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– and catches in Swedish fisheries

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Sammanfattning

Denna rapport är skriven på uppdrag av Havs- och vattenmyndigheten för att uppdatera 2019-års rapport: ”*Occurrence of skates and rays in northern European waters and catches in Swedish fisheries in the Skagerrak/Kattegat and the eastern North Sea*”. Syftet var att ge en heltäckande översikt över vilka broskfiskar (hajar, rockor och havsmusfiskar) som förekommer i svenska vatten och i vilken utsträckning dessa fångas i svenskt fiske. För att beskriva förekomst och rumslig utbredningen använde vi fiskerioberoende surveydata från 1967–2020, samt data från det nationella observatörsprogrammet av det kommersiella fisket (även kallat ombordprovtagning) och officiella landningsdata. Sammanlagt påträffades 21 arter av hajar, rockor och havsmus från Skagerrak, Kattegatt och Öresund under perioden.

Sju av arterna var vanliga i både fiskerioberoende och i kommersiell data, vilket tyder på att de är varaktigt hemmahörande i svenska vatten. Denna grupp omfattar tre hajarter; blåkäxa (*Etmopterus spinax*), småfläckig rödhaj (*Scyliorhinus canicula*) och pigghaj (*Squalus acanthias*); tre rockor; klorocka (*Amblyraja radiata*), knaggrocka (*Raja clavata*) och vitrocka (*Rajella lintea*); samt havsmus (*Chimaera monstrosa*). Rundrockan (*Rajella fyllae*) var också relativt vanlig i surveyfångster från de djupare delarna av Skagerrak. Alla vanliga arter förekom året runt, men pigghaj uppvisade också en säsongsmässig trend, där den var vanligare längs den norska kusten och i utsjön under första kvartalet, och fångades närmare den svenska kusten under tredje och fjärde kvartalet.

Det förekommer inte längre något riktat fiske efter haj och rocka i det svenska fisket, men bifångster är vanliga, främst vid bottentrålfiske i de djupare delarna av Skagerrak och i Norska rännan där bifångst förekom i huvuddelen av de observerade trålhalen. Användning av rist i kräft- och räkfisket verkar minska förekomsten av bifångst. Historisk och anekdotisk information tyder på att bifångster av pigghaj i nätfiske kan vara betydande, men eftersom all landning av pigghaj är förbjuden har inga data över fångster tillkommit sedan 2010 då landning av pigghaj förbjöds.

Klorocka och pigghaj utgör > 75 % av den skattade fångstvikten för alla hajar och rockor tillsammans. Mer än 90 % av fångsten kastas tillbaka, vilket inte är förvånande med tanke på att det är förbjudet att landa pigghaj, klorocka, slätrocka och knaggrocka från Skagerrak/Kattegatt. Vitrocka är den enda art som landats av svenska fartyg i någon större omfattning (några ton per år) de senaste fem åren. Svenska landningar av vitrocka kommer huvudsakligen från fisket efter nordhavsräka och demersalt trålfiske utan rist i de djupa delarna av Skagerrak.

Nyckelord: broskfisk, hajar, rockor, havsmus trålundersökning, bottentrål, utbredning, landningar, observatörsdata

Abstract

This report was written in response to a request from the Swedish Agency for Marine and Water Management to update an earlier technical note from SLU Aqua "Occurrence of skates and rays in northern European waters and catches in Swedish fisheries in the Skagerrak/Kattegat and the eastern North Sea". The aim was to provide a comprehensive overview of elasmobranchs present in Swedish waters and to what extent these species are caught in Swedish fisheries. To describe the occurrence and spatial distribution of sharks, rays and rabbit fish we used fisheries-independent survey data from 1967–2020, as well as data from the national on-board observer program and official landing data. During this time a total of 21 species of sharks, rays and rabbit fish were reported from the Skagerrak, Kattegat and the Sound.

Seven of the species were common in both the fishery independent and the commercial data supporting that they are native to Swedish waters. These species included three shark species; velvet belly (*Etmopterus spinax*), lesser spotted dogfish (*Scyliorhinus canicula*) and spurdog (*Squalus acanthias*); three species of rays; starry ray (*Amblyraja radiata*), thornback ray (*Raja clavata*), and sailray (*Rajella lintea*); and the rabbit fish (*Chimaera monstrosa*). The round ray (*Rajella fyllae*) was also relatively common in survey catches from the deeper parts of the Skagerrak. All common species were present year round, but spurdog also showed a seasonal trend, being more common along the Norwegian coast and in offshore part of the Skagerrak in the first quarter, and closer to the Swedish coast in the third and fourth quarter.

There are no longer any targeted fisheries for elasmobranchs by Swedish vessels but by-catches occur, predominantly in demersal trawl fisheries in the deeper parts (> 200 m) of Skagerrak and the Norwegian trench where a majority the observed hauls had by-catch of one or more species. Usage of a sorting device (grid) in the Nephrops and Pandalus trawl fisheries appear to reduce the amount of by-catches. Historical and anecdotal information suggest that by-catch of spurdog in gillnets could be significant, but as landing were prohibited in 2010, no data is available since then.

Starry ray and spurdog represents > 75 % of the estimated total catch weight of shark and rays combined. More than 90 % of elasmobranchs was discarded, which is not surprising given that landing of spurdog, starry ray, common skate and thornback ray are prohibited in 3a. Sailray is the only species landed to some extent (few tonnes per year) by Swedish vessels during the last five years. Swedish landings of sailray mainly come from the Pandalus fishery and from demersal trawl fishing without grids in the deeper parts of Skagerrak.

Keywords: elasmobranch, shark, skate, ray, rabbit fish, groundfish survey, bottom trawl, spatial distribution, landings, observer data

Preface

This report was written in response to a request from the Swedish Agency for Marine and Water Management to SLU. The request to SLU was to update the report "*Occurrence of skates and rays in northern European waters and catches in Swedish fisheries in the Skagerrak/Kattegat and the eastern North Sea*" with all elasmobranch species occurring in Swedish waters. The report will encompass data from Kattegat, Skagerrak and the North Sea and the data will be collected from international and national bottom trawl surveys, national on-board survey data and official landings data.

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1. Introduction

More than 30 species of sharks, skates, rays and rabbit fish have been reported from Swedish waters, but only a third of them are considered native (Stenberg et al 2015). Ten species are listed on the Swedish Red List (which uses the IUCN Red List Criteria), one of which is classified as nationally extinct, *Dipturus batis* (Artdatabanken 2020). Several species that have been observed in Swedish waters also occur on the red list published by HELCOM in 2013 (Kontula and Haldin 2013). Three species regularly observed in Skagerrak, porbeagle (*Lamna nasus*), thornback ray (*Raja clavata*) and spurdog (*Squalus acanthias*), are on the OSPAR List of Threatened and/or Declining Species and Habitats. Species that are on the OSPAR list have individual OSPAR recommendations for furthering their protection and conservation. These recommendations contain different measures that contracting parties should consider following to the protection of the species and improve its status (OSPAR 2014). Several shark species are listed in the Convention on the Conservation of Migratory Species of Wild animals (CMS), also called the Bonn convention (CMS, 1983). In the CMS convention there is a specific Memorandum of Understanding (MOU) regarding sharks, basking sharks (*Cetorhinus maximus*) are listed in appendix I and II and porbeagle, spurdog, common thresher shark (*Alopias vulpinus*) in appendix II. Basking sharks, porbeagle and common thresher shark are also listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) also called the Washington convention and are listed in appendix II (CITES, 1973).

Measures for protection and management of elasmobranchs can be found in both EU and national legislation. The main management prerequisite for many of the elasmobranch species occurring in 3a (and often in larger areas) is that they are prohibited species, i.e. when they are accidentally caught; they shall not be harmed and promptly released (Council Reg (EU) 2021/92). Three different pieces of legislation contain lists of prohibited elasmobranch species in area 3a and 4: (1) The annual regulation of fishing opportunities (the TAC and quota regulation, i.e. currently (EU) 2021/92, (2) the technical measures regulation (Regulation (EU) 2019/1241 and (3) national legislation (FIFS 2004:36). The EU and Swedish legislation exhibit large overlaps concerning the species covered. The current list

of protected elasmobranch species in 3a and 4 (including references to the relevant legislative document) are listed in Table 1.

Table 1. Overview of all prohibited/protected elasmobranch species in EU and national Swedish legislation and reference to the applicable legislation.

Species	Area	Legislation
Starry ray (*Amblyraja radiata*)	Union waters of 2a, 3a, 7d and 4	Art. 20 of Council Regulation (EU) 2021/92
Common skate (*Dipterus batis*) complex (*Dipturus cf. flossada* and *Dipturus cf. intermedia*)	Union waters of 2a, 3, 4, 6, 7, 8, 9 and 10	Art. 20 of Council Regulation (EU) 2021/92 and FIFS 2004:36
porbeagle (*Lamna nasus*)	All waters	Art. 20 of Council Regulation (EU) 2021/92 and FIFS 2004:36
Thornback ray (*Raja clavata*)	Union waters of 3a	Art. 20 of Council Regulation (EU) 2021/92 and FIFS 2004:36
Spurdog (*Squalus acanthias*)	Union waters of 2, 3, 4, 5, 6, 7, 8, 9 and 10	Art. 20 of Council Regulation (EU) 2021/92 and FIFS 2004:36
Basking shark (*Cetorhinus maximus*)	All waters	Annex I of Regulation (EU) 2019/1241 and FIFS 2004:36
Lesser spotted dogfish (*Scyliorhinus canicula*)	All waters for Swedish nationals	FIFS 2004:36

Another measure listed in the OSPAR recommendations is improving funding for research on for example life history and biology, movements and distribution and the identification of critical habitats. Recent work has provided information on long-term trends for many species of sharks, skates and rays (ICES 2020a, 2021a), but the focus of this work has largely been on the population level and has not provided sufficiently detailed information for management at the Swedish national level. Therefore, as a first start, this report presents analyses of existing data in order to increase the knowledge of the distribution and abundance of sharks, rays and rabbit fish in 3a and the easternmost parts of area 4 and how these species interacts with the main fisheries in the area. First, we describe the general distribution and abundance of relevant species of sharks, rays and rabbit fish in the Greater North Sea region based on fishery independent survey data for the years 1967–2020. We also look more closely at the seasonal distribution and abundance for the species observed in the Skagerrak and Kattegat in recent years. We then proceed to look at effort distribution of Swedish demersal fisheries in the Skagerrak, Kattegat and in the eastern North Sea together with reported landings and on-board observations of sharks, rays and rabbit fish by area, fishery and depth. We end the paper with a brief summary of our findings where we also make some recommendations on future monitoring and measures to reduce unwanted catches.

2. Methods

To describe the occurrence and spatial distribution of sharks, rays and rabbit fish in Swedish and adjacent waters we have used both fisheries-independent survey data and data from commercial fisheries.

2.1. Groundfish survey data

The fishery independent data comes from a series of large-scale groundfish surveys covering the continental shelf waters of the Northeast Atlantic. Quality controlled and standardized data was downloaded from DATRAS (https://datras.ices.dk/Data_products/Download/Download Data public.aspx) using the exchange format for biological data and the Swept area assessment product prepared by WKSAE_DATRAS/WKABSENS (ICES 2021bc) for haul information. The data product span from 1967 to 2020 and contains more than 95,000 unique trawl hauls. 53,044 of these comes from the Greater North Sea region (Figure 1).

The International Bottom Trawl Survey (NS-IBTS) contributed the most trawl hauls to the Greater North Sea data, followed by the Beam Trawl Survey (BTS) and the Inshore Beam Trawl Survey (DYFS) (Table 1). ICES subdivision 3a, Skagerrak (3a.20) and Kattegat (3a.21), are covered by the international trawl surveys, mainly through NS-IBTS (in Q1 and Q3) and BITS (in Q1 and Q4), but the number of stations is relatively limited, approx. 20 stations in each area and expedition. In all, 4821 hauls from 3a were registered in DATRAS from 1967–2020. The use of a fixed station design by NS-IBTS in 3a also limits the spatial resolution and since NS-IBTS only fish down to 250 meters, important habitats for elasmobranchs and rabbit fish in the deeper parts of Skagerrak are excluded from the survey area. To improve the spatial and temporal resolution in Swedish waters we included additional data from several national surveys. For the eastern North Sea and Skagerrak, we use data from the Norwegian bottom trawl survey for northern shrimp and from the Swedish Skagerrak Survey, both of which covers depths down to 500 m.

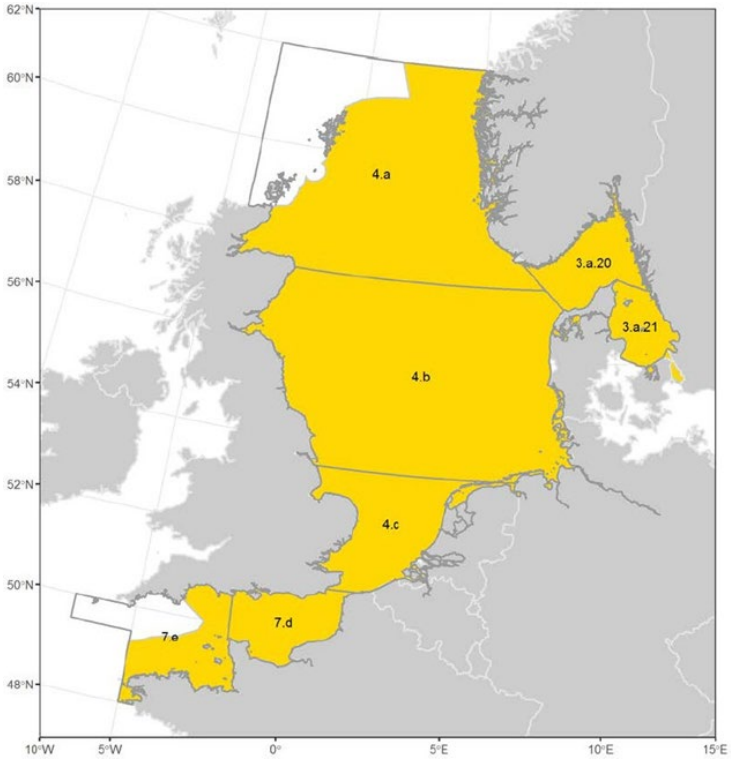

Figure 1. Map showing the Greater North Sea region including the Skagerrak (3.a.20) and the Kattegat (3.a.21), where the majority of Swedish demersal fisheries outside the Baltic are taking place. Map from ICES (2018).

The Norwegian shrimp survey in the Skagerrak and Norwegian Deep has been conducted since 1984 and revised over time. In the present analyses, we use data from the latest time series, 2006–2020 (Søvik 2020). The Swedish Skagerrak survey was initiated in 2018 to supplement the data collection carried out during NS-IBTS by expanding the geographical area and sampling in the deeper parts of the Skagerrak (Börjesson 2022). We also include data from coastal surveys conducted in coastal and fjord areas along the Swedish coast since 2001 (Svensson et al 2019). For the Kattegat, we add data from the Kattegat Cod Survey, CODS Q4 (Jørgensen et al 2019). The Danish survey data was kindly provided by DTU Aqua, Denmark.

To visualize the general distribution and abundance of sharks, rays and rabbit fish in the Greater North Sea region, we created a raster with the resolution 0.50 × 0.25 degree (longitude × latitude). For each grid cell, we calculated the mean catch per species in number per km2 over all surveys for the entire period. In this analysis, we have not taken into account differences in catchability or selectivity between surveys, nor have we considered temporal variation. We investigate temporal variation in distribution and abundance using survey data from Skagerrak, Kattegat and the Sound from 2018 to 2020, comparing catches in Q1 and Q3/Q4. Total catch

in numbers was standardized by swept area in km2 and presented on a haul-by-haul basis, by year and quarter.

2.2. Commercial data

For fisheries dependent data we use two different sources of data: the official logbook data and on-board sampling data, collected in the Swedish scientific on-board discard sampling programme. For the on-board sampling, both catches and hauls with zero catch of sharks, rays and rabbit fish were included to illustrate species distribution and the spatial coverage of the on-board sampling program. Note that for the commercial landing data, the grouping of different species is somewhat uncertain, especially for rays and skates that can be difficult to identify correctly.

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Table 2. Table 2. Summary of survey data used in the analyses.

Survey, quarter	Acronym	Area	No hauls in GNS (3a)	Years used	Reference
International Bottom Trawl Survey, Q1	NS-IBTS	Greater North Sea	19,354 (2065)	1967–2020	ICES (2020b)
International Bottom Trawl Survey, Q3	NS-IBTS	Greater North Sea	9,466 (1,381)	1991–2020	" "
Baltic International Trawl survey, Q1	BITS	Baltic, Kattegat, Skagerrak	698 (698)	1992–2020	ICES (2017a)
Baltic International Trawl survey, Q4	BITS	Baltic, Kattegat, Skagerrak	635 (635)	1993–2020	" "
Beam Trawl Survey, Q1	BTS	C & S North Sea	1,241 (0)	2006–2020	ICES (2019)
Beam Trawl Survey, Q3	BTS	C & S North Sea	10,505 (42)	1985–2020	" "
French Channel Ground Fish Survey, Q4	FR-CGFS	English Channel	2,080 (0)	1998–2020	ICES (2017b)
Scottish West Coast Bottom trawl Survey, Q1	SWC-IBTS	NE North Sea	11 (0)	1986–2000	ICES (2017b)
Scottish West Coast Bottom trawl Survey, Q4	SWC-IBTS	NE North Sea	11 (0)	1996–2000	" "
Inshore Beam Trawl Survey, Q3/Q4	DYFS	S North Sea	8,159 (0)	2002–2020	ICES (2021d)
Sole Net Survey, Q1	SNS	S North Sea	871 (0)	2002–2020	" "
Swedish Coastal survey, Q1	COASTS	Kattegat, Skagerrak	49 (49)	2002	Svensson *et al* (2019)
Swedish Coastal survey, Q2	COASTS	Kattegat, Skagerrak	367 (367)	2002–2008	" "
Swedish Coastal survey, Q4	COASTS	Kattegat, Skagerrak	518 (518)	2002–2012	" "
Swedish Coastal survey, Q4	COASTS	Skagerrak incl. fjord areas	270 (270)	2013–2020	" "
Kattegat Cod Survey, Q4	CODS	Kattegat	1008 (1008)	2008–2020	Jørgensen *et al* (2019)
Swedish Skagerrak Survey, Q3/Q4	SKAGS	Skagerrak	138 (138)	2018–2020	Börjesson (2022)
Norwegian Shrimp Survey, Q1	NO-SH	Norwegian Deep, Skagerrak	1212 (683)	2006–2020	Søvik (2020)

3. Results

3.1. Groundfish survey data 1967–2020

In total 37 species of sharks, rays, skates, and the rabbit fish (*Chimaera monstrosa*), were reported from the Greater North Sea in the groundfish trawl survey data from 1967–2020. Starry ray (*Amblyraja radiata*), lesser spotted dogfish (*Scyliorhinus canicula*), thornback ray (*Raja clavata*) and spurdog (*Squalus acanthias*) were the most frequently observed species and registered in several thousand hauls, whereas other species were only registered in a single or a very few hauls. Some of these species are probably rare in the Greater North Sea, and/or on the edge of their distribution. Others such as porbeagle (*Lamna nasus*) and thresher shark (*Alopias vulpinus*) may be more common than suggested by the groundfish survey data, but pelagic species have poor catchability in demersal trawls and cannot reliably be monitored by groundfish surveys.

Eight of the 37 species were frequently reported from the Skagerrak and Kattegat, including three shark species; velvet belly (*Etmopterus spinax*), lesser spotted dogfish and spurdog; four species of rays; starry ray, thornback ray, round ray (*Rajella fyllae*) and sailray (*Rajella lintea*); and the rabbit fish. Another five species have been reported 10 or more times; blackmouth catshark (*Galeus melastomus*), smooth hounds (*Mustelus asterias* and *M. mustelus*), longnosed skate (*Dipturus oxyrinchus*) and common skate (*Dipturus batis*). Distribution and relative abundance of the above-mentioned species that have been found in Skagerrak and Kattegat are presented in figure 2a and 2b.

In addition to the relatively frequently reported species in 3a, there were two observations of Greenland shark (*Somniosus microcephalus*) and one observation of nursehound (*Scyliorhinus stellaris*), The data also contained a few observations of spinytail skate (*Bathyraja spinicauda*) and spotted ray (*Raja montagui*). A list of the 37 species is given in Table 3 together with the number of hauls in which the species was observed in the Greater North Sea, in the Skagerrak/Kattegat and in Swedish national waters.

Table 3. Number of hauls with sharks, skates, rays and rabbit fish in bottom trawl surveys in the Greater North Sea.

Scientific name	AphiaID	Greater North Sea	Skagerrak / Kattegat	Swedish EEZ
Alopias vulpinus	105836	1		
Amblyraja radiata	105865	10252	1839	776
Bathyraja brachyurops	271509	8		
Bathyraja spinicauda	105868	16	11	1
Centrophorus squamosus	105901	1		
Centrophorus granulosus	105899	0		
Cetorhinus maximus	105837	1		
Chimaera monstrosa	105824	1245	766	142
Dasyatis pastinaca	105851	59		
Dasyatis tortonesei	105852	5		
Dipturus intermedia	105869	Included in the *Dipturus spp* complex,		
Dipturus flossada	105869	presented together with *D. batis*		
Dipturus batis	105869	108	19	5
Dipturus oxyrinchus	105872	29	12	
Etmopterus spinax	105913	1203	665	114
Galeorhinus galeus	105820	327		
Galeus melastomus	105812	231	22	
Lamna nasus	105841	1		
Leucoraja circularis	105873	20		
Leucoraja fullonica	105874	25		
Leucoraja lentiginosa	271564	1		
Leucoraja naevus	105876	1956		
Mustelus asterias	105821	2292	8	2
Mustelus mustelus	105822	361	2	
Raja brachyura	367297	545		
Raja clavata	105883	4621	162	89
Raja microocellata	105885	108		
Raja montagui	105887	1822	6	2
Raja undulata	105891	541		
Rajella fyllae	105894	146	42	2
Rajella lintea	1019159	162	119	9
Scyliorhinus canicula	105814	7908	117	55
Scyliorhinus stellaris	105815	498	1	1
Somniosus microcephalus	105919	2	2	2
Squalus acanthias	105923	2857	750	502
Torpedo nobiliana	321911	2		
Torpedo marmorata	271684	92		

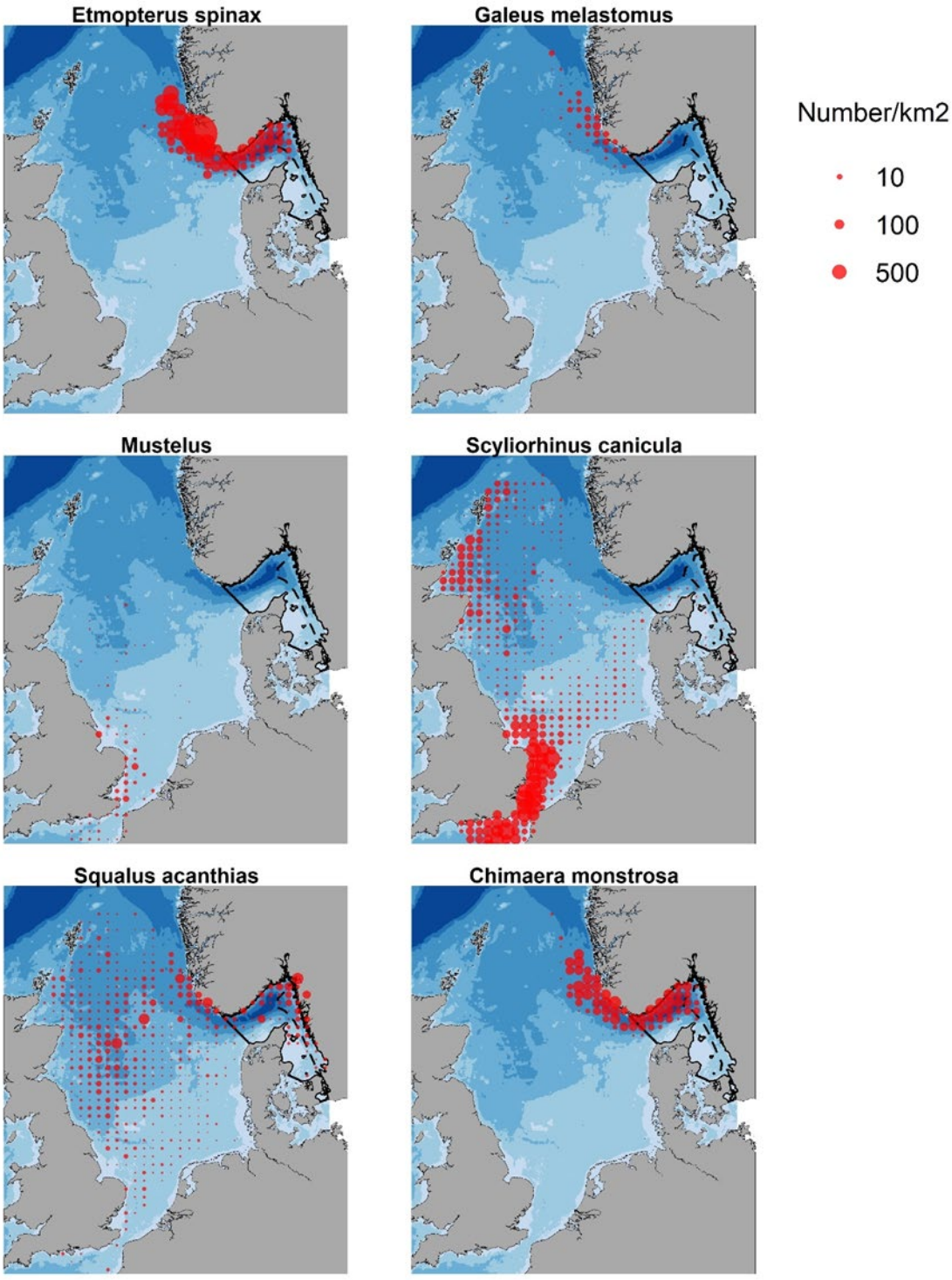

Figure 2a. Distribution and relative abundance (in number/km2) of sharks and rabbit fish in the Greater North Sea 1967-2020 from fishery independent bottom trawl surveys. Only species with observations from 3a are included in the figure. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500 m. Area 3a is delineated with solid line, Swedish economic zone with dashed line.

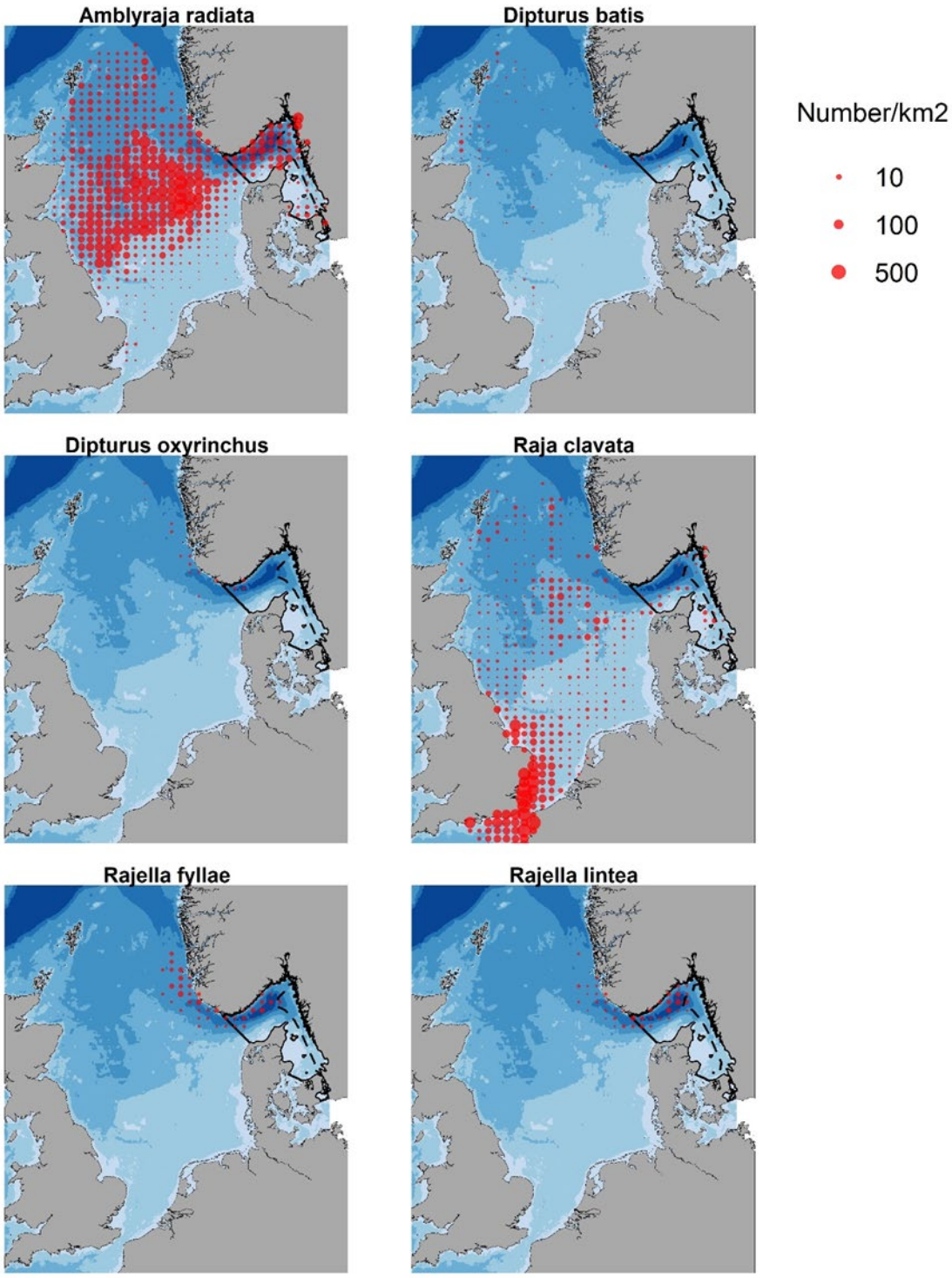

Figure 2b. Distribution and relative abundance (in number/km2) of skates and rays in the Greater North Sea 1967-2020 from fishery independent bottom trawl surveys. Only species with observations from 3a included in the figure. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500 m. Area 3a is delineated with solid line, Swedish economic zone with dashed line.

3.2. Seasonal abundance and distribution in area 3a 2018–2020

Spurdog was the only species showing a clear seasonal trend in Swedish waters. In quarter one; it is common in survey catches along the Norwegian coast and in offshore part of the Skagerrak. In quarter 3 and quarter 4, it seems to disappear from the Norwegian coast and appears to be closer to the Swedish coast and in the Kattegat (Figure 3a). Lesser spotted dogfish also occurred year round in Skagerrak and Kattegat but at low densities (Figure 3b).

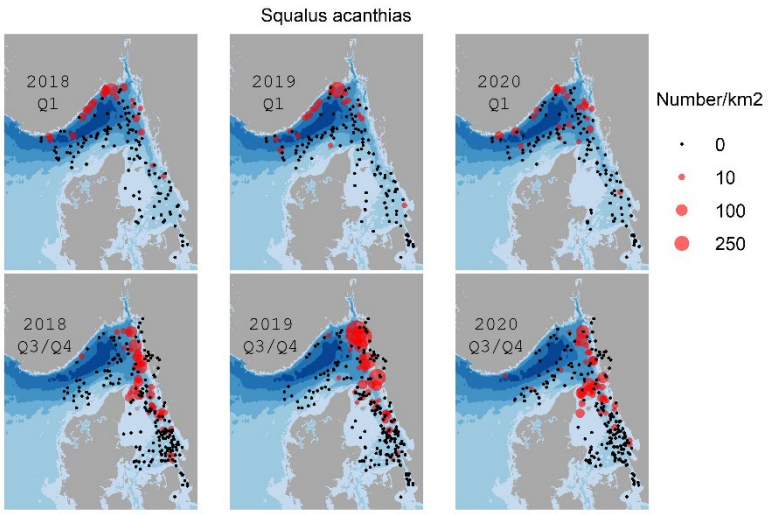

Figure 3a. Spatial distribution and catch per unit of effort (number/km2) of spurdog (Squalus acanthias) in the Skagerrak and Kattegat 2018-2020 in quarter 1, quarter 3 (Skagerrak) and quarter 3 & 4 (Kattegat). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

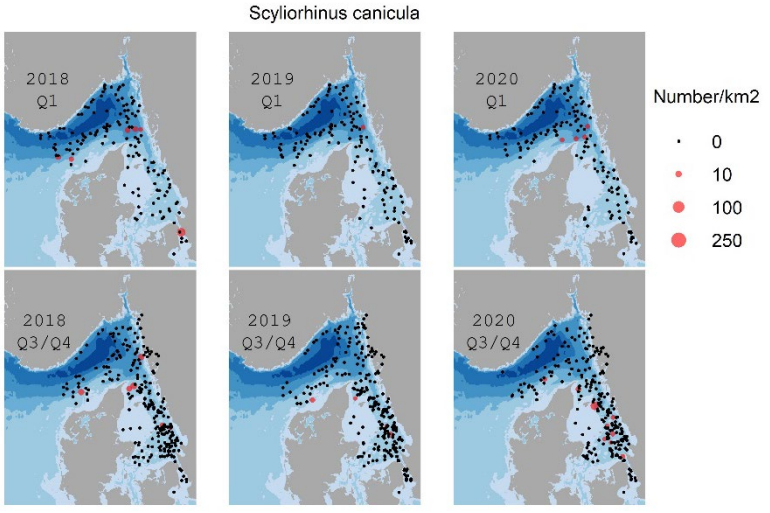

Figure 3b. Spatial distribution and catch per unit of effort (number/km2) of lesser spotted dogfish (Scyliorhinus canicula) in the Skagerrak and Kattegat 2018-2020 in quarter 1, quarter 3 (Skagerrak) and quarter 3 & 4 (Kattegat). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

The observations of rabbit fish, velvet belly, sailray and round ray are strongly associated with depths below 200–300 m and mainly registered in the Norwegian shrimp survey and in the Swedish Skagerrak survey. There appear to be somewhat higher abundances of rabbit fish and velvet belly in the first quarter but this could be a result of different catchability between surveys and needs to be investigated further (Figure 3c & 3d).

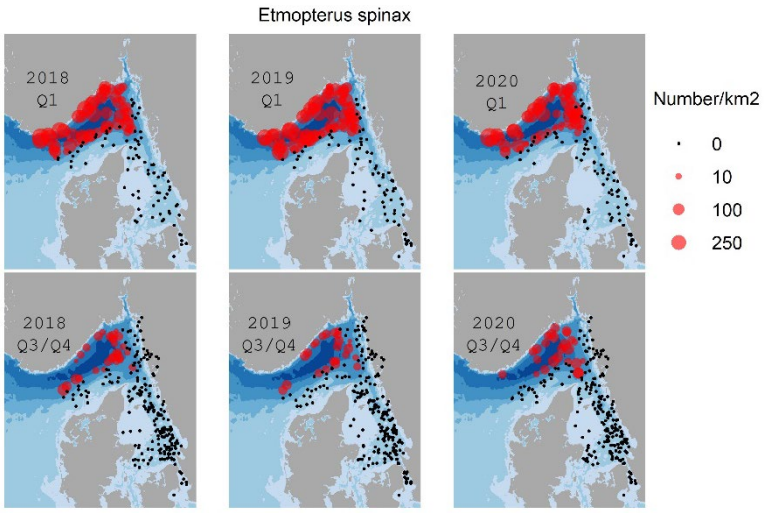

Figure 3c Spatial distribution and catch per unit of effort (number/km2) of velvet belly (Etmopterus spinax) in the Skagerrak and Kattegat 2018-2020 in quarter 1, quarter 3 (Skagerrak) and quarter 3 & 4 (Kattegat). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

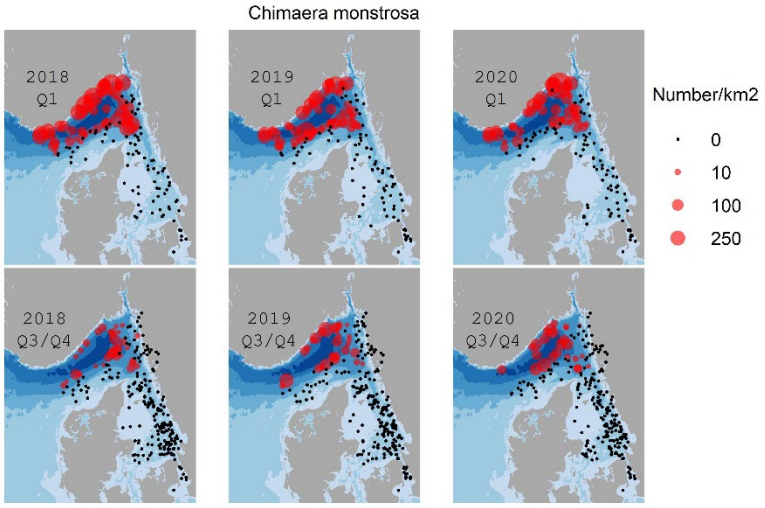

Figure 3d. Spatial distribution and catch per unit of effort (number/km2) of rabbit fish (Chimaera monstrosa) in the Skagerrak and Kattegat 2018-2020 in quarter 1, quarter 3 (Skagerrak) and quarter 3 & 4 (Kattegat). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

The starry ray is widespread in the Skagerrak and occur in all but the deepest area. It is also frequently observed in the fjord areas during the Swedish coastal survey carried out in the end of September each year. The number of observations decline further south, but somewhat surprisingly, it is regularly observed in the southernmost part of the Kattegat. From 2018 to 2020, it was reported from that area in both Q1 and Q3/Q4 each year (Figure 3e). Genetic samples have been collected for future investigations of stock identity. Thornback ray was also present in the fjords and in the southern parts of Kattegat, but at much lower densities (Figure 3f).

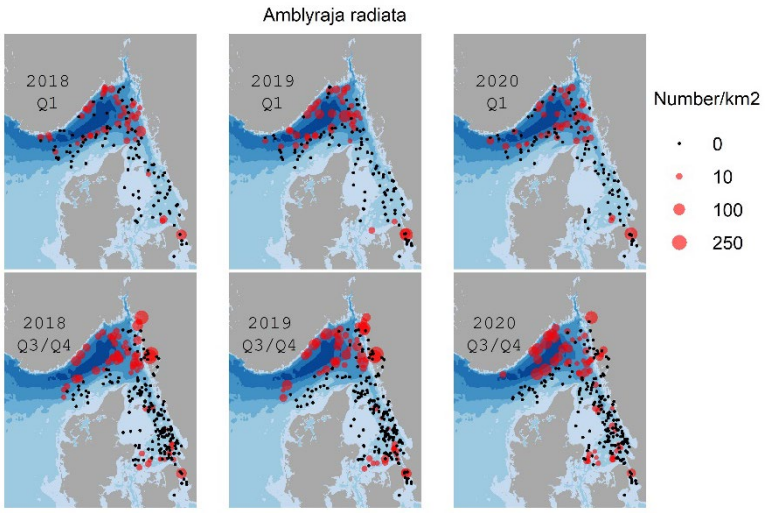

Figure 3e. Spatial distribution and catch per unit of effort (number/km2) of starry ray (Amblyraja radiata) in the Skagerrak and Kattegat 2018-2020 in quarter 1, quarter 3 (Skagerrak) and quarter 3 & 4 (Kattegat). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

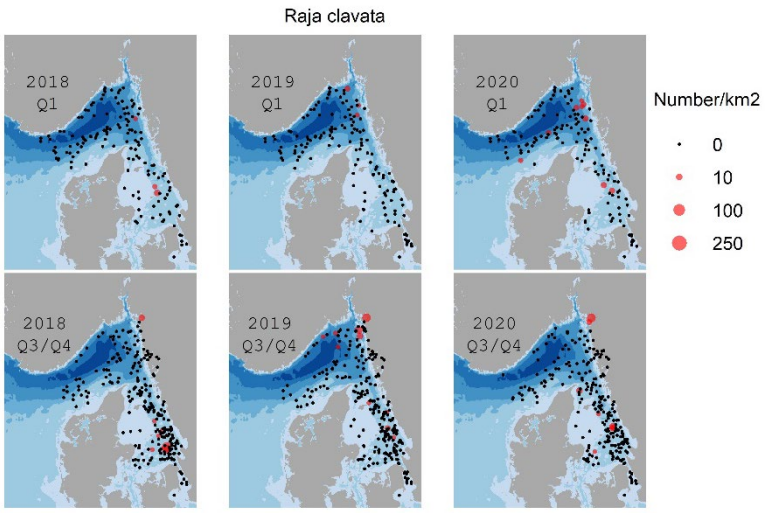

Figure 3f. Spatial distribution and catch per unit of effort (number/km2) of thornback ray (Raja clavata) in the Skagerrak and Kattegat 2018-2020 in quarter 1, quarter 3 (Skagerrak) and quarter 3 & 4 (Kattegat). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

The round ray and sailray are found in the deeper (>250 m) parts of the Skagerrak and in the Norwegian This is outside the depths covered by IBTS and records for these species comes from the Norwegian shrimp survey and the Swedish Skagerrak survey. Although the round ray is not very frequent it is regularly found, and the sailray is relatively common in the area (Figure 3g & 3h).

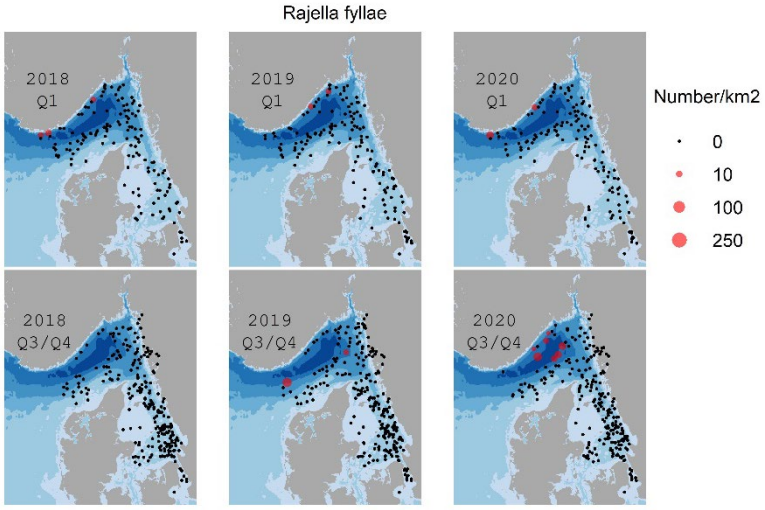

Figure 3g. Spatial distribution and catch per unit of effort (number/km2) of round ray (Rajella fyllae) in the Skagerrak and Kattegat 2018-2020 in quarter 1, quarter 3 (Skagerrak) and quarter 3 & 4 (Kattegat). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

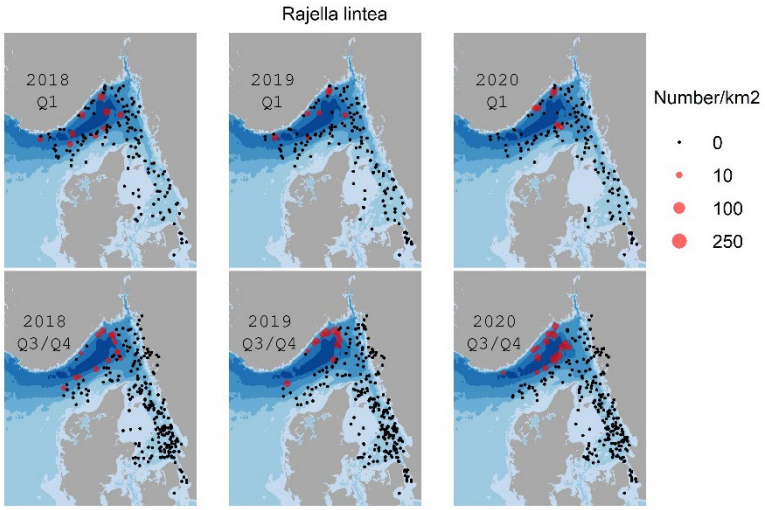

Figure 3h. Spatial distribution and catch per unit of effort (number/km2) of sailray (Rajella lintea) in the Skagerrak and Kattegat 2018-2020 in quarter 1, quarter 3 (Skagerrak) and quarter 3 & 4 (Kattegat). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

3.3. Spatial distribution of Swedish trawl fisheries in area 3a and 4 in 2018–2020

The Swedish demersal fisheries in area 3a are due to quota availability largely dominated by trawl fisheries targeting Nephrops or Pandalus. Both Nephrops-targeted (TR2, mesh size 70–99 mm) and Pandalus-targeted (> 35 mm) fisheries are divided into two fleets/sampling strata based on their gear usage (grid/non-grid trawls). Maximum grid bar spacing is 35 mm for Nephrops and 19 mm for Pandalus). Targeted trawl fisheries for demersal fish (mainly cod, haddock, saithe and witch flounder) also occur in 3a by Swedish vessels but are less common. The Swedish catches in eastern area 4 are limited; around ten Swedish vessels target Pandalus mainly during the first quarter of the year and a small TR1-fleet (mesh > 120 mm) fish for mixed demersal fish species like cod, haddock monkfish and saithe. More information about Swedish fisheries can be found in the Swedish fisheries atlas (Bergenius *et al* 2018). The spatial distributions of the main Swedish trawl fisheries in area 3a and 4 in 2018–2020 are shown in figure 4.

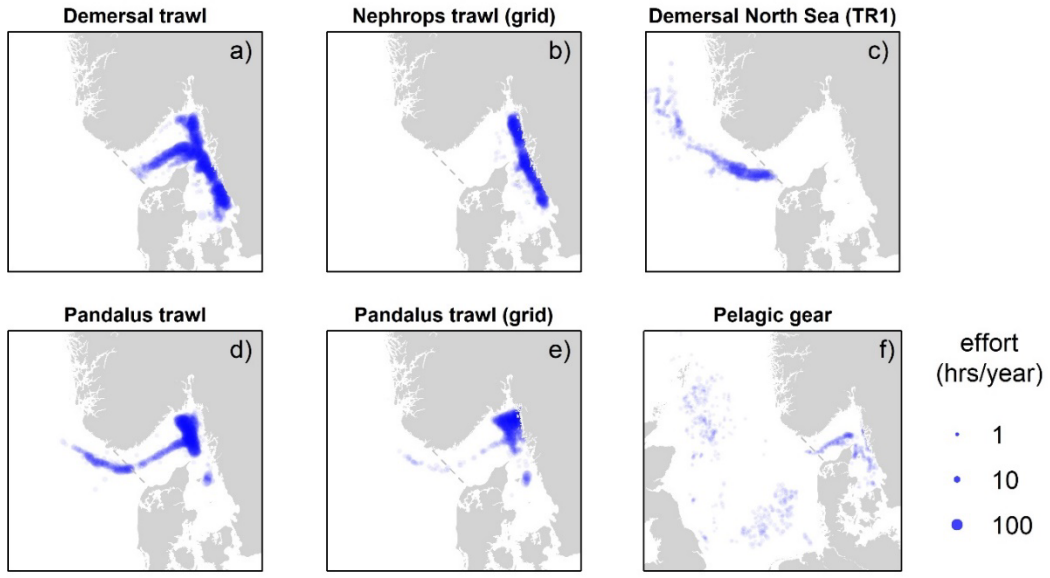

Figure 4. Spatial distribution of six main Swedish trawl and seine fisheries (average fishing effort in hours 2018–2020). a) Nephrops and demersal fish (MCD, mesh > 90 mm), b) Nephrops trawls with sorting grid (TR2), c) Demersal trawls in the North Sea (TR1, mesh > 120 mm), d) Pandalus trawls with grid and fish retention device (> 35mm), e) Pandalus trawls with grid (> 35 mm), and f) Pelagic gears.

3.4. Swedish landings of sharks, skates, rays and rabbit fish 2002–2020

All skates and ray species that are not EU-listed as prohibited species are TAC regulated in area 3a (and 4). The TAC is thus not species specific but for all (non-prohibited) species together. In 2021, the TAC was set at 45 tonnes in 3a, of which the Swedish quota was 10 tonnes. In area 4 corresponding figures was 540 tonnes and 0 tonnes respectively (Regulation (EU) 2021/92). Quota utilization by Sweden is normally very low (0–20 %). Skates and rays, as other quota species, are covered by the landing obligation since 2019. However, a preliminary and time limited survival exemption for all skates and ray species applies, as there is some evidence that survival rates are high for some species in specified fisheries. The evidence is however not considered robust enough for all species and fisheries and that more detail is required (the survival exemption is currently specified in Delegated Regulation (EU) 2020/2014). None of the non-prohibited shark species (or rabbit fish) that occur in 3a and 4 are quota regulated which means that they can be landed (or discarded) at will.

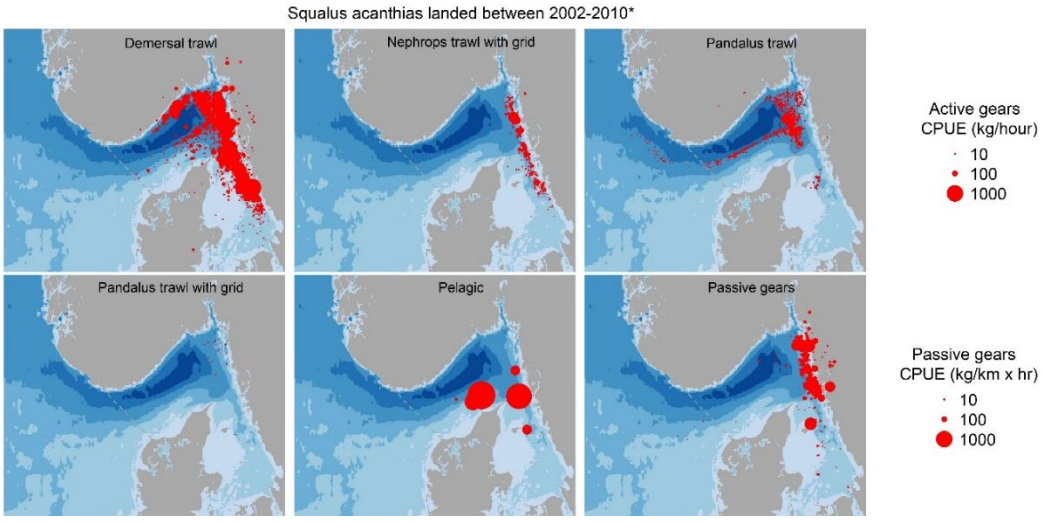

Figure 5a. Spatial distribution of spurdog (Squalus achantias) landings by fishery for Swedish vessels 2002-2010. From 2011 and onwards landing of spurdog was prohibited and only six landings were registered. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

Of the shark species common to Swedish waters, only spurdog (*Squalus acanthias*) is large enough to be of potential importance to the commercial fishery. Until 2007, there was no specific legislation regulating the fishery, but from 2008 to 2010, the fishery was restricted to licensed vessels with documented records of spurdog-targeted fishery, and from 2011, onwards landing of spurdog was prohibited. From 2002 to 2010, more than 95 % of the landed spurdog was caught in two fisheries: the demersal trawl fishery and a directed shark gillnet fishery. In the demersal trawl

fishery, most of the landings came from the fourth quarter (50 % of the hauls and 48 % by weight) whereas the directed gillnet fishery landed similar quantities in the second and fourth quarter (45–40 % by weight). Smallest landings were observed during the first quarter in both fisheries. Commercial landings of spurdog before 2011 is presented in figure 5a.

A few other shark species occur in the official landing data between 2002 and 2009; tope shark (*Galeorhinus galeus*), porbeagle (*Lamna nasus*), and two landings of Greenland shark (*Somniosus microcephalus*). Since 2010, six landings of sharks have been registered by Swedish vessels, all spurdog.

Rabbit fish are infrequently landed from Pandalus trawl fishery and the demersal trawl fishery in Skagerrak and in very small amounts (Figure 5b).

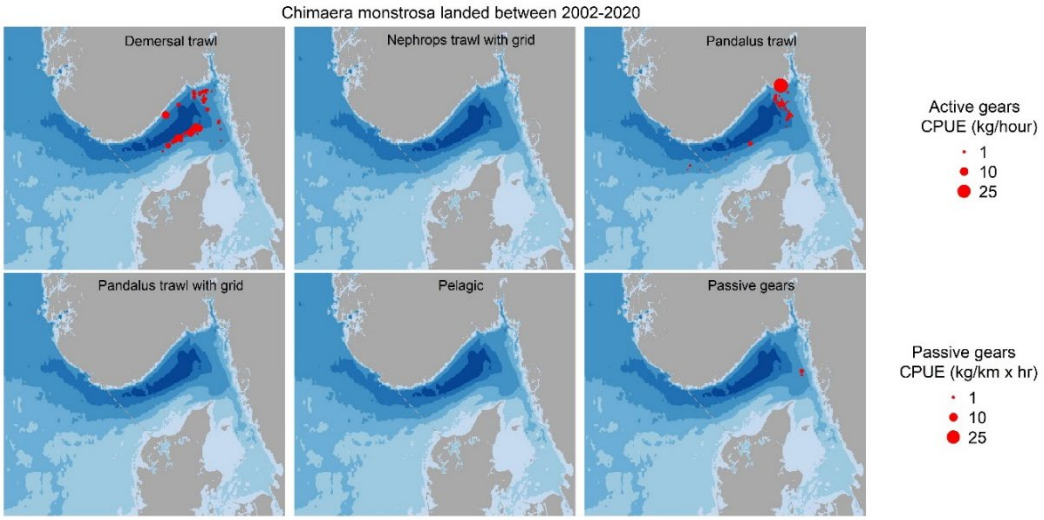

Figure 5b. Spatial distribution of rabbit fish (Chimaera monstrosa) landings by fishery for Swedish vessels 2002-2020. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

There are no targeted fisheries for skates and rays by Swedish vessels but by-catches occur, predominantly in demersal trawl fisheries (Bergenius *et al.,* 2018). Four species have been recorded in Swedish landings over the years (*Amblyraja radiata*, *Dipturus batis, Raja clavata*, and *Rajella lintea*). In the first half of the time series, most landings were recorded as *Rajidae spp*., thus not separated by species (figure 5 c). Landings of starry ray have only been registered four times from 2002 to 2020, but landings of both common skate and thornback ray have been reported throughout the period (Figure 5 d & e). Some of these landings are probably not correctly identified and based on the distribution in the deeper parts of the Skagerrak; it is possible that they consist of sailrails (Figure 5f)

In Figure 5c–f, the spatial distribution of ray landings per hour trawled (kg/h) per major fishery is presented. Swedish skate and ray landings are generally modest

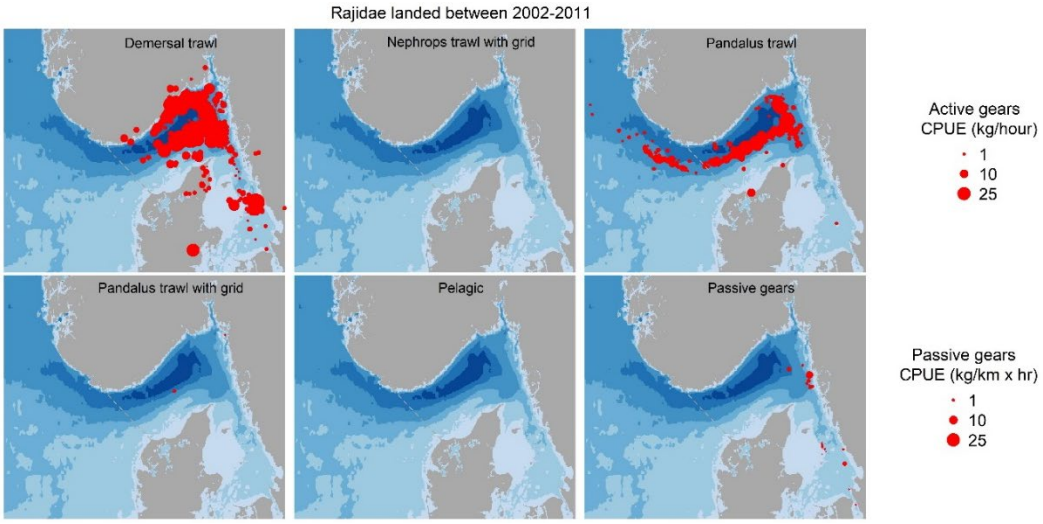

Figure 5c. Spatial distribution of skate and ray (Rajidae spp) landings by fishery for Swedish vessels 2002-2011. From 2012 and onwards skates and rays were registered at species level. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m

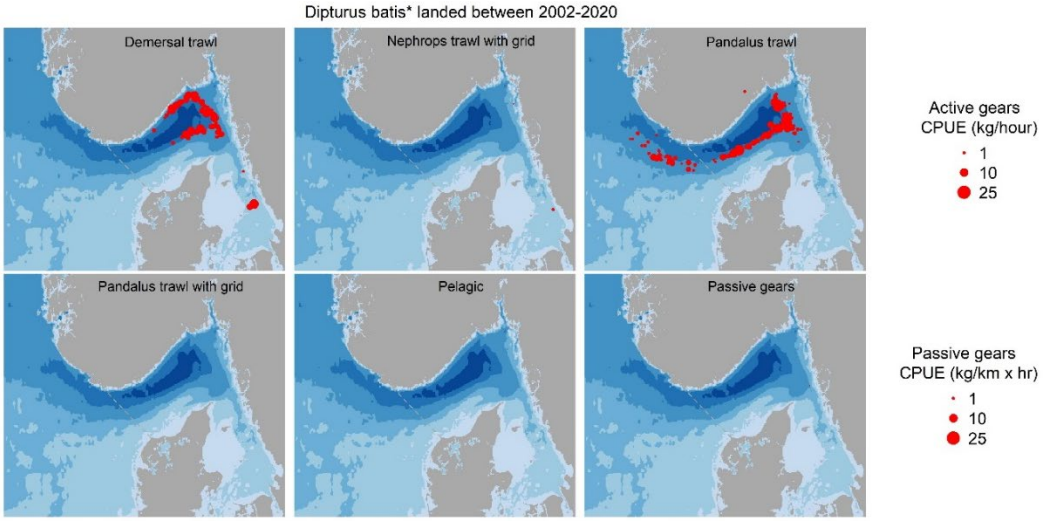

*Figure 5d. Spatial distribution of landings registered as common skate (Dipturus batis) by fishery for Swedish vessels 2002-2020. * Species identification most likely not correct and observations in Skagerrak could probably be sailray (Rajella lintea). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.*

(< 10 tons per year). The two fisheries that dominate the landings are demersal trawls (> 90 mm without grid) and Pandalus trawls (without grid before 2013 and with grid and fish retention device after 2013). From 2002 to 2020, they made up more than 97 % of the reported landings. Passive gear, pelagic gears and Nephrops and Pandalus trawls with sorting grids report none or very limited amounts of skates and rays per year.

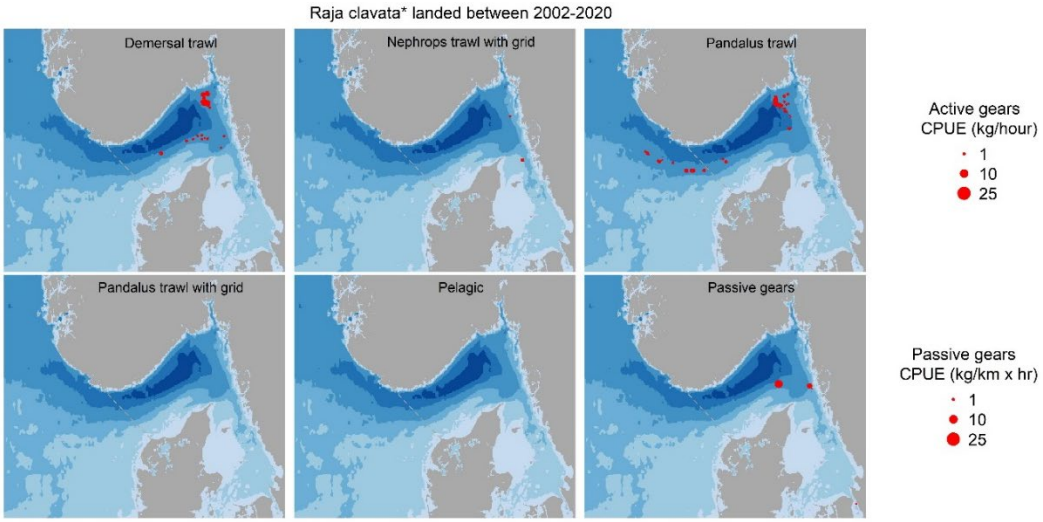

*Figure 5e. Spatial distribution of landings registered as thornback ray (Raja clavata) by fishery for Swedish vessels 2002-2020. * Species identification most likely not correct and could probably be sailray (Rajella lintea). Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.*

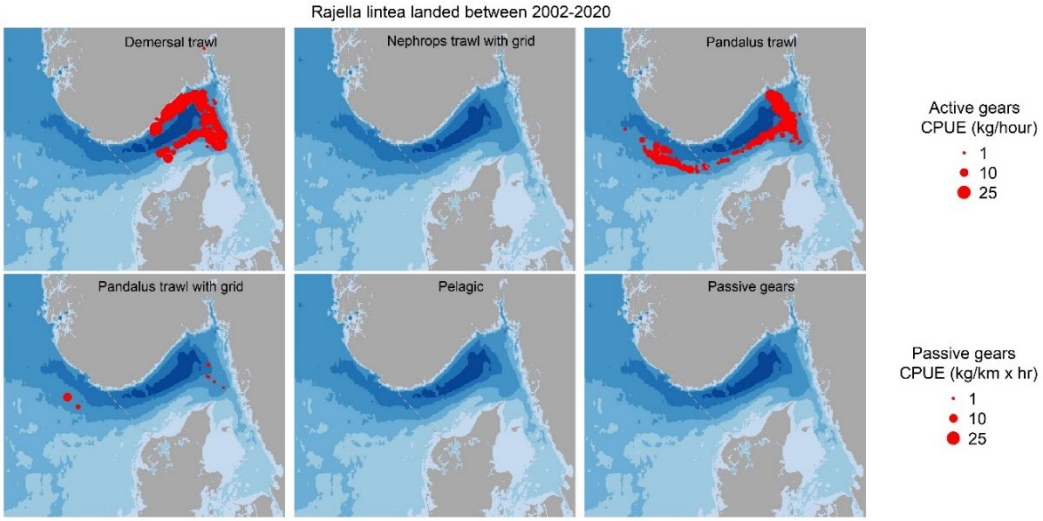

Figure 5f. Spatial distribution of sailray (Rajella lintea)) landings by fishery for Swedish vessels 2002-2020. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

3.5. Catches in the on-board sampling program 2002–2020

From 2002 to 2020, the Swedish on-board sampling program collected observer data from 1034 fishing trips (2282 valid hauls) in the demersal trawl fishery in the Skagerrak, Kattegat and easternmost part of area 4. Most of the species reported by the groundfish surveys (13 out of 17) were also present in the observer data. The exception were the two deep sea species, *Bathyraja spinincauda*, and *Rajella fyllae*, and two species, *Raja montagui* and *Scyliorhinus stellaris* which is more common in the western part of the North Sea.

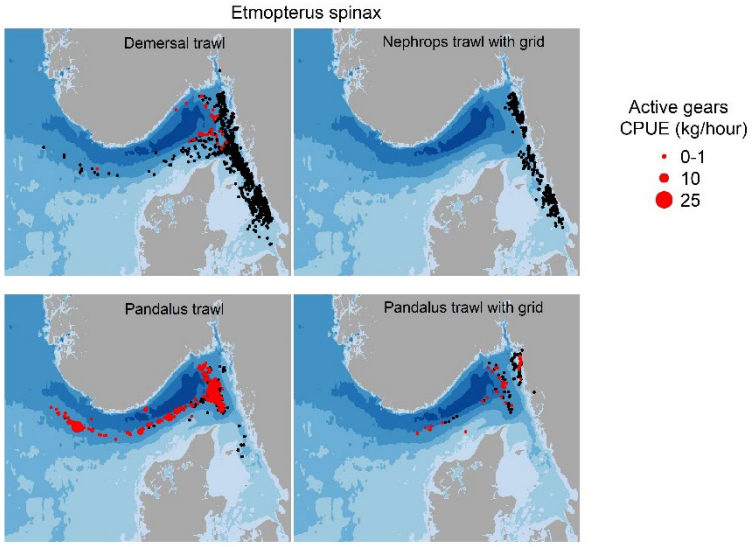

Figure 6a. Distribution of Etmopterus spinax (kg/hour) in the Swedish on-board sampling program 2002-2020. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

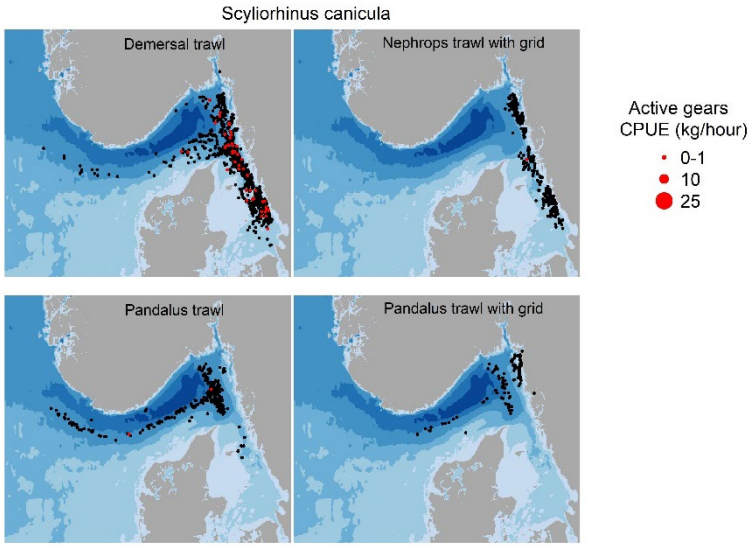

Figure 6b. Distribution of Scyliorhinus canicula (kg/hour) in the Swedish on-board sampling program 2002-2020. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

In addition to the previously listed species the observer programme also registered one cuckoo ray (*Leucoraja naevus*) in 2018 and a few hauls with catch of shagreen rays (*Leucoraja fullonica*) in 2007. Figure 6a–f shows catches per hour separated by species and fishery based on the Swedish scientific observer data from the demersal trawl fishery in Skagerrak, Kattegat and the easternmost part of area 4.

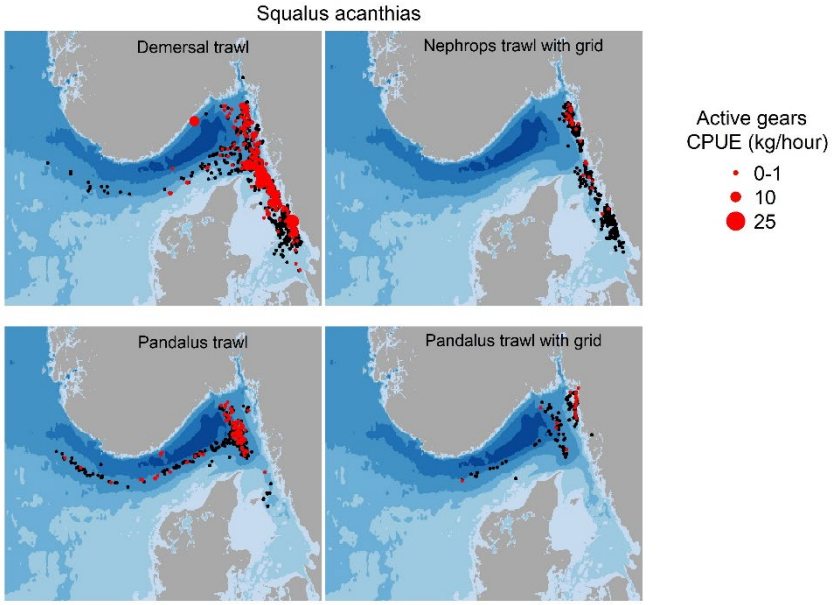

Figure 6c. Distribution of dogfish (Squalus acanthias) (kg/hour) in the Swedish on-board sampling program 2002-2020. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

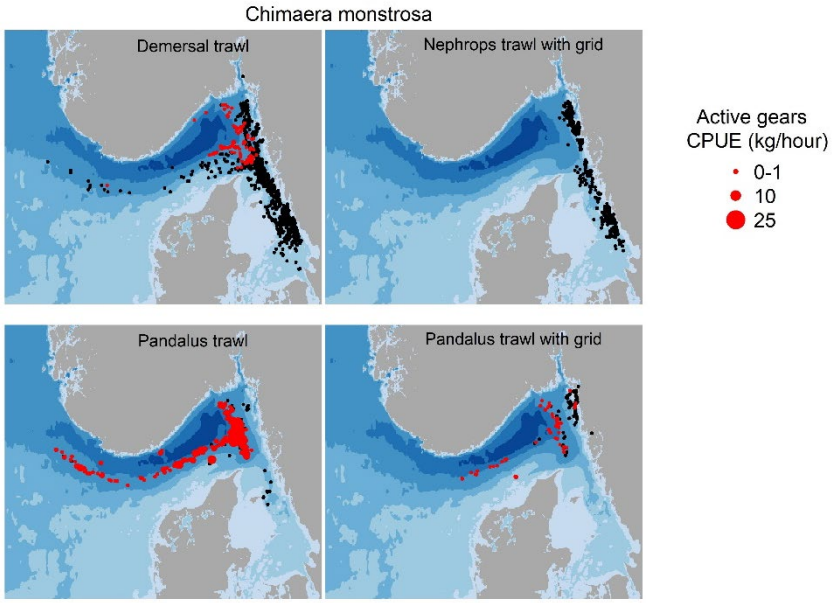

Figure 6d. Distribution of rabbit fish (Chimaera monstrosa) (kg/hour) in the Swedish on-board sampling program 2002-2020. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

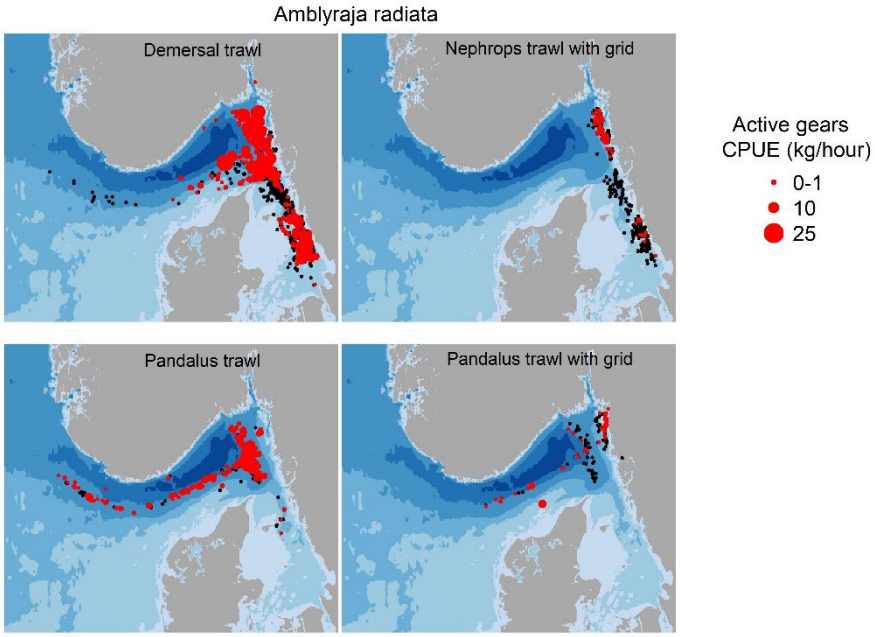

Figure 6e. Distribution of starry ray (Amblyraja radiata) (kg/hour) in the Swedish on-board sampling program 2002-2020. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

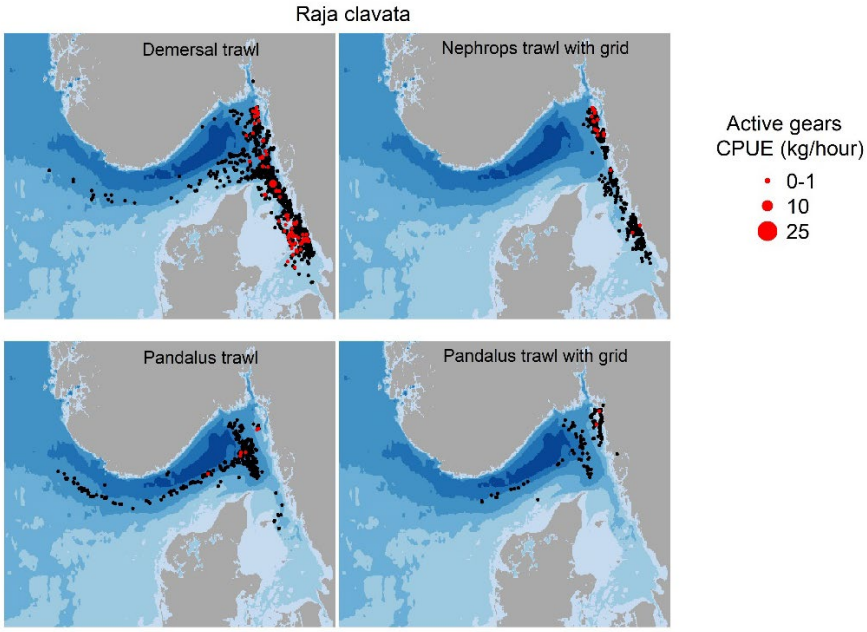

Figure 6f. Distribution of thornback ray (Raja clavata) (kg/hour) in the Swedish on-board sampling program 2002-2020. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

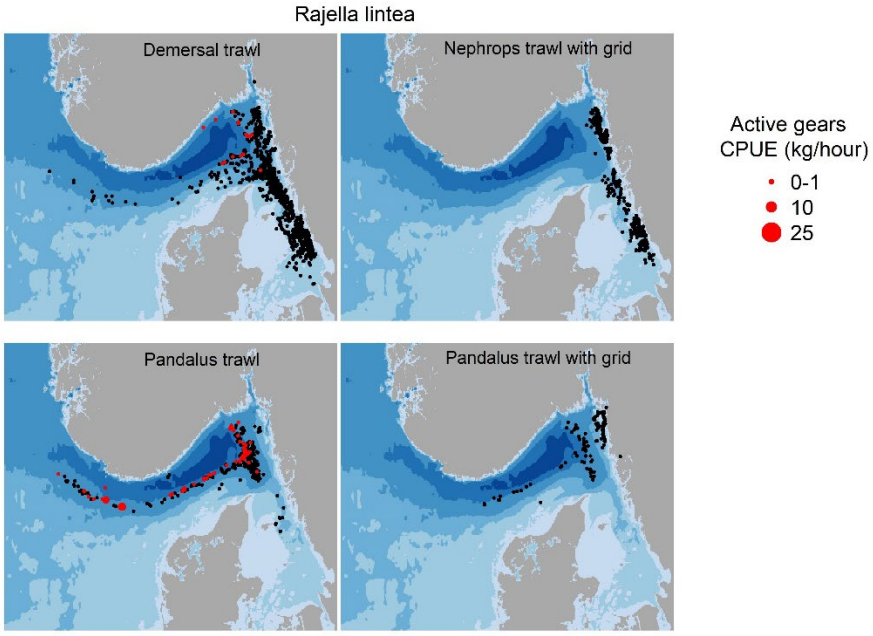

Figure 6g. Distribution of sailray (Rajella lintea) (kg/hour) in the Swedish on-board sampling program 2002-2020. Depth contours represents 0-20, 21-50, 51-100, 101-300, 301-500, >500 m.

Table 4 presents the same observer data as in Figure 6 but in a different way: Frequency of occurrence was calculated as the number of hauls where a species was presented as a percentage of the total number of hauls, by area (subdivision), fishery and depth. Starry ray was by far the most common species in the observer data, present in more than 900 hauls. The high number reflects the wide distribution and depth range of the species. Rabbit fish, velvet belly and spurdog were also very common, with 449, 302, and 392 observation in the data respectively.

Logbook landings and (raised) discard estimates for nine species of sharks and rabbit fish, and four species of skates and rays in the dominant Swedish fisheries 2008–2019 is presented in Table 5a and 5b, respectively. In summary, the total estimated average Swedish catches per year over the period 2008–2019 were just below 180 tonnes annually. Starry ray and spurdog represents > 75 % of the estimated total catch weight of shark and rays combined. More than 90 % of the catch was discarded, which is not surprising given that landing of spurdog, starry ray, common skate and thornback ray are prohibited in 3a. The only species landed to some extent (few tonnes per year) by Swedish vessels during the last five years is sailray (*Rajella linteus*), which is caught as by-catch in the Pandalus fishery and in demersal trawls without grid in the deeper parts (> 200 m) of the Skagerrak and the Norwegian trench (Figures 5f, 6g and Table 5b).

Table 4. Frequency of occurrence (in %) of sharks, rays and rabbit fish by main area, fleet and depth stratum in the Swedish on-board observer program 2002 – 2020. Only species observed in 1 % or more of the hauls are included in the table.

Area	Gear	Deth (m)	No. hauls	Amblyraja radiata *(n = 946)*	Chimaera monstrosa *(n= 481)*	Etmopterus spinax *(n = 335)*	Raja clavata *(n = 110)*	Rajella lintea *(n = 80)*	Scyliorhinus canicula *(n = 52)*	Squalus acanthias *(n = 395)*
4	Demersal trawl	100-200	11	36%	9%	9%	0%	0%	0%	0%
	Pandalus trawl	100-200	7	43%	57%	71%	0%	0%	0%	0%
	Pandalus trawl	200-300	27	85%	100%	100%	0%	33%	0%	11%
3a.20	Demersal trawl	0-100	307	36%	1%	0%	6%	0%	4%	32%
		100-200	221	81%	23%	3%	5%	1%	6%	28%
		200-300	45	98%	91%	58%	2%	33%	2%	27%
		300-400	6	100%	100%	100%	0%	0%	0%	17%
	Nephrops trawl with grid	0-100	351	22%	0%	0%	5%	0%	0%	8%
		100-200	4	25%	0%	0%	0%	0%	0%	25%
	Pandalus trawl	0-100	7	57%	0%	0%	29%	0%	0%	29%
		100-200	53	53%	70%	34%	0%	4%	0%	30%
		200-300	176	65%	97%	71%	1%	11%	1%	26%
		300-400	73	95%	96%	73%	4%	38%	1%	18%
		400-500	23	74%	83%	83%	4%	22%	0%	9%
	Pandalus trawl with grid	0-100	38	26%	3%	5%	5%	0%	0%	13%
		100-200	68	41%	12%	21%	0%	0%	0%	13%
		200-300	36	28%	75%	58%	0%	0%	0%	14%
		300-400	9	56%	89%	56%	0%	0%	0%	11%
		400-500	9	89%	89%	56%	0%	0%	0%	0%
3a.21	Demersal trawl	0-100	579	31%	0%	0%	9%	0%	4%	16%
	Nephrops trawl with grid	0-100	270	6%	0%	0%	1%	0%	0%	1%
	Pandalus trawl	0-100	9	33%	0%	0%	0%	0%	0%	0%

Table 5a. Swedish landings and discards (t) of sharks and rabbit fish in active gears by species, area and fishery for 2008-2019. Data from logbooks (landings) and raised observer data (discards). Discard estimates in area 4 are blank because the Swedish observer program has limited coverage outside area 3a (due to small Swedish fishing effort and catches in area 4). Discard estimates in 2020 uncertain due to limited coverage during the covid 19 pandemic and 2020 therefore left blank. Area 4 is the North Sea. Area 3.a.20 is Skagerrak and area 3.a.21 is Kattegat.

			2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018		2019	
Area	Fishery	Species	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)
4	Demersal trawl	Squalus acanthias	0.4		0.0		0.0		0		0		0		0		0		0		0		0		0	
	Pandalus trawl	Chimaera monstrosa	0		0		0		0		0		0		0.0		0		0		0.0		0.0		0	
		Squalus acanthias	0.0		0.0		0.0		0		0		0		0		0		0		0		0		0	
3.a.20	Demersal trawl	Chimaera monstrosa	0	1	0.0	11.5	0	1.3	0	1.2	0	1.9	0	3	0.0	0.6	0.1	0	0.0	0.4	0.0	2.8	0.0	1.2	0.0	1.3
		Etmopterus spinax	0	0.3	0	0.4	0	0.6	0	0	0	0.0	0	0.3	0	0	0	0	0	0	0	0.1	0	0.2	0	0.5
		Galeorhinus galeus*	0	0.1	0	0	0	0	0		0		0		0		0		0		0		0		0	
		Mustelus asterias	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
		Mustelus mustelus	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Scyliorhinus canicula	0	0.5	0	0.6	0	0.3	0	0.2	0	1	0	0	0	0	0	0.9	0	0	0	0.8	0	0.2	0	2.1
		Squalus acanthias	24.4	3.2	12.7	9.8	2.4	27.3	0.0	6.8	0	20.2	0	29.6	0	173.2	0	21.6	0	6.3	0.0	102.4	0	8.6	0.0	25.2
	Nephrops trawl with grid	Scyliorhinus canicula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0
		Squalus acanthias	0.3	0.0	0.7	0	0	0.1	0	1.4	0	0.1	0	0.3	0	0.0	0	2	0	0.4	0	0	0	0	0	6
	Pandalus trawl	Chimaera monstrosa	0	2.8	0	19.6	0.0	54.7	0	11.1	0	24.4	0.0	0.4	0	14.3	0.0	6.9	0.0	16.2	0.1	6.3	0.0	2.9	0.0	3.7
		Etmopterus spinax	0	3.3	0	17.2	0	32.6	0	5.9	0	22	0	1	0	3.2	0	0.9	0	5.6	0	1.7	0	0.5	0	6.5
		Galeus melastomus	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Scyliorhinus canicula	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0
		Squalus acanthias	0.4	0.2	1.4	0.0	0.6	4.4	0	0.6	0	7	0	0.1	0	0.3	0	0	0	1.1	0	0.4	0	1	0	0.2
	Pandalus trawl with grid	Chimaera monstrosa	0	0.0	0	0.4	0	0	0	0	0	0	0	0.1	0	0.8	0	0.2	0	0.9	0	1.3	0	0	0	0
		Etmopterus spinax	0	0	0	0.1	0	0	0	0	0	0	0	0.1	0	0.3	0	1.4	0	2	0	0.0	0	0.2	0	0.1
		Galeus melastomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0
		Squalus acanthias	0.1	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0.2	0	0.0	0	0.2	0	0.1	0	0.0	0	0.1	0	0
	Pelagic	Lamna nasus	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Squalus acanthias	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0.1	0	0	0
3.a.21	Demersal trawl	Scyliorhinus canicula	0	0.7	0	0.1	0	0.0	0	0	0	0	0	0.1	0	0.1	0	0	0	0.5	0	0.4	0	0.3	0	0
		Squalus acanthias	23.3	0.0	16	0.2	2	0	0	1.1	0	2.1	0	1.7	0	9.9	0	3.2	0	5	0	2.7	0	1.3	0	37.5
	Nephrops trawl with grid	Squalus acanthias	0.8	0	0.7	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0.0	0	0
	Total estimated catch			**62**		**91.4**		**126.3**		**28.3**		**79**		**36.9**		**202.7**		**37.4**		**39.2**		**119.3**		**16.6**		**83.1**

** Registered as Carcharhinidae*

Table 5b. Swedish landings and discards (t) of skates and rays in active gears by species, area and fishery for 2008-2019. Data from logbooks (landings) and raised observer data (discards). Discard estimates in area 4 are blank because the Swedish observer program has limited coverage outside area 3a (due to small Swedish fishing effort and catches in area 4). Discard estimates in 2020 uncertain due to limited coverage during the covid 19 pandemic and 2020 therefore left blank.

			2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018		2019	
Area	Fishery	Species	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)	Lan (t)	Dis (t)
4	Demersal trawl	Raja clavata	0		0		0		0		0		0		0		0		0,0		0		0		0	
		Rajidae	0.3		0		0		0		0		0		0		0		0		0		0		0	
	Pandalus trawl	Amblyraja radiata	0		0		0		0,0		0		0		0		0		0		0		0		0	
		Dipturus batis	0		0		0,0		0.1		0,0		0.1		0		0		0		0,0		0		0	
		Raja clavata	0		0		0		0		0		0		0		0		0		0.1		0,0		0,0	
		Rajella lintea	0		0		0		0,0		0,0		0.2		0.3		0.1		0.8		0.3		0.3		0.2	
		Rajidae	0.1		0.1		0.3		0.3		0		0		0		0		0		0		0		0	
3.a.20	Demersal trawl	Amblyraja radiata	0	50,0	0	117.8	0	114.9	0	75.8	0	51.3	0	46.7	0	43.7	0	55.4	0	7,0	0	10.8	0	76.4	0	108.3
		Dipturus batis	0	0	0	0.1	0	0	0,0	6.2	0.4	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0,0	0
		Raja clavata	0	2,0	0	0.9	0	1.2	0	1.4	0	0.4	0	0	0	0	0	4.3	0	1.1	0.1	0.1	0,0	6.1	0,0	8.2
		Rajella lintea	0	0	0	0.3	0	0	0.1	0	1.2	2.1	0.4	0	0.7	0	0.6	0	0.3	0	0.7	0	1.1	0	1.5	1,0
		Rajidae	5.7	0	1.2	0	1.7	0	0.6	0	0	0	0	0	0	0	0	0	0,0	0	0	0	0	0	0	0
	Nephrops trawl with grid	Amblyraja radiata	0	4.1	0	1.2	0	1.3	0	1.1	0	2.2	0	3,0	0	3.6	0	0.1	0	1.4	0	2.1	0	4.1	0	0.8
		Dipturus batis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Leucoraja naevus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0
		Raja clavata	0	0.2	0	0.2	0	0.2	0	0.1	0,0	0.4	0	0	0	0.1	0	0.3	0	0.4	0	0.3	0	0.1	0,0	0.5
	Pandalus trawl	Amblyraja radiata	0	13.2	0	5.7	0	38.5	0	18.7	0	24.5	0	2.5	0	16.3	0	3.5	0	12,0	0	47.6	0	14.6	0	10.6
		Dipturus batis	0	0	0	0	0.5	2.3	0.6	0.4	0.9	0	1.7	0	0	1.3	0	0	0	1.8	0	0	0	0.6	0,0	0
		Raja clavata	0	0	0	0	0	0	0	0	0	4.8	0	0	0	0	0	0,0	0	1,0	0.1	0	0.1	0	0	1.5
		Rajella lintea	0	0	0	0.6	0	0.3	0.2	2.5	0.4	9.1	3.6	5.3	2.1	6.4	2,0	0	2.4	6.7	0.3	33.2	1.7	4.5	0.8	0.7
		Rajidae	0.3	0	0.5	0	7.5	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pandalus trawl with grid	Amblyraja radiata	0	0,0	0	0,0	0	0.2	0	0.1	0	0,0	0	0.2	0	0,0	0	0.9	0	1.4	0	0.2	0	0.1	0	0.1
		Raja clavata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0
		Rajella lintea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0	0	0	0	0	0	0	0	0,0	0
		Rajidae	0	0	0	0	0	0	0,0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.a.21	Demersal trawl	Amblyraja radiata	0	6.9	0	6.6	0	1.7	0	0.6	0	3.1	0	0	0	0	0	0.2	0	16.9	0	0	0	0.4	0	0.5
		Dipturus batis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0	0
		Raja clavata	0	3,0	0	0.7	0	6.5	0	1.6	0	9.1	0	0.7	0	0.6	0	4.5	0	0.9	0	1.4	0	8.5	0	2.7
		Rajidae	0	0	0.1	0	0,0	0	0,0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nephrops trawl with grid	Amblyraja radiata	0	0.6	0	0.3	0	0,0	0	0.2	0	0.6	0	0,0	0	0	0	0	0	0.9	0	0	0	0	0	0
		Dipturus batis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0	0	0	0	0	0	0	0
		Raja clavata	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0
	Total estimated cacth			**86.4**		**136.7**		**177,0**		**112.3**		**110.8**		**64.6**		**75.2**		**71.9**		**55.1**		**97.3**		**119.3**		**137.4**

4. Summary

In total 17 species of sharks, skates, ray and rabbit fish was reported in 3a from the different scientific surveys during the covered time period (1967 – present). With the addition of four more species in the Swedish commercial fisheries (from logbook records and the on-board sampling program) during the last 20 years, the total number of observed elasmobranchs in 3a and easternmost area 4 adds up to 21 species. The species encountered in this review are listed by group in falling order of occurrence in Skagerrak/Kattegat below. In the list we have also indicated at which depth interval each species mainly occur and in which fishery they are most likely to be caught. We also indicate how by-catches can be further mitigated through selectivity measures.

4.1. Sharks and rabbit fish

Spurdog (*Squalus acanthias*) are common and widespread in the Skagerrak and Kattegat. It occurs both in shallow waters, from 20–100 meters, and deeper waters 200–400 meters but is slightly less common at larger depths. In 2018 to 2020 survey data indicate that spurdog distribution changes from winter Q1 to Q3/4 which is consistent with logbook data from 2002–2010 when spurdog was fished commercially. Data from the on-board sampling programme indicate that this is a dominating species and that by-catches are regular in all demersal trawl fisheries. Based on historical landings in logbook data, spurdogs are also exposed to bycatch in pelagic gear. Risk of by-catch is considerably lower when trawls (for both Nephrops and Pandalus) are equipped with sorting grids. Fishing and landing of spurdog is prohibited in 3a and 4.

Velvet belly (*Etmopterus spinax*) is very common in the deeper parts of Skagerrak and the eastern parts of area 4.a, following the slopes of the Norwegian trench. The catches are higher in the Norwegian shrimp survey during Q1 than in the Skagerrak survey in Q3/Q4 but this could potentially be a catchability issue. Based on the observer data, velvet belly is mainly caught in depths from 200 to 500 meters and occurs in 56–83 % of all commercial hauls from these depths. At these depths, observer data indicate that the risk of bycatch in Pandalus trawls with grid is lower, than in Pandalus trawls using fish retention device.

Lesser spotted dogfish (*Scyliorhinus canicula*) is widely distributed in the Greater North Sea and is very common in the southwestern corner of the North Sea and in the English Channel. It

occurs in the southern parts of Skagerrak and the Kattegat year round, but at densities much lower than in the North Sea. It is caught in demersal trawls in both Skagerrak and Kattegat, mainly in shallow waters from 20–200 meters. This species is prohibited to fish.

Nursehound (*Scyliorhinus stellaris*) also occurs in the groundfish survey dataset but it is not very frequent in the North Sea, and was only caught once in Skagerrak/Kattegat. Nursehound has not been observed in the observer program.

Blackmouth catshark (*Galeus melastomus*) is mainly found in the deeper parts of the northeastern North Sea in area 4a along the Norwegian coast. It has only been reported from 22 survey hauls in the Skagerrak but never in the Swedish EEZ. In the Swedish on-board program, blackmouth catshark has been noted in 19 times from the eastern part of 4a and three times from the Skagerrak.

Starry smooth hounds (*Mustelus asterias* and *M. mustelus*) occur quite frequently in the southeastern part of the North Sea along the British coast and there are some uncertainties about species identification in the groundfish data set. Both species have been reported from 3a but in very low numbers, in eight, and two survey hauls respectively. Smooth hounds are very rarely caught in the demersal trawl fishery and have only been observed in six out of 2340 hauls from 2002–2020.

Tope (*Galeorhinus galeus*) is relatively common in the groundfish survey dataset (in 327 hauls), but has not been recorded during trawl survey in the Skagerrak or Kattegat. Between 2003 and 2008 tope was landed from Skagerrak (27 trips) and Kattegat (two trips) by Swedish vessels on average three times/year. All landings but one reported from Skagerrak were caught using shark nets, *i.e.*, large-meshed gillnets. One of the landings from Kattegat were caught in demersal trawl, the other is unknown.

Porbeagle (*Lamna nasus*) has only been recorded from groundfish surveys in the Greater North Sea once between 1967 and 2020. From 2002–2009 it was landed by Swedish vessel from 12 fishing trips, three from the North Sea, eight from the Skagerrak and one from the Sound (area 3.b.23). The largest quantities were caught in longlines, but demersal trawl, pelagic trawl and gillnets were represented in the porbeagle landings. This species is prohibited to fish and land.

Greenland shark (*Somniosus microcephalus*) is very rare in the groundfish survey data. It has been observed in the Skagerrak/Kattegat two times. It has also been landed in the Pandalus fishery twice, once in 2004 and once in 2009.

Rabbit fish (*Chimaera monstrosa*) is common in the deeper parts of Skagerrak and the eastern parts of area 4.a, following the slopes of the Norwegian trench. The catches are higher in the Norwegian shrimp survey during Q1 than in the Skagerrak survey in Q3/Q4 but this could potentially be a catchability issue. Based on the observer data, rabbit fish is mainly caught in depths from 200 to 500 meters and occurs in 75–100 % of all commercial haul from these depths. At these depths, observer data indicate that catches in Pandalus trawls with grid is > 20 % lower, than in Pandalus trawls using a fish retention device. It is not prohibited to fish and land rabbit fish but by-catches are very rarely landed.

4.2. Skates and rays

Starry ray (*Amblyraja radiata*) are common in the survey data sets. It occurs in the entire 3a, both in shallow and deep waters. Data from the sea-sampling programme indicate that this is the dominating species (≈ 80 %) and that by-catches are regular in all demersal trawl fisheries. By-catch rate (no./h) of starry ray is higher in fisheries carried out in deep water (> 200 m). By-catch rate is considerably lower when trawls (for both Nephrops and Pandalus) are equipped with sorting grids. Fishing and landing of starry ray is prohibited in 3a and 4.

Sailray (*Rajella lintea*) occur in the deeper (> 250 m) parts of Skagerrak (3a.20). This is outside the depths covered by IBTS so records of sailrays from this survey are missing. However, results from the Norwegian shrimp survey and the Swedish Skagerrak survey indicates that the species is fairly common in deeper areas. Sailrays are regularly caught as by-catch in the Pandalus fishery and in other demersal trawl fisheries carried out at those depths (observer data). As for the previous species by-catch rates are considerably lower when trawls (Pandalus) are equipped with sorting grids are used. It is not prohibited to fish and land sailray and by-catches are sometimes landed and counted against the Swedish skates and rays quota (which is 10 tonnes for 3a in 2019; Council Reg (EU) 2019/124).

Round rays (*Rajella fyllae*) also occur in the deeper (> 250 m) parts of Skagerrak (3a.20) and is common in the Norwegian trench in 4a. The species is believed to be rare in Skagerrak, but occurs relatively frequent in the catches in the Norwegian shrimp survey and the Swedish Skagerrak survey.

Thornback ray (*Raja clavata*) is regularly caught in the surveys but in low numbers. The species mainly occurs in shallower (< 100 m or even < 50 m in 3a.21) parts of 3a, predominantly in the south and central part of the Kattegat (3a.21). Data from the observer programme show that by-catches occur on a sparse but regular basis and that they are concentrated to the central Kattegat. By-catch rate is considerably lower for trawls (mainly Nephrops) equipped with sorting grids. Fishing and landing of thornback ray is prohibited in 3a.

Common skate (*Dipturus batis*) mainly occurs in the deeper parts of 3a were it has been caught in the IBTS survey. Common skate are only rarely encountered in fishing trips covered by the observer programme (caught in 21 out of 2282 observed hauls from 2002–2020). The sporadic by-catches origins from the Pandalus fishery (primarily when the fishery takes place in area 4 and in other demersal trawl fisheries carried out at greater depths. Fishing and landing of common skate is prohibited in 3a and 4.

Longnosed skate (*Dipturus oxyrinchus*) has rarely been encountered in the deeper (> 200 m) part of Skagerrak (3a.20) and Norwegian trench. It has not been recorded in the IBTS in in the area but this may be dependent on the limited depth coverage by IBTS. The species was found in one of the deeper hauls in the Swedish Skagerrak survey in 2018. The species has been recorded in the observer programme but are extremely rare (two individuals in 2282 observed hauls).

Spinytail skate (*Bathyraja spinicauda*) has been observed in the Norwegian shrimp survey but not in any of the other groundfish surveys. No observations of spinytail skate has been made in the commercial fishery.

Spotted ray (*Raja montagui*) is common to the western North Sea and northeast Atlantic. It was recently reported from the Kattegat cod survey. No observations of spotted ray has been made in the commercial fishery.

Shagreen ray (*Leucoraja fullonica*) has not been recorded in any of the surveys in 3a. Shagreen ray was recorded in the observer programme in one out of 2340 observed hauls from 2002–2020.

Cuckoo ray (*Leucoraja naevus*) has not been recorded in any of the surveys in 3a. One individual of cuckoo ray was recorded in the observer programme in one out of 2282 observed hauls from 2002–2020.

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