COMPARISON OF GILL NETS AND FYKE NETS FOR THE STATUS ASSESSMENT OF COASTAL FISH COMMUNITIES

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WATERS is a five-year research programme that started in spring 2011. The programme's objective is to develop and improve the assessment criteria used to classify the status of Swedish coastal and inland waters in accordance with the EC Water Framework Directive (WFD). WATERS research focuses on the biological quality elements used in WFD water quality assessments: i.e. macrophytes, benthic invertebrates, phytoplankton and fish; in streams, benthic diatoms are also considered. The research programme will also refine the criteria used for integrated assessments of ecological water status.

This report is a deliverable of one of the scientific sub-projects of WATERS and evaluates two methods used in environmental monitoring of coastal fish communities with respect to how they are likely to perform in an indicator-based assessment of environmental status.

WATERS is funded by the Swedish Environmental Protection Agency and coordinated by the Swedish Institute for the Marine Environment. WATERS stands for 'Waterbody Assessment Tools for Ecological Reference Conditions and Status in Sweden'.
Programme details can be found at: http://www.waters.gu.se

Table of contents

Summary

The use of standardized methods is fundamental for consistent data collection in environmental monitoring. In the Swedish national environmental monitoring program, coastal fish communities are usually surveyed using two methods: fyke nets are used predominantly at the Swedish west coast and gill nets in the Baltic Sea. Both methods are intended to target mainly demersal and demersal-pelagic fish in shallow areas (typically at depths of 0–10 m, sometimes to depths of 30 m). The following study addresses how these two methods differ in terms of the species sampled and how they are likely to perform in environmental status assessments.

The assessment was conducted based on data from surveys in which sampling using fyke nets and gill nets had been performed in parallel at the same site and time of year. The studies were originally conducted for purposes other than monitoring, typically at a greater than usual depth range.

The analyses of Baltic Sea datasets clearly suggested that gill nets are likely to perform better than fyke nets in assessing both the species composition and environmental status of coastal fish communities in the Baltic Sea. Samples obtained using fyke nets were considerably smaller and did not efficiently represent Baltic Sea coastal fish assemblages. These conclusions were based on data from two surveys in the southern Baltic Proper but are considered applicable to other Baltic Sea areas as well.

For the Swedish west coast, the data available for analysis were collected using different types of gill nets in different datasets. However, some general patterns could be discerned. Gill nets typically sampled more species and individuals, whereas fyke nets were more selective towards demersal and demersal-pelagic species. This observed pattern may to some extent reflect differences in total catch size. Comparing biodiversity metrics that were standardized against catch size revealed no consistent differences between the two methods.

Sampling efficiency was evaluated for the Swedish west coast datasets by comparing the effort required to obtain a certain degree of precision using each method. This evaluation treated a set of potential environmental status indicators. Overall, less total time in the field was required for fyke nets than for gill nets. The greatest differences between methods were seen for the indicators “abundance of eelpout” and “abundance of mesopredators” (better in fyke nets) and for “abundance of large individuals” and “proportion of large individuals” (better in gill nets). For other indicators, such as “abundance of cod”, differences were small. One factor that likely strongly influences the outcome in the case of small differences is the expected catches of shore crab, as more time is required to handle shore crabs caught in gill nets than in fyke nets. A higher shore

crab catch in gill nets will also affect costs related to gear damage and damaged catches. With respect to environmental aspects, fyke nets caught a smaller proportion of species not directly needed for the indicator-based assessment. Fyke nets were also expected to induce less stress and mortality in captured fish, as most of the catch can be released live after being record-ed.

In summary, for the Baltic Sea, gill nets were seen as a suitable method for surveying coastal fish communities. Adding information from fyke net sampling did not contribute significantly to the information obtained by gill net sampling in the present case study. For the Swedish west coast datasets, gill net sampling provided larger total species lists, whereas fyke nets appeared more suitable for providing quantitative information. In terms of monitoring efficiency, combining differences in estimated precision, expected handling time, and gear longevity between the two types of gear, fyke nets were considered preferable to gill nets.

Svensk sammanfattning

Standardiserad metodik är en grundläggande del av miljöövervakning och datainsamling. I den nationella miljöövervakningen används idag framför allt två olika metoder vid övervakning av grunda kustnära fisksamhällen. I Östersjön används som regel provfisken med nät, och på västkusten provfisken med ryssjor. I den här studien har vi jämfört data från studier där provfisken med nät och ryssjor har utförts parallellt. Syftet har varit att se hur de två metoderna skiljer sig åt i fråga om vilka delar av kustfisksamhället de representerar och hur det dataunderlag man får fram fungerar för bedömning av miljöstatus.

Analyserna gjordes på data som ursprungligen samlats in för andra ändamål. Det fanns därför vissa begränsningar i vilka typer av jämförelser som var möjliga att göra. Till exempel var provtagningen gjord på ett större djup än som vanligen är fallet inom miljöövervakningen.

För Östersjöns kustområden verkade provfisken med nät (Nordiska kustöversiktsnät) fungera klart bättre än ryssjor både för att skatta artsammansättning och miljöstatus. Fångsterna med ryssjor var låga och hade låg artrikedom. I analysen ingick data från två fältstudier, båda utförda i Hanöbukten i Egentliga Östersjön.

På västkusten varierade typen av provfiskenät mellan de fältstudier som fanns tillgängliga för analys. Det gick dock att notera vissa generella mönster. Även här fångade nät ett högre antal arter och individer än ryssjor. Nät verkade fungera bättre för att representera totalt artantal, medan ryssjor var mer selektiva och i första hand fångade bottenlevande och bottennära arter. Resultatet kan till viss del återspegla skillnader i total fångststorlek. Vid en jämförelse av indikatorer för biologisk mångfald som beaktar total fångsstorlek fanns det inga genomgående skillnader mellan nät och ryssjor.

Provtagningens effektivitet utvärderades på basen av data från västkusten genom att beräkna antal stationer och total tidsåtgång som krävs för att uppnå en viss precision. Beräkningen utför-des för några tidigare föreslagna indikatorer för miljöstatus på västkusten. Generellt krävde prov-fisken med ryssjor en lägre total tidsåtgång för att uppnå en viss precision. Resultatet beror i hög grad på en lägre hanteringstid per station vid provfiske med ryssjor. Den största skillnaden sågs för indikatorerna ”antal tånglake” och ”antal mesopredatorer” (bättre i ryssjor), samt ”antal stor fisk” och ”proportion stor fisk” (bättre i nät). För andra indikatorer, t ex ”antal torsk”, var skillnaden mellan metoder liten. En faktor som påverkar utfallet starkt i sådana fall är sannolikheten för att strandkrabba ska ingå i fångsten, eftersom hanteringstiden för fångad strandkrabba är betydligt högre vid provfiske med nät. Höga fångster av strandkrabba kan även påverka andra kostnader, så som skador på redskapen och påverka den totala fångstens användbarhet för analys. Med avseende på bifångster var andelen arter som inte direkt behövdes för statusbedömningen lägre i ryssjor. Därtill bedömdes risken för skada och död vara lägre, eftersom fångsten i ryssjor i de flesta fall kan återsättas levande efter registrering.

Sammantaget indikerade resultaten från Östersjön att provfisken med nät ger ett bättre underlag för miljöstatusbedömning än ryssjefisken i Östersjön. Informationen som erhölls från provfisken med ryssjor var begränsad och gav ingen signifikant kompletterande information till den som erhölls genom nätprovfiske i den tillämpade fallstudien. För västkusten visade studien att nätprovfisken kan vara mer informativa än provfisken med ryssjor om syftet är att fånga ett så stort artantal som möjligt. När det gäller användbarhet inom miljöövervakningen på västkusten var ryssjor mer lämpliga, baserat på en högre kostnadseffektivitet i relation till fastställda precisionsmål, och även en lägre risk för skada på redskap och fångster.

1 Introduction

The use of standardized methods is fundamental for consistent data collection in environmental monitoring, and is a necessity for providing reliable assessments of environmental status over time and among areas. Variation due to methodological aspects (i.e., sampling error) may be introduced if different gear types are used, but may also arise due to differences in sampling design, for example, regarding sampling time, season, or spatial representation.

In monitoring coastal fish communities, methodological choices will affect the fish abundance, species composition, and size structure of the catches, and thereby also affect estimates used as environmental status indicators. The expected results are strongly related to differences in the biology and ecology of different fish species. Fish morphology and behavior will directly affect the probability of catching a certain species using a particular gear type. Such differences in catchability will depend on how the gear is constructed in terms of, for example, mesh size and materials, as well as on how the gear is positioned and used in the water (Söderberg et al. 2004, Fische et al. 2010). Catchability is also affected by the fact that different species have different depth distributions, migration patterns, and habitat preferences (Aro 1989, Pihl and Wennhage 2002, Saulamo and Neuman 2002). The expected species composition of the catch will be affected, for example, by the depths and habitat types sampled and the timing of the survey (Guy and Willis 1991, Pope and Willis 1996, Pihl and Wennhage 2002), and by small-scale changes in local temperatures and currents, as these may affect the swimming and feeding activity of fish (Neuman 1974, Saulamo and Neuman 2002).

Consequently, different monitoring methods and sampling designs will result in different sections of the prevalent fish assemblages being sampled. Hence, it is critical to understand how estimates of environmental status are influenced by methodological aspects, when interpreting the results of an indicator-based status assessment.

2 Background

In Swedish national environmental monitoring of coastal fish communities, fish are typically surveyed using two passive capture techniques: multi-mesh gill nets and fyke nets. These two methods are used to some extent along all of the Swedish coast, but in general, fyke nets are used predominantly at the Swedish west coast and gill nets in the Baltic Sea (Thoresson 1996, Söderberg 2008, Andersson 2009).

The use of two methods has been justified by the differences between the biological conditions prevalent in the two regions (Andersson 2009). Gill and fyke nets both target juvenile and adult fish above a certain size (approximately 10–12 cm), whereas other methods are used for estimating the abundances of fish in earlier life stages (e.g., Snickars et al. 2007, Bergström et al. *in prep*.). However, the inconsistency of methods applied among geographical areas restricts data interpretation at a larger geographical scale. It is often desirable to compare different geographical areas with each other, to obtain status assessments that are as harmonized as possible. It is therefore important to assess and compare how different methods function in terms of the sections of the coastal fish communities they represent. To support the evaluation of ongoing monitoring programs, it is also of interest to clarify how well different methods meet up to prevailing status assessment requirements (EEC 1992, EC 2000, EC 2008).

Few explicit comparisons have been made of the effectiveness and selectivity of fyke nets versus gill nets. Existing studies have, for example, compared gear types in terms of species selectivity (Rudstam et al. 1984., Kraft and Johnson 1992, Booth and Potts 2006), effects on fish mortality and by-catch (Hopkins and Cech 1992), and practical applicability in different ecological settings (Bonar et al. 2009). In Sweden, no studies have hitherto systematically compared gill nets and fyke nets with respect to these aspects.

3 Objective

The aim of the following study was to compare the results of fish surveys using gill nets versus fyke nets in Swedish coastal waters, to see how they differ in relation to three aspects: species selectivity, indicator performance, and environmental impact. More specifically, we asked the following questions:

- Do fyke nets and gill nets select for different parts of the fish assemblage and, if so, what are the differences?
- Do fyke nets and gill nets differ in sampling efficiency and how they represent biodiversity?
- What is the extent of by-catch and expected mortality of the two methods?

4 Methods

4.1 Data included

The reported analyses were based on existing environmental monitoring data. To minimize variation due to aspects other than gear type, only studies in which sampling had been performed in parallel with both gill nets and fyke nets, using similar sampling designs, were included. Suitable datasets were identified by screening the national database for coastal fish data (www.slu.se/kul) and by consulting regional and local experts in coastal fish monitoring.

Six datasets were identified as suitable for the present purpose. These represented four fishing surveys conducted at the Swedish west coast and two in the Baltic Sea. In all datasets, test fishing had been performed using both gill nets and fyke nets for the same locations, depth conditions, seasons, times of day, and sampling durations (Table 4.1). However, the datasets differed from one another regarding these aspects, and to some extent regarding gear type as well. The fyke net surveys were conducted using the same gear type in all cases, but the number of fyke nets set at each station varied. For gill nets, one net was set per station in all cases, but the type of gill net used differed. Still, all datasets listed in Table 4.1 were included, as using a more restricted subset would unduly limit the ability to draw generalized conclusions. Furthermore, it was assumed that variation related to differences in gear specification would not override any general differences among fyke nets and gill nets, as this comparison would also be limited by other differences in sampling design, as described above.

In all, four types of gill nets were represented (Table 4.1). Nordic coastal multi-mesh nets, which are the Swedish national standard for coastal fish monitoring in the Baltic Sea (Söderberg 2008), were used in both Baltic Sea datasets (i.e., the Hanö 2009 and Hanö 2012 datasets) and in one of the west coast datasets (i.e., the Vinga 2012 dataset). This type of gear contains mesh sizes ranging from 10 to 60 mm. A similar type of net was used in the Gullmar Fjord dataset at the Swedish west coast (i.e., the Gullmar Fjord dataset). The gear used at Gullmar Fjord differs from the Nordic coastal nets in that it includes a larger range of mesh sizes, from 6.25 to 75 mm, which increases the potential size range of the catch (Nyberg and Degerman 1988). The two other datasets from the Swedish west coast (i.e., the Vinga 2006 and Fladen 2003 datasets) were sampled using net series comprising connected nets of different mesh sizes, i.e., 38-75 mm at Vinga and 17-120 mm at Fladen. Net series were the standard method used in all Swedish coastal fish monitoring before the introduction of Nordic coastal multi-mesh nets in the early

2000s (Thoresson 1996. They are still used at some monitoring sites, to ensure continuity of established time series nationally and internationally (HELCOM 2012a). They have also been preferred over Nordic coastal multi-mesh nets in some offshore surveys in areas subject to rough weather conditions, as they are more persistent and less likely to cause sampling errors relating to damaged gear (Naturvårdsverket 2010). Fyke nets are used as a national standard for monitoring coastal fish communities at the Swedish west coast, and have also frequently been used in fish inventories to depths as great as 20–30 meters (e.g., Fredriksson et al. 2010, Naturvårdsverket 2010, Andersson et al. 2013).

Most of the studied datasets were sampled within a time period of less than one month each, in summer (July) or autumn (September–October; Table 4.1). However, the Gullmar Fjord dataset was sampled over all seasons, in the months of January, April, June, August, and October. Data for this area were available aggregated over all seasons, separately for six subareas (Pihl and Wennhage 2002). This dataset was of interest because it was the only one in which sampling had been stratified by habitat type, so that information was available separately for three rocky and three soft-bottom habitats.

Catch information was available as the number of individuals per species in all datasets. Estimates were computed at the station level (i.e., number of individuals per species and station) except for the Gullmar Fjord dataset, in which they were computed at the subarea level (i.e., number of individuals per species and subarea totaled for all seasons). For three of the datasets, information on the length distribution was also available (Fladen 2003, Vinga 2006, Hanö 2012).

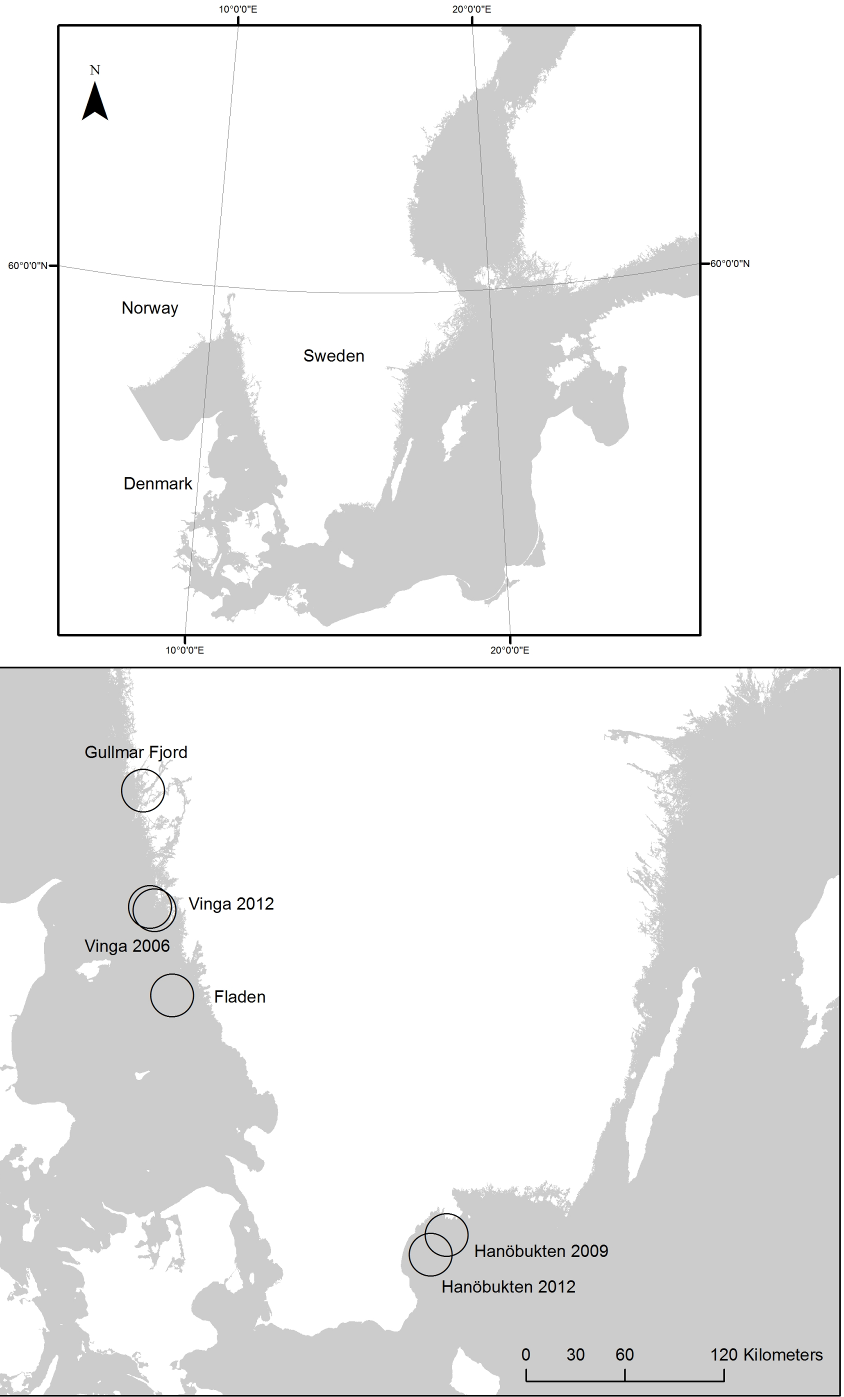

FIGURE 4.1
Sampling sites for the datasets included in the analyses. For details of each dataset, see Table 4.1.

TABLE 4.1
Overview of datasets included in the study. In column two, the numbers within parentheses indicate specifications of the gear type.

Dataset	Gear type (sample)	Month	Depth	No. of stations	Sets of gear per station	Source
Baltic Sea						
Hanö 2012	Fyke net (1)	Oct	0–20 m	15	2	SLU (2012) (a)
	Gill net (2)	Oct	0–20 m	15	1	
Hanö 2009	Fyke net (1)	Jul	15–40 m	48	2	Engdahl and Wikström (2010) (b)
	Gill net (2)	Jul	15–40 m	48	1	
West coast						
Vinga 2012	Fyke net (1)	Oct	0–20 m	25	1	SWECO Environment (2012) (a)
	Gill net (2)	Oct	0–20 m	25	1	
Vinga 2006	Fyke net (1)	Oct	20–30 m	29	6	County Adm. Board of Västra Götaland (2007) (a)
	Gill net (3)	Oct	20–30 m	20	1	
Fladen 2003	Fyke net (1)	Sep	0–20 m	24	5	Naturvårdsverket (2010) and SLU (unpubl. data) (a)
	Gill net (4)	Sep	0–20 m	24	1	
Gullmar Fjord, soft bottom 1–3 (c)	Fyke net (1)	Apr–Jan	0–9 m	NA	1	Pihl and Wennhage (2002)
	Gill net (5)	Apr–Jan	0–9 m	NA	1	
Gullmar Fjord, rocky 1–3 (c)	Fyke net (1)	Apr–Jan	0–9 m	NA	1	Pihl and Wennhage (2002)
	Gill net (5)	Apr–Jan	0–9 m	NA	1	

(1) K054, fyke net with a mesh size of 17 mm in lead, 10 mm in house (Andersson 2009; n.b. 8 mm in house in Gullmar Fjord)
(2) K064, Nordic coastal nets, monofilament multimesh nets with nine different mesh sizes, 10–60 mm (Söderberg 2008)
(3) K051, net series composed of four woven nylon nets with mesh sizes of 38–75 mm (Thoresson 1996).
(4) K069, net series composed of seven woven nylon nets with mesh sizes of 17–120 mm (Naturvårdsverket 2010)
(5) Monofilament multimesh gill nets with 14 mesh sizes, 6.25–75 mm (Nyberg and Degerman 1988)

a) Data obtained from the KUL database at SLU, Department of Aquatic Resources
b) Data obtained from Marine Monitoring AB
c) Fishing was conducted in three subareas with soft-bottom and rocky habitats, respectively, on five occasions in 1998–1999; available data were aggregated over all occasions, based on 12 replicates per occasion and subarea for fyke nets and 9 replicates for gill nets.

4.2 Analyses

To account for the differences among the studied datasets in terms of sampling design and gear specification (Table 4.1), quantitative comparisons were not conducted across datasets. Instead, differences between gill nets and fyke nets were compared within each dataset. The presence of general patterns was assessed based on the results of these pairwise comparisons. If not stated otherwise, comparisons were made after transformation from absolute species numbers to relative species numbers within each sample.

Differences in terms of species selectivity were assessed by comparing dominant species, species composition, and the representation of species from different functional groups. Indicator performance was estimated based on diversity, according to three commonly used diversity indices. In addition, the precision in estimating a set of potential indicators of coastal fish community status was assessed. Aspects relating to environmental impact in relation to sampling were assessed by estimating the proportion of target species in the catches. The analyses of indicator performance were restricted to datasets in which fish abundance was high enough to allow for meaningful comparison among gear types and in which information was available at the station level (Fladen 2003, Vinga 2006, Vinga 2012).

4.2.1 Species selectivity

Differences in species composition between the fyke net and gill net catches were assessed by comparing dominant species in the fyke net and gill net samples within each dataset, and by comparing total species lists.

For the Swedish west coast datasets, overall differences between gear types were also assessed using multivariate analysis. To evaluate the relative influence of gear type on the observed species composition of a sample, in relation to other potential sources of variation, such as habitat type, sampling depth, season, and gear specifications, all datasets from the Swedish west coast were included in the same overall analysis. The analysis was performed by first calculating similarity in species composition among samples, by pairwise comparison of all samples. Similarity was quantified using the Bray–Curtis index based on log-transformed data. The Bray–Curtis index indicates whether two samples have many species in common, and whether these species occur in similar relative abundances. In addition, it does not assume that two samples are more similar to each other just because they happen to lack the same species (Zuur et al. 2007). One sample was defined as the average catch for one gear type and dataset (cf. column 2 in Table 4.1). However, for the Gullmar Fjord dataset, data from all six subareas were included as separate samples. The result of the analysis of similarity was visualized by means of principal coordinates analysis (PCO) using the PERMANOVA+ addition to PRIMER 6.0 (Clarke and Warwick 2001).

In addition, the composition of species in relation to their functional attributes was assessed in the same way as described above for taxonomic composition. For this analysis, species were categorized according to their predominant habitat use during different life history phases and their vertical distribution in the water column (see Appendix 1).

The association of a species with a certain category was assigned based on its predominant behavior during the adult life stage, using information from the literature (Elliott and Dewailly 1995, Pihl and Wennhage 2002) and the Fishbase website (www.fishbase.org).

For categorization according to habitat use during different life history phases, the following definitions were used:

CR = coastal resident species, living in the coastal habitat or shallow coastal zone almost all of their life cycle

MJ = marine juvenile migrant species, which use the coastal habitat primarily as nursery and/or feeding grounds

MS = marine seasonal migrant species, which make regular seasonal visits to the coastal habitat, usually as adults

MA = marine adventitious visitors, which appear irregularly in the coastal area but have their primary habitat in deeper waters

C/A = catadromous/anadromous migrant species, which use the coastal habitat when migrating between marine and freshwater for spawning and feeding

For categorization according to vertical distribution, the following definitions were used:

B = benthic species, living on the seabed
D = demersal species, living mainly near the bottom
D-P = demersal-pelagic species, living approximately equal amounts of time in the water column and near the bottom
P = pelagic species, living mainly in the water column

4.2.2 Indicator performance

Differences in how sampling with fyke nets versus gill nets estimates biodiversity based on indicators were assessed based on three commonly used biodiversity indices: species richness, the Shannon index, and Pielou's evenness index. These three indices were included because they reflect slightly different aspects of biodiversity. Species richness is the number of species in each sample, whereas the Shannon index takes into account the number of both individuals and species. Pielou's evenness index describes how individuals are distributed among species (Ricklefs and Schluter 1993).

The indices were computed separately for each sample, that is, for each gear type and dataset (cf. column 2 in Table 4.1). Due to the great differences in total abundance among samples, a rarefaction procedure was used when estimating species richness. This was done to account for the fact that the number of species in a sample often increases with the total number of individuals (Gotelli and Colwell 2001). Cumulative species richness curves were produced to provide estimates of species richness at a gradually increasing number of individuals. Comparisons among samples were made at a species richness corresponding to 100 individuals per sample, which corresponds to the maximum number of individuals in the smallest sample included, rounded down to the nearest 100. The calculations were performed using the PAST statistical software package (Hammer et al. 2001). The corresponding approach was not applied for the other two indices, which proved less sensitive to variation in abundance.

Differences in precision were assessed by comparing the effort needed to obtain a precision of 40% in a set of metrics reflecting aspects of coastal fish community structure (Table 4.2). The metrics used have previously been proposed as potential indicators of good environmental status in coastal fish communities of the Swedish west coast in relation to the Marine Strategy Framework Directive (Wennhage et al. 2012; see also SwAM 2012). The analyses were restricted to datasets in which information was available at the station level (Table 4.1) and in which abundances were high enough to allow for meaningful comparisons, i.e., the Fladen 2003, Vinga 2006, and Vinga 2012 datasets. Metrics requiring information on length distributions could not be computed for the Vinga 2006 dataset.

Precision was estimated according to the following formula:

$$n = \frac{s^2 t^2_{\alpha(2),(n-1)}}{d^2}$$

where n is the number of samples, s^2 is the estimated variance, $t_{\alpha(2),(n-1)}$ is the critical two-sided t-value at the $1 - \alpha$ confidence level and with $n - 1$ degrees of freedom, and d is half the desired confidence interval. The formula was solved to give the number of samples required to achieve a confidence interval for the mean equal to 40% of the mean at $\alpha = 0.05$. Values for n were obtained by iteration using the solver function of MS Excel.

Subsequently, to translate the required number of samples into costs, the time required in the field to obtain the corresponding precision was calculated. This measure is significant because the main costs related to coastal fish monitoring, using both fyke nets and gill nets, are typically related to duration in the field (in the form of salaries and travel-related expenses). Time required in the field was estimated by multiplying the number of replicates needed by an estimated handling time per replicate (station), separately for each gear type. Information on handling time was obtained from the data providers for this study, i.e., SLU Aqua and Marine Monitoring AB. To account for potential differences among areas and due to external conditions, a time range was applied, assuming that sampling using fyke nets requires on average 0.7–0.9 hours per station and gill nets 2.5–2.9 hours per station, based on the obtained responses.

4.2.3 Environmental impact

Both gill nets and fyke nets are passive gear, and have no or very minor impact on the seafloor where they are used. The main environmental impact of both types of gear is therefore the mortality of the species caught. One potential issue in this respect is the level of by-catch, that is, the part of the catch not directly needed to achieve the aims of the study. In this study, target species are defined as the fish species mentioned by name in Table 4.2 (i.e., eelpout, rock cook, corkwing wrasse, goldsinny wrasse, black goby, and all piscivore species including cod); all other fish species are defined as non-target species (i.e., by-catch).

The proportion of by-catch was estimated as the number of non-target fish in relation to the total number of fish caught. The by-catch calculations were made for the Fladen 2003, Vinga 2006, and Vinga 2012 datasets.

TABLE 4.2
Potential indicators of coastal fish environmental status at the Swedish west coast. CPUE denotes catch per unit effort and was calculated as numbers per station.

Name	Computation
Total abundance of fish	CPUE of all fish
Proportion of large individuals	Proportion of all fish over 30 cm length
Abundance of large individuals	CPUE of all fish over 30 cm length
Abundance of cod	CPUE of cod
Abundance of juvenile cod	CPUE of cod below 38 cm length
Abundance of eelpout	CPUE of eelpout
Proportion of piscivores	CPUE of species with trophic levels ≥4.0 according to www.fishbase.org
Abundance of mesopredators	CPUE of rock cook, corkwing wrasse, goldsinny wrasse, and black goby

5 Results

5.1 Species selectivity

5.1.1 Dominant species

There were clear differences in species composition between the catches obtained using fyke nets versus gill nets in all datasets. Both the total number of species and the dominant species generally differed. A particularly great difference was observed in the Baltic Sea datasets. Sampling using gill nets resulted in a list of seven species in the Hanö 2009 dataset and ten species in the Hanö 2012 dataset, whereas only one and two species, respectively, were obtained when using fyke nets (Table 5.1). Cod was the only species observed in samples caught using both gear types.

TABLE 5.1
Species occurring in the Baltic Sea datasets, presented as the mean number of individuals per station and gear type. Values in parentheses indicate standard deviation. Data from Hanö 2009 included 48 stations and data from Hanö 2012 included 15 stations. For scientific names, see Appendix 1.

Species	Hanö 2009		Hanö 2012	
	Fyke net	Gill net	Fyke net	Gill net
Black goby		0.0 (0.1)		0.1 (0.3)
Cod	2.0 (1.7)	8.4 (4.2)	0.1 (0.5)	8.0 (4.2)
European perch				0.1 (0.3)
European whitefish				0.3 (0.6)
Fifteen-spined stickleback			0.1 (0.3)	
Flounder		0.5 (0.8)		0.8 (1.3)
Greater sandeel				0.6 (1.2)
Herring		0.2 (0.6)		2.3 (2.3)
Longspined bullhead				0.1 (0.4)
Shorthorn sculpin		0.0 (0.2)		1.5 (1.1)
Small sandeel				0.1 (0.3)
Sprat		0.1 (0.4)		
Turbot		0.2 (0.5)		

In the datasets from the Swedish west coast, the species lists for the gill net catches included 17–41 species, whereas the species lists for the fyke net catches included 11–24 species (Appendix 2). Due to the high total number of species observed (59 species), dominant species were assessed by identifying the five most abundant species within each dataset and gear type.

The most frequent species were cod and goldsinny wrasse, which were included among the five most abundant species in all datasets and for all gear types except one (Table 5.2). According to the pairwise comparisons, four species were more dominant in the fyke net catches in at least two datasets, but never in the gill net catches (i.e., black goby, eel, eelpout, and shorthorn sculpin). Six species were more dominant in the gill net catches in at least two datasets, but never in the fyke net catches (i.e., dab, flounder, greater weever, herring, hooknose, and whiting). For many species, however, the main differences in abundance appeared among datasets rather than gear types (e.g., cod and goldsinny wrasse in the Fladen 2003, goldsinny wrasse in the Gullmar Fjord rocky habitat, and shorthorn sculpin in the Vinga 2012 datasets).

A more detailed description of all species included is presented in Figure 5.1 and Appendix 1. At the overall level, species occurring only in the fyke net catches, combined for all datasets, were Nilsson's pipefish, two-spotted goby, and spotted dragonet. All of these species, however, occurred at low overall frequencies. The main species occurring only in the gill net catches were grey gurnard, mackerel, and horse mackerel. These three species occurred in the gill net catches in all datasets except one, but never in the fyke net catches. In addition, 19 species were regularly or occasionally observed in the gill net series, but not in the fyke net series (i.e., megrim, common goby, Norwegian topknot, greater pipefish, painted goby, topknot, tub gurnard, lesser sandeel, turbot, garfish, brill, greater sandeel, sand goby, scaldfish, greater weever, sprat, herring, and three-spined stickleback).

TABLE 5.2
List of species included among the five most abundant in any of the samples from the Swedish west coast (one sample = one dataset and gear type; F = fyke net, G = gill net). Numbers indicate the rank of each species within each sample, in which 1 = most abundant, 2 = second most abundant, etc. An “X” indicates that the species occurred but was not ranked among the five most abundant. Dark shading indicates cases in which the species were more dominant in fyke nets, light shading when they were more dominant in gill nets, when compared within the same dataset. For scientific names, see Appendix 1.

	Vinga 2012		**Vinga 2006**		**Fladen 2003**		**Gullmar Fjord, soft**		**Gullmar Fjord, rocky**	
	F	**G**	**F**	**G**	**F**	**G**	**F**	**G**	**F**	**G**
Black goby	X	X	3	-	-	-	4	X	X	X
Cod	2	4	4	4	2	1	5	X	5	3
Corkwing wrasse	X	-	2	X	X	X	X	3	3	2
Dab	-	X	X	1	X	3	-	X	X	X
Eel	X	-	X	-	4	X	X	-	X	X
Eelpout	X	X	X	-	X	X	1	X	2	X
Flounder	-	X	X	3	-	-	X	X	X	X
Goldsinny wrasse	4	2	1	-	1	2	3	5	1	1
Greater weever	-	-	-	-	-	5	-	X	-	X
Herring	-	X	-	-	-	-	-	1	-	X
Hooknose	-	5	-	X	X	X	-	X	-	X
Plaice	5	X	X	2	X	X	X	X	X	X
Pollack	3	X	-	-	-	-	-	X	-	X
Rock cook	-	-	5	-	3	X	-	X	X	X
Shorthorn sculpin	1	1	X	X	X	X	2	4	4	5
Sole	-	-	-	-	5	4	X	X	X	X
Whiting	X	3	X	5	-	X	X	2	X	4

FIGURE 5.1
List of all fish species represented in the Swedish west coast datasets. For each dataset, a bar indicates whether the species occurred. The color of the bar indicates how dominant the species was in the fyke net catches (dark shading) and gill net catches (light shading), based on the proportion of each species in each dataset and for each gear type. Bars dominated by dark shading indicate that the species was relatively more abundant in fyke nets, and light shading that it was relatively more abundant in gill nets.

5.1.2 Species composition

The overall analysis of all datasets from the Swedish west coast indicated that the differences in species composition among samples were related to the gear type used and the dominant type of habitat (Figure 5.2). Generally, the relative abundances of eelpout, eel, and goldsinny wrasse were higher in the fyke net series, whereas the relative abundances of herring and whiting were higher in the gill net series. Differences in species composition that could be related to gear type were related mainly to variation along the first PCO axis, which encompassed about one third (30.5%) of the total variation in the dataset.

The PCO analysis also indicated some clear differences within the Gullmar Fjord dataset between samples from soft-bottom versus rocky habitats. Samples from the rocky subareas in Gullmar Fjord were characterized by goldsinny wrasse, regardless of the gear type used; however, samples from the soft-bottom habitats were characterized by plaice, eel, and eelpout when sampled using fyke nets, but by herring and whiting when sampled using gill nets.

Comparing the different datasets, the fyke net sample from the Vinga 2012 dataset was most similar to the fyke net sample from the Gullmar Fjord soft-bottom habitats, whereas the fyke net sample from the Fladen 2003 dataset was most similar to the fyke net samples from the Gullmar Fjord rocky habitats. This distinction was not seen in the corresponding gill net samples.

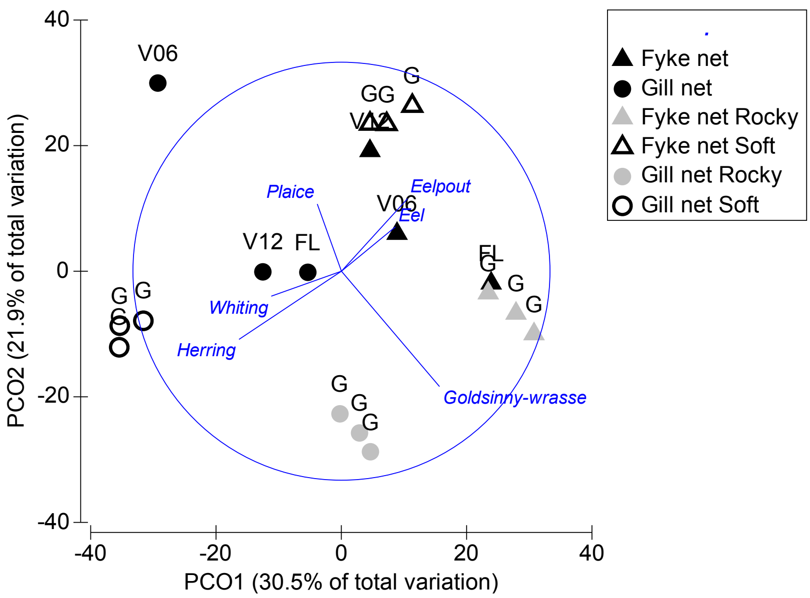

FIGURE 5.2
Results of a multivariate ordination by principal coordinates analysis (PCO). In the graph, samples positioned near each other are more similar to each other in terms of species composition than are samples positioned far from each other. Similarity in

species composition was estimated using the Bray-Curtis index. Code to samples: FL = Fladen 2003, V06 = Vinga 2006, V12 = Vinga 2012, G = Gullmar Fjord. Circles = gill net samples, triangles = fyke net samples. The lines radiating from the centre of the plot are vectors of the species that contributed most to the observed pattern. A vector points in the direction of samples containing relatively high abundances of a given species.

5.1.3 Functional attributes

In the Baltic Sea datasets, the gill net catches clearly included species from a higher number of functional categories than did the fyke net catches (Figure 5.3). This was due to the overall very low species richness in the fyke net catches, in which only two species occurred (cod and fifteen-spined stickleback; Table 4.2).

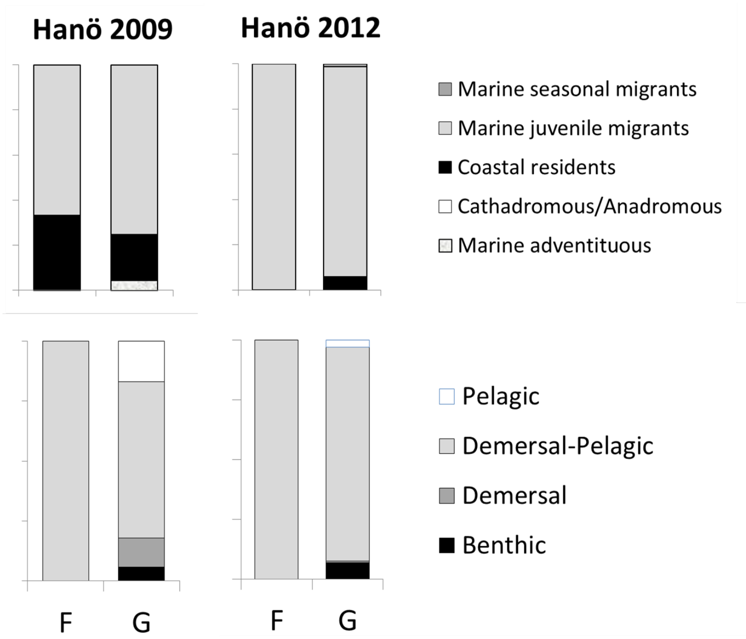

FIGURE 5.3
Species composition of the Baltic Sea datasets represented by functional attributes. Proportions of fish in different categories of habitat use (upper panel) and vertical distribution (lower panel). F = catches in fyke nets, G = catches in gill nets.

In the west coast datasets, fyke nets selected mainly for species categorized as coastal residents. Coastal resident species constituted 74–88% of the fyke net catches in all datasets except the Vinga 2012 dataset, in which they constituted 48% (Figure 5.4). Coastal residents were also the most common group in the gill net catches in the Gullmar Fjord rocky habitat (85%) and Vinga 2012 (82%) datasets. In the other datasets, the gill net catches mainly comprised marine juvenile migrants (51–85%), which were also the second most represented category in the fyke net catches. Catadromous/anadromous species were more common in the fyke net catches, which could be related to the higher prevalence of eel in these series (2–7% in fyke nets versus 0–3% in gill nets). Marine seasonal migrants occurred only in the gill net series (0–8%). The occurrence of marine adventitious species appeared to be related mainly to site. This group was most common in the Vinga 2006 and Fladen 2003 datasets, and displayed no clear pattern of occurrence in relation to gear type.

With respect to vertical distribution, the fyke net catches comprised mainly demersal-pelagic and demersal species (93–100%) in all datasets (Figure 5.4). These species were also the most prevalent in the Gullmar Fjord rocky habitats (97%) and in the gill net catches in the Vinga 2012 dataset (92%). The gill net catches in the other datasets mainly comprised benthic species (Vinga 2006, 75% and Fladen 2003, 38%) or pelagic species (Gullmar Fjord soft-bottom habitats, 56%).

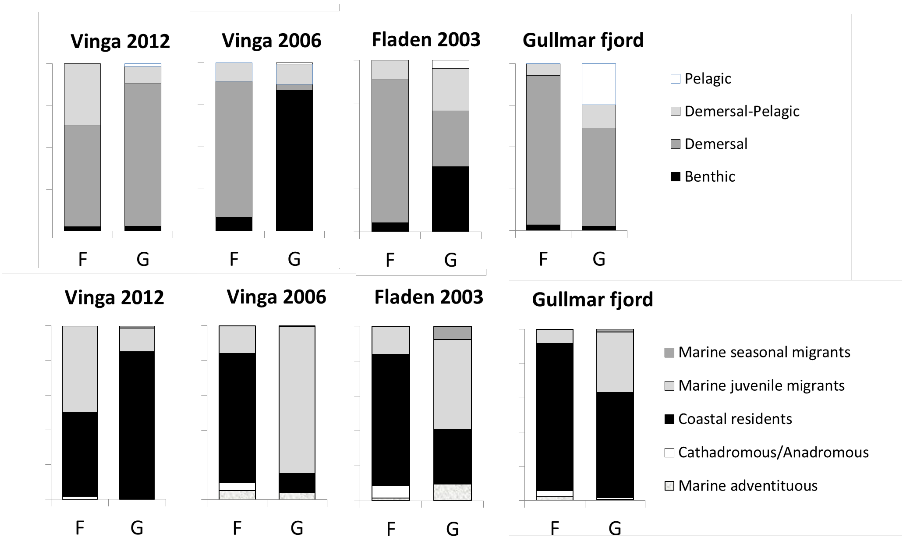

FIGURE 5.4
Composition (%) of functional groups in terms of vertical distribution and habitat use, according to sampling with fyke nets (F) and gill nets (G) in the Swedish west coast datasets.

Differences in functional groups were also compared at the overall level, using multivariate analyses in the same way as for taxonomic species composition. Clear differences among samples were seen with respect to both vertical distribution and habitat use. In both cases, much of the total variation was associated with the first PCO axis (71.4% for vertical distribution and 88.9% for habitat use). Inspection of the ordination plots indicated that this was mainly due to the clear separation of samples in which demersal species (Figure 5.5, upper panel) and catadromous/anadromous species were highly prevalent (Figure 5.5, lower panel). These samples were also very similar to each other, and included all samples except for the gill net samples from the Fladen 2003 and Vinga 2006 dataset and from Gullmar Fjord soft-bottom habitats. In the Gullmar Fjord dataset, in which it was possible to distinguish between catches from soft-bottom and rocky habitats, the gill net catches from rocky habitats were more similar to the fyke net catches, regardless of dataset, than to the other gill net catches. In addition, the Vinga 2012 gill net series was more similar to other fyke net samples than to other gill net samples.

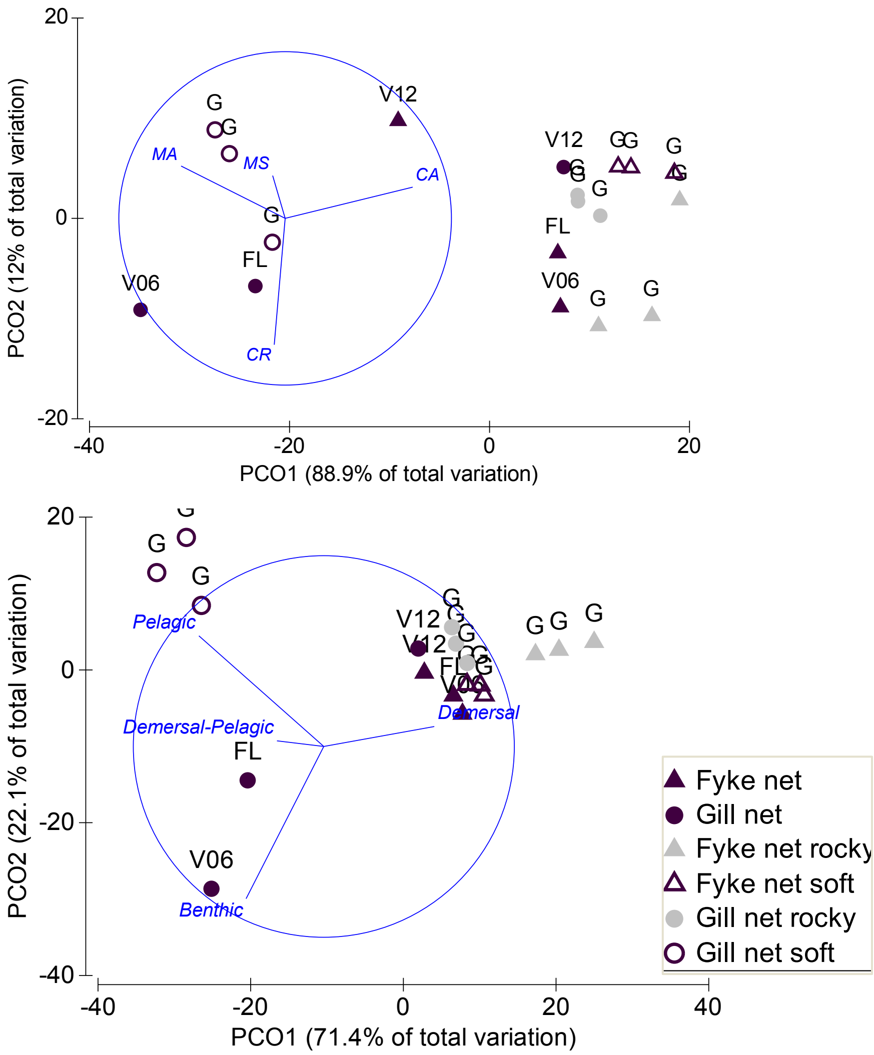

FIGURE 5.5
Plot of similarity among samples (datasets and gear types) with respect to species composition by functional attributes. Upper panel: species categorized according to habitat use during different life history phases. Lower panel: species categorized according to vertical distribution. Samples positioned near each other are more similar to each other than are samples farther from each other. Similarity was estimated using the Bray-Curtis index and ordinated by principal coordinates analysis (PCO). The lines radiating from the centre of the plot are vectors of the functional categories included. A

vector points in the direction of samples containing a relatively high abundance of that category. Code to categories of habitat use: MJ = marine juvenile migrant species, MA = marine adventitious species, CR = coastal resident species, CA = catadromous/anadromous species. Code to datasets: FL = Fladen 2003, V06 = Vinga 2006, V12 = Vinga 2012, G = Gullmar Fjord. Code to gear type: Circles = gill net samples, triangles = fyke net samples.

Similarity among samples was further visualized using hierarchical cluster analysis (Figure 5.6). Generally, fyke net samples were more similar to each other than were gill net samples. The similarity among fyke net samples was approximately 90% for vertical distribution and above 75% for habitat use. For gill nets, the similarity among samples was slightly below 60% for vertical distribution and slightly above 60% for habitat use.

With respect to habitat use during different life history phases, the observed patterns were related mainly to a higher proportion of catadromous/anadromous species in the fyke net samples and of marine adventitious species in the gill net series. Catadromous/anadromous species were mainly represented by eel, but also by trout (e.g., in the Vinga 2012 dataset). Marine adventitious species were represented by several species, varying in abundance among datasets (Appendix 1). With respect to vertical distribution, demersal species were more abundant in the fyke net catches, whereas pelagic and benthic species were more abundant in the gill net catches. However, the proportion of demersal species was also high in the gill net catches at the Gullmar Fjord rocky habitats and in the Vinga 2012 dataset.

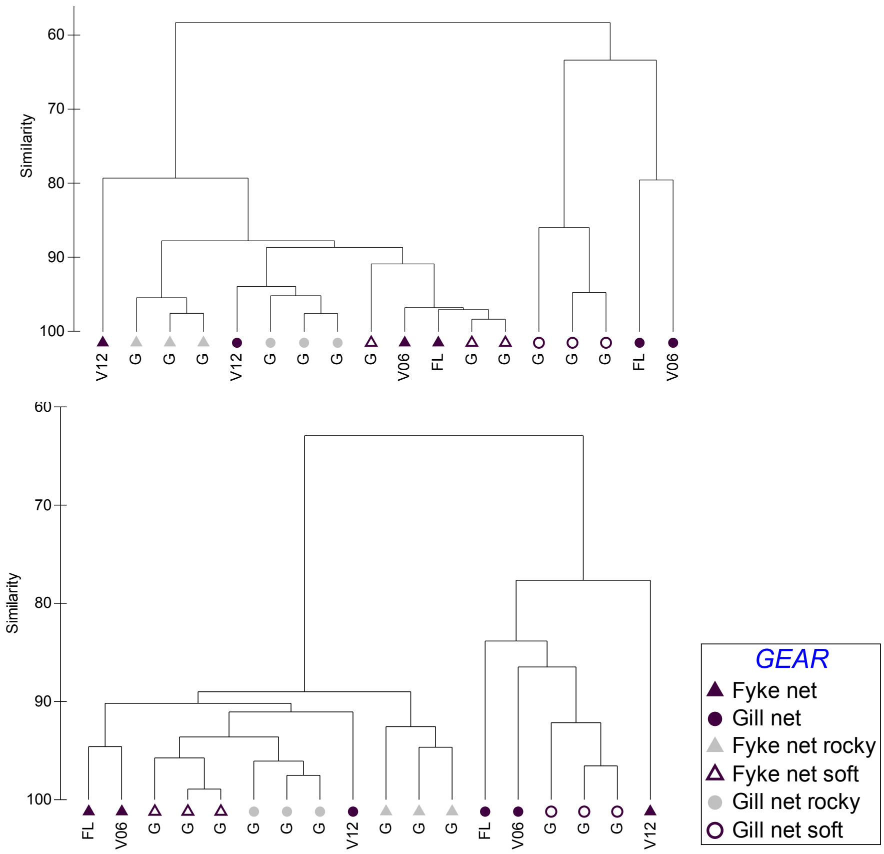

FIGURE 5.6
Results of hierarchical cluster analyses showing similarity among samples (datasets and gear types) in terms of species composition by functional attributes. Upper panel: habitat use during different life history phases. Lower panel: vertical distribution. FL = Fladen 2003, V06 = Vinga 2006, V12 = Vinga 2012, G = Gullmar Fjord (three subareas sampled at rocky and three at soft-bottom habitats). Similarity was assessed using the Bray-Curtis index.

5.2 Indicator performance

5.2.1 Biodiversity

The biodiversity metrics displayed no consistent pattern when fyke net and gill nets series were compared. Species richness values were equal between the fyke net and gill net sample series in one case, higher in fyke nets in one case, and higher in gill nets in one case (Figure 5.7). The Shannon index and Pielou's evenness index were higher for the fyke net series in two of the three datasets. The biodiversity metrics were compared in only the Fladen 2003, Vinga 2006, and Vinga 2012 datasets, due to data limitations in the other datasets (see "Analyses").

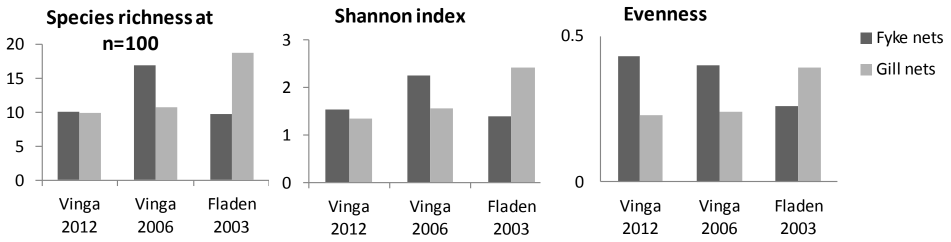

FIGURE 5.7
Comparison of diversity metrics computed from catches in monitoring using fyke nets and gill nets in three datasets from the Swedish west coast.

5.2.2 Precision

Based on estimates per station, precision was higher in the gill net than the fyke net catches in two of three cases (Table 5.3). In the Vinga 2012 dataset, which was sampled using Nordic coastal multimesh nets, precision was higher using fyke nets. However, when accounting for differences in handling time, precision was better using fyke nets in the Fladen 2003 dataset as well, whereas the results for the Vinga 2006 dataset did not change.

With respect to the individual indicators, the greatest differences among gear types were seen for the indicators “abundance of eelpout” and “abundance of mesopredators”, which were more precise in the fyke net catches in all cases. For the other indicators, the magnitude of differences among gear types was minor. No indicator was consistently more precise in gill nets.

TABLE 5.3
Estimated effort required to achieve a precision of 40% in sampling with fyke nets (F) and gill nets (G). Pairwise comparisons were made within each dataset. For each pair, the gear type with better precision is highlighted by dark shading. An overlap in the range of estimates is indicated by light shading. “Hours required” was estimated assuming a handling time of 0.7–0.9 hours per station for fyke nets and 2.5–2.9 hours for gill nets. The type of gill net used and number of gear sets per station varied among datasets, as indicated in rows 3 and 4.

	Vinga 2012		**Vinga 2006**		**Fladen 2003**	
Gear type	**F**	**G**	**F**	**G**	**F**	**G**
Gear specification	**K054**	**K064**	**K054**	**K051**	**K054**	**K072**
Number of gear sets per station	**2**	**1**	**6**	**1**	**5**	**1**
Required stations						
Total abundance of fish	12	15	34	9	18	10
Proportion of large individuals	-	-	151	27	23	10
Abundance of large individuals	-	-	367	71	38	8
Abundance of cod	39	36	85	15	22	7
Abundance of juvenile cod	-	-	88	16	21	7
Abundance of eelpout	319	666	367	-	239	642
Proportion of piscivores	28	33	58	9	20	5
Abundance of mesopredators	189	250	65	548	29	24
Required hours						
Total abundance of fish	8–11	38–44	24–31	23–26	13–16	25–29
Proportion of large individuals	-	-	106–136	68–78	16–21	25–29
Abundance of large individuals	-	-	257–330	178–206	27–34	20–23
Abundance of cod	27–35	90–104	60–77	38–44	15–20	18–20
Abundance of juvenile cod	-	-	62–79	40–46	15–19	18–20
Abundance of eelpout	223–287	1665–1931	257–330	-	167–215	1605–1862
Proportion of piscivores	20–25	83–96	41–52	23–26	14–18	13–15
Abundance of mesopredators	132–170	625–725	46–59	1370–1589	20–26	60–70

5.3 Environmental impact

The proportion of captured species not directly needed in order to compute the suggested environmental status indicators (Table 4.2) was higher in the gill net catches in all three datasets studied, or 45–87% for gill nets and 2–53% for fyke nets.

Target species were identified as all species named in Table 4.2, and all piscivore species in addition to cod. The proportion of eelpout was higher in the fyke net series in all datasets. The proportions of mesopredators and piscivores were higher in the fyke nets series in two of the three studied datasets. The proportion of cod was higher in the fyke nets series in one case and in the gill net series in another case, and equal in the third case (Table 5.4).

TABLE 5.4
Estimated proportions of target and non-target species used in computing the environmental status indicators applied in this study (see Table 4.2). Values are shown separately for fyke net (F) and gill net (G) catches in each dataset. For each dataset and species, the sample with the higher proportion of the target species is highlighted. The overall proportion of non-target species (by-catch) is shown in the last row.

	Vinga 2012		Vinga 2006		Fladen 2003	
	F	G	F	G	F	G
Number of stations sampled	25	25	29	20	24	24
Total abundance in the catch (all species)	110	464	300	620	661	694
Total abundance of target species	92	157	281	132	696	531
Total number of species in the catch	11	17	24	20	16	29
Total number of target species in the catch	7	7	8	4	7	10
Relative abundance of each target species (%)						
Cod	36	4	9	9	11	22
Eelpout	2	0	1	0	2	0
Piscivores (including cod)	38	11	16	12	20	30
Mesopredators	7	18	68	0.3	72	25
Relative abundance of all target species (%)	47	30	85	13	94	54
Proportion of non-target species (by catch, %)	53	70	15	87	6	46

6 Discussion

The field surveys on which this study was based were not specifically dedicated to comparing fyke net and gill net catches, but were originally conducted for other purposes. Therefore, the analyses were limited to what was considered feasible, in order to focus on variation that could be related to differences between gear types. Other potential sources of variation among datasets and samples include differences in sampling season, sampling depth, level of replication, or gear specifications (especially for the gill net catches). Still, general differences between the two gear types could be noted with respect to both species composition of the catches and sampling precision.

6.1 Species selectivity

There were some consistent differences in species selectivity between the two gear types. Gill nets were generally less selective and provided a wider representation of functional groups than fyke nets. With respect to individual species, some species appeared more suitable for targeting by fyke nets (i.e., eel, eelpout, black goby, and shorthorn sculpin) and others by gill nets (i.e., dab, flounder, greater weever, herring, hooknose, and whiting). Other species appeared to be suitable target species for both gear types (i.e., cod and goldsinny wrasse).

The fyke net catches were typically dominated by demersal and demersal-pelagic species, to a fairly similar degree in all datasets, whereas the gill net catches varied more among datasets. Typically, the gill net catches included a greater share of pelagic species than did the fyke net catches. These differences can largely be explained by how the two gear types are positioned in the water column. Fyke nets are located near the substrate and reach approximately 0.5–0.7 meters high. Gill nets are also located near the substrate but extend up in the water column to approximately 1.5 meters high, depending on the gear specifications, and are thus somewhat more likely to catch pelagic species. Comparing differences in absolute abundances between gear types was not considered feasible, due to obvious differences between sampling methods and setups.

With respect to habitat use during different life history phases, fyke net sampling was typically more selective for coastal resident species (local species), whereas gill net sampling was variable in this respect among datasets. The gill net catches were dominated by marine juvenile migrants in three cases and by coastal residents in two cases.

The results indicate that the species composition of the fyke net catches is likely to be more similar over time and among geographical areas, whereas gill nets are more likely to also catch species that occur in given areas at smaller temporal and spatial time scales. This was also indicated by the multivariate analyses, which identified a tendency toward greater variation in species composition in the gill net than the fyke net catches.

Differences in species composition were also observed in relation to local habitats, based on results from the Gullmar Fjord datasets. A similar assessment could not be directly made for the other datasets, as habitat type was not mapped in relation to sampling. However, geological surveys at Fladen have indicated a predominance of rocky habitats in this area, and the area has also been estimated to have a high probability of the occurrence of brown algae (*Laminaria* spp.) that occur only on hard substrates (Bergström et al. 2011). For the Vinga 2006 dataset, sampling was performed in an area dominated by soft substrates, which served as a reference area for monitoring fish in an adjacent artificial reef (County Administrative Board of Västra Götaland 2007). The fish species composition at Fladen was very similar to that found at rocky habitats in the Gullmar Fjord, whereas the fish species composition captured in the Vinga 2006 dataset most resembled that found in soft-bottom habitats in the Gullmar Fjord, indicating that some of the observed variation among the other datasets could be explained by differences in local habitat structure.

6.2 Indicator performance

Three datasets from the Swedish west coast were analyzed to examine indicator performance. In terms of biodiversity, gill net catches included a higher total number of species than did the fyke net catches. However, when accounting for the differences in the total number of individuals caught, the performance of the two gear types was similar. Both fyke nets and gill nets sampled on average 10 species per 100 individuals, except for one fyke net sample (in the Vinga 2006 dataset, 17 species were sampled per 100 individuals) and one gill net sample (in the Fladen 2003 dataset, 19 species were sampled per 100 individuals). Values for the Shannon index and the Pielou's evenness index were higher in the fyke net than the gill net catches in two of the three studied cases.

The effort needed to achieve a certain sampling precision was generally lower for fyke nets than for gill nets, when accounting for numbers of samples required and hours required in the field to collect one sample. Fyke nets performed better than did gill nets in two of the three cases. The differences among datasets may reflect the fact that different types of gill nets were used in the different studies. It is also possible that the precision of a certain gear type actually varies among habitat types. Another aspect that may affect the interpretation is that the datasets included in this evaluation typically represent a slightly greater depth range than is currently covered by ongoing monitoring programs. National monitoring is typically conducted at a depth of 0–10 meters versus 0–20 meters in this evaluation. At shallower depths, the precision of sampling of the target species is likely to be greater than in the current examples, and the interactions with shore crabs stronger (see below). Other factors that could affect precision include prevalent fish densities or differences in fish behavior among habitat types. However, these aspects were beyond the scope of this study.

Obviously, the reported results are highly dependent on the estimates of expected handling time applied in the evaluation. In reality, the expected handling time will be influenced by various external factors, such as weather conditions, catch size, personal experience in using the method, and familiarity with the survey area. Particularly on the Swedish west coast, handling time is strongly dependent on the expected abundance of shore crabs in the catches. The shore crabs become trapped in the gear and are to some extent also attracted to the gear by the fish being caught. This problem increases the differences in cost efficiency between gear types in several ways. First, much more time is required to handle one shore crab in gill net sampling than in fyke net sampling. In addition, the rate of crab damage to the gear is higher in gill nets, further reducing the shorter expected longevity of gill nets compared with fyke nets. Since the shore crabs are often strongly entangled, they often damage the gear to such an extent that the gill nets can be used only once before they have to be replaced. The shore crabs can also threaten the data quality: they can sometimes damage the captured fish and, more seriously, entangled crabs impair the functionality of the gill nets. Therefore, using gill nets in areas with high abundances of shore crabs is closely associated with increased costs stemming from both increased handling time and direct gear costs.

The current study focused on aspects of species composition, whereas aspects of size structure were only briefly addressed. This was mainly due to constraints in the data available for analysis, largely stemming from the variation in gill net specifications among datasets. The range of mesh sizes used is well known to strongly affect the size structure of the catches. The size selectivity of Nordic coastal multi-mesh gill nets was assessed in detail by Söderberg et al. (2004). Subsequent analyses based on large datasets from the Baltic Sea area have demonstrated that this gear is suitable for providing quantitative estimates of individuals with a minimum length of 12 cm (HELCOM 2012a). The net series used in compiling the Vinga 2006 and Fladen 2003 datasets have larger mesh sizes (Table 4.1) and are thereby expected to provide a higher share of large-sized fish than the Nordic coastal multi-mesh nets.

6.3 Environmental impact

The proportion of species not targeted for status assessment was typically higher in the gill net than the fyke net catches, with respect to the studied set of indicators. The difference was quite great between gear types. The proportion of by-catch (i.e., non-target species) was 2–53% in fyke nets versus 46–87% in gill nets, suggesting that fyke nets have less impact than do gill nets on ambient fish populations for these indicators. Naturally, in relation to other indicators (with other target species), gill nets may be more suitable.

However, the final effect will obviously also depend on the number of stations that need to be sampled to achieve the desired precision, for each gear type. Another potential consideration is the fate of the species caught. In general, fyke nets induce far less stress on captured fish than does entanglement gear such as gill nets, so most fish captured in fyke nets can be released unharmed after being recorded.

6.4 Fyke nets and gill nets in the Baltic Sea

This study was biased towards more in-depth comparisons of datasets from the Swedish west coast, whereas the Baltic Sea area was subject to less analysis. This focus of the study was motivated mainly by data availability. However, the analyses made of available Baltic Sea datasets quite clearly suggested that gill nets are likely to perform better than are fyke nets in assessing both the species composition and environmental status of coastal fish communities in the Baltic Sea. Catches made using fyke nets were small in the studied datasets, and analyses of species composition indicated that fyke nets are not very efficient in providing representative estimates of Baltic Sea coastal fish assemblages. However, the fact that both datasets were obtained from the same geographical area suggests that care is warranted in relation to generalizing the results; other geographical areas with different biological and topographical conditions might yield different results.

A more detailed analysis of how different functional groups of coastal fish are represented in coastal areas of the Baltic Sea and at the Swedish west coast was provided by Karlsson et al. (2012). A set of indicators for assessing good environmental status in the Baltic Sea based on gill net sampling was presented by HELCOM (2012a,b).

6.5 Fyke nets and gill nets at the Swedish west coast

In general, gill nets caught more individuals and appeared more suitable for estimating the total number of species in an area. However, in relation to indicator-based status assessments, the two gear types performed equally well when using metrics of species diversity that were not influenced by total abundance levels.

In terms of efficiency, weighting differences in estimated precision, expected handling time, and gear longevity between the two types of gear, fyke nets were considered preferable to gill nets. Fyke nets also produced a lower rate of by-catch and lower expected mortality rates, as fewer individuals are caught and most individuals caught can be released live after being recorded.

In relation to the representation of different species, fyke nets appeared more suitable for monitoring species that reside in the coastal area and live relatively near the substrate, whereas gill nets appeared better suited for supplementary sampling of species that migrate through coastal and open sea areas, and for sampling a wider range of the prevalent fish assemblage. The differences in species representation have some implications for how data from the two methods can be used in mapping and monitoring, as fish mobility is strongly connected to the geographical scale at which a species will reflect changes in the environment. Whereas local species are likely to primarily reflect local influences, species with wider total distribution ranges are more likely to reflect changes also occurring in other parts of the sea area.

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Appendix 1

Categorization of species according to functional attributes. Species were categorized by their habitat use during different life history phases (CR = coastal resident species, MJ = marine juvenile migrant species, MS = marine seasonal migrant species, MA = marine adventitious visitors, C/A = catadromous/anadromous migrant species) and by their vertical distribution in the water column (B = benthic, D = demersal, D-P = demersal-pelagic, P = pelagic). The “Origin” column provides additional information on the categorization of species as marine (M) or freshwater (F). This information was not used in the study.

English name	Scientific name	Origin	Habitat use	Vertical distribution	Feeding groups
Alpine bullhead	*Cottus poecilopus*	F	CR	D	IF
American plaice	*Hippoglossoides platessoides*	M	MA	B	IF
Anchovy	*Engraulis encrasicolus*	M	MS	P	PL
Atlantic catfish	*Anarhichas lupus*	M	MA	D	I
Ballan wrasse	*Labrus berggylta*	M	CR	D	I
Baltic whitefish	*Coregonus maraena*	F	CR	D-P	I
Black goby	*Gobius niger*	M	CR	D	IF
Bleak	*Alburnus alburnus*	F	CR	P	I
Bream	*Abramis brama*	F	CR	D	I
Brill	*Scophthalmus rhombus*	M	MJ	B	IF
Broadnosed pipefish	*Syngnathus typhle*	M	CR	D	IF
Bullhead	*Cottus gobio*	F	CR	D	I
Burbot	*Lota lota*	F	CR	D	Pi
Butterfish	*Pholis gunnellus*	M	CR	D	I
Cod	*Gadus morhua*	M	MJ	D-P	Pi
Common dragonet	*Callionymus lyra*	M	MA	B	I
Common goby	*Pomatoschistus microps*	M	CR	B	I
Corkwing wrasse	*Symphodus melops*	M	CR	D	I
Crucian carp	*Carassius carassius*	F	CR	D-P	O
Cuckoo wrasse	*Labrus mixtus*	M	CR	D	I
Dab	*Limanda limanda*	M	MJ	B	IF
Dace	*Leuciscus leuciscus*	F	CR	D-P	O
Eelpout, viviparous blenny	*Zoarces viviparus*	M	CR	D	I
European eel	*Anguilla anguilla*	M	CA	D	IF
European perch	*Perca fluviatilis*	F	CR	D-P	Pi
European pike-perch	*Sander lucioperca*	F	CR	D-P	Pi
Fifteen-spined stickleback	*Spinachia spinachia*	M	CR	D-P	I
Five-beard rockling	*Ciliata mustela*	M	MA	D	IF
Flounder	*Platichthys flesus*	M	CR	B	IF
Four-beard rockling	*Enchelyopus cimbrius*	M	MA	D	I
Four-horned sculpin	*Triglopsis quadricornis*	F	CR	D	IF
Garfish	*Belone belone*	M	MS	P	Pi
Goldsinny wrasse	*Ctenolabrus rupestris*	M	CR	D	I
Grayling	*Thymallus thymallus*	F	CR	D-P	IF
Greater pipefish	*Syngnathus acus L.*	M	CR	D	I
Greater sandeel	*Hyperoplus lanceolatus*	M	MA	D-P	Pi
Greater weever	*Trachinus draco*	M	MA	B	Pi
Grey gurnard	*Eutrigla gurnardus*	M	MS	B	IF
Haddock	*Melanogrammus aeglefinus*	M	MA	B	Pi
Hake	*Merluccius merluccius*	M	MA	D	Pi
Herring/Baltic herring	*Clupea harengus*	M	MJ	P	PL
Hooknose	*Agonus cataphractus*	M	CR	D	I
Horse mackerel	*Trachurus trachurus*	M	MA	P	Pi
Ide	*Leuciscus idus*	F	CR	D-P	IF
Lemon sole	*Microstomus kitt*	M	MA	B	I
Lesser forkbeard	*Raniceps raninus*	M	CR	D	IF
Ling, drizzie	*Molva molva*	M	MA	D	Pi
Longspined bullhead	*Taurulus bubalis*	M	CR	D	IF
Lumpsucker	*Cyclopterus lumpus*	M	MS	D	IF
Mackerel	*Scomber scombrus*	M	MS	P	Pi
Megrim	*Lepidorhombus whiffiagonis*	M	MA	B	Pi

Continues on next page

Appendix I(cont.).

English name	Scientific name	Origin	Habitat use	Vertical distribution	Feeding groups
Minnow	*Phoxinus phoxinus*	F	CR	P	I
Montagu's sea-snail	*Liparis montagui*	M	MA	D	I
Nilsson's pipefish	*Syngnathus rostellatus*	M	CR	D	I
Nine-spined stickleback	*Pungitius pungitius*	M	CR	D-P	IF
Northern pike	*Esox lucius*	F	CR	D	Pi
Norway bullhead	*Micrenophrys lilljeborgii*	M	MA	D	IF
Norway pout	*Trisopterus esmarkii*	M	MA	D-P	IF
Norwegian topknot	*Phrynorhombus norvegicus*	M	MA	B	I
Painted goby	*Pomatoschistus pictus*	M	CR	D	I
Picked dogfish, spurdog	*Squalus acanthias*	M	MA	D-P	Pi
Plaice	*Pleuronectes platessa*	M	MJ	B	IF
Pollack	*Pollachius pollachius*	M	MJ	D	Pi
Poor cod	*Trisopterus minutus*	M	MA	D	IF
Pounting	*Trisopterus luscus*	M	MJ	D	IF
Rainbow/steelhead trout	*Onchorhynchus mykiss**	-	-	-	-
Roach	*Rutilus rutilus*	F	CR	D-P	I
Rock cook	*Centrolabrus exoletus*	M	CR	D	I
Round goby	*Neogobius melanostomus**	-	-	-	-
Rudd	*Scardinius erythrophthalmus*	F	CR	D-P	O
Ruffe	*Gymnocephalus cernuus*	F	CR	D-P	I
Saithe	*Pollachius virens*	M	MJ	D-P	Pi
Salmon	*Salmo salar*	F	CA	P	Pi
Sand/little goby	*Pomatoschistus minutus*	M	CR	B	I
Scaldfish	*Arnoglossus laterna*	M	MA	B	IF
Sea perch (sea bass)	*Dicentrarchus labrax*	M	MJ	D	Pi
Shorthorn sculpin	*Myoxocephalus scorpius*	M	CR	D	IF
Silver bream	*Abramis bjoerkna*	F	CR	D-P	I
Small sandeel/lesser sandeel	*Ammodytes spp.*	M	MA	D-P	IF
Smelt	*Osmerus eperlanus*	F	CA	P	IF
Snake pipefish/greater pipefish	*Entelurus aequoreus*	M	MA	D	IF
Sole	*Solea solea*	M	MJ	B	IF
Solenette	*Buglossidium luteum*	M	MA	B	I
Spotted dragonet	*Callionymus maculatus*	M	MA	B	I
Sprat	*Sprattus sprattus*	M	MS	P	PL
Straight - nosed pipefish	*Nerophis ophidion*	M	CR	D	I
Surmullet	*Mullus surmuletus*	M	MA	B	I
Tench	*Tinca tinca*	F	CR	D-P	O
Thick-lipped mullet	*Chelon labrosus*	M	MS	D-P	O
Thornback ray	*Raja clavata*	M	MA	B	Pi
Three-spined stickleback	*Gasterosteus aculeatus*	M	CR	D-P	IF
Topknot	*Zeugopterus punctatus*	M	MA	B	Pi
Transparent goby	*Aphia minuta*	M	CR	P	PL
Trout	*Salmo trutta*	F	CA	P	IF
Tub gurnard	*Chelidonichthys lucerna*	M	MA	B	IF
Turbot	*Psetta maxima*	M	MJ	B	Pi
Two-spotted goby	*Gobiusculus flavescens*	M	CR	D-P	PL
Vendace	*Coregonus albula*	F	CR	P	PL
Whiting	*Merlangius merlangus*	M	MJ	D-P	Pi
Vimba	*Abramis vimba*	F	CR	D-P	I
Worm pipefish	*Nerophis lumbriciformis*	M	CR	D	IF
Yarrell's blenny/Atlantic warbonnet	*Chirolophis ascanii*	M	MA	D	I

Appendix 2

Datasets from the Swedish west coast included in the assessment. Values indicate abundances of each species per dataset and gear type, estimated as mean numbers per station for the Vinga 2006, Vinga 2012, and Fladen 2003 datasets, and per subarea for the Gullmar Fjord dataset. Values in parentheses are standard deviations of the mean. Note: Abundance estimates cannot be directly compared among datasets and types of gear due to differences in the methods and survey designs applied.

		Vinga 2012		Vinga 2006		Fladen 2003		Gullmar fjord 1998-1999			
								Soft substrate		Rocky substrate	
		Fyke nets	**Gill nets**	**Fyke nets**	**Gill nets**	**Fyke nets**	**Gill nets**	**Fyke nets**	**Gill nets**	**Fyke nets**	**Gill nets**
	Gear specification	K054	K064	K054	K051	K054	K069	K054	NA	K054	NA
	Fyke nets/gill nets per station	2	1	6	1	5	1	NA	NA	NA	NA
	Number of stations	25	25	29	20	24	24	NA	NA	NA	NA
Species	**Scientific name**										
Ballan wrasse	*Labrus berggylta*						0.37 (0.64)			1.66 (2.08)	42 (26.8)
Black goby	*Gobius niger*	0.04 (0.2)	0.12 (0.33)	1.10 (1.37)				12.3 (10.6)	32 (30.2)	7 (5.56)	22.3 (8.50)
Brill	*Scophthalmus rhombus*						0.33 (0.56)		0.33 (0.57)		
Broadnosed pipefish	*Syngnathus typhle*			0.03 (0.18)					1.66 (2.08)		0.33 (0.57)
Butterfish	*Pholis gunnellus*		0.04 (0.2)	0.10 (0.30)					1.33 (1.52)	1.33 (0.57)	2 (1)
Cod	*Gadus morhua*	1.6 (1.93)	0.76 (0.87)	0.89 (1.61)	2.65 (1.95)	3.12 (2.81)	6.41 (3.32)	10.6 (11.5)	36.6 (25.0)	24.3 (4.72)	101. (23.6)
Common dragonet	*Callionymus lyra*			0.06 (0.25)	0.45 (0.82)	0.08 (0.28)	0.70 (1.62)		1 (1.73)		
Common goby	*Pomatoschistus microps*								0.33 (0.57)		
Corkwing wrasse	*Symphodus melops*	0.08 (0.27)		2.06 (4.11)	0.1 (0.44)	0.41 (0.77)	0.45 (0.83)	3.33 (3.05)	70.3 (38.2)	39 (30.4)	132. (43.7)
Cuckoo wrasse	*Labrus mixtus*					0.04 (0.20)	0.45 (0.97)				3.66 (4.04)
Dab	*Limanda limanda*		0.4 (0.76)	0.24 (0.51)	17.4 (13.6)	0.5 (0.93)	4.66 (9.56)		5.33 (5.85)	0.33 (0.57)	2.66 (3.05)
Eelpout	*Zoarces viviparus*	0.08 (0.27)	0.04 (0.2)	0.06 (0.25)		0.58 (1.74)	0.04 (0.20)	56.3 (41.4)	6 (2)	47.3 (8.14)	4.66 (0.57)
European eel	*Anguilla anguilla*	0.08 (0.27)		0.44 (1.05)		2 (3.10)	0.08 (0.28)	6.33 (2.88)		13.3 (7.23)	0.33 (0.57)
Fifteen-spined stickleback	*Spinachia spinachia*								4.66 (8.08)		4.66 (3.05)
Five-beard rockling	*Ciliata mustela*			0.06 (0.25)						9.66 (7.50)	0.66 (1.15)
Flounder	*Platichthys flesus*		0.12 (0.33)	0.06 (0.25)	2.8 (5.35)			10 (2)	34.3 (24.1)	0.33 (0.57)	2.66 (1.15)
Garfish	*Belone belone*								0.33 (0.57)		0.33 (0.57)
Goldsinny wrasse	*Ctenolabrus rupestris*	0.2 (0.57)	3.24 (10.2)	3.27 (6.06)		17.0 (17.4)	6.37 (6.00)	17 (8)	58.6 (26.3)	216. (48.0)	1514 (120)
Greater pipefish	*Entelurus aequoreus*			0.13 (0.35)		0.29 (0.75)					0.66 (1.15)
Greater pipefish	*Syngnathus acus L.*										0.33 (0.57)
Greater sandeel	*Hyperoplus lanceolatus*						0.04 (0.20)		1 (1.73)		1.66 (2.88)
Greater weever	*Trachinus draco*						1.12 (1.67)		0.33 (0.57)		0.66 (0.57)
Grey gurnard	*Eutrigla gurnardus*				0.05 (0.22)		1.08 (1.81)		2.33 (1.52)		
Herring	*Clupea harengus*		0.04 (0.2)						768. (495)		41 (41.7)
Hooknose	*Agonus cataphractus*		0.68 (1.21)		0.2 (0.52)	0.04 (0.20)	0.12 (0.44)		0.33 (0.57)		2.33 (2.30)
Horse mackelel	*Trachurus trachurus*				0.1 (0.30)		0.37 (1.09)		1.33 (0.57)		1 (1)
Lemon sole	*Microstomus kitt*				0.05 (0.22)	0.04 (0.20)	0.20 (0.41)	0.33 (0.57)		0.66 (0.57)	0.66 (1.15)
Lesser forkbeard	*Raniceps raninus*									0.33 (0.57)	0.66 (1.15)
Ling, drizzie	*Molva molva*					0.04 (0.20)	0.04 (0.20)				
Longspined bullhead	*Taurulus bubalis*	0.04 (0.2)	0.08 (0.27)	0.03 (0.18)			0.12 (0.44)	2.33 (2.08)	2 (1.73)	22.3 (10.2)	43.6 (23.0)
Lumpsucker	*Cyclopterus lumpus*						0.04 (0.20)			0.33 (0.57)	1.33 (1.52)
Mackerel	*Scomber scombrus*		0.12 (0.33)		0.1 (0.30)		1.04 (1.94)		34.6 (14.0)		6.33 (2.30)
Megrim	*Lepidorhombus whiffiagonis*										0.33 (0.57)
Nilsson's pipefish	*Syngnathus rostellatus*			0.06 (0.25)							
Norwegian topknot	*Phrynorhombus norvegicus*								0.33 (0.57)		
Painted goby	*Pomatoschistus pictus*								0.66 (0.57)		
Plaice	*Pleuronectes platessa*	0.12 (0.43)	0.04 (0.2)	0.34 (0.85)	4.2 (3.03)	0.04 (0.20)	0.37 (0.71)	6.33 (2.08)	22 (19.9)	0.33 (0.57)	1 (1)
Pollack	*Pollachius pollachius*	0.44 (0.86)	0.12 (0.33)						1.33 (2.30)		6 (5.56)
Poor cod	*Trisopterus minutus*			0.17 (0.46)	0.45 (0.68)		0.16 (0.38)				
Rock cook	*Centrolabrus exoletus*			0.58 (2.07)		2.29 (3.19)	0.29 (0.62)		1 (1)	3.66 (3.78)	54.6 (39.5)
Saithe	*Pollachius virens*				0.05 (0.22)		0.5 (2.44)		16.3 (27.4)	1.66 (1.52)	43 (14.9)
Sand/little goby	*Pomatoschistus minutus*								4.33 (4.16)		1 (1.73)
Scaldfish	*Arnoglossus laterna*				0.05 (0.22)				4.33 (7.50)		0.66 (0.57)
Shorthorn sculpin	*Myoxocephalus scorpius*	1.68 (1.77)	11.4 (5.22)	0.13 (0.35)	0.25 (0.55)	0.16 (0.38)	0.79 (0.88)	17.3 (7.57)	66.3 (32.1)	29.3 (8.08)	83.3 (26.7)
Small sandeel	*Ammodytes spp.*								0.66 (1.15)		
Sole	*Solea solea*				0.8 (0.95)	0.79 (1.06)	2.29 (2.29)	0.33 (0.57)	1 (1)	0.66 (0.57)	1.66 (2.08)
Spotted dragonet	*Callionymus maculatus*									0.33 (0.57)	
Sprat	*Sprattus sprattus*		0.12 (0.33)						10 (8.54)		1.33 (0.57)
Straight-nosed pipefish	*Nerophis ophidion*			0.03 (0.18)	0.05 (0.22)				0.33 (0.57)		
Surmullet	*Mullus surmuletus*			0.10 (0.40)					3.66 (0.57)		1.66 (0.57)
Three-spined stickleback	*Gasterosteus aculeatus*								38.6 (34.0)		
Topknot	*Zeugopterus punctatus*						0.08 (0.28)				
Trout	*Salmo trutta*		0.04 (0.2)					0.33 (0.57)	21.6 (11.1)		14 (5.29)
Tub gurnard	*Chelidonichthys lucerna*				0.1 (0.30)						
Turbot	*Psetta maxima*						0.12 (0.33)				
Two-spotted goby	*Gobiusculus flavescens*			0.06 (0.37)				0.33 (0.57)			
Whiting	*Merlangius merlangus*	0.04 (0.2)	1.16 (2.54)	0.17 (0.38)	1.05 (0.88)		0.16 (0.48)	2.33 (1.52)	173 (88.7)	0.33 (0.57)	96.3 (20.5)
Worm pipefish	*Nerophis lumbriciformis*			0.03 (0.18)	0.05 (0.22)						

Comparison of gill nets and fyke nets for the status assessment of coastal fish communities

Environmental monitoring of coastal fish communities in Sweden is conducted using fyke nets and gill nets. This report addresses how the two methods differ in terms of what part of the local fish assemblage they sample, and how they are likely to perform in an indicator-based assessment of environmental status. Differences between the methods are compared at a general level, and are evaluated in relation to prevailing monitoring aims.

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