10 Norway lobster (*Nephrops* spp.) in Division 3.a (Skagerrak, Kattegat)

10.1 *Nephrops* in Division 3.a

10.1.1 General

At present, there are two functional units in Division 3.a: Skagerrak (3.a.20) and Kattegat (3.a.21). This separation was based on observed differences between Skagerrak and Kattegat regarding *Nephrops* size composition in catches in the 1980s and 1990s. However, the distribution of *Nephrops* is almost continuous from southern Kattegat into Skagerrak, and the exchange of pelagic larvae between the southern and northern areas is very likely. With the longer data series now available, it seems the differences in size composition between the two areas are more likely to be random or caused by factors from fishing operations. The assessment is therefore conducted on *Nephrops* in 3.a as one stock.

Ecosystem aspects

Nephrops live in burrows in suitable muddy sediments and is characterised by being omnivorous and emerge out of the burrows to feed. It can, however, also sustain itself as a suspension feeder in the burrows (Loo *et al*., 1993). This ability may contribute to maintaining a high production of this species in 3.a, due to increased organic production. *Nephrops* have recently been found to have a high prevalence of plastics which may have implications for the health of the stock (Murry and Cowie, 2011).

Severe depletion in oxygen content in the water can force the animals out of their burrows, thus temporarily increasing the trawl catchability of this species during such environmental changes (Bagge *et al*. 1979). An especially severe case was observed in the end of the 1980s in the southern part of 3.a in late summer, where unusually high catch rates of *Nephrops* were observed. The increasing amount of dead specimens in the catches led to the conclusion of severe oxygen deficiency in especially the Kattegat (3.a.21) in late 1988 (Bagge *et al*., 1990).

No information is available on the extent to which larval mixing occurs between *Nephrops* stocks, but the similarity in stock indicator trends between 3.a.20 and 3.a.21 for both Denmark and Sweden indicates that recruitment has been similar in both areas. These observations suggest they may be related to environmental influences.

ICES Advice

The most recent advice for *Nephrops* in 3.a was given in 2020. ICES concluded that:

'The stock size is considered to be stable. The estimated harvest rate for this stock is currently below F_{MSY}.'

Management for FU 3 and FU 4

The TAC for *Nephrops* in ICES area 3.a was increased from 5318 tonnes in 2015 to 11 001 tonnes in 2016, 12 715 tonnes in 2017, 11 738 tonnes in 2018, 13 733 tonnes in 2019 and 2020 and 12360 tonnes in 2021. The large increase in quota 2015 to 2016 was due to the fact that the EU shifted from providing landings advice to providing catch advice. The minimum conservation reference size (previously referred to as minimum landings size) for *Nephrops* in area 3.a was reduced in 2016 from 40 to 32 mm carapace length. The historically large MLS led to a high discard ratios (discards/(discards + landings)) around 50%, and the discard proportion 2016 was decreased to

12% of the catch (in numbers) in 3.a consisted of undersized individuals. Since 2017, the discard proportion has been around 30% (Figure 10.2.1.1). The reduction in MLS has reduced the proportion of the catch discarded considerably. Furthermore, it is expected that ongoing experimental work on improving gear selectivity will further reduce the amount discarded. A discard ban was implemented in EU waters from 1 January 2015. The discard ban became applicable to *Nephrops* from 1 January 2016, however an exemption for high survivability was introduced. New technical measures have also been agreed upon and have been implemented since 1 February 2013.

Swedish gear regulations since 2004 imply that it is mandatory to use a 35 mm species selective grid together with an 8 m full square-mesh codend of 70 mm and extension piece when trawling for *Nephrops* in Swedish national waters. Additionally, the Danish gear regulations since 2011 imply a mandatory use of either the grid or the use of the SELTRA trawl which compromise a 90 mm cod end with either a square-mesh panel (180 mm in the Kattegat and 140 mm in the Skagerrak) or 270 mm diamond mesh panel. In Article 11 in the cod recovery plan, member states may apply for unlimited number of days when using the species selective grid trawl.

10.1.2 Data available from Skagerrak (FU3) and Kattegat (FU4)

Landings

Division 3.a includes FU 3 and 4, which are assessed together. Total *Nephrops* landings by FU and country are shown in Table 10.2.1.1 and Table 10.2.1.2.

FU 3 is primarily exploited by Denmark, Sweden and Norway. Denmark and Sweden dominate this fishery, with 61 % and 35 % by weight of the landings in 2020, respectively. Landings by the Swedish creel fishery represented 13–18 % of the total Swedish *Nephrops* landings from the Skagerrak in the period 1991 to 2002. Since 2002, creel catches have been steadily increasing and have in 2009 to 2016 accounted for more than 30% of Swedish Skagerrak landings (Table 10.2.2.1). In the early 1980s, total *Nephrops* landings from the Skagerrak increased from around 1000 tonnes to just over 2670 tonnes. Since then, they have been fluctuating around a mean of 2500 tonnes (Figure 10.2.2.1). In 2020, landings were 3368 tonnes (Table 10.2.1.1).

Both Denmark and Sweden have *Nephrops* directed fisheries in the FU 4 (Kattegat). In 2020, Denmark accounted for about 76% of total landings in FU4, while Sweden took 24 % (Table 10.2.2.5). Minor landings have been taken by Germany (< 1%).

After a decline in the observed landings in 1994, total *Nephrops* landings from the Kattegat increased again until 1998 and have fluctuated around 1500 tonnes. However, since 2006 the landings have increased and were in 2010 the highest on record over the previous 50-year period (Figure 10.2.2.3). From 2010 till 2015, landings show a decreasing trend. Landings have increased since 2015 reaching 3128 tonnes in 2019, the maximum observed in the time series. A general trend of reduced landing of *nephrops* during 2020 was observed also in Kattegat with a catch in 2020 of 2531 tonnes.

Length compositions

For the Skagerrak, size distributions of both the landings and discards are available from both Denmark and Sweden for 1991–2019. In the beginning of the time series, the Swedish data can be considered as being the most complete, since sampling took place regularly throughout the time period and usually covered the whole year. Trends in mean size in catch and landings for Skagerrak are shown in Figure 10.2.2.2 and Table 10.2.2.4. Mean sizes for landings are fluctuating without trend. Mean size for undersized show an increasing trend from 2005 till 2015 but are observed to be at lower level in recent years.

For Kattegat, size distributions of both the landings and discards are available from Sweden for 1990–2019, and from Denmark for 1992–2020. The at-sea-sampling intensity has generally increased since 1999. The Danish sampling intensity was low in 2007 and 2008, but was normalized in 2009 to 2019. Information on mean size is shown in Figure 10.2.2.4 and Table 10.2.2.8. Notice, that except for small mean sizes from 1993 to 1996 all categories have since been fluctuating without trend until 2016 when the minimum landing size was decreased from 40 to 32 mm carapace length.

In earlier years, the Swedish discard samples were obtained by agreement with selected fishermen, and this might have tempted fishermen to bias the samples. However, the reliability of the catch samplings was cross-checked by special discard sampling projects in both the Skagerrak and the Kattegat. In recent years, the Swedish *Nephrops* sampling has been carried out by onboard observers in both Skagerrak and Kattegat. In 1991, a biological sampling programme of the Danish *Nephrops* fishery was started on board fishing vessels in order to also cover the discards in this fishery. Due to its high cost and the lack of manpower, Danish sampling intensity in the early years was in general not satisfactory, and seasonal variations were not often adequately covered. The Norwegian *Nephrops* fishery is small and has not been sampled.

Natural mortality, maturity at age and other biological parameters

In previous analytical assessments (when Length Cohort Analyses were performed, see e.g. WGNEPH 2003), natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females. Discard survival was assumed to be 0.25 for both males and females (after Gueguen and Charuau, 1975, Redant and Polet, 1994, and Wileman *et al*. 1999).

Growth parameters are as follows:

Males:	$L\infty$ = 73 mm CL, k = 0.138.
Immature females:	$L\infty$ = 73 mm CL, k = 0.138.
Mature females:	$L\infty$ = 65 mm CL, k = 0.10, Size at 50% maturity = 29 mm CL.

Growth parameters for males were taken from Ulmestrand and Eggert (2001) and female growth parameters have been assumed to be similar to those of Scottish *Nephrops* stocks.

Data on size at maturity for males and females were presented at the ICES Workshop on *Nephrops* Stocks in January 2006 (ICES WKNEPH, 2006).

Catch and effort data–FU3

Effort data for the Swedish fleet are available from logbooks for 1978–2020 (Figure 10.2.2.1 and Table 10.2.2.2). During the period 1998 to 2005, twin trawlers shifted to targeting both fish and *Nephrops*, which resulted in a decreasing trend in LPUE during this period (Table 10.2.2.2). Since 2005, LPUE for twin trawls has increased. The LPUE for single trawls has shown and increasing trend throughout the entire time series. The long-term trend in LPUEs is similar in the Swedish and Danish fisheries (Figure 10.2.2.1). Total Swedish trawl effort shows a decreasing trend since 1992 and has been fluctuating without trend since 2003. From 2007 onwards, total Swedish trawl effort has been estimated from LPUEs from the single trawl with a grid (targeting only *Nephrops*).

Danish effort figures for the Skagerrak (Table 10.2.2.3 and Figure 10.2.2.1) were estimated from logbook data. For the whole period, it is assumed that effort is exerted mainly by vessels using twin trawls. The overall trend in effort for the Danish fleet is similar to that in the Swedish fishery. After having been at a relatively low level in 1994–1998, effort increased again in the next four years, followed by a decrease to a relatively low level in 2007 to 2017. Also, the trend in LPUE is similar to that in the Swedish single trawl fishery, however with a much more marked

increase in the Danish LPUE for 2007 and 2008. This high LPUE level is likely to be a consequence of the national (Danish) management system introduced in 2007.

It has not been possible to explicitly incorporate 'technological creeping' in a further evaluation of the Danish effort data. However, since 2000 the Danish logbook data have been analysed in various ways to elucidate the effect of factors likely to influence the effort/LPUE, e.g. vessel size (Figure 10.2.2.3).

Catch and effort data–FU4

Swedish total effort has been relatively stable over the period 1978–1990. Effort increased from 1990 to 1993, followed by a decrease to 1996. During the last 20 years effort has remained relatively stable, except for 2007 and 2008 where effort increased (Figure 10.2.2.3 and Table 10.2.2.6). Figures for total Danish effort are based on logbook records since 1987. Danish effort increased from 1995 to 2001, decreased from 2002 to 2007 and has been fluctuating without trend since (Figure 10.2.2.3 and Table 10.2.2.7).

Since 2000, the Danish logbook data have been standardised to account for changes in fishing power due to changes in the physical characters of the *Nephrops* fleet. The data have been analysed in various ways to elucidate the effect of factors likely to influence the effort/LPUE, e.g. vessel size.

10.1.3 Combined assessment (FU 3 and 4)

Reviews of last year's assessment

"No major issues. It was noted that it would be useful to show confidence intervals around the UWTV estimates. The LPUE considerations were moved to additional considerations."

10.1.3.1 TV survey in 3.a

In 2008 and 2009, an exploratory UWTV survey was carried out by Denmark. In 2010, the TV survey was expanded covering the main *Nephrops* grounds in the western part of Skagerrak (Subarea 1) and Northern part of Kattegat (Subarea 2). Since 2011, the TV survey has been carried out in collaboration between Denmark and Sweden and covers the main *Nephrops* fishing grounds in 3.a (Subarea 1–6). In 2014, Subarea 1 was extended to the west (Subarea 7; Figure 10.2.3.2) and in 2017 (2016 benchmark) Subarea 2 was extended east (Subarea 9). Figure 10.2.3.4 presents the distribution of stations with valid density estimates from 2011 to 2020. A similar survey design has been applied for both national surveys: a fixed grid with random stratified stations.

In order to estimate the total population numbers, the density estimates have to be raised from the survey areas to total area of the population distribution. VMS information is currently the best available proxy to estimate the *Nephrops* stock distribution in 3.a. VMS data from the Swedish and Danish fishery from 2010 were used (Figure 10.2.3.3) and are described in more detail in ICES (2011). The area estimates for each Subarea are defined in Table 10.2.3.1. Burrow counting and identification follows the standard protocols defined by WGNEPS (ICES 2013).

Abundance indices from UWTV surveys

The number of valid stations conducted in the UWTV survey in 3.a divided into subareas Figure 10.2.3.2 is shown in Table 10.2.3.1 and Figure 10.2.3.4.

In WK*NEPH (*2009), a number of bias sources were highlighted relating to the "counted" density from the TV surveys. These bias sources are not easily estimated and are largely based on expert opinion. For the *Nephrops* stock in 3.a, it is assumed that the largest source of perceived bias is the "edge effect", due to the relative large sizes of the burrow systems. The cumulative biases result in a correction factor to take the raw counts to absolute densities. The correction factor for

3.a was set to be 1.1, meaning that the raw TV survey is likely to overestimate *Nephrops* abundance by 10 %. TV survey results are presented as absolute values (i.e. the bias already taken into account).

FU	Area	Edge effect	Detection rate	Species identification	Occupancy	Cumulative bias
3 and 4	Skagerrak and Kattegat	1.3	0.75	1.05	1	1.1

10.1.3.2 Assessment

The assessment of the state of the *Nephrops* stock in 3.a is based on the UWTV survey from 2020. Additional used information was trends in total combined (Denmark and Sweden) LPUE, and discards (numbers) as a proxy for recruitment during the period 1990–2020.

Combined relative effort declined slightly over the period 1990 to 2020 (Figure 10.2.4.1) while combined relative LPUE shows an increasing trend and is at a high level but decreased slightly in 2020 (Figure 10.2.4.2). This high level may be attributed to the change in the Danish management system (Individual Transferable Quotas) in 2007 and the change in minimum landing size in 2016. Technical creep, changes in targeting behaviour, stock size and catchability may also be responsible for some of this increase. High LPUEs attributable to sudden changes in catchability (caused by e.g. poor oxygen conditions) are known to occur but are generally of short duration.

Since the abundance of small *Nephrops* (typically discards of specimens below minimum landing size) may also be regarded as an index of recruitment, they can be used to further explain the current developments in the stock. The large amounts of discards in the periods 1993–1995 and 1999–2000 reflect strong recruitment during these years (Figure 10.2.4.3). The high levels of discards in 1993–1995 are believed to have significantly contributed to the high LPUE in 1998–1999. The high amount of discards observed in 2007, 2008 and 2009 would then indicate high recruitment in these years, as could the low amount of discards in 2014 and 2015 indicate a low recruitment. The discards in 2016 is the lowest since 1991 due to the lowered MCRS. Low discard rate may also be due to a very low recruitment and/or an increase in gear size selectivity.

MSY considerations (TV–survey)

There are no precautionary reference points defined for *Nephrops*. Under the ICES MSY framework, exploitation rates which are likely to generate high long-term yields (and low probability of stock overfishing) have been explored and proposed for Division 3.a. Owing to the way *Nephrops* are assessed, it is not possible to estimate F_{MSY} directly and hence proxies for F_{MSY} are determined. WGNSSK (2010) developed a framework for proposing F_{MSY} proxies for the various *Nephrops* stocks based upon their biological and historical characteristics, and is described in Section 1 of that report. Three candidates for F_{MSY} are $F_{0.1}$, $F_{35\%SpR}$ and F_{MAX}. There may be strong differences in relative exploitation rates between the sexes in many stocks. To account for this, values for each of the candidates have been determined for males, females and the two sexes combined. An appropriate F_{MSY} candidate has been selected according to the perception of stock resilience, factors affecting recruitment, population density, knowledge of biological parameters and the nature of the fishery (relative exploitation of the sexes and historical harvest rate vs stock status).

A decision-making framework based on the table below was used in the selection of preliminary stock-specific F_{MSY} proxies (ICES, 2010a). These proxies may be modified following further data exploration and analysis. The combined sex F_{MSY} proxy should be considered appropriate if the resulting percentage of virgin spawner-per-recruit for males or females does not fall below 20%. When this does happen a more conservative sex-specific F_{MSY} proxy should be picked instead of the combined proxy.

		Burrow density (average burrows m^{-2})		
		Low	Medium	High
		<0.3	0.3-0.8	>0.8
Observed harvest rate or landings compared to stock status	> F_{max}	$F_{35\%SpR}$	F_{max}	F_{max}
	F_{max} - $F_{0.1}$	$F_{0.1}$	$F_{35\%SpR}$	F_{max}
	< $F_{0.1}$	$F_{0.1}$	$F_{0.1}$	$F_{35\%SpR}$
	Unknown	$F_{0.1}$	$F_{35\%SpR}$	$F_{35\%SpR}$
Stock size estimates	Variable	$F_{0.1}$	$F_{0.1}$	$F_{35\%}$
	Stable	$F_{0.1}$	$F_{35\%SpR}$	F_{max}
Knowledge of biological parameters	Poor	$F_{0.1}$	$F_{0.1}$	$F_{35\%SpR}$
	Good	$F_{35\%SpR}$	$F_{35\%SpR}$	F_{max}
Fishery history	Stable spatially and temporally	$F_{35\%SpR}$	$F_{35\%SpR}$	F_{max}
	Sporadic	$F_{0.1}$	$F_{0.1}$	$F_{35\%SpR}$
	Developing	$F_{0.1}$	$F_{35\%SpR}$	$F_{35\%SpR}$

The absolute burrow density in Division 3.a is medium (0.3–0.8/m^2), the observed harvest rate is below $F_{0.1}$ and historically the fishery is stable both spatially and temporally. This means that $F_{0.1}$ may be selected as a proxy for F_{MSY}. As the MLS has been decreased in 2016 it is recommended to use F_{max} as a proxy for F_{MSY} as in last years. For 2020 this corresponds to a TAC of 14512 tonnes. Under a landings obligation it may well be necessary to recalculate a harvest rate associated with F_{MSY} as total catches would be subjected to 100% mortality (current discard survival is estimated to be 25 %).

Harvest rate as proxy for F_{MSY} for 3.a from length cohort analysis 2011 (2008–2010):

	Male	Female	Combined
F_{max}	6.8%	10.0%	7.9%
$F_{0.1}$	4.9%	7.6%	5.6%
$F_{35\%SpR}$	8.1%	12.9%	10.5%

The harvest rates ((landings + dead discards)/total stock abundance) equivalent to F_{MSY} proxies are based on yield-per-recruit analyses from length cohort analyses. These analyses utilise average length frequency data taken over the 3 year period (2008–2010). All F_{MSY} proxy harvest rate values are considered preliminary and may be modified following further data exploration and analysis.

Norway lobster in Division 3.a. The catch scenarios (weight in tonnes):

Catch scenarios assuming recent discard rates

Basis	Total catch	Dead removals	Projected landings	Projected dead discards	Projected surviving discards	% harvest rate *	% advice change **
	PL + PDD + PSD	PL + PDD	PL	PDD	PSD	for PL+ PDD	
ICES advice basis							
MSY approach	14514	13896	12042	1854	618	7.9	-15.9
Other scenarios							
$F = F_{MSY}$	14514	13896	12042	1854	618	7.9	-15.9
$F = F_{MSY\ lower}$	10288	9850	8536	1314	438	5.6	-40
$F = F_{MSY\ upper}$ ***	14514	13896	12042	1854	618	7.9	-15.9
$F = F_{35\%SpR}$	19290	18469	16005	2464	821	10.5	11.8
$F = F_{2020}$	7083	6781	5876	905	302	3.9	-59

*** Calculated in numbers for dead removals.**

**** Advice basis values for 2022 relative to the 2021 advice values (17 255 tonnes).**

***** FMSY upper = FMSY for this stock.**

A summary of the results from the TV survey 2020 is presented in Table 10.2.3.1. The estimated abundance index was 0.304 resulting in a total abundance of 43797 million individuals. Total removals (landings + dead discards) were estimated to 146 million individuals resulting in a harvest rate of 3.9%.

Conclusions drawn from the indicator analyses

The combined logbook recorded effort has decreased by 50% since 2002 and is currently at a low level while LPUE shows an increasing trend and is at a long-term high level in recent years (Figures 10.2.4.1 and 10.2.4.2). Mean sizes are fluctuating without trend. There are no signs of overexploitation in 3.a.

The conclusion from this indicator-based assessment is that the stock is exploited sustainably.

10.1.4 Biological reference points

No biological reference points are used for this stock.

10.1.5 Quality of the assessment

Estimating size composition for the Swedish creel and trawl fleets for 2020

From on-board sampling of size composition of catches, size distributions are raised to total landings. This is an important step of the stock assessment which builds on the combination of counts of individuals, and mean sizes of individuals in the population. The routine is that on-board sampling of catches is performed regularly for the Swedish and Danish trawling fleets, as well as for the Swedish creel fleet. The raising of size composition is done for the fleets separately. For German and Norwegian fleets, the combined size composition from Swedish and Danish fleets is raised to the landing.

Due to Covid-19 restrictions part of the on-board catch sampling programs could not be completed in 2020. The Danish on-board sampling program seem to have had a wider coverage (Table 10.1.1) and was deemed feasible for use in the 2021 assessment. However, observers were only able to join a very limited number of Swedish *Nephrops* fishing trips in both Skagerrak and Kattegat (Table 10.1.1).

Table 10.1.1. Number of observer trips on vessels targeting *Nephrops* in Skagerrak or Kattegat during 2020.

	Sweden				Denmark			
Quarter	2017	2018	2019	2020	2017	2018	2019	2020
1	15	16	11	13	20	30	25	15
2	16	14	16		20	32	27	25
3	16	15	13	1	30	30	40	29
4	13	14	15	2	17	15	21	10

Size data was available for the Swedish fleet for quarter 1 but not for the rest of the year. Available size data for other years was scrutinized to investigate if it could be applicable for 2020 circumstances and be used to make the necessary raising.

Size structure depending on discarding routines

Minimum landing size (MLS) for *Nephrops* in FU 3 and 4 was changed from 40 mmCL to 32 mmCL in 2016. However, discarding is still allowed above the MLS due to an exemption from the landing obligation because of high survival. This change in regulation hade very different effects on the Danish and the Swedish trawl fleets. The Danish fleet used to discard a large proportion of it catch but changed its discarding pattern after the change in regulation (Figure 10.1.1.a). The Swedish fleet also lowered its discard rate in 2016. Since 2018, however, the Swedish fleet discard large proportions of *Nephrops*, except in quarter 2, driven in large part by market prices (Figure 10.1.1.b.) 2018 and 2019 were the two years with most stable discard patterns for both Swedish and Danish fleets.

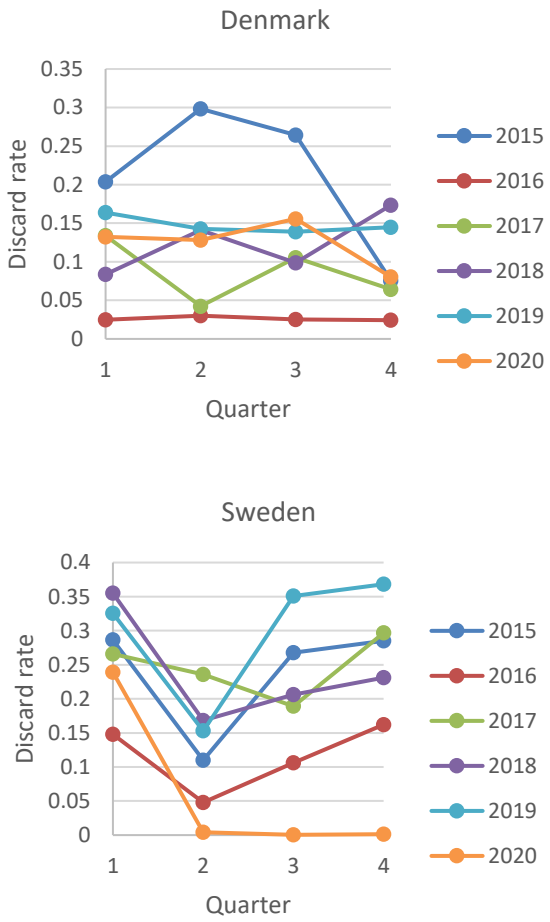

Figure 10.1.1. Discard rates by weight by quarter for the a) Danish and b) Swedish trawl fleets 2015–2020, as reported to Intercatch.

The following scenarios on how to pool data for the Swedish fleets were suggested:

1. Use only 2020 size data, for each fleet separately (default routine)
2. Use Danish data for 2020
3. Use Swedish data pooled for 2019–2020
4. Use Swedish data pooled for 2018–2020
5. Use Swedish data pooled for 2017–2020
6. Use relative discard rates DK:SE to transform Danish size data for 2020 to resemble Swedish size data.

For each scenario, the data were pooled and used to raise to the total landings. The size composition was used to calculate the average size of landed and discarded individuals and the total number of dead removals. These are the main components influencing the forecast and advice of the stock.

In order to perform scenario 6 relative discard rates had to be calculated. The fleets have different discarding patterns as described above (Figure 10.1.1). Discard rates by numbers can only be done for on-board samples, but comparing discard rates by weights can be done for both Intercatch reported landings and discards as well as for the on-board sampling. Discard rates by weight by quarter for on-board sampling of 2018–2019 (Figure 10.1.2) repeats the pattern of discards between the Danish and the Swedish trawl fleets seen in the Intercatch data.

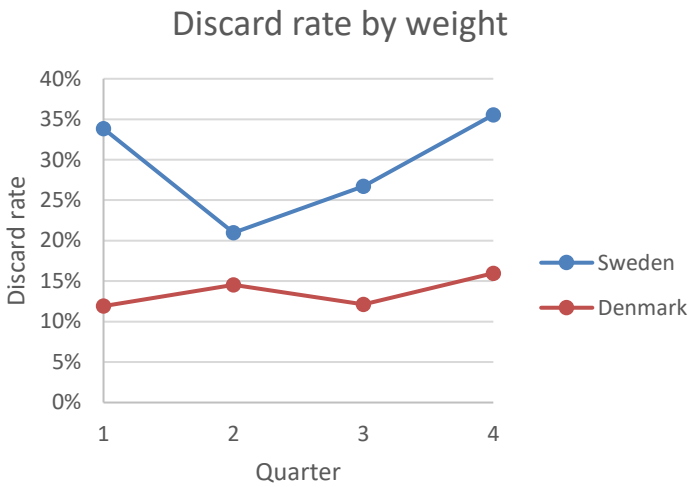

Figure 10.1.2. Discard rate by weight by quarter from on-board sampling of 2018–2019.

The on-board sampling data on counts of individuals was used to calculate the relative discard rate between the Danish fleet and the Swedish fleet simply by dividing the discard rate by quarter for the Swedish fleet with the discard rate by quarter for the Danish fleet. The proportion was then used to transform the numbers of discards per size class in the sampling of the Danish fleet to resemble the discard pattern of the Swedish fleet. The resulting size composition of each fleet was then used to raise sizes to the landings data in the default manner. The resulting parameters are given in Table 10.1.2.

Through this exercise and for all scenarios the generic raising procedure for the stock was maintained. The only change between scenarios were the assumptions of input sampling data to be used for raising.

Table 10.1.2. Raising factors by quarter for the transformation of size composition data from the Danish trawl fleet to the Swedish trawl fleet.

Quarter	Raising factor
1	2.32
2	1.09
3	1.69
4	1.65

Results on key parameters for the different scenarios are given in Table 10.1.3. The changes in parameters was generally small. All scenarios including Danish data for 2020 resembled each other, and the scenarios not including Danish data for 2020 resembled each other. Transforming Danish sampling data to resemble the Swedish trawl fleet discard pattern did not result in parameters similar to sampled data for the Swedish fleet from previous years.

Table 10.1.3. Resulting values of mean sizes, discard rate, Removals and other parameters following the scenarios on different assumptions on data used for calculations.

Scenario	Weight Consume	Weight discard	Discard rate, by number	Removals (million)	Mean weight	Pop.num (million)	Pop.est.tonnes	Landing + Dead disc	Harvest rate	Mean weight 3-year average	Weight Consume, 3-year ave-rage	Weight Discard, 3-year average	Discard rate 3-year Average
1	54.30	23.00	27.16	142.80	45.76	3796.0	173697	6534	3.76	44.73	54.33	23.35	30.98
2	53.20	22.20	25.38	139.65	45.30	3796.0	171967	6326	3.68	44.61	54.02	23.18	30.52
3	54.20	24.60	31.53	146.93	44.85	3796.0	170232	6589	3.87	44.50	54.30	23.78	32.13
4	54.40	24.20	31.60	146.39	44.85	3796.0	170247	6565	3.86	44.50	54.37	23.65	32.15
5	54.40	23.60	32.01	147.14	44.53	3796.0	169024	6552	3.88	44.41	54.37	23.49	32.26
6	52.80	22.40	27.89	144.53	44.32	3796.0	168244	6406	3.81	44.35	53.91	23.21	31.14

Scenario	Weight Consume	Weight discard	Discard rate, by number	Removals (million)	Mean weight	Pop.num (million)	Pop.est.tonnes	Landing + Dead disc	Harvest rate	Mean weight 3-year average	Weight Consume, 3-year average	Weight Discard, 3-year average	Discard rate 3-year Average
1	54.30	23.00	27.16	142.80	45.76	3796.0	173697	6534	3.76	44.73	54.33	23.35	30.98
2	53.20	22.20	25.38	139.65	45.30	3796.0	171967	6326	3.68	44.61	54.02	23.18	30.52
3	54.20	24.60	31.53	146.93	44.85	3796.0	170232	6589	3.87	44.50	54.30	23.78	32.13
4	54.40	24.20	31.60	146.39	44.85	3796.0	170247	6565	3.86	44.50	54.37	23.65	32.15
5	54.40	23.60	32.01	147.14	44.53	3796.0	169024	6552	3.88	44.41	54.37	23.49	32.26
6	52.80	22.40	27.89	144.53	44.32	3796.0	168244	6406	3.81	44.35	53.91	23.21	31.14

Scenario	Weight Consume	Weight discard	Discard rate, by number	Removals (million)	Mean weight	Pop.num (million)	Pop.est.tonnes	Landing + Dead disc	Harvest rate	Mean weight 3-year average	Weight Consume, 3-year average	Weight Discard, 3-year average	Discard rate 3-year Average
1	54.30	23.00	27.16	142.80	45.76	3796.0	173697	6534	3.76	44.73	54.33	23.35	30.98
2	53.20	22.20	25.38	139.65	45.30	3796.0	171967	6326	3.68	44.61	54.02	23.18	30.52
3	54.20	24.60	31.53	146.93	44.85	3796.0	170232	6589	3.87	44.50	54.30	23.78	32.13
4	54.40	24.20	31.60	146.39	44.85	3796.0	170247	6565	3.86	44.50	54.37	23.65	32.15
5	54.40	23.60	32.01	147.14	44.53	3796.0	169024	6552	3.88	44.41	54.37	23.49	32.26
6	52.80	22.40	27.89	144.53	44.32	3796.0	168244	6406	3.81	44.35	53.91	23.21	31.14

It was decided that Scenario 4 was the most feasible option for two main reasons. First, not any case involving the Danish sampled data (scenario 1, 2 and 6) resembled any of the cases with only Swedish data. Secondly 2018 and 2019 showed a stabilizing trend in discard pattern following the changed regulation of MLS in 2016 (Figures 10.1.1 and 10.1.2).

Thus, for the Swedish trawl and creel fleets separately, on-board sampling data was aggregated for 2018-2020 to reflect size composition of landings and discards in 2020.

Apart from 2020, the length and sex composition of the landings data is considered to be well sampled. Discard sampling in this fishery has been conducted on a quarterly basis for Danish and Swedish *Nephrops* trawlers since 1990, and is considered to represent the fishery adequately.

The UWTV survey 2019 was conducted in all 8 defined subareas in 3.a. A correction factor of 1.1 was used. A total weighted mean density was estimated based on density estimates from each Subarea and weighted by the size of each Subarea. The estimated F_{MSY} proxies for this stock provide a relatively low harvest rate which may be a result of the high discards ratios (31% in weight) which occur due to an exemption of landing obligation (high discard survival) in 3.a. These removals do not increase the yield from the stock.

The Danish LPUE data used as indicators for stock development have been standardised regarding engine size. However, LPUE is also influenced by changes in catchability due to sudden changes in the environmental conditions or/and changes in selectivity, gear efficiency or a change in targeting behaviour due to the cod management plan in 3.a. Also, the changes in management systems (indicated by the broken red line in Figure 10.2.4.2), which occurred in 2007 in Denmark, caused a general increase in LPUE. In 3.a, fluctuations in catches of small *Nephrops* has been used as indicators of recruitment (Figure 10.2.4.3). This indicator will start a new series in 2016 depending on the lowered MCRS.

10.1.6 Status of the stock

The *Nephrops* stock in Division 3.a was assessed with an UWTV survey for the tenth year (2011–2020; new Subarea 7 only in 2014–2020 and new Subarea 9 in 2017 and 2019) and the time series of UWTV estimates is still insufficient to draw conclusions regarding stock trajectory (Figure 10.2.4.4).

The average 2016–2020 harvest rate was estimated to be relatively low (3.3 % from UWTV surveys) implying the stock appears to be exploited sustainably.

The analysis of commercial LPUE and effort data indicate that LPUE shows an increasing trend while effort shows a decreasing trend and the WG concludes that current levels of exploitation appear to be sustainable.

Table 10.1.4. Status of the stock traffic light plot given by Stock Assessment Graphs. Removed from Advice sheet in 2021.

	Fishing pressure				Stock size			
		2018	2019	2020		2018	2019	2020
Maximum sustainable yield	F_{MSY}	✓	✓	✓ Appropriate	MSY $B_{trigger}$	?	?	? Unknown
Precautionary approach	F_{pa},F_{lim}	?	?	? Undefined	B_{pa},B_{lim}	?	?	? Unknown
Management plan	F_{MGT}	–	–	– Not applicable	B_{MGT}	–	–	– Not applicable

10.1.7 Division 3.a: *Nephrops* management considerations

The observed trends in effort, LPUE and discards are similar for FU 3 and FU 4. Our present knowledge on the biological characteristics of the *Nephrops* stocks in these two areas does not indicate obvious differences, and therefore the two FUs are treated as one single 'stock' in the assessment.

The UWTV-survey in 3.a suggests that the harvest rate of the stock is relatively low and the stock is exploited at a sustainable level.

The combined logbook recorded effort has decreased since 2002 and is currently the lowest level in the time series while LPUE has increased and is at a relatively high level in the last ten years (figures 10.2.4.1 and 10.2.4.2). The increase in LPUE in 2016 is due to the lowered MCRS in 2016 from 40 to 32 mm carapace length. Mean sizes are fluctuating without trend (figures 10.2.2.2 and 10.2.2.4). Note that the decrease in mean size for 2016 depends on the lowered MCRS. There are no signs of overexploitation in 3.a.

Given the apparent stability of the stock, the WG concludes that current levels of exploitation appear to be sustainable.

The WG encourages the work on size selectivity in *Nephrops* trawls to reduce the large amount of discarded undersized *Nephrops* in 3.a.

Mixed fishery aspects

Cod and sole are significant by-catch species in these fisheries in 3.a, and even if data on catches, including discards, of the bycatch gradually become available, they have not yet been used in the management. The WG has for many years recommended the use of species selective grids in the fisheries targeting *Nephrops* as legislated for Swedish national waters. New technical measures (Swedish grid and SELTRA trawl) have recently been agreed upon for the *Nephrops* directed fishery and have been implemented since 1 February 2013. The European Union and Norway have also agreed that a discard ban will be implemented in EU waters from 1 January 2015. The discard ban was applicable to *Nephrops* from 1 January 2016 but preliminary results indicating high discard survival has resulted in an exemption of landing obligation for *Nephrops* in 3.a during 2016 to 2020.

Table 10.1.5. Definition of *Nephrops* Functional Units in Division 3.a and Subarea 4 in terms of ICES statistical rectangles.

FU no.	Name	ICES area	Statistical rectangles
3	Skagerrak	3.aN	47G0; 46F9–G1; 45F8–G1; 44F7–G0; 43F8–F9
4	Kattegat	3.aS	44G1; 42-43 G0–G2; 41G1–G2
5	Botney Cut - Silver Pit	4.b,c	36–37 F1–F4; 35F2–F3
6	Farn Deeps	4.b	38–40 E8–E9; 37E9
7	Fladen Ground	4.a	44–49 E9–F1; 45–46E8
8	Firth of Forth	4.b	40–41E7; 41E6
9	Moray Firth	4.a	44–45 E6-E7; 44E8
10	Noup	4.a	47E6
32	Norwegian Deep	4.a	44–52 F2–F6; 43F5–F7
33	Off Horn Reef	4.b	39–41F5; 39–41F6
34	Devil's Hole	4.b	41–43 F0–F1

Table 10.2.1.1. Division 3.a: Total *Nephrops* landings (tonnes) by Functional Unit, 1981–2020.

Year	FU 3	FU 4	Total
1981	992	1728	2720
1982	1470	1828	3298
1983	2205	1472	3677
1984	2675	2036	4711
1985	2191	1798	3989
1986	2018	1807	3825
1987	2441	1605	4046
1988	2363	1364	3727
1989	2564	1313	3877
1990	2866	1475	4341
1991	2924	1304	4228
1992	1893	1012	2905
1993	2288	924	3212
1994	1981	893	2874
1995	2429	998	3427
1996	2695	1285	3980
1997	2612	1594	4206
1998	3248	1808	5056
1999	3194	1755	4949
2000	2894	1816	4710
2001	2282	1774	4056
2002	2977	1471	4448
2003	2126	1641	3767
2004	2312	1653	3965
2005	2546	1488	4034
2006	2392	1280	3672
2007	2771	1741	4512
2008	2851	2025	4876
2009	3004	1842	4846
2010	2938	2185	5123
2011	2511	1475	3986
2012	2536	1893	4429
2013	2147	1613	3760
2014	2856	1294	4150
2015	2123	1228	3350
2016	3238	1652	4890
2017	3129	2082	5211

Year	FU 3	FU 4	Total
2018	4222	2878	7100
2019	4625	3128	7753
2020	3367	2548	5915

Table 10.2.1.2. Division 3.a: Total *Nephrops* landings (tonnes) by country, 1991–2020.

Year	Denmark	Norway	Sweden	Germany	Total landings	Total Disc.	Total Catch
1991	2824	185	1219		4228	5183	9411
1992	2052	104	749		2905	2523	5428
1993	2250	103	859		3212	8493	11705
1994	2049	62	763		2874	6450	9324
1995	2419	90	918		3427	4464	7891
1996	2844	102	1034		3980	2148	6128
1997	2959	117	1130		4206	3469	7675
1998	3541	184	1319	12	5056	1944	7000
1999	3486	214	1243	6	4949	4108	9057
2000	3325	181	1197	7	4710	5664	10374
2001	2880	138	1037	1	4056	3767	7823
2002	3293	116	1032	7	4448	4311	8760
2003	2757	99	898	13	3767	2208	5975
2004	2955	95	903	12	3965	2532	6497
2005	2901	83	1048	2	4034	3014	7048
2006	2432	91	1143	6	3672	2926	6598
2007	2887	145	1467	13	4512	6524	11036
2008	3174	158	1509	19	4860	4746	9606
2009	3372	128	1331	15	4846	6129	10975
2010	3721	124	1249	29	5123	3548	8671
2011	2937	87	945	17	3986	2847	6833
2012	2970	104	1355	0	4429	4771	9200
2013	2550	73	1134	3	3760	4010	7770
2014	2785	88	1269	7	4150	1854	6004
2015	2121	91	1138	0	3350	1038	4389
2016	3440	87	1363	0	4889	256	5145
2017	3700	81	1430	1	5211	1024	6234
2018	5133	97	1870	0	7100	1336	8435
2019	5697	112	1944	0	7753	1719	9472
2020	3977	124	1796	17	5915	683	6597

Table 10.2.2.1. *Nephrops* in Skagerrak (FU 3): Landings (tonnes) by country, 1991–2020.

Year	Denmark	Norway			Sweden			Germany	Total
		Trawl	Creel	Sub-total	Trawl	Creel	Sub-total		
1991	1639	185	0	185	949	151	1100	0	2924
1992	1151	104	0	104	524	114	638	0	1893
1993	1485	101	2	103	577	123	700	0	2288
1994	1298	62	0	62	531	90	621	0	1981
1995	1569	90	0	90	659	111	770	0	2429
1996	1772	102	0	102	708	113	821	0	2695
1997	1687	117	0	117	690	118	808	0	2612
1998	2055	184	0	184	864	145	1009	0	3248
1999	2070	214	0	214	793	117	910	0	3194
2000	1877	181	0	181	689	147	836	0	2894
2001	1416	125	13	138	594	134	728	0	2282
2002	2053	99	17	116	658	150	808	0	2977
2003	1421	90	9	99	471	135	606	0	2126
2004	1595	85	10	95	449	173	622	0	2312
2005	1727	71	12	83	538	198	736	0	2546
2006	1516	80	11	91	583	201	784	0	2391
2007	1664	127	18	145	709	253	962	0	2771
2008	1745	124	34	158	675	273	948	0	2851
2009	2012	101	27	128	605	260	864	0	3004
2010	1981	105	20	125	563	266	829	4	2938
2011	1801	74	12	87	432	188	621	2	2510
2012	1516	80	24	104	592	324	916	0	2536
2013	1309	57	16	73	484	279	763	0	2146
2014	1868	68	20	88	594	305	899	0	2856
2015	1226	66	25	91	479	327	806	0	2123
2016	2260	66	21	87	604	289	892	0	3239
2017	2118	60	20	81	672	258	930	0	3129
2018	2938	71	25	97	897	290	1187	0	4222
2019	3295	86	26	112	920	298	1217	0	4625
2020	2053	84	41	124	897	292	1190	0	3367

Table 10.2.2.2. *Nephrops* Skagerrak (FU 3): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling) of Swedish specialized *Nephrops* trawlers, 1991–2020. (* Include only *Nephrops* trawls with grid and square mesh codend+ Seltra traws).

Single trawl					
Year	**Catches**	**Landings**	**Effort**	**CPUE**	**LPUE**
1991	676	401	71.4	9.5	5.6
1992	360	231	73.7	4.9	3.1
1993	614	279	72.6	8.4	3.8
1994	441	246	60.1	7.3	4.1
1995	501	336	60.8	7.8	5.2
1996	754	488	51.1	14.8	9.6
1997	643	437	44.4	14.4	9.8
1998	794	557	49.7	16.0	11.2
1999	605	386	34.5	17.5	9.3
2000	486	329	32.7	14.9	10.9
2001	446	236	26.2	17.0	10.4
2002	503	301	29.4	17.1	8.8
2003	310	254	21.5	13.9	11.4
2004*	474	257	20.1	23.6	13.4
2005*	760	339	29.7	25.6	12.7
2006*	839	401	37.5	22.4	12.2
2007*	894	314	24.1	37.0	13.0
2008*	605	264	20.0	30.3	13.2
2009*	482	285	19.6	24.5	14.5
2010*	476	286	20.7	23.0	13.8
2011*	334	198	16.8	19.9	11.8
2012*	542	238	16.0	33.8	14.9
2013*	251	137	11.3	22.2	12.1
2014*	240	157	11.0	21.7	14.2
2015*	187	133	9.5	19.6	14.0
2016*	216	188	14.9	14.4	12.6
2017*	362	232	16.9	21.4	13.7
2018*	369	265	13.5	27.3	19.6
2019*	287	224	12.7	22.5	17.6
2020*	275	215	12.0	22.9	17.9

Table 10.2.2.2 (cont'). *Nephrops* Skagerrak (FU 3): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling) of Swedish specialized *Nephrops* trawlers, 1991–2020. (* Include only *Nephrops* trawls with grid and square mesh codend+ Seltra trawls).

Twin trawl					
Year	**Catches**	**Landings**	**Effort**	**CPUE**	**LPUE**
1991	740	439	39.5	18.7	11.1
1992	370	238	34.1	10.9	7.0
1993	568	258	35.9	15.8	7.2
1994	444	248	34.1	13.1	7.3
1995	403	270	32.9	12.2	8.2
1996	187	121	13.0	14.4	9.3
1997	219	149	17.5	12.5	8.5
1998	254	178	16.7	15.2	10.6
1999	382	244	27.6	13.8	8.8
2000	349	237	31.3	11.1	10.1
2001	470	249	33.7	14.0	7.4
2002	392	244	33.3	11.8	7.1
2003	168	138	22.5	7.5	6.1
2004	217	118	21.7	10.0	5.4
2005	263	117	22.1	11.9	5.3
2006	253	121	19.6	12.9	6.2
2007*	248	87	5.4	45.6	16.0
2008*	139	61	3.4	41.3	18.0
2009*	211	125	7.1	29.5	17.5
2010*	165	99	5.9	27.8	16.7
2011*	202	120	7.7	26.3	15.6
2012*	544	239	12.9	42.2	18.6
2013*	423	231	13.8	30.7	16.8
2014*	484	316	16.0	30.3	19.8
2015*	328	234	11.3	28.9	20.6
2016*	471	410	20.1	23.4	20.4
2017*	667	427	17.5	38.2	24.5
2018*	851	610	21.1	40.4	29.0
2019*	847	662	23.7	35.8	28.0
2020*	851	665	23.7	35.9	28.0

Table 10.2.2.3. *Nephrops* Skagerrak (FU 3): Logbook recorded effort (kW days, Days at sea, and fishing days) and LPUE (kg/day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2020.

Year	kW days	Days at sea	Fishing days	LPUE
1991	5501223	21043	18762	87
1992	4043742	16125	13970	82
1993	3728965	13698	11958	124
1994	3276355	12324	10778	120
1995	3024232	12070	10448	150
1996	3020019	11871	10385	171
1997	3053570	11950	10509	161
1998	3353072	12131	10899	189
1999	3967797	13767	12376	167
2000	4371006	14849	13307	141
2001	3970228	13337	11579	122
2002	4693962	16575	14197	145
2003	3476385	11589	10333	138
2004	3871974	13149	11694	136
2005	3757466	12560	11166	155
2006	3296744	10825	9725	156
2007	2424063	8026	7294	228
2008	2332056	8016	7300	239
2009	2549895	8814	8058	250
2010	2668904	9027	8338	238
2011	2666680	9767	8912	202
2012	2183682	8330	7507	202
2013	1738286	6770	6332	207
2014	2094860	8060	7653	244
2015	1592065	6337	5923	207
2016	2032034	8060	7673	295
2017	1940952	7391	7061	300
2018	2366657	8345	7936	370
2019	2666092	8980	8513	387
2020	2277212	7343	6842	300

Table 10.2.2.4. Skagerrak (FU 3): Mean sizes (mm CL) of male and female *Nephrops* in catches of Danish and Swedish combined, 1991–2020.

Year	Catches					
	Undersized		Full sized		All	
	Males	Females	Males	Females	Males	Females
1991	30.2	30.9	41.2	42.7	30.9	29.8
1992	33.3	32.3	43.3	44.7	33.3	32.2
1993	33.0	31.5	42.0	43.6	33.0	31.5
1994	31.7	29.6	41.7	43.6	31.7	29.6
1995	30.0	28.5	41.6	41.3	32.9	29.8
1996	33.2	31.9	42.9	44.0	37.6	37.0
1997	35.8	34.5	44.6	44.1	39.8	39.1
1998	34.8	34.4	46.1	43.9	40.7	37.3
1999	34.6	33.9	44.9	43.8	39.3	36.1
2000	30.6	30.5	45.6	45.0	32.5	34.1
2001	33.6	33.6	45.5	43.6	37.3	36.4
2002	33.9	33.7	44.0	42.5	37.2	37.3
2003	33.5	32.6	43.2	43.4	38.0	36.7
2004	34.3	33.4	44.6	45.2	38.7	36.6
2005	33.5	32.4	43.7	43.0	36.4	35.3
2006	33.2	32.9	44.7	42.7	37.1	36.1
2007	32.6	31.9	44.4	42.4	34.9	33.5
2008	33.6	32.3	44.0	42.7	36.5	34.5
2009	35.0	33.8	45.3	42.8	39.8	35.9
2010	34.2	33.8	46.2	44.8	38.9	36.6
2011	33.8	33.1	44.5	43.3	38.4	36.5
2012	34.8	34.1	44.2	42.5	38.2	36.2
2013	35.1	34.8	45.0	42.9	38.6	36.9
2014	35.7	35.3	45.5	43.7	41.7	39.1
2015	35.5	36.2	47.2	44.1	43.6	41.1
2016	32.0	31.8	43.5	41.0	42.2	39.9
2017	32.3	31.5	42.4	41.7	39.1	39.0
2018	31.1	30.7	41.6	41.1	38.7	37.6
2019	32.5	31.8	42.1	41.7	38.8	38.5
2020	33.0	31.5	42.4	41.2	38.9	36.0

Table 10.2.2.5. *Nephrops* Kattegat (FU 4): Landings (tonnes) by country, 1991–2020.

Year	Denmark	Sweden		Sub-total	Germany	Total
		Trawl	Creel			
1991	1185	119	0	119	0	1304
1992	901	111	0	111	0	1012
1993	765	159	0	159	0	924
1994	751	142	0	142	0	893
1995	850	148	0	148	0	998
1996	1072	213	0	213	0	1285
1997	1272	319	3	322	0	1594
1998	1486	306	4	310	12	1808
1999	1416	329	4	333	6	1755
2000	1448	357	4	361	7	1816
2001	1464	304	6	309	1	1774
2002	1240	219	5	224	7	1471
2003	1336	287	5	292	13	1641
2004	1360	270	11	281	12	1653
2005	1175	303	8	311	2	1488
2006	916	347	11	358	6	1280
2007	1223	491	15	505	13	1741
2008	1429	561	16	577	19	2025
2009	1360	450	16	467	15	1842
2010	1740	403	17	420	25	2185
2011	1136	308	16	324	15	1475
2012	1454	406	33	439	0	1893
2013	1241	341	27	368	3	1612
2014	917	335	34	369	7	1294
2015	895	301	31	333	0	1228
2016	1180	436	34	470	0	1650
2017	1581	468	31	500	1	2082
2018	2195	649	33	683	0	2878
2019	2401	694	33	726	0	3128
2020	1924	606	26	632	17	2574

Table 10.2.2.6. Kattegat (FU 4): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling) of Swedish *Nephrops* trawlers, 1991–2020 (* Include only specialized *Nephrops* trawls with grid and square mesh codend + Seltra trawls).

Single trawl					
Year	**Catches**	**Landings**	**Effort**	**CPUE**	**LPUE**
1991	66	39	10.3	6.4	3.7
1992	44	28	11.6	3.8	2.4
1993	128	58	14.9	8.6	3.9
1994	95	53	16.2	5.7	3.2
1995	79	53	9.6	7.8	5.5
1996	207	134	13.7	15.1	9.8
1997	269	183	18.0	15.0	10.2
1998	181	127	13.1	13.8	9.7
1999	146	93	8.1	17.9	11.4
2000	114	77	8.5	13.4	9.1
2001	117	62	7.6	15.4	8.2
2002	42	25	3.7	11.2	6.7
2003	49	40	4.6	10.7	8.7
2004	70	44	4.3	16.2	10.1
2005	147	100	12.3	11.9	8.1
2006	234	154	15.1	15.5	10.2
2007*	107	51	4.1	25.7	12.3
2008*	121	57	4.4	27.6	13.0
2009*	157	81	5.1	30.9	16.1
2010*	181	102	7.6	23.8	13.4
2011*	75	45	3.8	20.0	12.0
2012*	80	45	3.4	23.5	13.3
2013*	44	26	2.3	19.5	11.6
2014*	35	25	2.2	15.8	11.6
2015	43	29	2.6	16.6	11.0
2016*	50	47	5.4	9.4	8.7
2017*	65	45	4.0	16.2	11.2
2018*	84	63	4.1	20.4	15.4
2019*	92	71	4.6	20.0	15.5
2020*	61	48	3.4	18.0	13.9

Table 10.2.2.6 (cont'). Kattegat (FU 4): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling) of Swedish *Nephrops* trawlers, 1991–2020 (* Include only specialized *Nephrops* trawls with grid and square mesh codend + Seltra trawls).

Twin trawl					
Year	**Catches**	**Landings**	**Effort**	**CPUE**	**LPUE**
1991	93	55	8.8	10.6	6.2
1992	101	65	14.2	7.1	4.6
1993	187	85	17.8	10.6	4.8
1994	138	77	14.2	9.7	5.4
1995	125	84	11.0	12.2	7.7
1996	97	63	7.5	13.0	8.4
1997	183	124	12.7	14.3	9.7
1998	215	151	15.0	14.4	10.1
1999	306	195	20.1	15.2	9.7
2000	330	224	24.5	13.5	9.1
2001	353	187	25.1	14.1	7.4
2002	256	153	23.2	11.0	6.6
2003	222	181	24.8	8.9	7.3
2004	253	158	16.5	15.4	9.6
2005	198	135	15.3	12.9	8.8
2006	183	121	12.7	14.4	9.5
2007*	112	54	3.6	30.9	14.8
2008*	164	78	4.8	34.1	16.1
2009*	309	161	11.0	28.2	14.6
2010*	297	167	9.2	32.2	18.1
2011*	266	159	9.7	27.3	16.3
2012*	406	231	12.4	32.8	18.6
2013*	354	210	15.0	23.7	14.0
2014*	282	206	14.4	19.6	14.4
2015	262	173	11.3	23.2	15.4
2016*	404	378	19.4	20.9	19.5
2017*	603	418	17.5	34.4	23.8
2018*	774	586	18.7	41.4	31.3
2019*	760	589	20.0	38.0	29.4
2020*	682	528	20.0	34.1	26.4

Table 10.2.2.7. *Nephrops* Kattegat (FU 4): Logbook recorded effort (kW days, Days at sea, and fishing days) and LPUE (kg/day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991–2020.

Year	kW days	Days at sea	Fishing days	LPUE
1991	4223351	23040	16770	71
1992	3689413	20184	14240	63
1993	2827025	15392	10598	72
1994	2480847	13989	10985	68
1995	2330909	13023	10028	85
1996	2707363	14856	11688	92
1997	2807943	14389	11558	110
1998	2957280	15264	12380	120
1999	3417242	16734	13536	105
2000	3642120	18307	14661	99
2001	3826693	18764	15294	96
2002	3258819	16568	13325	93
2003	3173969	15345	12507	107
2004	2929407	14229	11289	120
2005	2452852	11814	9337	126
2006	2147461	10431	8467	108
2007	2022910	9883	7897	155
2008	2148132	10538	8469	169
2009	2219200	11120	8726	156
2010	2438736	12055	9707	179
2011	2009409	10286	8099	140
2012	2292229	11800	9661	150
2013	2221959	11669	9226	135
2014	1908170	10393	7865	117
2015	1847763	10094	7704	116
2016	1899286	10249	7815	151
2017	1939311	10074	7703	205
2018	2204244	12294	9035	243
2019	2477989	12294	9587	250
2020	2367713	11680	8977	214

Table 10.2.2.8. *Nephrops* Kattegat (FU 4): Mean sizes (mm CL) of male and female *Nephrops* in discards, landings and catches, 1991–2020. Since 2005 based on combined Danish and Swedish data.

Year	Catches					
	Discards		Landings		All	
	Males	Females	Males	Females	Males	Females
1991	30.7	31.1	42.4	42.5	32.5	32.9
1992	33.0	30.3	44.4	43.2	36.7	34.9
1993	30.5	29.3	42.3	43.1	31.3	30.1
1994	29.7	28.3	40.8	40.2	31.2	28.9
1995	30.8	30.5	42.4	42.0	33.7	33.2
1996	32.7	31.3	42.0	44.0	36.7	37.3
1997	33.6	33.2	45.0	44.5	37.1	35.0
1998	34.2	33.2	45.6	44.1	41.3	36.8
1999	32.9	33.8	45.3	40.9	37.8	34.9
2000	35.1	35.2	45.7	42.1	40.4	36.9
2001	32.2	33.0	44.1	41.9	35.9	36.5
2002	34.4	33.3	44.4	43.8	37.2	36.2
2003	33.0	33.2	43.5	42.2	37.1	36.0
2004	34.7	34.2	45.1	43.2	39.9	37.5
2005	33.5	33.9	45.8	43.1	38.7	38.7
2006	33.2	33.6	45.1	42.8	37.9	37.4
2007	33.9	33.2	44.8	43.5	37.2	35.5
2008	32.6	32.4	44.0	43.9	37.5	35.9
2009	33.8	33.1	44.7	44.1	36.8	35.2
2010	34.6	33.8	45.9	44.5	39.8	36.9
2011	33.7	32.9	44.7	43.3	38.1	35.5
2012	33.8	33.2	44.3	42.9	37.1	35.7
2013	34.4	34.6	44.8	42.9	38.0	36.5
2014	35.0	34.8	45.6	42.9	40.4	37.4
2015	34.5	34.8	45.6	42.7	40.9	38.3
2016	30.1	29.8	45.1	40.6	43.4	38.5
2017	30.1	30.6	42.6	40.6	38.6	36.7
2018	32.1	31,5	42.7	40.5	39.8	36.9
2019	32.6	32.2	43.6	41.0	37.8	34.7
2020	32.9	32.6	42.7	40.2	39.6	36.7

Table 10.2.3.1. Summary output of the TV-survey in 3.a from 2020.

Subarea	Area (km^2)	Number of stations	Absolute mean density	Population numbers (mill.)
1	2575	30	0.275	707.833
2	1958	39	0.400	784.059
3	2613	37	0.297	775.086
4	962	12	0.356	342.272
5	996	19	0.425	423.662
6	1719	23	0.235	404.772
7	1295	13	0.122	157.362
8		5	0.084	
9	385	3	0.524	201.740
Total	12503	181	0.310	3796.786
			Harvest rate	0.0386
	Removals 2020 (landings + dead discards**)			146.39

*** In millions**

**** The survival rate of discard is estimate to be 25% (Wileman *et al*., 1999)**

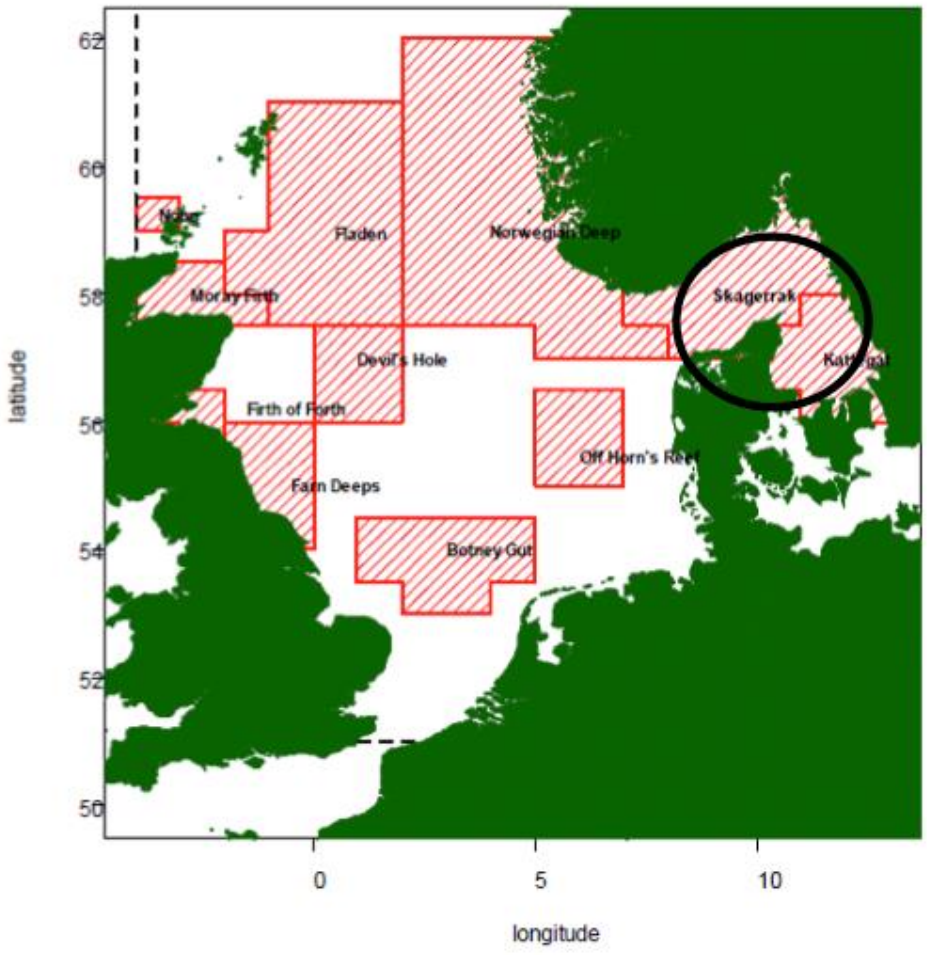

Figure 10.1.1. *Nephrops* Functional Units in the North Sea and Skagerrak/Kattegat region.

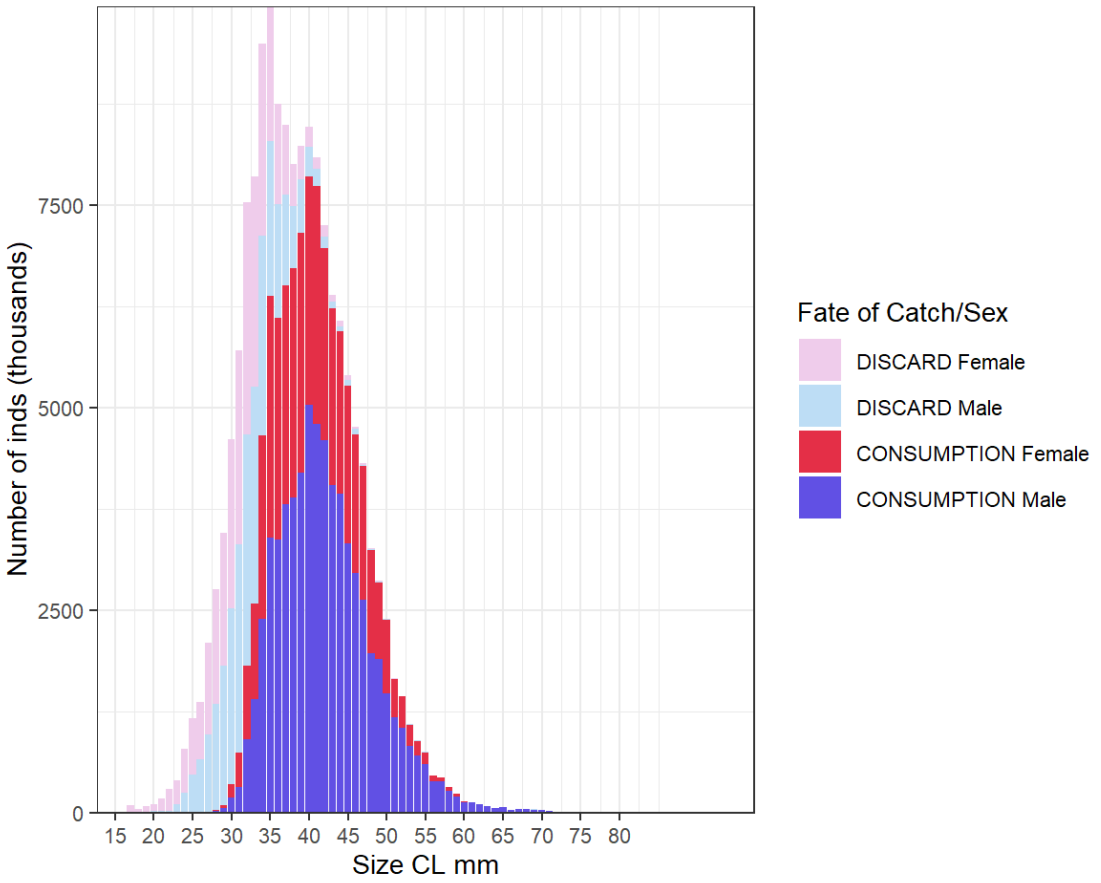

Figure 10.2.1.1. Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of *Nephrops* catches, split by catch fraction (landings and discards) and sex. Data for Denmark and Sweden combined for 2020.

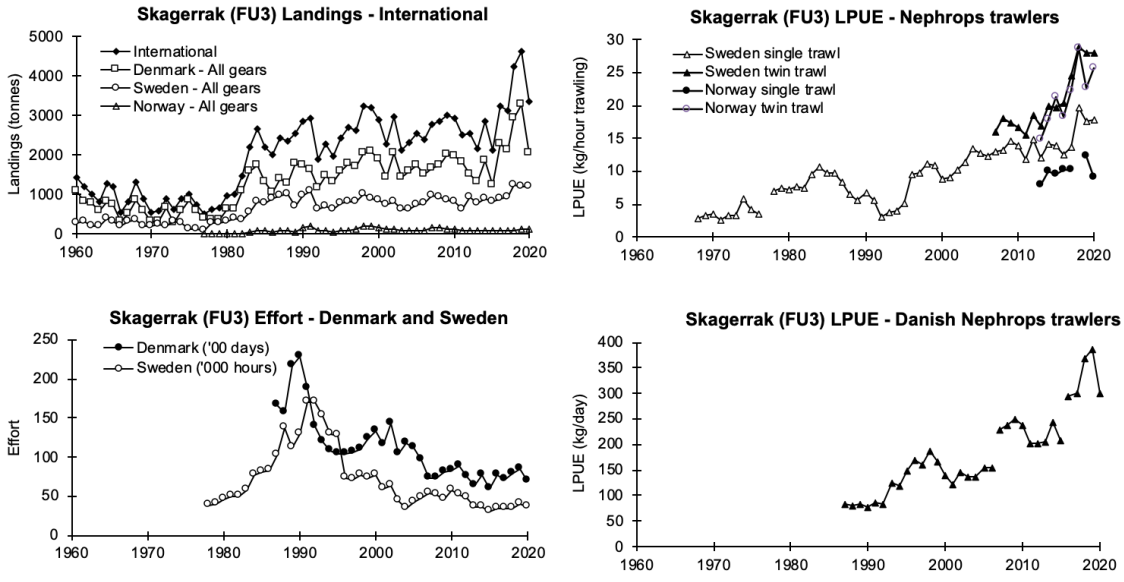

Figure 10.2.2.1. *Nephrops* Skagerrak (FU 3): Long-term trends in landings, effort, and LPUEs.

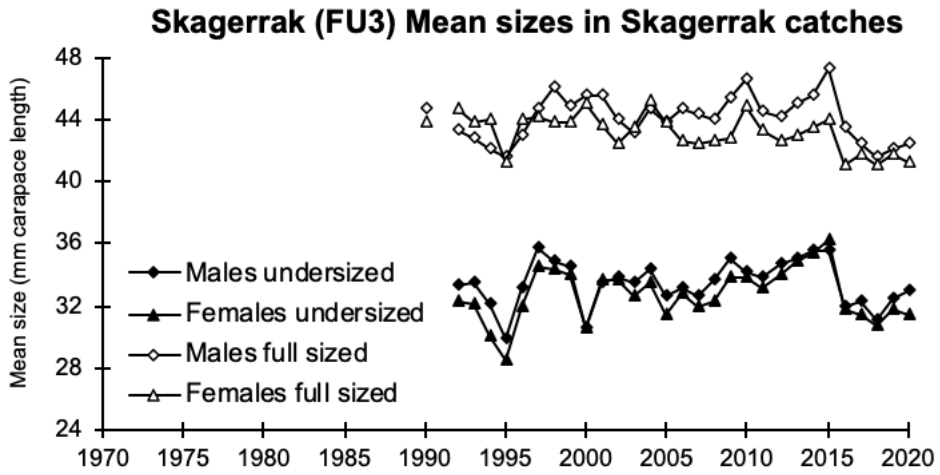

Figure 10.2.2.2. *Nephrops* in FU 3. Mean sizes in the catches.

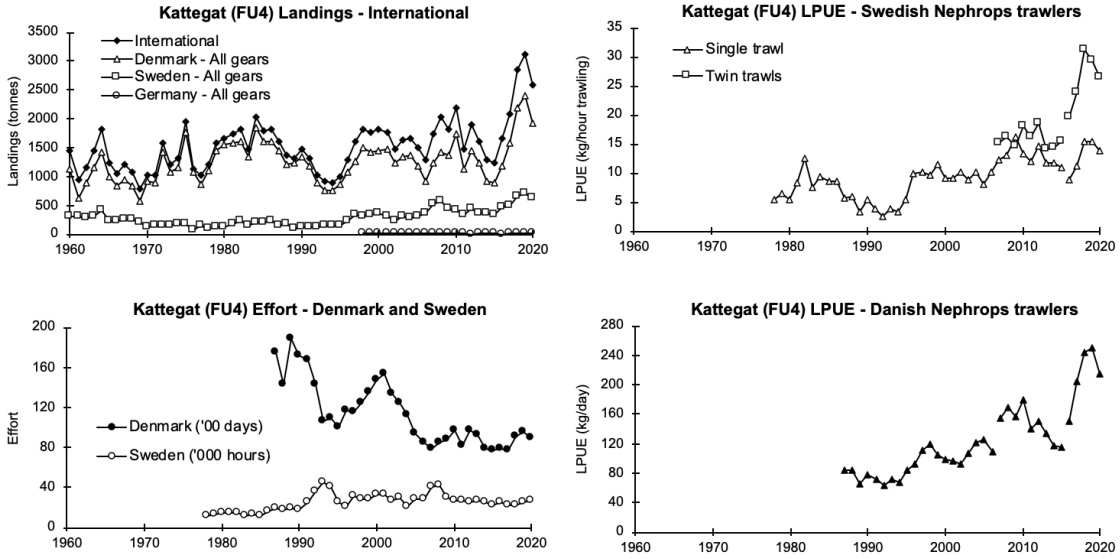

Figure 10.2.2.3. *Nephrops* Kattegat (FU 4): Long-term trends in landings, effort and LPUEs.

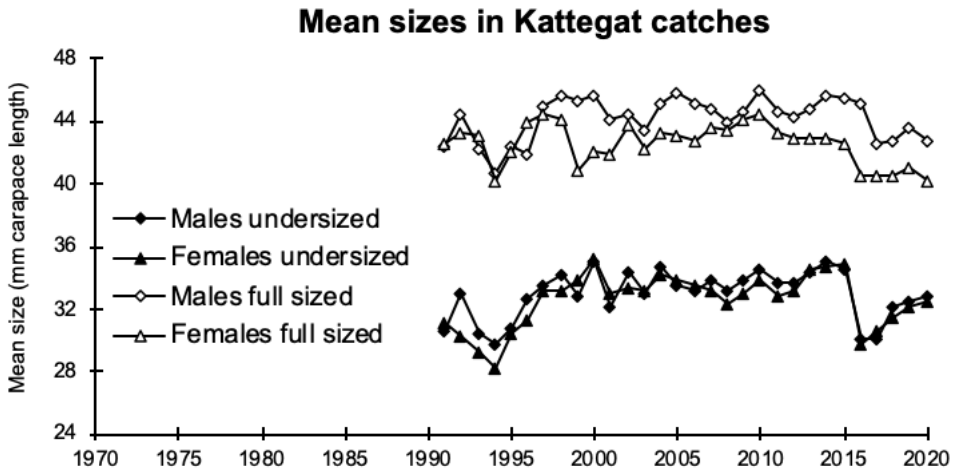

Figure 10.2.2.4. *Nephrops* in FU 4: Mean sizes in the catches.

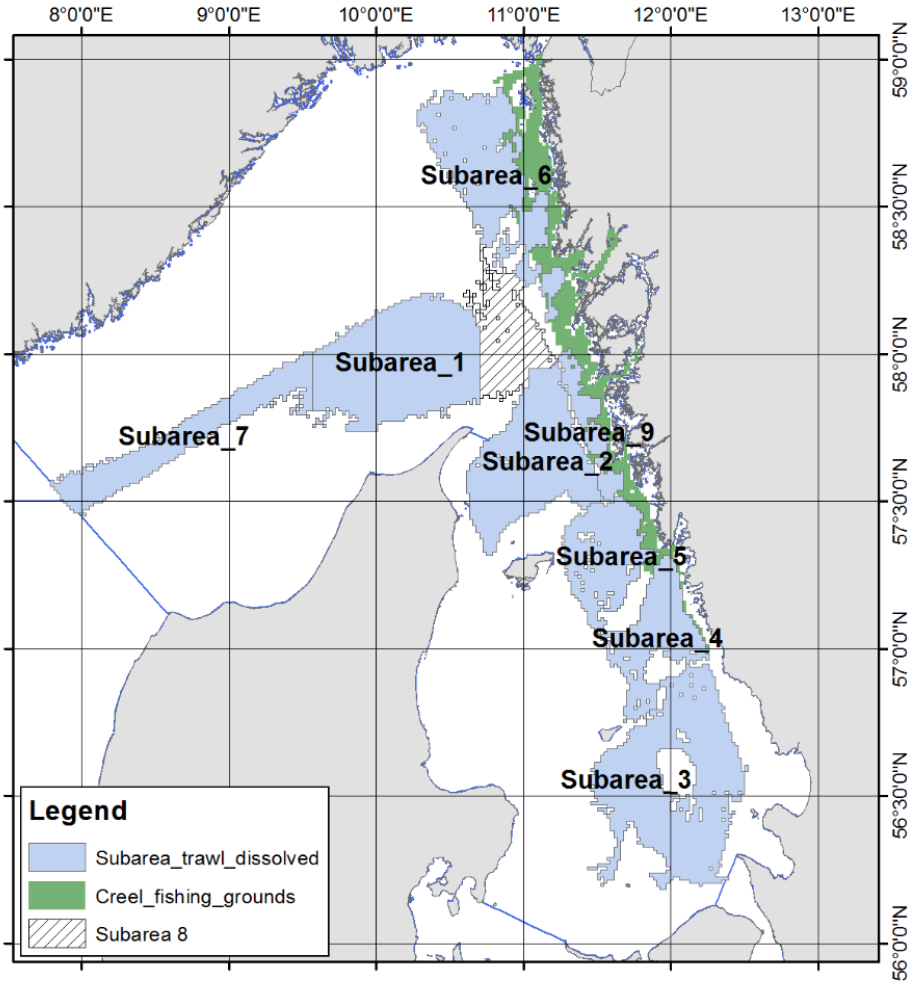

Figure 10.2.3.2. The defined subareas of the *Nephrops* stock in 3.a.

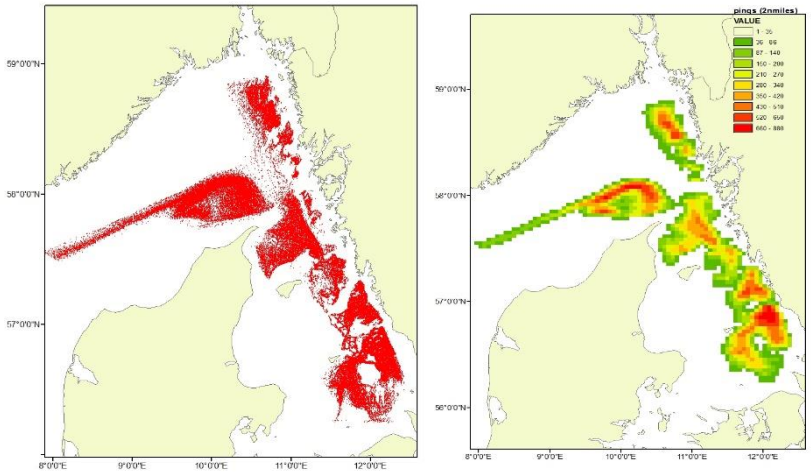

Figure 10.2.3.3. The spatial distribution of the Danish and Swedish *Nephrops* fishery in 2010: Left map shows VMS pings and the right map shows density of VMS pings.

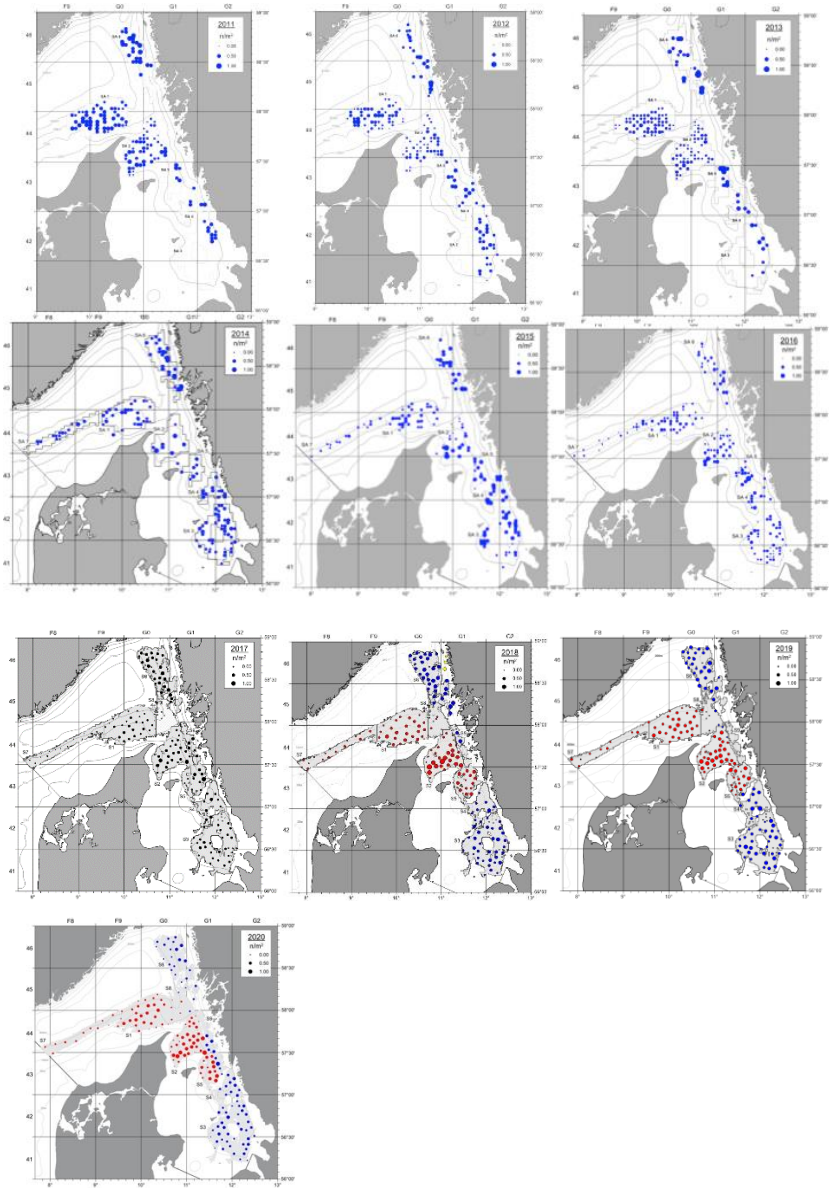

Figure 10.2.3.4. Sampling locations and *Nephrops* burrow density in the UWTV survey in the Skagerrak and Kattegat (FU 3 and 4) in 2011 (146 stations), 2012 (166 stations), 2013 (157 stations), 2014 (154 stations), 2015 (154 stations), 2016 (176 stations), in 2017 (171 stations), 2018 (177 stations), 2019 (173) and 2020 (176).

Figure 10.2.4.1 *Nephrops* in Area 3.a: Combined Effort for FU 3 and 4.

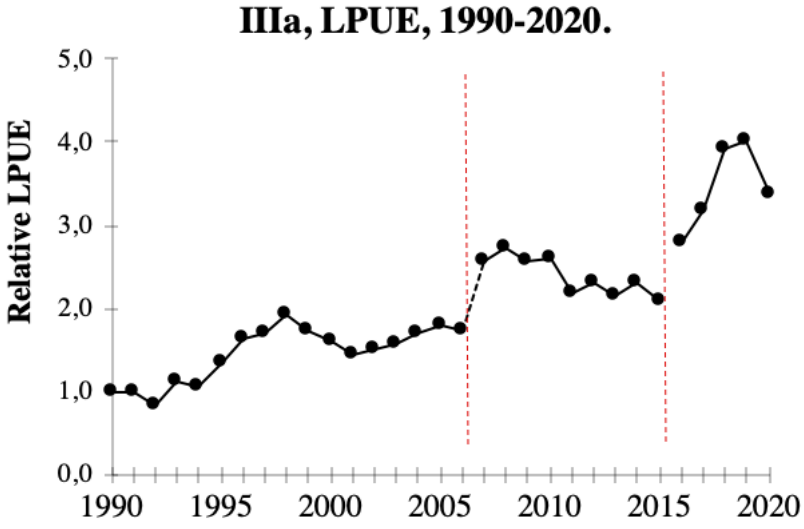

Figure 10.2.4.2 *Nephrops* in Area 3.a: Combined LPUE for FU 3 and 4. Red dotted line shows the year at the shift in Danish management system and, to the right, change in MCRS.

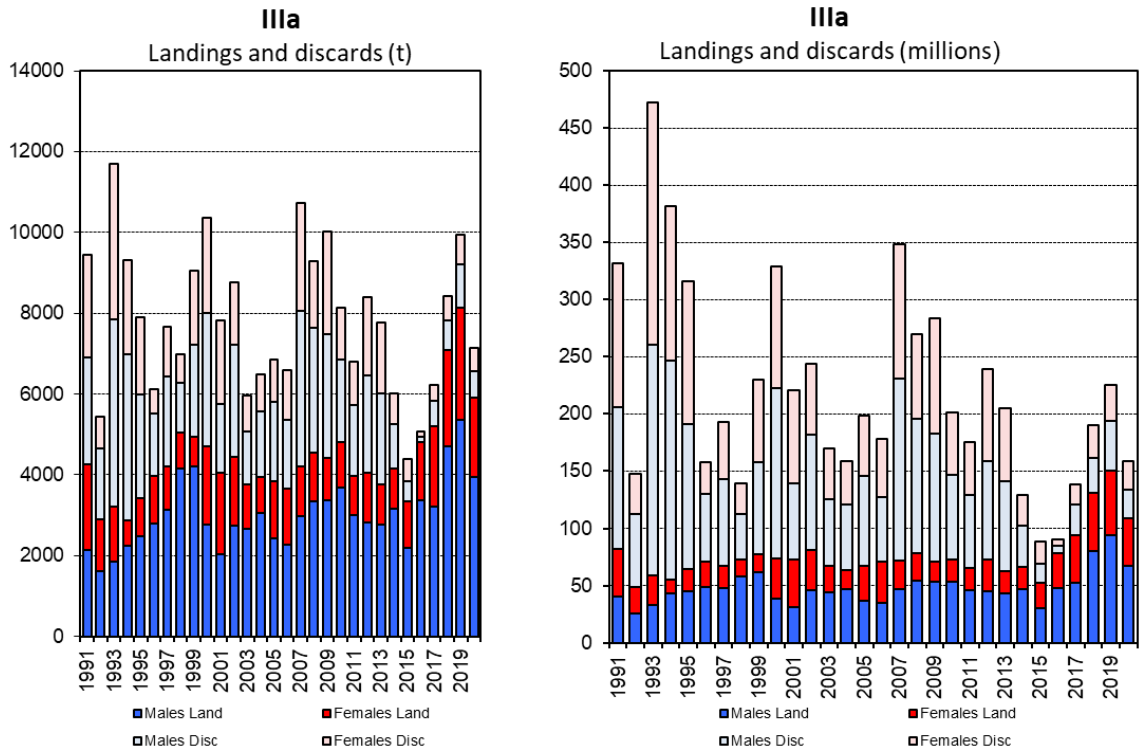

Figure 10.2.4.3. *Nephrops* in 3.a: Catch by sex and size category in biomass and numbers.

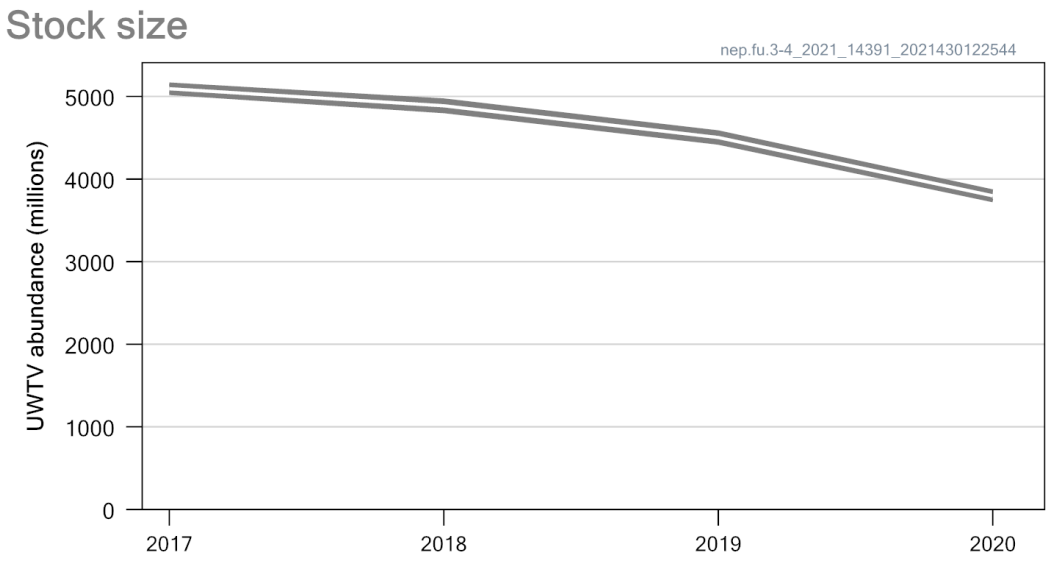

Figure 10.2.4.4. Mean abundance in 3.a by year: Error bars indicate the 95% confidence intervals.