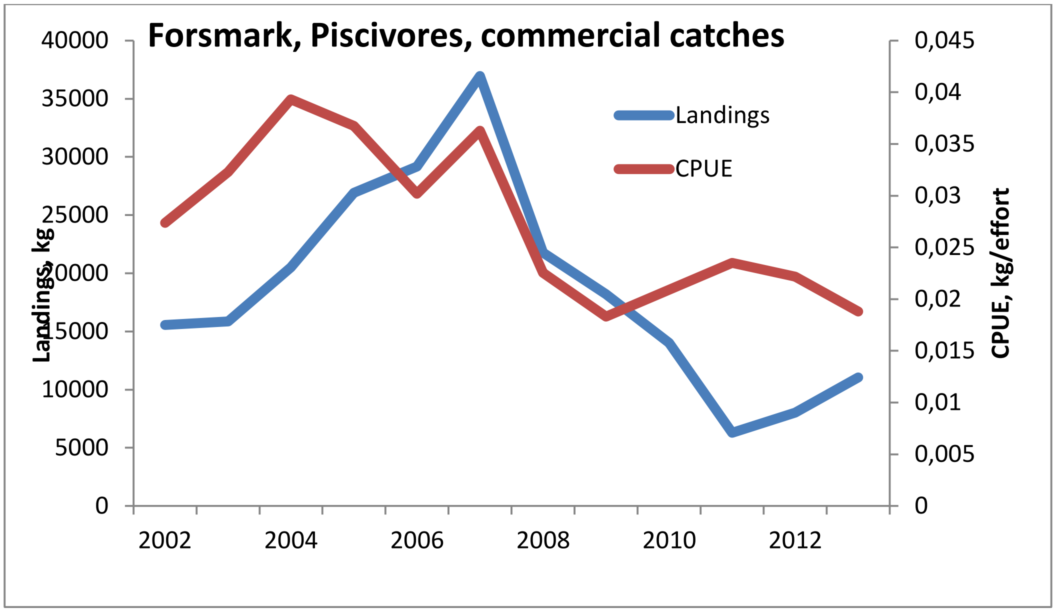
The landings and CPUE of perch in gill nets have fluctuated and increased over time. The abundance of perch in the gill net monitoring program in the area does not exhibit any trend, but the abundance of large perch show an increase over time.

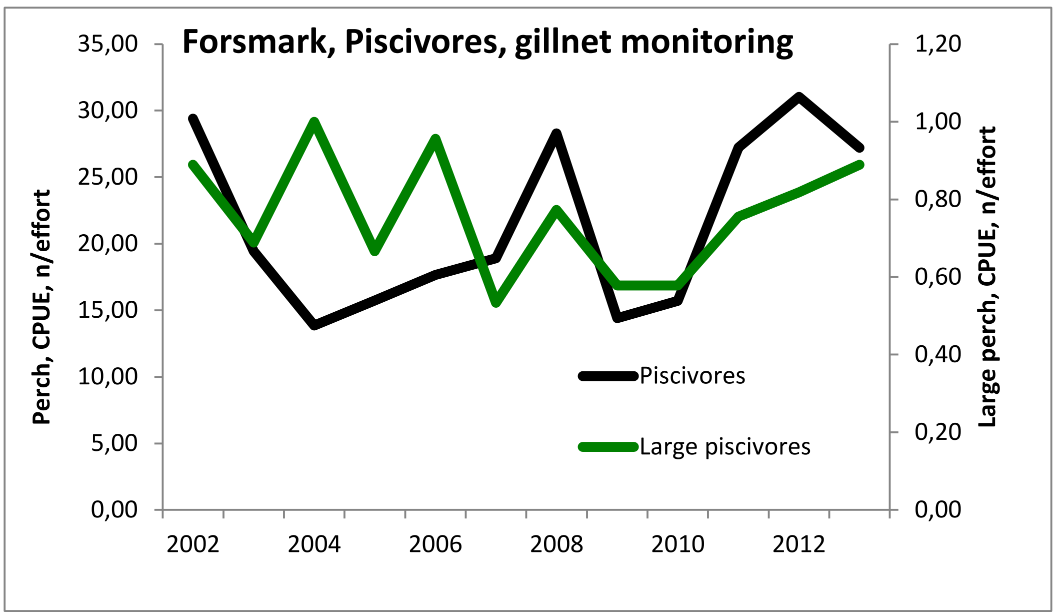




There was a match between the landings and effort in the commercial fishery (R^2 = 0.38), and the highest correlation was found between CPUE and large perch (R = 0.69).

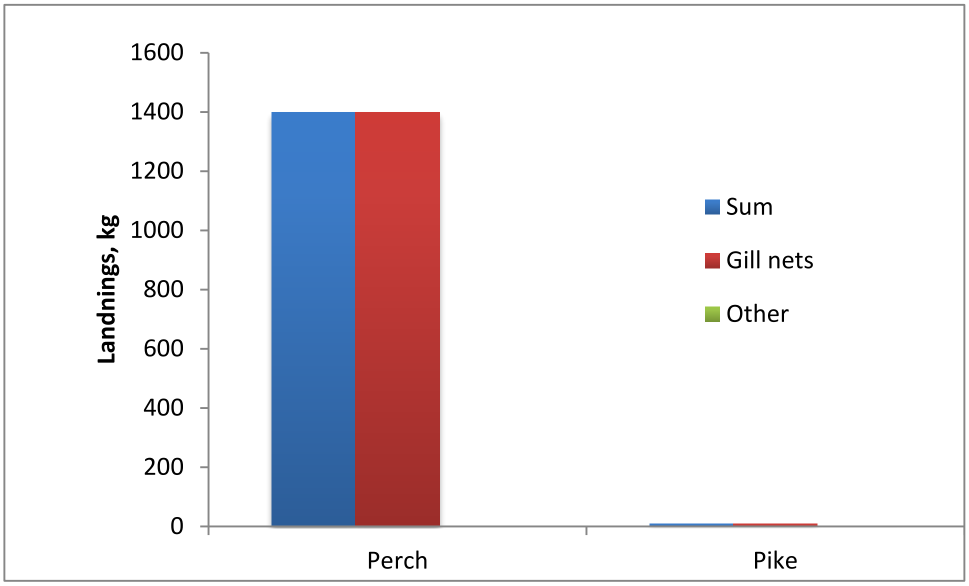
The landings of piscivores in the Forsmark area have decreased during recent years, and the CPUE exhibit a negative trend over the whole time period. Data from the gill net monitoring program show no trend for either of the two indicators abundance of piscivores and abundance of large piscivores. There was a rather poor match between landings and effort for piscivores in the commercial fishery (R^2 = 0.10), and the highest correlation was found between CPUE and large piscivores (R = 0.12).


Forsmark, Piscivores, commercial catches
Landings
CPUE
Landings, kg
CPUE, kg/effort
40000
35000
30000
25000
20000
15000
10000
5000
0
0,045
0,04
0,035
0,03
0,025
0,02
0,015
0,01
0,005
0
2002
2004
2006
2008
2010
2012


Forsmark, Piscivores, gillnet monitoring
Piscivores
Large piscivores
Perch, CPUE, n/effort
Large perch, CPUE, n/effort
35,00
30,00
25,00
20,00
15,00
10,00
5,00
0,00
1,20
1,00
0,80
0,60
0,40
0,20
0,00
2002
2004
2006
2008
2010
2012

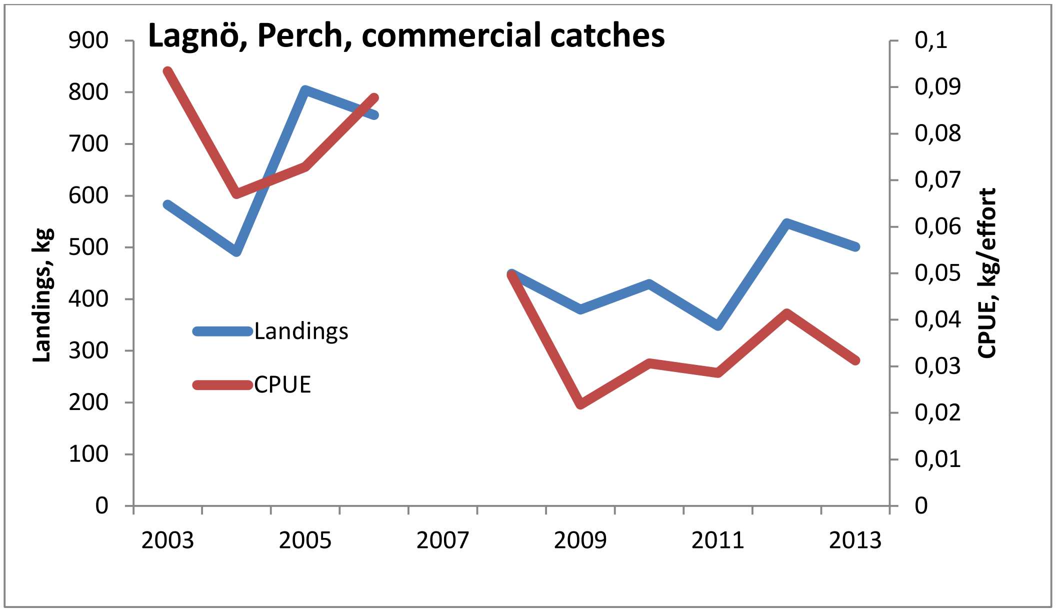
7.6 Lagnö (ICES rectangle 4864)

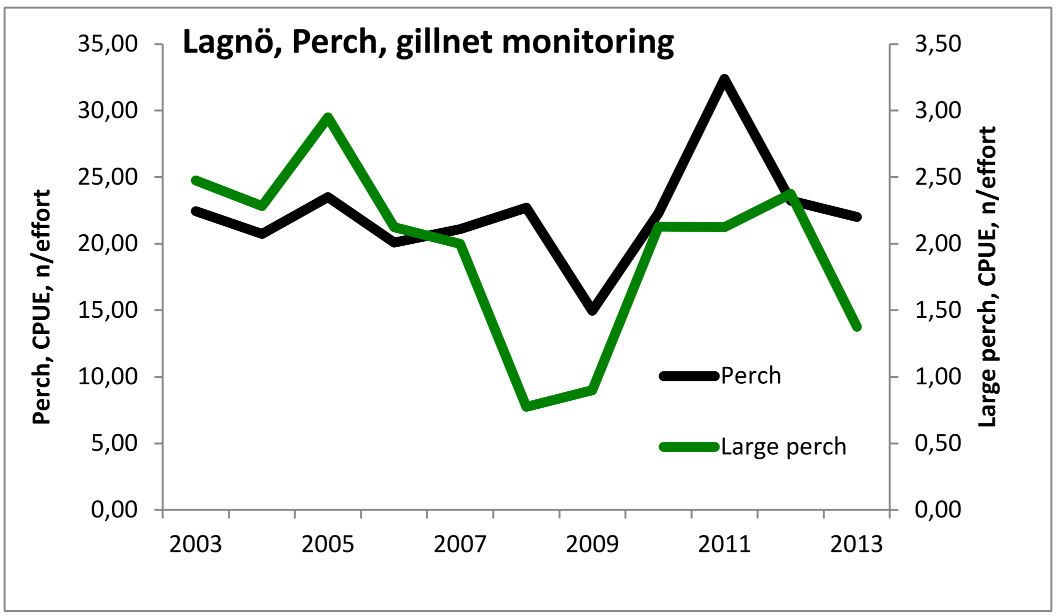
Commercial fishing in the Lagnö area is mainly targeting perch, fished exclusively using gill nets.



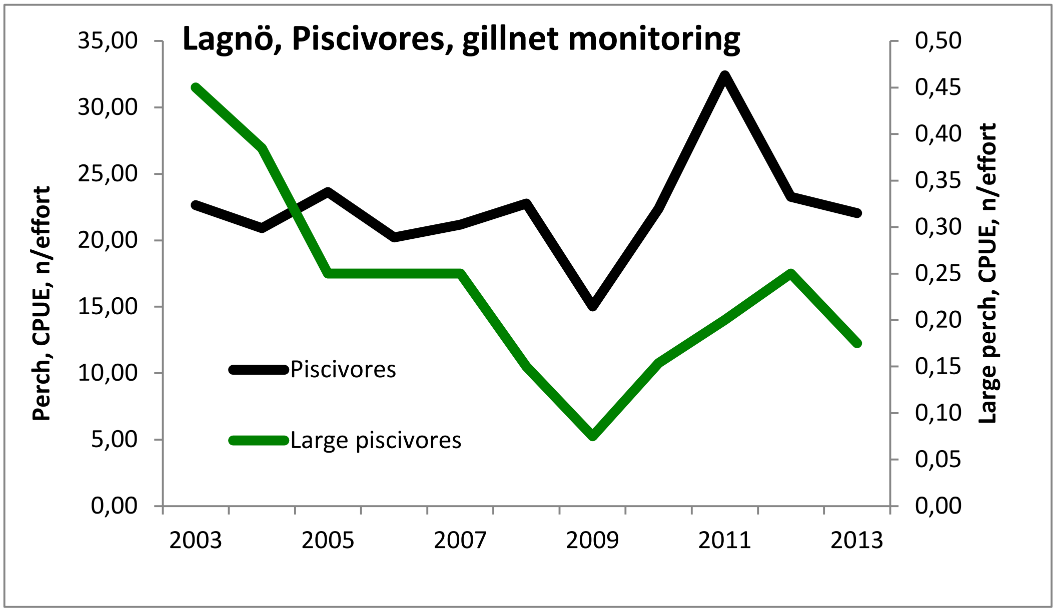
The commercial landings and CPUE of perch has both decreased over time, whereas no trend is discernible for the abundance of perch and large perch in the gill net monitoring program.

There is a poor match between landings and effort in the commercial fishery ($R^2 = 0.16$), and the highest correlation was found between landings and large perch ($R = 0.68$).





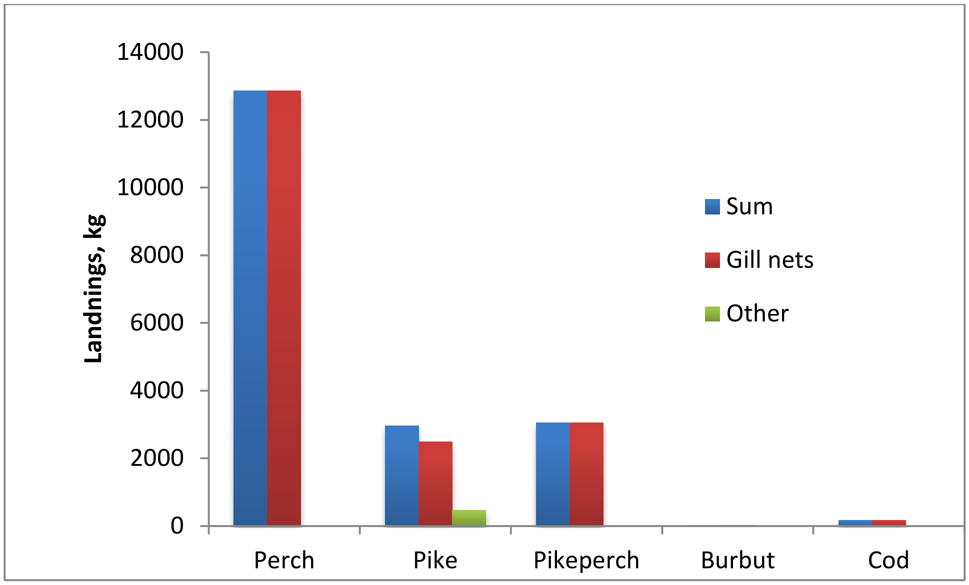
The data for piscivores are the same as for perch with regards to the data from the commercial fishery. In the gill net monitoring in the area, the abundance of piscivores has been stable over time, but there is a tendency for a decrease in large piscivores.



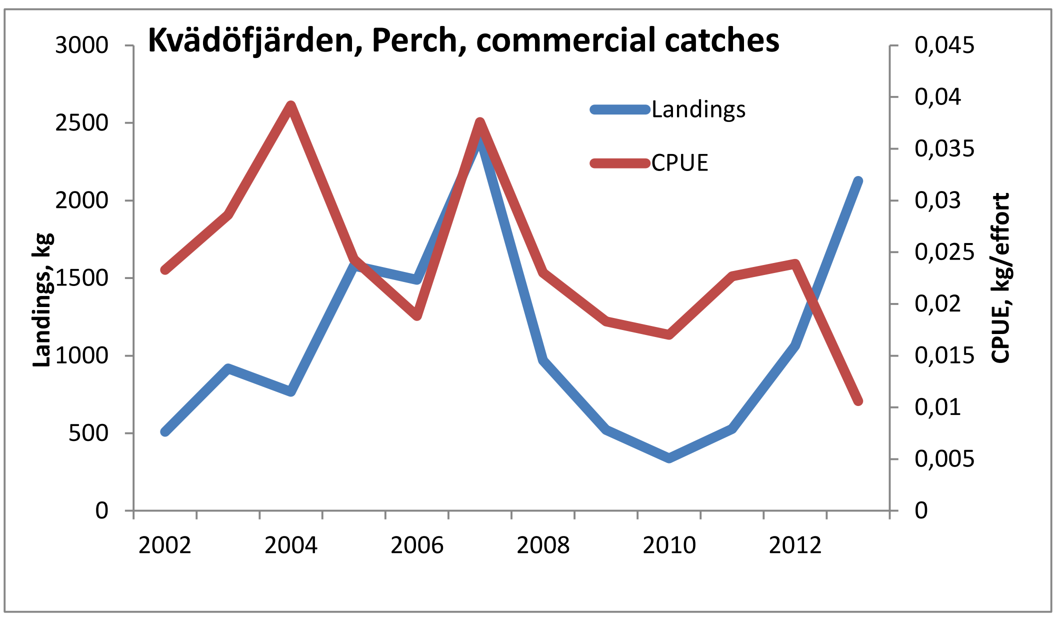
The best match was found between CPUE and the abundance of large piscivores (R = 0.78).

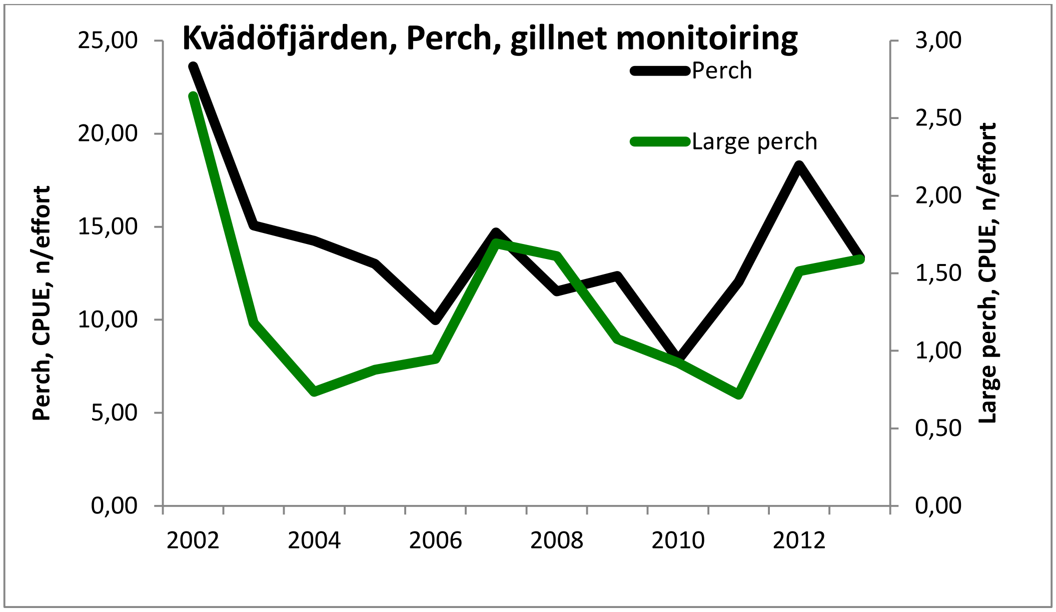
7.7 Kvädöfjärden (ICES rectangle 4561)

Commercial fishing in the Kvädöfjärden area is mainly targeting perch using gill nets, but pike, pikeperch, burbot and cod also make up a share of the catch.



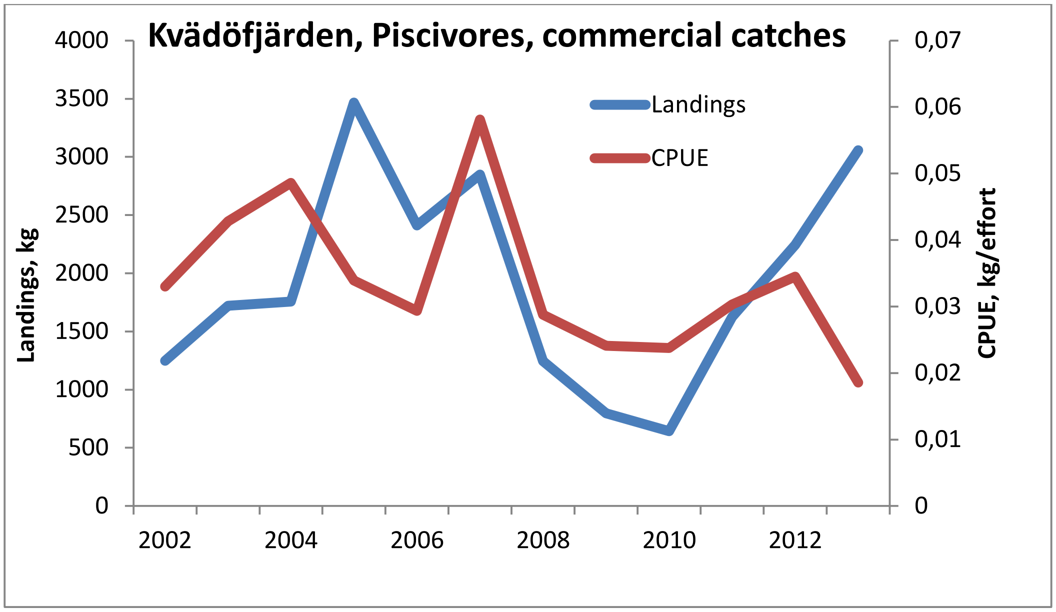
Whereas no trend is discernible for the landings in the commercial fishery for perch, there is a slight decrease in CPUE. In the gill net monitoring program in the area, there has been a slight decrease over time in both the abundance of perch and large perch.

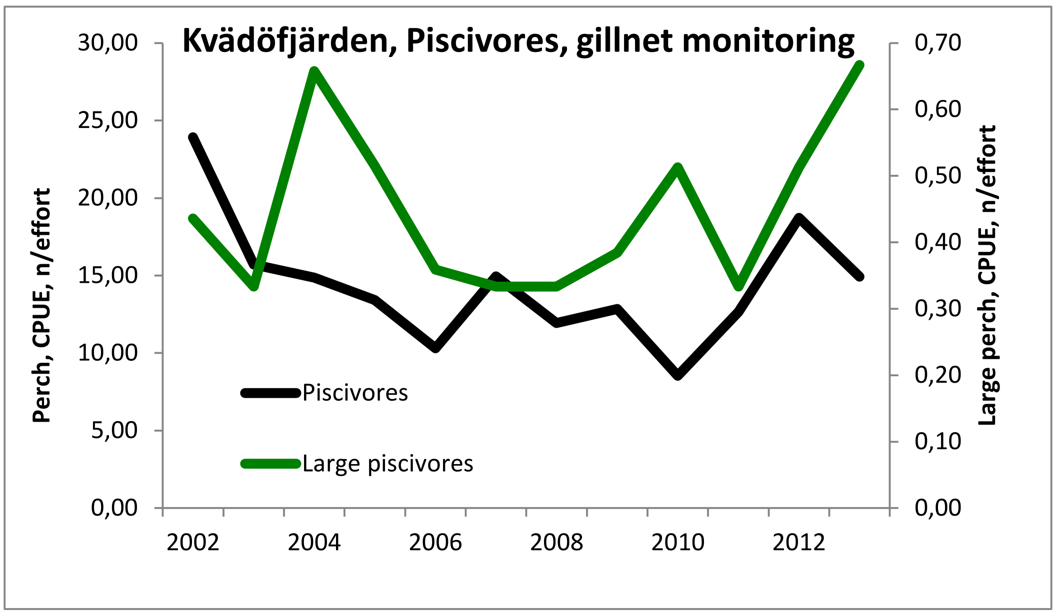




There is a match between landings and effort in the commercial fishery (R^2 = 0.20), and the highest correlation was found between CPUE and large perch (R = 0.31).

The landings of piscivores in the area show no trend, but there is a slight decrease in CPUE of piscivores. In the gill net monitoring program in the area, there is a weak negative trend for the abundance of piscivores, whereas the abundance of large piscivores has been rather stable over time.

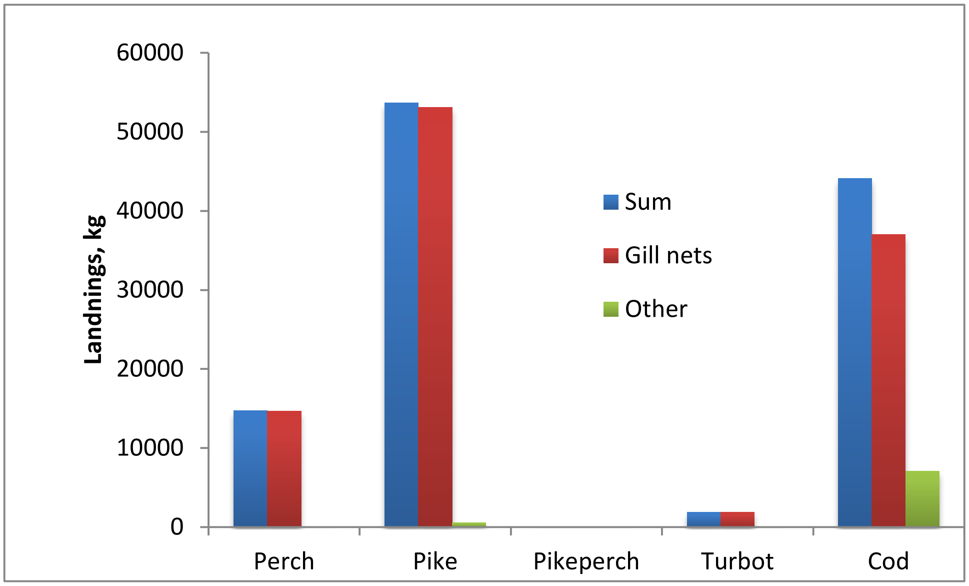




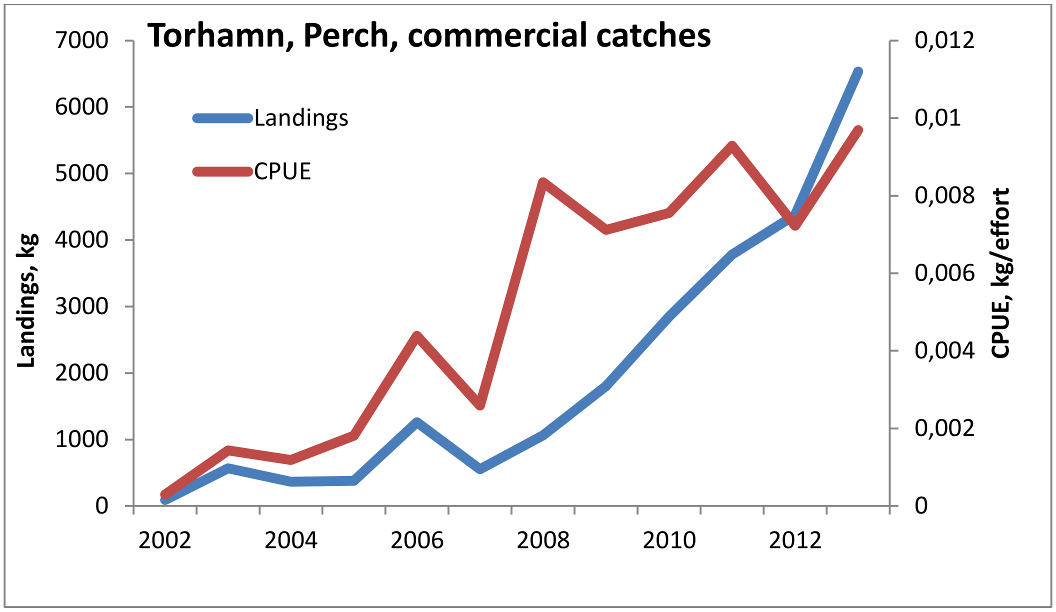
There is a rather good match between landings and effort of piscivores (R^2 = 0.48), and the highest correlation was found between landings and large piscivores (R = 0.75).

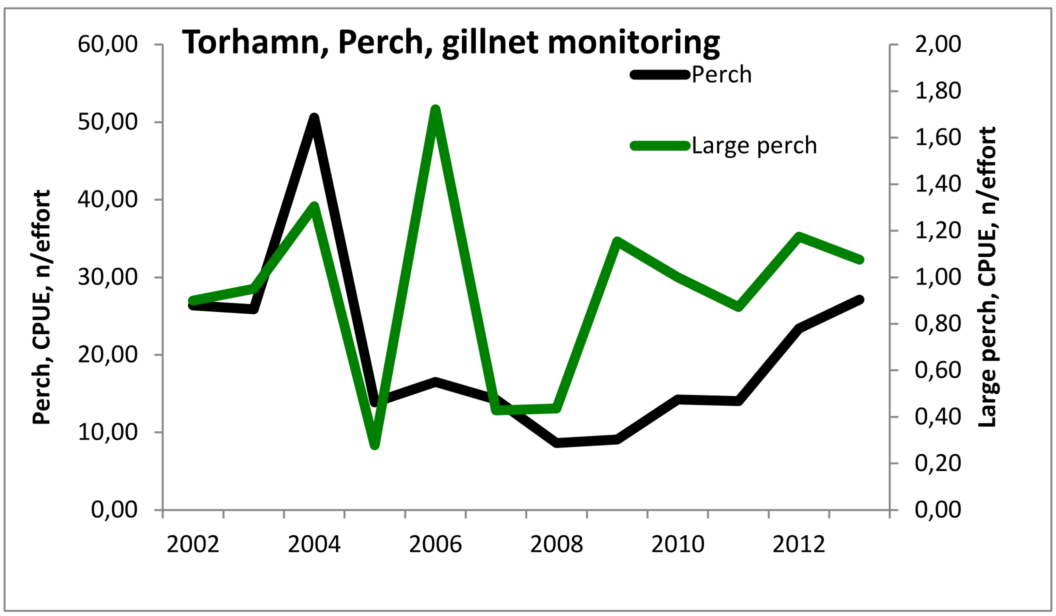
7.8 Torhamn (ICES rectangle 4160)

The coastal commercial fishery in the Torhamn area is mainly targeting pike and cod, but there is also a share of perch, pikeperch and turbot landings. Fishing is mainly undertaken using gill nets for these species.



The landings and CPUE of perch in the commercial fishery has both increased rather dramatically over time. In the gill net monitoring program, however, there has been a slight decrease in the abundance of perch over time whereas the abundance of large perch does not show any trend.

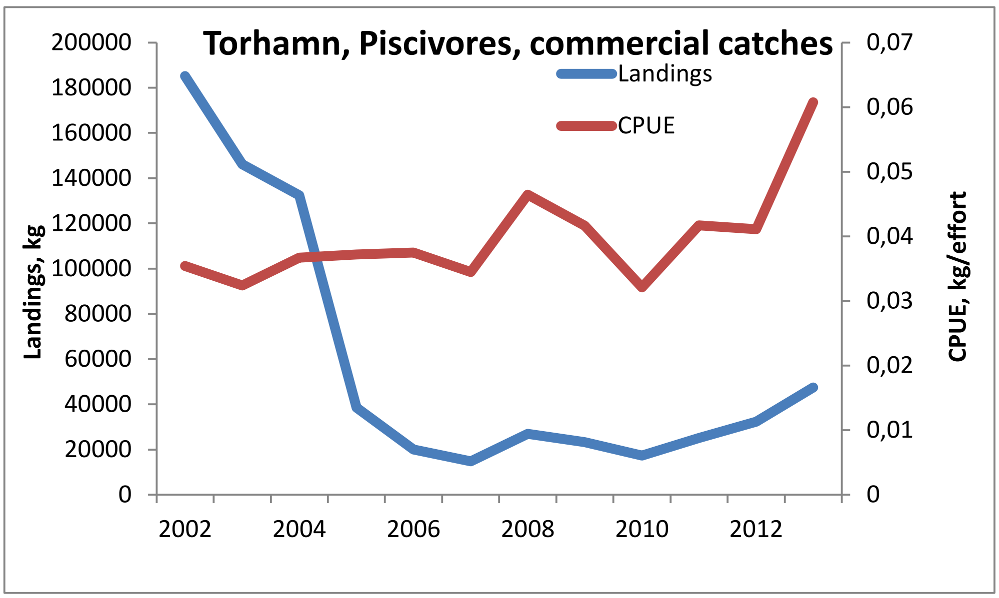

Torhamn, Perch, commercial catches
Landings
CPUE
Landings, kg
CPUE, kg/effort
7000
6000
5000
4000
3000
2000
1000
0
0,012
0,01
0,008
0,006
0,004
0,002
0
2002
2004
2006
2008
2010
2012

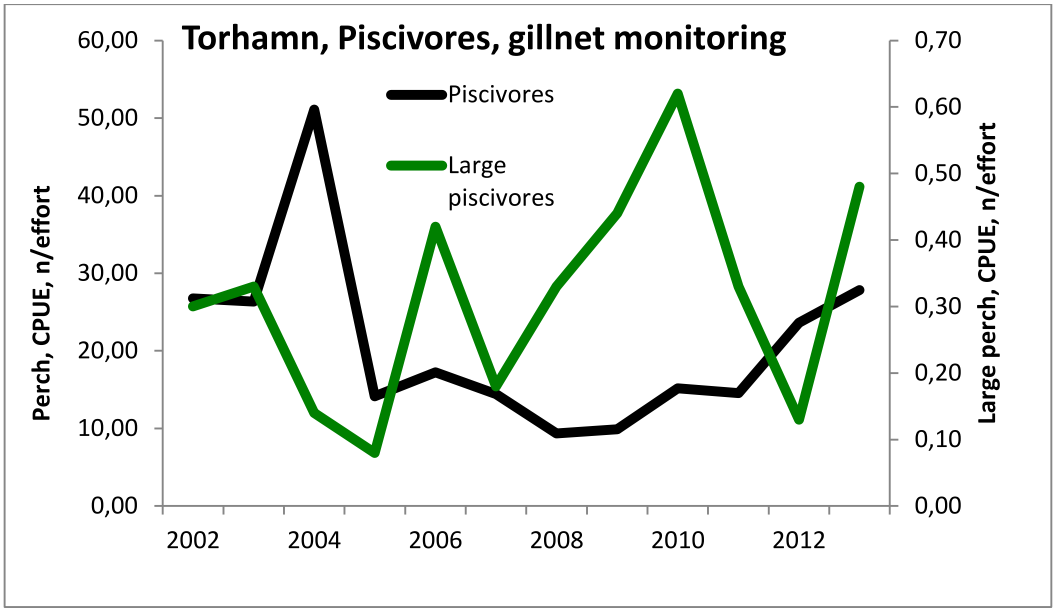

Torhamn, Perch, gillnet monitoring
Perch
Large perch
Perch, CPUE, n/effort
Large perch, CPUE, n/effort
60,00
50,00
40,00
30,00
20,00
10,00
0,00
2,00
1,80
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
2002
2004
2006
2008
2010
2012

There is a rather good match between landings and effort of piscivores (R^2 = 0.48), and the highest correlation was found between landings and large perch (R = 0.25).

The commercial landings of piscivores in the Torhamn area show a sharp decrease over time driven by a decrease in the landings of cod, but a slight increase in the CPUE of piscivores. This contrasting pattern is due to an increase in the CPUE of perch and pike. For the gill net monitoring data, there has been a slight decrease in the abundance of piscivores, but no change in the abundance of large piscivores.

The match between the landings and effort in the commercial fishery for piscivores was high (R^2 = 0.99), and the highest correlation was found between landings and piscivores (R = 0.67). When excluding cod, both the landings and CPUE increase over time and the best match is found between CPUE and large piscivores (R = 0.34).




Torhamn, Piscivores, gillnet monitoring
Piscivores
Large piscivores
Perch, CPUE, n/effort
Large perch, CPUE, n/effort
60,00
50,00
40,00
30,00
20,00
10,00
0,00
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
2002
2004
2006
2008
2010
2012