Evaluation of closed areas in Kattegat to promote the rebuilding of the cod stock

Summary

The aim of this report was to evaluate the establishment of closed areas in the Kattegat in 2009 to promote the rebuilding of the cod stock. The work has been organised through a Working Group consisting of Danish and Swedish scientists, control experts and experts on socioeconomics.

ToR. a) Evaluate the effect of the closure on the cod stock & ToR. b) Evaluate the effect of the closure on the fishery

The working group concluded that the increase (in the range 45-112% as estimated by ICES) in spawning stock biomass (SSB) estimated for 2012 compared to the values estimated for 2009 can partly be attributed to the measures related to the implementation of closed areas. It is, however, unclear how the trends in harvest rates differ between stock units. Cod coming from spawning localities in the Kattegat can be assumed to be behaviourally different and distributed to other areas of the Kattegat than cod recruited from the North Sea. It is quite possible that the stock units we want to preserve are more confined to the closed and semi-closed areas than to other parts of the Kattegat, whereas cod recruited from the North Sea and migrating back at ages 2-3 are more widely spread and for the time being more susceptible to fishing.

The report shows that Danish fishing effort in 2009 and 2011 has been redistributed into areas of lower CPUE of cod (based on modelled stock distribution from survey data), however high fishing intensity was recorded in the partially closed area in 2010 (see Fig. 1.2.1 for reference to areas and regulations). No major change is visible in Swedish effort distribution in the timeframe 2008-2011, as the permanently closed area was hardly fished by Sweden in 2008, and the Swedish effort continued in the partially closed area after the implementation of closures as Swedish fishers applied the use of mandatory selective gear (sorting grid). A calculation of fishing impact using spatial distribution of cod and detailed distribution of fishing effort shows that the area closures in combination with the general effort reduction in the Kattegat, and the use of more selective gears have reduced fishing impact on cod to around 40% of what it was in in 2008. The effect of the closures cannot, however, be disentangled from the use of selective gears since access to the otherwise closed area depends on use of selective gears.

Since the introduction of the closed area scheme in the Kattegat 2009, many new alternative trawl configurations have been introduced into legislation.

The working group concluded that common definitions of minimum selectivity for cod is needed in order to clearly state what is needed in order to evaluate future gear options against common standards. Therefore, the working group suggests that definitions are needed both to avoid small fish in the entire Kattegat (as these are more widely distributed) and for large fish in the partially and seasonally closed areas (where the large cod appear to reside). Definitions then need to be linked to the objectives of the management (see ToR f below).

ToR. c) Evaluate the effect of the closure on fisheries communities

For the analysis of the effects of the closed areas, the two ICES-squares 41G2 and 42G2 are analysed. The two ICES-squares do not fit the closed areas perfectly, but they cover a large share of the areas. Since 2009 many policies and measures that affects the fishery in Kattegat have been revised and new measures have been implemented (e.g. changes in quotas, KW-days system). There is also a general rationalization going on in the fishery. An analysis of the development of the fishery as a whole in the closed area compared to the development in Kattegat shows that the development is similar to the overall development in Kattegat. The number of vessels active has decreased and the total value of landings has decreased. The 41G2- and 42G2 -share of the total value of landings in Kattegat has been stable over the years. The average value of landings per vessel in different length classes has generally not decreased. Nephrops has become economically more important both in Kattegat and the two ICES-squares. The largest effect of the closure on the fisheries is probably on costs, as the closures may force the fishermen to move into other fishing areas. Unfortunately, there is no detailed data to measure this cost change. However, from the analysis on value of landings it is observed that there is no trend that the share of total value of landings from the two ICES-squares has diminished.

ToR. d) Describe potential effect of the closure for obtaining good environmental status (GES)

Fishing has several effects on the marine environment and a suite of management tools including closed areas will be needed to make sure that GES is achieved, especially for all aspects of biodiversity (Marine strategy framework directive, Descriptor 1). Most obviously, closed areas may contribute to the recovery of the Kattegat cod population towards GES (Descriptor 3). For other stationary commercially used species with local populations, the closed areas may reduce evolutionary effects of fishing and maintain genetic diversity. A rebuilt cod stock should also lead to more natural food webs with the potential for cod as a functional top-predator in the system (Descriptor4). By protecting the sea-floor from abrasion by trawling in the permanently closed area, critical processes of benthic ecosystems are safe-guarded even though the response of these processes to fishing may not always be known (Descriptor 6).

It is recommended that Sweden and Denmark agree on common indicators and targets for GES, and that these indicators are evaluated at the Kattegat scale. It is further suggested that relevant indicators from descriptors 1, 3, 4 and 6 are considered specifically when future monitoring related to the closed area for the protection of cod in the Kattegat is decided.

ToR. e) Evaluate the enforcement scheme for the closed areas

To ensure that infringements are discovered an effective control is necessary. From a control point of view the most effective method is a fully closed area, either permanently or periodically over the year. Air surveillance and vessel monitoring system (VMS) are effective ways to monitor such areas. Permission to fish in an area with certain gears complicates monitoring when it largely relies on inspections at sea.

Swedish control 2009-2011: A total of 27 inspections at sea were carried out. The inspections resulted in 2 observed and reported infringements. The air surveillance resulted in 22 reported infringements. All infringements were detected in the permanently closed area.

Danish control 2009-2011: In total 144 inspections were carried out in or in the vicinity of the closed areas, which resulted in 6 infringements. In order to document the selective gear in use, national regulation was issued on the 14th of July 2011, demanding fishermen to report the exact type of gear used in the logbook. Inspections at sea and on landing in 2011 has shown that all the inspected vessels actually used or carried on board the new selective gears as prescribed -although this was not always correctly registered in the vessels logbook.

ToR. f) Recommend potential changes in objectives, area design, access criteria and monitoring and enforcement considering potential contribution to GES from the closure

The primary objective of the closed area and the zonation of fisheries in the Kattegat is to protect and rebuild the cod stock by reducing the overall fishing mortality on cod. Since the cod spawning stock biomass (SSB) in the Kattegat still is at historically low levels, and below biomass reference points, the working group concluded that the objective to rebuild the stock is still valid. To specify the objective in detail the working group suggest to develop the objective accordingly:

- To protect adults (decrease F and increase SSB) at age 2 and older (as cod in the Kattegat tend to mature already at age 2)
- To protect juveniles (i.e. 1 year old)

Based on spatial and temporal distribution of cod and the current exploration pattern, the working group recommend the following with regard to area design, access and monitoring:

January- April:

a) Closed areas

Higher densities of larger, spawning cod are found in the closed areas. Recommendation: maintain the present regulation in the seasonally, partially and permanently closed areas in Kattegat (yet it is recommended that the closure period is extended to April due to historical fisheries). Maintain the present regulation in the Kilen area in the Sound.

b) Outside

To reduce the presently high discard of juvenile cod catches must be reduced. Fishery should therefore only be allowed with designs 1, 2, 4 and 5 (or gear with documented similar selectivity characteristics) in all other parts of Kattegat

May-December:

a) Closed areas

Higher density of larger cod is found in the partially closed area. Recommendation: maintain the partially closed area.

Low density of larger cod has in general been found in the permanently closed area, but survey results from December 2011 indicate an increase.

Recommendation by SLU scientists: maintain the permanently closed area. An option may be to allow access for selective gears that avoids by-catch of large cod, i.e. having retention probability of less than 10% for cod larger than 40 cm and catching less than 1,5% cod according to EC Council Reg. 1342/2008, Article 11. However, the working group could not agree on the need to apply this definition as discussed below.

Recommendation by DTU aqua scientists: The permanently closed area may be merged with the partially closed area, such that fisheries with selective gears (as discussed below) are allowed in the presently permanently closed area.

Fishery in the partially and seasonally closed areas is today allowed with gear designs 4 (grid) and 5 (SELTRA 300). A larger protection of large cod is obtained by excluding design 5. This will, however, result in relatively higher catch of juvenile cod, and a loss of species like sole and plaice. The group was not in a position to quantify costs and benefits of changing the criteria for getting access to the seasonally, partially and permanently closed areas. There was no consensus in the working group on the need for changing the access criteria to those areas.

To monitor the effects of closed areas a targeted survey for cod is recommended by the working group. The current cod-survey has provided important input to this evaluation and it is recommended that this survey continue. No S-DK joint cod survey will be carried out in 2012 due to lack of funding.

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1. Background

This report was requested by the Swedish Ministry for Rural Affairs and the Danish Ministry of Food, Agriculture and Fisheries. The work has been organised through a Working Group consisting of Danish and Swedish scientists and control experts and other relevant experts. The group held one meeting in Göteborg 8-10 May and have been working by correspondence since then. Stakeholders joined the WG meeting in capacity as observers.

The working group is tasked with terms of references a-f listed under each chapter in the report

1.1. Rationale for implementing closed areas in Kattegat

Under the framework of the Environmental Quality Objectives for the Swedish environment the Swedish Board of Fisheries (SBF) were tasked by the Swedish Government as responsible for the establishment of six Marine Protected Areas (MPAs) where all fishing should be prohibited in order to protect fish stocks that could gain benefit from area closures. The areas were to be established both in the coastal zone and in offshore waters. In March 2008 this was reported to the Government by SBF and one of the proposals was to protect cod in the southeastern Kattegat (Sköld et al. 2008). In parallel, the issue with the poor status of the Kattegat cod stock were discussed at ministerial level and the Swedish and Danish ministers responsible for fisheries agreed to protect the stock by using closed areas and selective gears.

In September 2008, the Swedish Board of Fisheries Institute of Marine Research and DTU Aqua presented a memorandum suggesting closed areas for cod in the Kattegat and the northern part of the Sound with the aim of protecting and rebuilding the cod stock (Hjelm et al. 2008). The aim of the proposal was to present management measures to complement the TAC and fishing effort measures in the cod recovery plan. The aim was to protect the local cod population in the Kattegat by using MPAs and thereby reducing the overall fishing mortality on the Kattegat cod management unit, in order to rebuild the resident and historically productive Kattegat cod stock. The limited migration behaviour of the Kattegat cod stock and the well-known spawning grounds implied that introduction of MPAs were likely to contribute to the protection and rebuilding of the cod stock resident in the Kattegat. The proposal included a year-round no-take zone encompassing the main spawning grounds and in addition, a seasonally closed area surrounding the no-take zone (Fig. 1.1). The spawning ground in the northern Sound was included in the seasonally closed area as it is located close to the cod spawning grounds in the southern Kattegat and because cod migrations take place between the two areas.

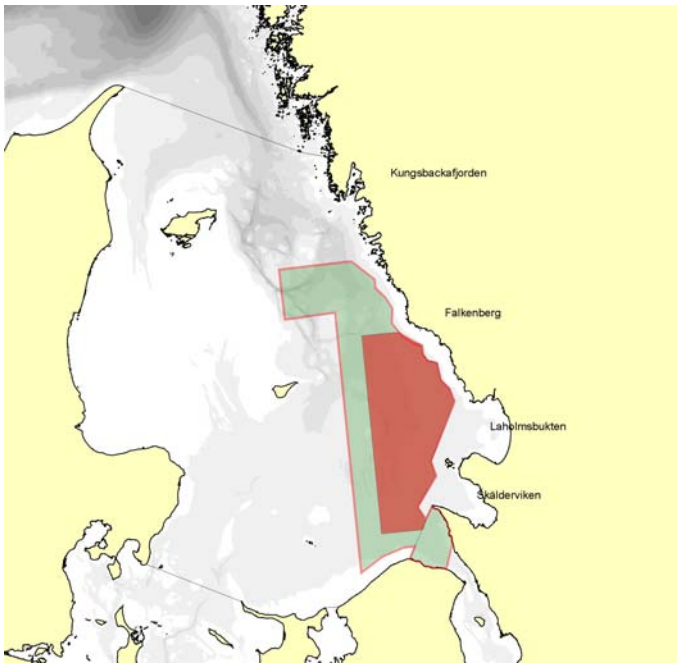

Fig. 1.1. The 2008 proposal by SBF and DTU Aqua seasonally closed area (green area enclosed by a red line) and the permanent no-take zone (red area).

1.2 Implemented measures

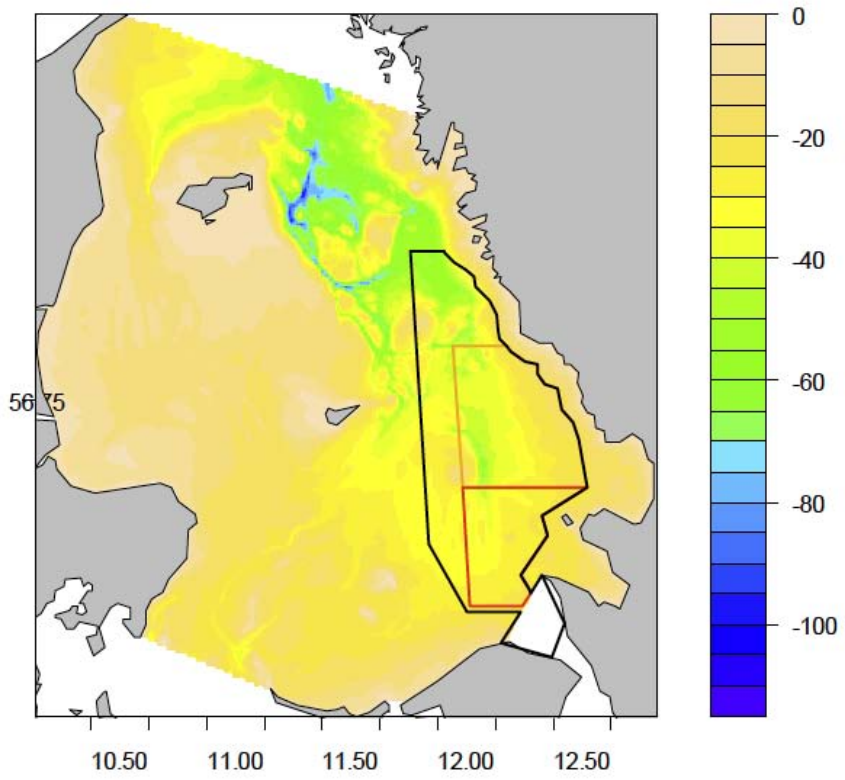

Fig. 1.2.1 Bathymetry of Kattegat and Closed areas:

- The “black” seasonally closed area is closed during the period 1st January to 31th March, except for fishery with selective gears; The “black” area in the Northern Sound (”Kilen” or the Triangle) is closed 1st February to 31th March, except for fishery with selective gears;
- The “orange” partially closed area is closed for all fisheries in the period 1st January to31th March. Fisheries with selective gears is allowed 1st April to 31th December;
- The “red” permanently closed area is closed for all fisheries, including recreational fisheries.

Fishing gears: Technical legislation in Kattegat today

Since the introduction of the closed area scheme in the Kattegat 2009, many new alternative trawl configurations have been developed and introduced in legislation. The following list of gear designs is present in current legislation (Swedish or Danish):

1. 4-panel cod-end with a 180 mm square mesh panel installed 4-7 meter from the codline.
2. 4-panel cod-end with a diamond mesh panel with a minimum mesh size of 270 mm installed 4-7 meter from the codline.
3. 2-panel cod-end with a 180 mm square mesh panel installed 4-7 meters from the codline.
4. Trawl gear with a Swedish *Nephrops*-grid and 8 m long 70 mm square mesh cod-end installed.
5. Cod-end with a 300 mm square mesh panel installed 3–6 meters from the codline.
6. Topless trawl in combination with a cod-end with a minimum 175 mm square mesh panel installed 3-6 meters from the codline.
7. 90 mm cod-end with a 120 mm square mesh panel installed 6-9 meters from the codline (only legal in the last quarter of the year)
8. 90 mm cod-end

Before 2009 only three of the trawl designs were in Kattegat legislation (designs 4, 7 and 8). Some of the current legal alternatives are applicable for Danish fishermen (designs 1-7), while others are available for Swedish fishermen (designs 4, 5, 7 and 8). The extended list since 2009 is a consequence of both the closed area scheme and of effort derogation and by-back measures in accordance with the prevailing cod recovery plan (art. 11 and 13 of EC Council reg. 1342/2008). This means that currently, only designs 4 and 5 are legal for demersal trawls inside the seasonally and partially (orange and black) closed areas, while the other designs may be used in other parts of the Kattegat.

2. Effects on the cod stock

ToR. a) Evaluate the effect of the closure on the cod stock

- *Quantify changes in stock distribution, stock abundance, size distribution and fishing mortality of cod in Kattegat, and by relevant stock components;*
- *Quantify the effect of the area closures on the changes of the cod stock.*

2.1. Cod in the Kattegat – stock identity

2.1.1 The Kattegat cod population structure

The biological Kattegat stock is defined as cod spawning in the Kattegat area. However, the Kattegat management unit is composed of cod caught in the Kattegat and may comprise a mixture of cod originating from different

areas (the Kattegat, North Sea and Western Baltic including the Belt Sea and the Sound). It is a challenge to separate between these stock units.

Cod spawning aggregations occur in the central and southern part of the Kattegat. Tagging have shown that the northern Kattegat also function as a nursery area for North Sea cod, and that return migration to the North Sea is common.

The present knowledge about the biological Kattegat stock can be summarised as follows:

• The biological Kattegat cod have limited migration

• There is a small but significant genetic differentiation between cod in the Kattegat and the North Sea/ Skagerrak, i.e. the biological Kattegat stock is unlikely to be replenished from elsewhere

• The historical spawning grounds in the Kattegat are well documented

• Spawning still occurs at these particular grounds

2.1.2 Additional studies: Genetic characterisation of cod year class in the Kattegat in 2011

In order to elucidate whether or not the recruitment of cod has improved in the Kattegat, a genetic survey was carried out based on juveniles born in 2011. The analysis showed that juvenile cod in the Kattegat were genetically similar to spawning populations in the North Sea/ western Skagerrak, i.e. most of the juveniles in the Kattegat 2011 were not spawn from the local population. In addition, the juvenile cod in the Kattegat were almost identical to juvenile cod in the Skagerrak, implying that most juvenile cod in the Skagerrak-Kattegat area in 2011 were recruited from the same source (i.e. the North Sea/ western Skagerrak). These results thus show that no major improvement in recruitment of the Kattegat cod stock has occurred.

2.2 Changes in stock distribution, stock abundance, size distribution and fishing mortality

2.2.1 Kattegat cod stock status estimated by ICES (Baltic Fisheries Assessment Working Group)

Spawning stock biomass (SSB) of cod in the Kattegat has been at a historically lowest level and below biomass reference points since 2000, with the lowest values of SSB estimated for 2010. The SSB for 2012 was estimated considerably higher (in the range 45% to 112% higher depending on the model used) compared to 2009 when closed areas were introduced (Fig 2.2.1). Preliminary estimates indicate that increasing trend in total biomass and SSB continues in 2012. The current level of total fishing

mortality is unknown due to a pronounced difference between the catch data (landings and discards estimated from observer data) and the total removals (including e.g. return migrations of North Sea cod which have entered the Kattegat as juveniles) from the stock estimated within the model based on survey data. The available discard data indicate a stable high fishing mortality on cod age-groups 1-2 in 2008-2011 when used in the assessment (Fig. 2.2.2). These values are however from an assessment without estimation of unallocated mortality (e.g. migration of North Sea cod back to the North Sea) and with a low (0.20) natural mortality of juveniles. A higher natural mortality (e.g. around 1.0 for age 1 and around 0.7 for age 2 as used in the North Sea cod assessment) will decrease the estimate of discard mortality considerably.

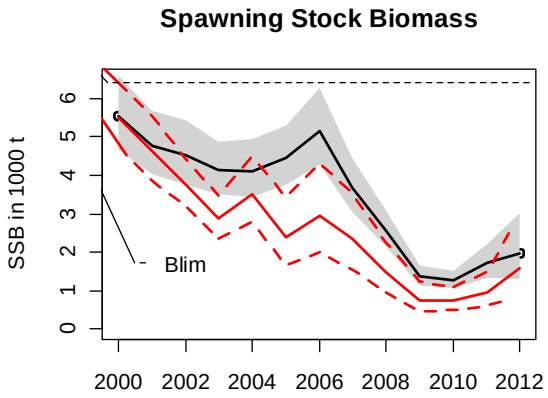

Fig 2.2.1. Spawning stock biomass of cod in the Kattegat estimated in ICES assessment: i) excluding discards and estimating total removals within the model (black line) and ii) including the discards (red line). Shaded area and dashed lines represent 95% confidence intervals for the two runs, respectively (ICES 2012).

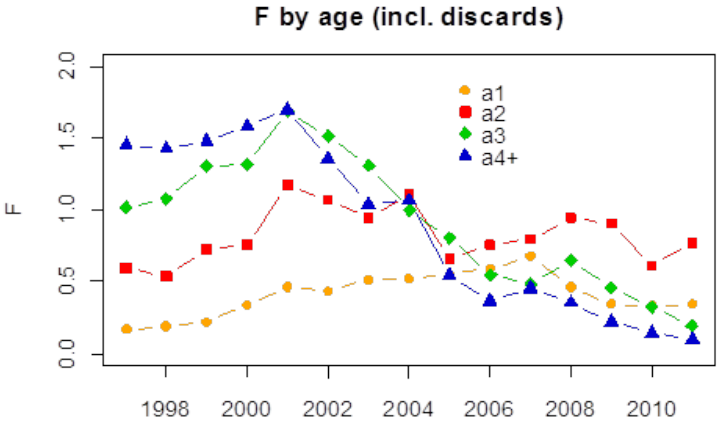

Fig. 2.2.2. Fishing mortality of age-groups 1 and 4+ from the assessment run using the reported landings and estimated discards based on observer trips as total removals from the stock. (from ICES 2012).

2.2.2 Fishing impact analysis

The relative fishing impact (proxy for fishing mortality) has been quantified for the Danish and Swedish TR2 segment which is the most economical important fishery in Kattegat and the fishery with the largest cod catches. Fishing impact is calculated from the temporal and spatial distribution of the cod stock (estimated from survey observations) and the fishery effort (estimated from VMS). It is assumed that fishing impact is proportional to the sum of product of the local cod density, local fishing effort and the size selection of the applied gears. In other words, the method gives a robust prediction of the fishing impact on the cod stock, given that we know the distribution of the cod and the fishery. The assumption is that fishery in an area with high cod density has a larger effect on the cod stock than fishery in an area with a lower cod density. The total fishing impact is simply calculated as the sum of the fishing impacts from all places in Kattegat. In this calculation the different gear selection has also been accounted for.

Stock distribution
Statistical analysis of trawl survey catches of cod shows that the distribution of young and older cod is different and that the distribution changes within a year (Fig. 2.2.3).

Older cod was mainly found in the deeper part of the eastern and southern Kattegat, while the distribution of younger cod was more dispersed. Survey coverage has in general been poor in the shallow and coastal areas, which might have resulted in a biased distribution pattern of especially the young cod.

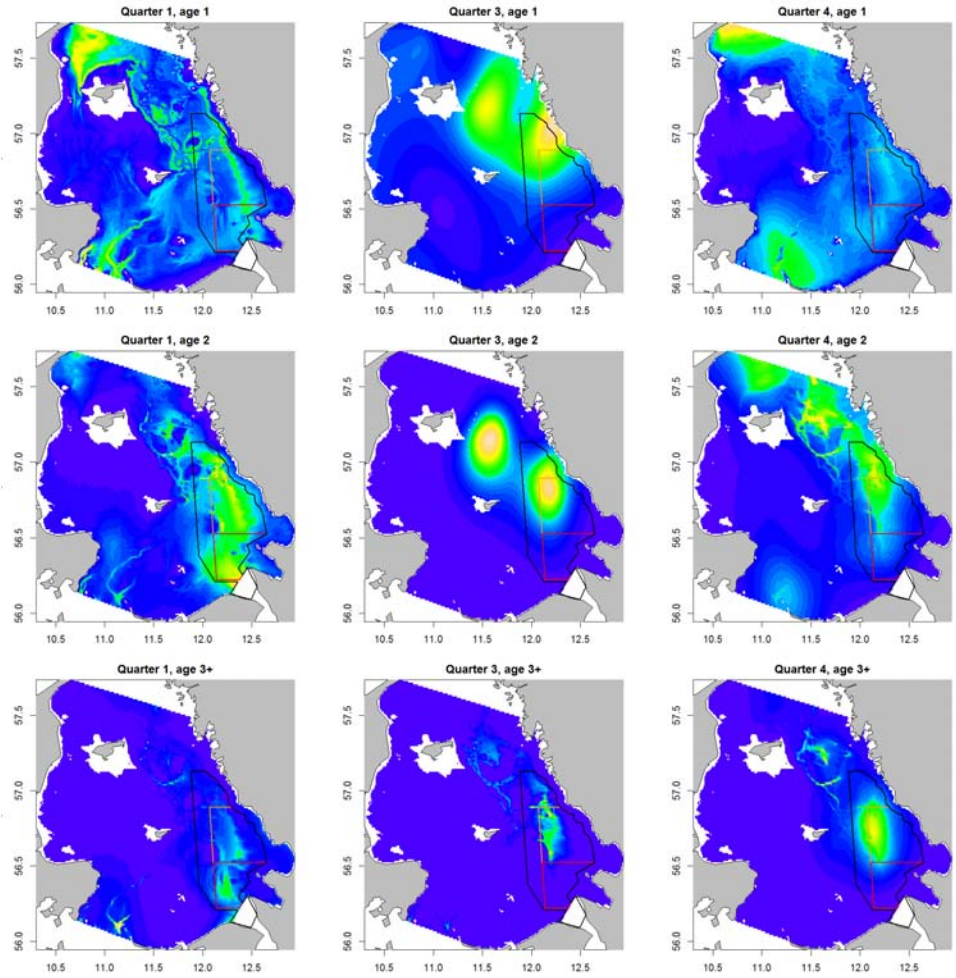

Fig 2.2.3. Estimated stock distribution of cod by age and quarter averaged over years (see appendix 3 for details of survey coverage and time series). The blue colour shows a low density, green medium and orange the highest density of cod. White areas inside the Kattegat are areas with depth less than 5 m.

All the closed areas in quarter 1 (at spawning time) contain a large proportion of the population of older cod. The density of cod the Kilen area in the northern Sound is considerably higher than in the Kattegat, but has due to scaling problems been excluded from Fig. 2.2.3.

There is no up-to-date survey for quarter 2 to model the stock distribution.

Survey data from quarter 3 are insufficient for an accurate estimate of stock distribution, but the estimated stock distribution for the oldest cod is quite similar to the one estimated for quarter 4.

In quarter 4 cod age 2 and older is mainly found in the partially closed area and more northerly. The density of cod in the permanently closed area was low.

The statistical analysis shows an increase in the cod abundance for all ages since the closures were implemented in 2009.

Distribution of fishing effort
The distribution of effort for the Danish and Swedish TR2 segment was estimated from VMS data. Figure 3.2.2 shows an example of such data by year.

Relative fishing impact
The fishing impact on cod in 2011 was estimated to be 41%, 35% and 31% of the level in 2008 (i.e. before the closures were implemented), for age 1, age 2 and age 3 plus, respectively (see table below).

Year	Age 1	Age 2	Age 3+
2008	100%	100%	100%
2009	69%	54%	47%
2010	59%	47%	44%
2011	41%	35%	31%

The reduction in fishing impact was highest in the first year of closure, followed by a modest further reduction in succeeding years. The relative reduction in fishing impact was estimated to be lower for Denmark compared to Sweden for age 2 cod and older, while the Danish fishery obtained a higher reduction for age 1 since the area closures. In absolute terms, Denmark also had higher impact on all age classes except age 1. In terms of fishing impact per nominal effort (kW days), Swedish impact in 2011 was larger than Danish for age 1 and 2. This was due to that the Swedish fishery overlaps to a larger extent with the cod distribution of age 1 and 2, and the 90mm fishery (gear 8) by Swedish fishers had a high impact due to a high retention of small cod. The impact per nominal effort on age 3+ was quite similar for the Danish and Swedish fishery in 2011.

Sensitivity analyses show that the assumed size selection of cod by the different gears has a direct effect on the absolute estimate of fishing impact and the contributions from the two nations. However the estimate of change in fishing impact between years seems rather robust to the choice of size selection parameters as long as the values used are reasonable well estimated.

Separating the effects of different measures, i.e. closed areas, use of more selective gears, and reduction in overall effort, is not possible due to some of them being connected or even resulting from one another. The use of selective gears has increased, at least partly, to get access to the partially closed areas. Further, Denmark has obtained additional fishing effort (according to article 13 in the cod recovery plan (EC) No 1342/2008) due to implementation of the closures.

It is unclear how the fishing impact differs between stock units. Cod coming from spawning localities in the Kattegat can be assumed to be behaviourally different and distributed to other areas of the Kattegat than cod recruited from the North Sea. Most of the older cod is within closed areas in quarter 1, which is the spawning period for cod and the (spawning) North Sea cod is thus assumed to be outside Kattegat. This means that the closed areas have a direct effect on the Kattegat cod in quarter 1, but for other quarters it is not possible, without further information, to estimate separately the effect of the closures on the cod population that spawn in the Kattegat.

The fishing impact analysis uses the average distribution pattern over all the years considered. Previous analysis (Vinther et al, 2010) showed that the centre of gravity of survey CPUE may change between years, but this is more due to the variation in CPUE and not related to consistent changes in distribution. However if a change in cod distribution has happened within the last three years, the fishing impact results will be biased. Given an anticipated relative higher increase of cod within the closed areas, the effect of the closures might be even higher than estimated, as a larger proportion of the cod stock would then have gained protection from the closures.

Fishing impact and the cod recovery plan

The present cod management plan includes a target F_{3-5} at 0.4. Fishing impact on age 3 plus (equivalent to ages 3-5) in 2011 is estimated to be 31% of the value in 2008. Therefore, the absolute F_{3-5} is at present likely below target F at 0.40 (for SSB > Bpa). However, SSB is low and most likely below Blim. In such cases the management plan dictates that F shall be reduced by 25% per year (equivalent to 0.75^3=42% of the F level remaining after a period of 3 years), which is a smaller reduction than the estimated realized reduction in fishing impact. These calculations indicate that the aim of the management plan to reduce F_{3-5} has worked, but the objective to rebuild SSB to above Bpa has clearly not been reached, even though an increase in SSB has been detected from this analysis and the ICES stock assessment.

For cod age 3+ the estimated reduction in fishing impact is similar to the decrease in F estimated by the assessment where reported landings and

discards from observer data are treated as total removals from the stock (Fig 2.2.2). However, for cod of age 1-2 there is a discrepancy between the results of the impact analysis (41% of the value since 2008 for age 1 and 35% of the value age 2) and the continuously high F_1 and F_2 as estimated by ICES when including discard estimates from observer data (Fig. 2.2.2). The reasons for this discrepancy are unclear and are likely related to combinations of the following issues:

- the realized selectivity in commercial practice differs from that estimated in controlled scientific trials;
- the uncertainties in the current knowledge of spatial and temporal distribution of cod;
- the uncertainties in discard estimates;
- the uncertainties in ICES assessment (see sec 2.2.1) .

References

Appendix 3. Changes in fishing mortality of Kattegat cod due to the introduction of closed areas and other management measures

Appendix 2. Raw data on cod cpue from surveys

2.2.3 Statistical evaluation of the cod closures in Kattegat

In the Kattegat there are several surveys in place with different distributions of hauls. The only two surveys that covered all the areas of the cod closure with more than one haul, was the Sole survey and the Cod survey. These two surveys were consequently the only two that were analysed statistically.

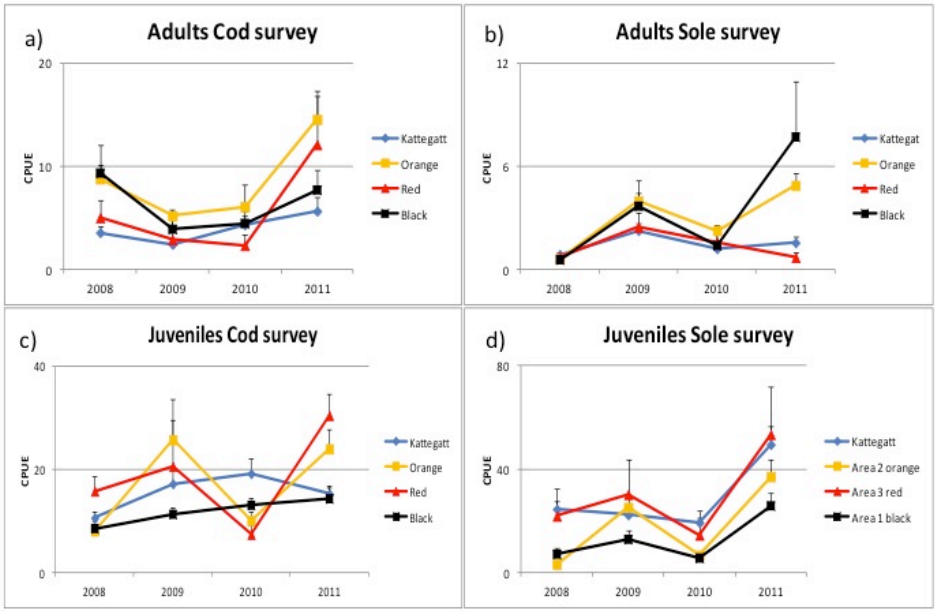

Fig 2.2.3.1. Mean catch per unit of effort +/- Standard Error (CPUE) by Year for a) Adult cod in the Cod survey, b) Adult cod in the Sole survey c) juvenile cod in the Cod survey, d) juvenile cod in the Sole survey orange=partially, black=seasonally and red=permanently closed area.

Interactions between areas and year were significant in both surveys using different statistical approaches. In the cod survey year 2011 had the highest CPUE for adult cod in the partial and permanently closed area (Fig. 2.2.3.1). In the sole survey, there was higher CPUE of adult cod in the partially closed and in the seasonally closed area in 2011. The CPUE in permanently closed area was however low in 2011.

There was a significantly higher CPUE of juvenile cod in 2011 and 2008 in comparison to 2007 and 2009 in both surveys. There was no difference between the areas concerning CPUE of juvenile cod. Both surveys thus show that the CPUE of juvenile cod is mainly related to variability between years with no difference between areas.

2.2.4. Assessment from hydro acoustic surveys

To follow up effects of the closed areas in Kattegat an acoustic survey was carried out by SLU-Aqua in late November – early December 2009, 2010

and 2011. In contrast to traditional bottom trawl surveys, the acoustic method provide means to obtain information on fish abundance in all habitats, i.e. not only in habitats where trawling is possible. It is also possible to sample the whole water column, while bottom trawling only samples the height of the trawl gear used. Species composition still needs to be verified by fishing however, since acoustics cannot discriminate between species. The acoustic survey where therefore carried out during the same time of year as the joint Swedish and Danish survey for cod in the Kattegat, and the estimated cod abundance was based on the assumption that the proportion of cod in each size class was the same during the acoustic and the bottom trawl survey. However, since no samples were taken from observed fish echoes during the acoustic survey this assumption cannot be directly evaluated.

Small fish (20 – 40 cm) was observed throughout the surveyed area, whereas large fish (40 – 100 cm) likely to be cod were confined to a few hot-spots along the 20 m depth contour to the north east of the partially closed area, and in the north-eastern part of the reference area. During 2010 and 2011 the abundance of large fish was also relatively high on the border between the closed areas (Fig. 2.2.4.1).

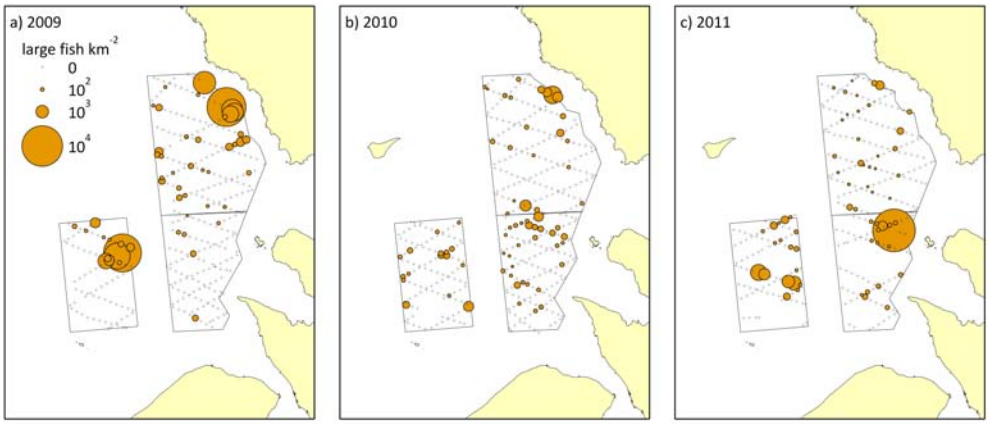

Fig. 2.2.4.1. Spatial distribution of large fish (40 – 100 cm) based on acoustic survey data. a) 5 – 16 November 2009; b) 22 November – 8 December 2010; c) 21 November – 7 December 2011.

Based on acoustic data, the estimated abundance of especially large cod, in the closed areas and in the reference area was very low in 2009, 2010 and 2011. In the permanently closed area (red), the trend was increasing which agrees with data from the joint Swedish and Danish survey for cod in the Kattegat. In the partially closed area (orange) however, the abundance of large cod decreased from 2009 to 2011.

Abundance of small cod estimated from acoustics was significantly higher than estimates based on catch per unit effort during the joint Swedish and Danish survey for cod in the Kattegat. The difference in absolute numbers indicates that the proportion used to calculate abundance of small cod may have been too high; in spite of this the overall trend was similar. For large cod, the acoustic and trawl based estimates were within the same order of magnitude. However, whereas the acoustic data show a decrease of large cod in the partially closed area, the trawl-based data indicate an increase from 2010 to 2011. In the permanently closed area, the trend was increasing in both data sets. It should be noted that the estimated cod abundance, especially of large cod, was very low over the study period and that trends in the data are weak.

2.3 Summary of the effect of the closed areas on cod.

The fishing impact analysis shows a substantial reduction in fishing mortality since 2008 which is due to a combination of the introduction of the closed areas in 2009, use of more selective gears and a general reduction in fishing effort. The analysis also shows an increase in the cod stock since 2008-2009, which is confirmed by the statistical analyses of the catches in the trawl surveys in quarter 4.

Information is in general limited to show consistent changes of the distribution of the stock in the short period since the closures were implemented. Data for the Quarter 4 include two trawl surveys and one hydro acoustic survey with a substantial effort, but only for three years. However, the trawl surveys show a similar picture with significant changes in abundance between areas and years. In both trawl surveys, the abundance of adult cod had high abundance in 2011 in the partially closed area. While the cod survey shows a significant increase also in the permanently closed area in 2011, the sole survey shows an increase in the seasonally closed area. The hydro acoustic survey indicates an increase in the permanently closed are but in contrast a decrease in the partially closed are.

All surveys show that the CPUE of juvenile cod is mainly related to variability between years with less pronounced difference between areas.

3. Effects on the fishery

ToR. b) Evaluate the effect of the closure on the fishery

- *Describe the changes in the fishery with respect to target species and application of gears with low cod selectivity;*
- *Quantify the effect of the application of selective gears on cod catches;*

- *Quantify the effect of the closed areas on species composition, total catch weight and value.*

3.1 Landings from the Kattegat in value and weight

The fishery in Kattegat is almost exclusively Danish and Swedish, with these countries taking about two third and one third of the landings, respectively. Kattegat cod are mainly taken by otter-trawls, Danish seines and gill-nets, the former being the most important. Within the trawling group, three fisheries (métiers) have historically been important for the cod catches, the *Nephrops* fisheries, the flatfish fisheries, and the cod directed fisheries historically taking place during the first months of the year.

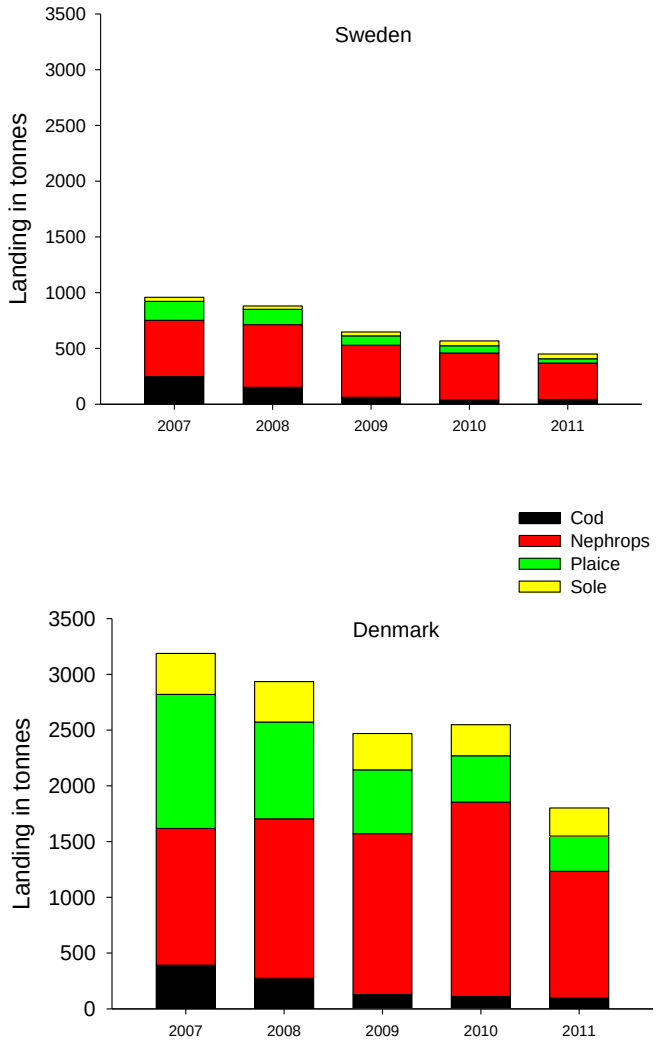

Fig. 3.1.1 Landings in tones by species and nation for the four most important species caught in the trawl segment.

Denmark has a higher part of the sole TAC and sole and plaice are considered important by- catch species in Denmark. During recent years, both in Swedish and Danish fisheries, cod is caught as a by-catch species in fisheries primarily targeting *Nephrops* and landings are distributed throughout a year.
For both nations Nephrops has an increasing importance and in Sweden the *Nephrops* fishery is presently accounting for 88% of the total value of the four investigated species (cod, *Nephrops*, plaice and sole). For both nations the relative importance of cod has decreased from close to 6% to just above 1% in the timeframe investigated. The plaice has only been caught in small amounts in the Swedish fishery in recent years and it is presently not of economic value for Sweden. In 2007 the Danish plaice fishery in Kattegat accounted for close to 10% in value, however this has decreased and today the plaice landings are only accounting for 2%. Although the amount of sole landed is not much larger than for plaice, the value of this species makes it economically important. In Denmark, sole landings accounted for 23% of landings value in 2007 and decreased to 17%, presently. In the Swedish fishery the trend is reversed with a small increase in importance from 5-7% to 9% presently.

3.2 Effort

Besides TAC regulation, fishing in Kattegat are restricted by effort limitations. The predominant trawl is TR2 (mesh size 70-99 mm) which accounted for 80% of the total effort and 92% of the regulated effort. Trends in nominal effort (kWdays) for TR2 are shown in Fig. 3.2.1. The overall TR2 effort decrease with 30% between 2000-2005, remained fairly stable in 2005-2008 and has further decreased since 2008. Sweden has a derogation from the effort system for *Nephrops* trawls equipped with sorting grids. The relative importance of the grid fisheries have as a consequence increased. The grid fishery has in recent years been more common than the conventional fishery. Denmark introduced in 2010 a cod avoidance plan, which allows Member States to avoid reductions in effort by introducing measures to avoid catching cod. As a part of this plan it is mandatory in Danish fisheries to use a SELTRA trawls (180 square mesh panel or 270 diamond mesh panel) during the first three quarters of the year.

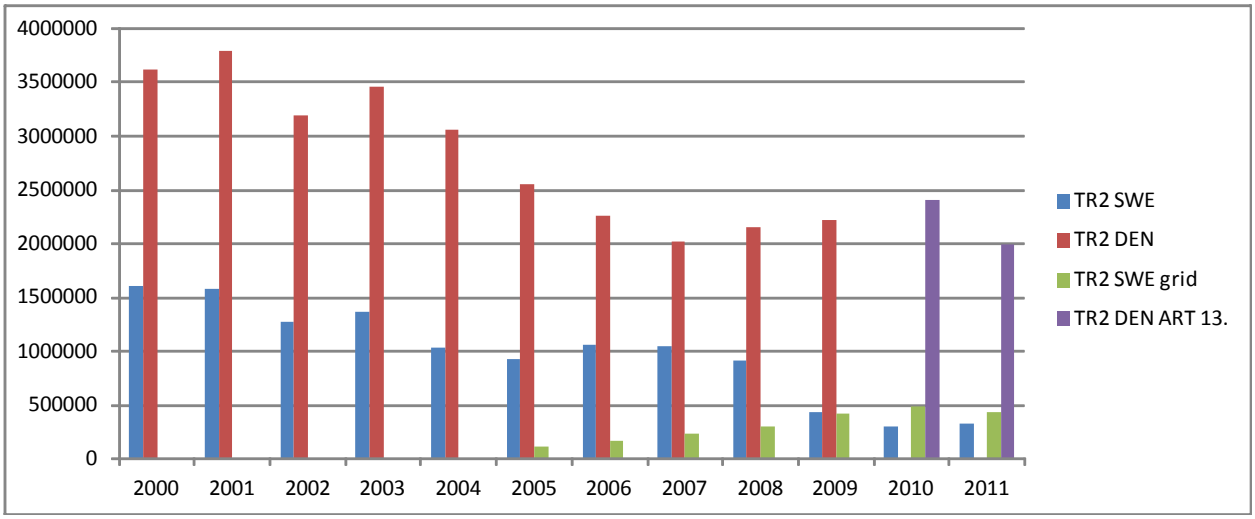

Figure 3.2.1 showing trends in exploited kWdays for TR2 (otter trawls with mesh size 70-99) 2000-2011.

3.2.1 Spatial distribution of effort from satellite positioning of fishing vessels (VMS)

High resolution effort data were available to describe the spatial distribution of fishing effort. VMS records from fishing vessels with speed 2-4 knots (Denmark) or 1.5-3.5 knots (Sweden) were classified as “fishing” activity and afterwards merged with logbook data by trip (Denmark) or by haul (Sweden) to allocate each trip to the fleet segments (TR1, TR2 or other based on gear and mesh size information). In this process, misclassification of both vessel activity and segment may occur.

The different spatial distribution of the Danish and Swedish fishery is clearly seen from Fig 3.2.2. The Swedish fishery is mainly in the deeper parts of Kattegat closer to the Swedish coastline, while the Danish fishery covers the same area and areas closer to Denmark. Sweden had almost no fishery in the permanently closed area in the recent years before the closure while Denmark had considerable activity in the area. The response to the closure of the partially closed area is also different. Sweden maintained the activity in the area after the closure due to the use of sorting grid, while the Danish activity in the area was limited in 2009. In 2010, the Danish fishery was high in the partially closed area, where the use of SELTRA 300 is allowed, whereas in 2011 both the Danish and Swedish effort in this area decreased.

Some VMS fishing activity has been recorded in the permanently closed area in 2010 (May-August), while VMS activity in this area in other periods has been insignificant.

The seasonal closure in the northern Sound (“Kilen”) and a later permanent ban on the use of Danish seine in this area have almost entirely removed VMS activity and cod catches by segment TR1 and TR2 in this area.

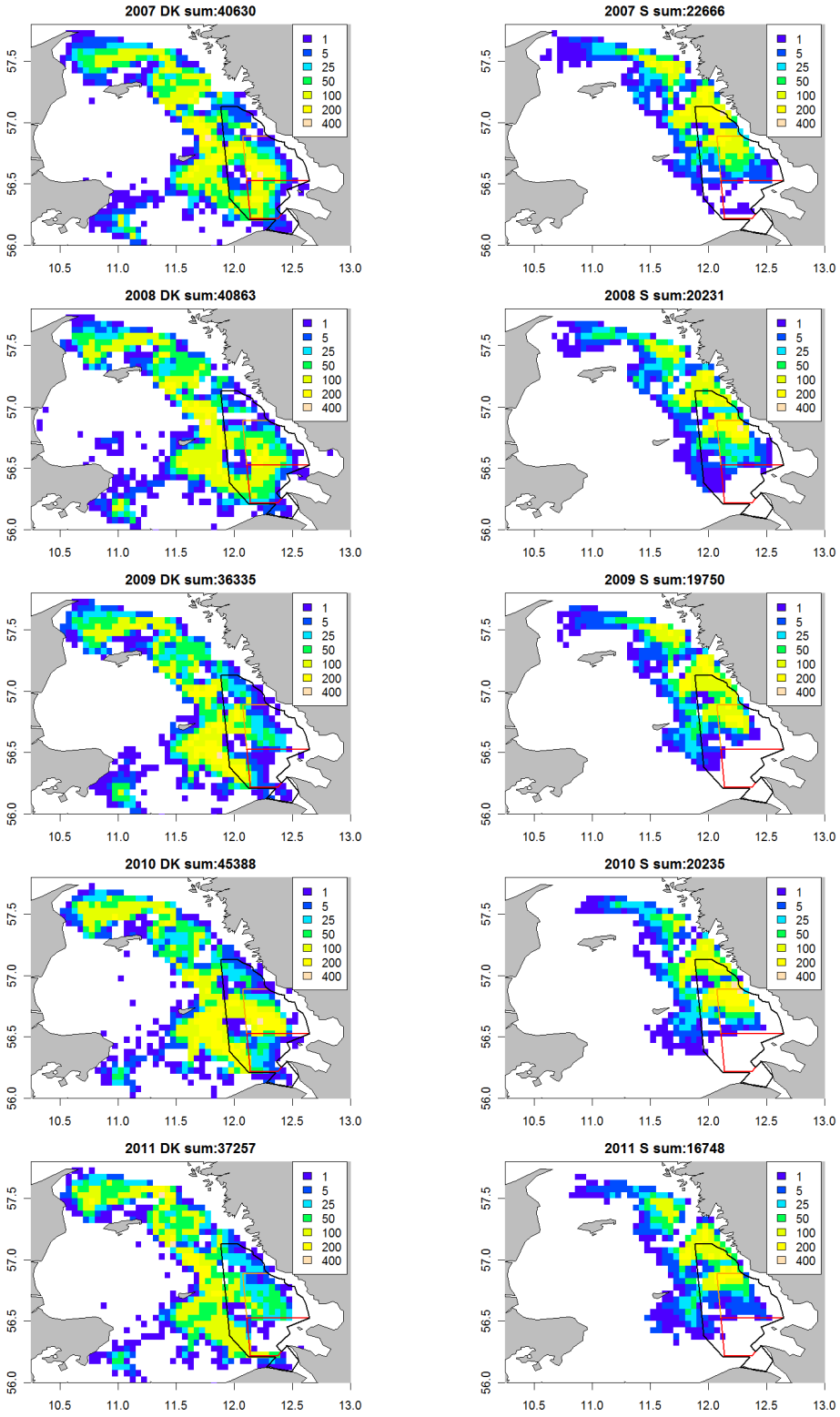

Figure 3.2.2. Distribution fishing effort (sum of VMS hourly ping assigned to fishery) Danish and Swedish TR2 segment.

3.3 Discards

Both Denmark and Sweden are sampling the Kattegat fisheries for discards. The amount of estimated cod discards, expressed in weight, have in recent years been at the same level as the reported landings. Expressed in numbers it is close to 90 % of the cod caught in Kattegat which is discarded (Fig. 3.3.1) (Anon, 2012).

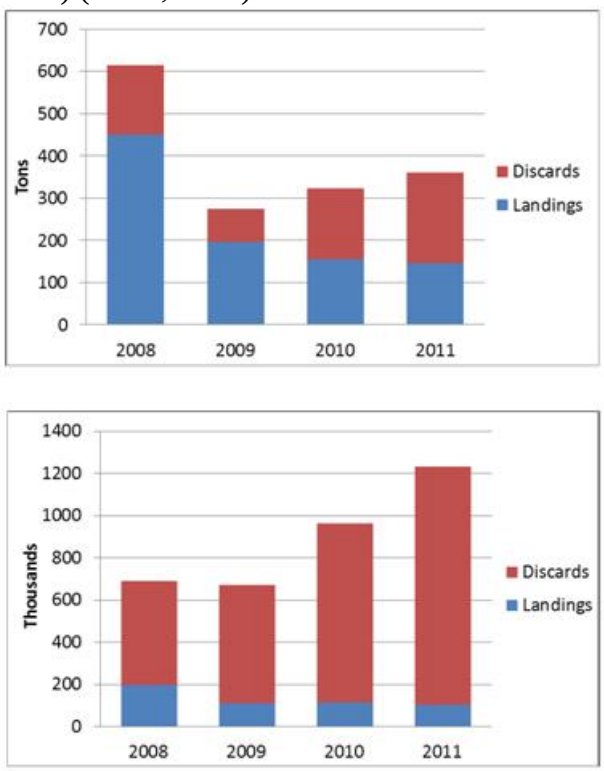

Fig. 3.3.1 showing weight and number of cod discards and landings

Cod is primarily discarded because the individuals are below minimum landing size (MLS). Most of the cod discarded is 1 or 2 years old (figure 3.3.2).

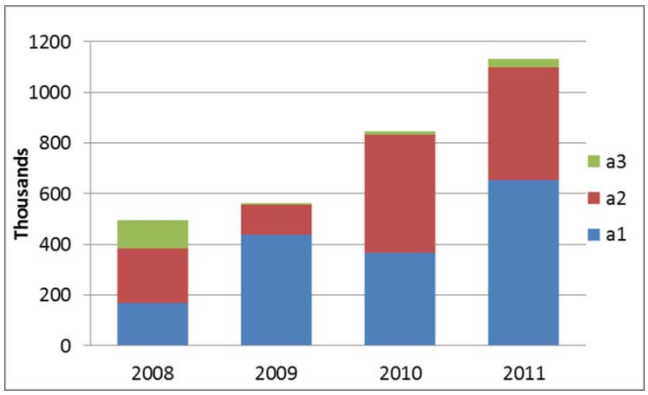

Fig. 3.3.2 showing discarded cod by age.

Data from the discard sampling schemes could also indicate how the different gears perform in reality. It is however important to realise that the composition of the catch is not only a function of the selective properties of the gear but also on the populations at the fishing ground, implying that time and space have an impact. Figure 3.3.3 shows percentage of cod (landed and discarded) in hauls sampled within the Swedish sea sampling programme 2008-2011. 68% of the hauls in the fishery using grid contained less than 1.5% cod. In the fishery using a 90 mm trawl the corresponding figure is 14%. The grid fishery and the 90 mm fishery is throughout the time period (all quarters and years with one exemption) while the fishery using a 120 mm panel is sampled more sparsely.

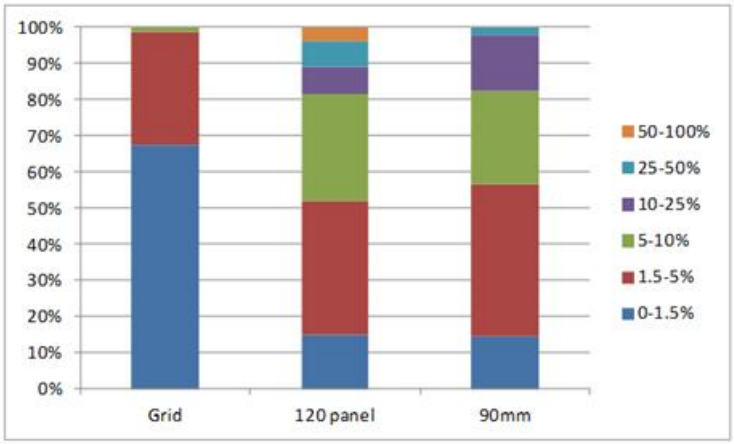

Fig. 3.3.3 showing number of sampled hauls with different percentage of cod (landings and discard) in the catch for three different gears in the Swedish fishery (numbers of hauls grid=83, 120 mm panel=27 and 90mm=97).

3.4.1 Implemented gear in relation to the closed area scheme

Two of the seven legal gear alternatives accessible for Danish fishermen have probably never been used (designs 4 and 6). Designs 1, 2, 3, 5 and 7 have thus been use to varying degree (section 1.2 on compilation of fishing gear). Danish fishermen use design 5 inside the closed areas, while the majority use designs 1 and 2 in other parts of the Kattegat. Furthermore, since Aug 2011 only designs 1 and 2 are legal for Danish fishermen in other parts of the Kattegat (except for the last quarter of the year when design 7 may be used).

Swedish fishermen in Kattegat use trawl designs 4, 7 and 8. Swedish fishermen exclusively use design 4 inside the closed areas when allowed. All gear designs are used outside the closed areas, of which design 4 dominates effort for the entire Kattegat.

3.4.2 Selectivity by length and age for current legal trawl designs

The selectivity of currently legislated gear designs (shown in Fig. 3.4.1 and 2) shows that both size and age selectivity exhibit very different characteristics between designs. Design 8 shows the poorest size selectivity with a 50% retention probability for 24 cm cod. The selection curve for design 7 (120 mm window) is highly uncertain (see Appendix 7). Earlier published results indicated that size selectivity was similar to design 8, although new data suggest that selectivity can be greatly enhanced by slight changes in gear design (4 m extension piece). A 4 m extension piece is however not specified in current legislation or used in the fishery, why the new selectivity estimates is probably not representative in commercial practice. The selectivity of design 4 has a bell-shaped selectivity curve. Thus cod smaller than 21 cm and larger than 30 cm have a retention probability of less than 10%. The SELTRA cod-ends (designs 1 and 2) have increased retention with increased size. However, size selectivity for small cod is much enhanced compared to traditional cod-ends and all SELTRA designs have estimated retention probabilities of less than 10% for 25 cm cod, while L50s vary between 38 and 45 cm.

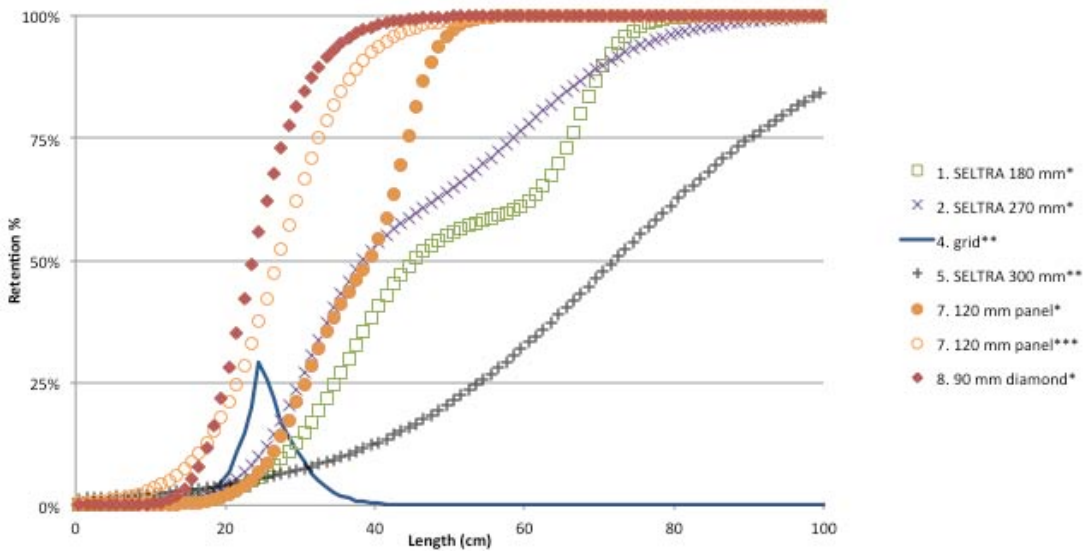

Fig. 3.3.1. Cod size selectivity for different *Nephrops* trawl options in the Kattegat fishery. Asterisks denotes references to reported results: (*) DTU gear Appendix 7 to this report (**) Madsen and Valentinsson 2010 (***) Frandsen et al 2009.

The different selectivity characteristics of the different trawl designs results in different patterns when analysing estimated selectivity by age. For cod of age 0, all gear designs have low retention probability (<5%, Fig. 3.4.2). For all other age classes design 7 and 8 has considerably lower selectivity than the other gear designs (Fig. 3.4.2). The SELTRA- and grid trawls all show low retention probability for cod of age 0 and 1. For age 2 and older cod the SELTRA designs shows higher retention probabilities than the sorting grid, for which the retention decreases (Fig. 3.4.2). The difference in selectivity between SELTRA and grid trawl increases for older (larger) fish.

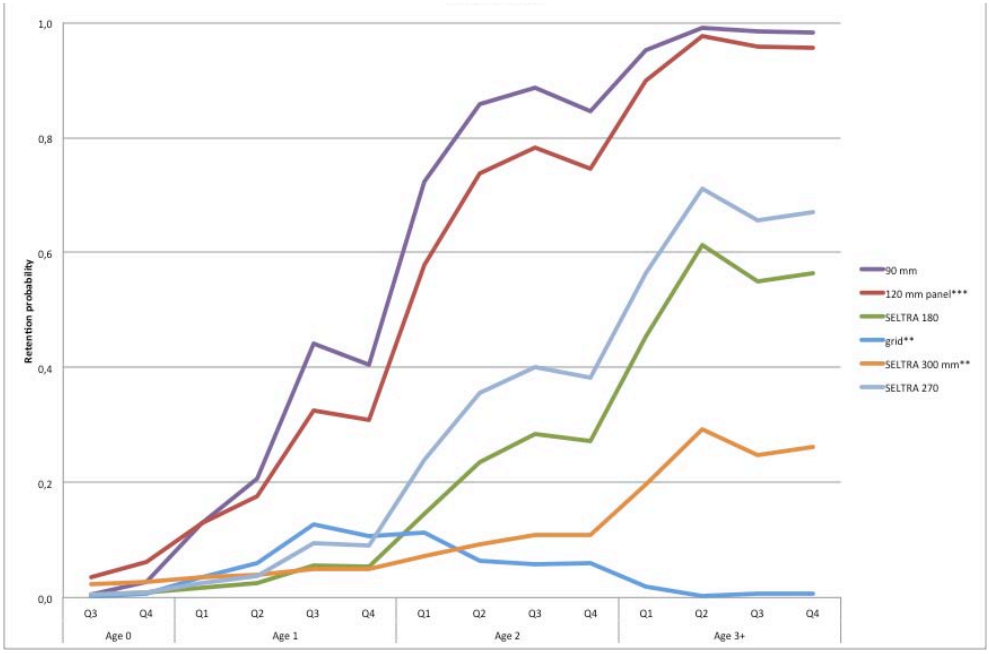

Fig. 3.4.2. Estimated selectivity for different cod age groups by quarter for *Nephrops* trawl deisgns in the Kattegat fishery. Asterisks denotes references to reported results: (**) Madsen and Valentinsson 2010 (***) Frandsen et al 2009. Age and length distribution from survey data (ICES/datras). Age 3 is a plus group i.e. includes 3 year old fish and older.

3.3.3 Observed cod catch composition

Sea sampling by Swedish and Danish observer programs between 2010 and spring 2012 sampled a total of 192 hauls in the Kattegat by the current gear designs (26 hauls for designs 1 and 2 combined, 46 hauls for design 4, 20 hauls for design 5, 48 hauls for design 7 and 52 hauls for design 8). The relative size composition of cod catches is strikingly similar given the different selectivity characteristics for the various gear designs (Fig. 3.4.3).

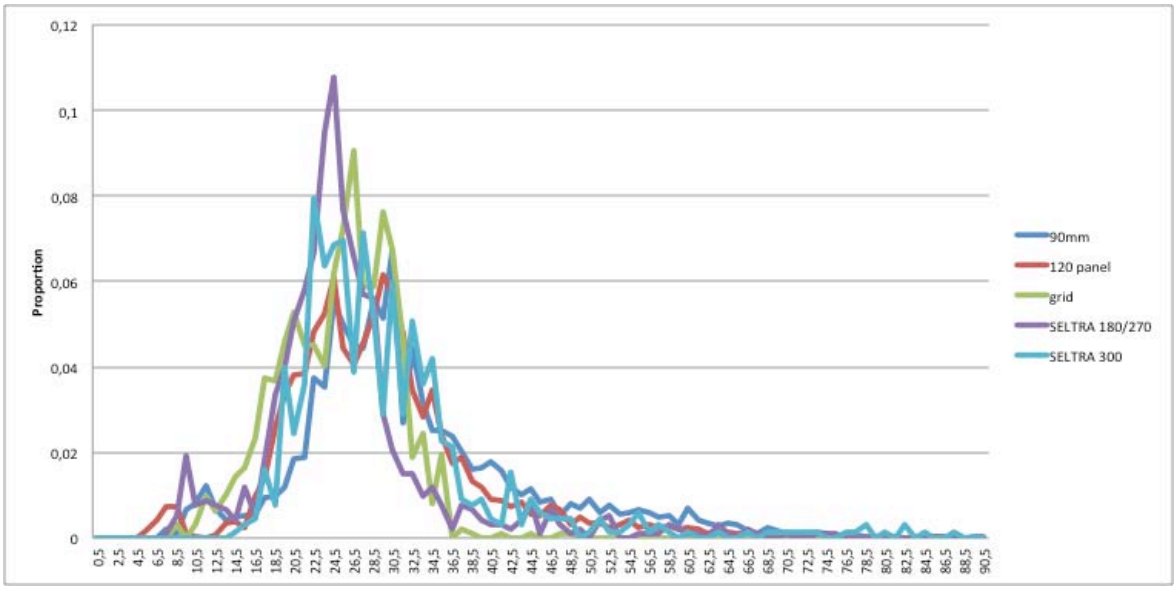

Fig. 3.4.3. Relative size composition of commercial cod catches from alternative legal trawl designs. Swedish and Danish observer data combined for 2010-2012.

Contrary to expectations, there are no apparent differences in catches of small cod between designs 1-5 and designs 7-8 (Fig. 3.4.3). Clear is however the absence of cod larger than ca. 35 cm in grid trawls, which is in line with theory (Fig 3.4.1). Possible explanations for the lack of apparent differences in catch size composition is that the Kattegat cod stock is strongly dominated by small fish and that the effects of selective gear will therefore not have a discernible effect on size composition in catches, or that the realized selectivity in commercial practice differs from that estimated in controlled scientific trials.

3.4.4 Cod selectivity targets

One unresolved issue since the introduction of the closed area scheme in 2009 is the lack of a common definition of what constitutes a selective gear with regard to cod. The current cod management plan (EC Council Reg. 1342/2008) stipulates two levels (1.5% or 1 % cod of total catches; art. 11 resp. 13). The Swedish grid is exempted in accordance with article 11 (less than 1.5% cod). Danish targets for introduction of selective gear in the black and orange areas have been that an approved gear shall reduce cod catches by 70% compared to a baseline gear (90 mm trawl). There are obvious problems of using by-catch limits based on percentages, for example it can create perverse incentives not to reduce other catch components and is dependent on stock size structure. These and other aspects for defining appropriate metrics for gear selectivity will be considered in a STECF sub-

group meeting in October 2012.

The working group concluded that common definitions of minimum selectivity for cod are needed in order to clearly state what is needed in order to evaluate future gear options against common standards. Furthermore, the working group suggests that definitions are needed both to avoid small fish in the entire Kattegat (as these are more distributed) and for large fish in the partially and seasonally closed areas (where the large cod appear to reside).

4. Socioeconomic effects

ToR. c) Evaluate the effect of the closure on fisheries communities

- *Describe socioeconomic effects for selected fisheries communities.*

For the analysis of the effects of the closed areas, the two ICES-squares 41G2 and 42G2 are analysed (for orientation see Fig. 4.1). The two ICES-squares do not fit the closed areas perfectly, but they cover a large share of the areas. Looking at the port most dependent on fishery in these ICES-squares, Gilleleje in Denmark and Träslövsläge and Glommen in Sweden were identified.

The number of Gilleleje vessels active in Kattegat has been reasonably stable at 35-40 vessels since 2005. The importance of ICES-squares 41G2 and 42G2 has been reduced for the vessels. The average landings value per Gilleleje vessel has been reduced and so has the average landings value in 41G2 and 42G2.The latter reduction has primarily been due to reduced landings of cod and herring, while the landings of Nephrops have increased. Whether the reduction in average landings value has been due to the implemented restrictions or are just following the trends observed in the rest of Kattegat is impossible, with the available information, to analyse. However, the two squares still seem to be attractive for the Gilleleje vessels, given the increased number of vessels fishing there.

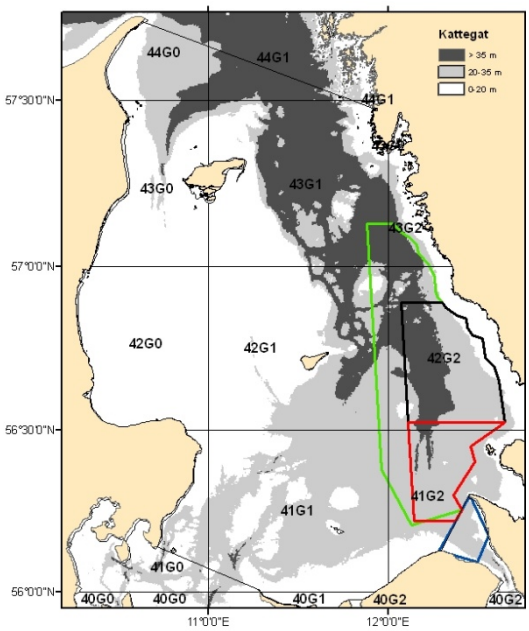

Fig. 4.1 Kattegat with ICES squares and closed areas.

Regarding total or average value of landings of the vessels in Glommen and Träslövsläge before and after the closure, there is no decreasing trend. In Glommen total value of landings has increased after the closure. For individual vessels there may have been a negative development though. There is a trend that larger vessels have decreased their share of value of landings in the ICES-squares 41G2 and 42G2. For Träslövsläge, the number has been stable except for a decrease in 2010 - 2011 from 26 to 20 vessels. The number of Glommen vessels active in the two ICES-squares has decreased, from 13 to 7 vessels. It is uncertain to what extent the closed areas has contributed to the development. Since the closure Nephrops has become economically more important for the two fishing communities while the importance of herring, sprat and cod has decreased.

The number of Gilleleje vessels fishing in the ICES-square 41G2 in the Sound (Kilen) have decreased to almost half the number before and after 2009 (From around 80 to around 40 vessels). Furthermore, the average landings value obtained by vessel fishing in 41G2 in the Sound has also been reduced after 2009, but was approximately at the same level in 2011 as in 2005. Before 2009, the Gilleleje vessels accounted for around 60% of the landings value obtained from fishing in 41G2 in the Sound, but this level was increased to around 90% after 2009. The number of Swedish vessels active in Kilen has been stable around 20-25 vessels 2005-2011. Average

value of landings for the vessels has been reduced after 2009, but was at the same level 2011 as in 2005. The share of value of landings from cod has decreased.

Conclusion

Since 2009 many policies and measures that affects the fishery in Kattegat have been revised and new measures have been implemented (e.g. changes in quotas, KW-days system). There is also a general rationalization going on in the fishery. An analysis of the development of the fishery as a whole in the ICES-squares 41G2 and 42G2 compared to the development in Kattegat shows that the development in the two ICES squares is similar to the overall development in Kattegat. The number of vessels active has decreased and the total value of landings has decreased. The 41G2- and 42G2 -share of the total value of landings in Kattegat has been stable over the years. The average value of landings per vessel in different length classes has generally not decreased, but there can be individual vessels that have had large decreases in value of landings. Nephrops has become economically more important both in Kattegat and the two ICES-squares.

The largest effect of the closure on the fisheries is probably on costs, as the closures may force the fishermen to move into other fishing areas. Unfortunately, there is no detailed data to measure this cost change. However, from the analysis on value of landings it is observed that there is no trend that the share of total value of landings from the two ICES-squares has diminished.

5. Potential effects for obtaining good environmental status

ToR. d) Describe potential effect of the closure for obtaining good environmental status (GES)

The indicators and targets for GES within the Marine Strategy Framework Directive (MSFD) have not been implemented yet and the ToR has therefore primarily been addressed from a theoretically perspective In addition, exploratory analyses was carried out to indicate if any trends in other fish species or benthic macrofauna could be related to the closed area. Given the generation times of fish and soft bottom macrofauna it is however unlikely that a general recovery would be detected as early as three years after the area was closed.

Preliminary exploration of fish assemblages and benthic macrofauna

Multivariate statistics indicated that the fish assemblages differed among areas and among the four years investigated, but no difference showing that the closures had developed over the 3 years different than the other areas (appendix 9). The trends in abundance of the most common fish species in the four areas are shown in the Appendix. For a few species, a higher abundance is indicated in the permanently closed area (Cod survey), but the trends are not consistent with those from the “Sole survey”.

Benthic macrofauna exhibited both temporal and spatial differences, but no interaction between year and area to indicating a recovery in the area where trawling has ceased (the permanently closed area). Again, three years is a short period for the recovery of long-lived species believed to be most vulnerable to trawling, especially in the perspective that trawling activity occurred in the area after the closure (see 3.2.1).

There was however differences in the community structure between sampling stations categorised as having high or low trawling intensity indicating that VMS positioning of bottom trawlers is a promising indicator for the pressure trawling exhibits on benthic macrofauna species composition.

In conclusion, the closed area evaluated in this report is no general solution to achieve GES for the descriptors most affected by fishery. Fishing has several effects on the marine environment and a suite of management tools including closed areas will be needed to make sure that GES is achieved. Fishing primarily affects MSFD descriptors 1, 3, 4, and 6 representing biodiversity, commercial species, food-webs and seafloor processes. Most obviously, the closed areas may contribute to the recovery of the Kattegat cod population towards GES. A rebuilt cod stock should also lead to more natural food webs with the potential for cod as a functional top-predator in the system. By protecting the sea-floor from abrasion by trawling, species sensitive to physical disturbance will be protected, and in that respect also biodiversity. For stationary species with local populations, the closed area may reduce evolutionary effects of fishing and maintain genetic diversity. Therefore, protecting a part of the sea from anthropogenic pressures should be a valid option when the level of pressures corresponding to sustainable use (sensu MSFD) are not known for all aspects of the marine environment.

6. Fisheries Control measures. Description and evaluation of the enforcement scheme

ToR. e) Evaluate the enforcement scheme for the closed areas

- *Describe the enforcement scheme, the extent of illegal fishing and quantify related cod catches*

To ensure that infringements are discovered an effective control is necessary. From a control point of view the most effective method is a fully closed area either permanently or periodically closed during the year. Air surveillance and vessel monitoring system (VMS) are effective ways to monitor such areas.

Permission to fish in an area with certain gears complicates monitoring when it largely relies on inspections at sea. Clear and precise rules result in an effective control and contribute to an increased respect for them. Restrictions on fishing in closed areas should apply to all nations who have the right to fish in the sea area.

Coordination between the two parties of the control operations at sea gives a higher presence and contributes to become more cost effective.

6.1 Description of the Swedish control

During 2009-2011 a total of 27 inspections at sea were carried out. The inspections resulted in 2 observed and reported infringements. The air surveillance resulted in 22 reported infringements. All infringements were detected in the permanently closed area.

6.2 Presentation of the Danish control measures in place in relation to the Cod Avoidance Plan in 2011

During the period from 2009 to 2011 the inspection of fishing vessels and the surveillance of the closed areas in Kattegat, has been given high priority by the Danish AgriFish Agency. In total 144 inspections were carried out in or in the vicinity of the closed areas, which resulted in 6 infringements. It has also been prioritized to inspect fishing vessels in port after fishing in Kattegat. The main focus for the inspections has been to assure compliance with the rules governing the closed areas, and the compliance with the rules governing the use of more selective fishing gears, which was introduced in 2009 and extended in the second half of 2011. In order to document the selective gear in use, national regulation was issued on the 14th of July 2011, demanding fishermen to report the exact type of gear used in the logbook. Inspections at sea and on landing in 2011 has shown that all the inspected vessels actually used or carried on board the new selective gears

as prescribed -although this was not always correctly registered in the vessels logbook.

7. Overall evaluation and recommendations

ToR. f) Recommend potential changes in objectives, area design, access criteria and monitoring and enforcement considering potential contribution to GES from the closure

7.1 Objectives

The primary objective of the closed area and the zonation of fisheries in the Kattegat is to protect and rebuild the cod stock by reducing the overall fishing mortality on cod. Since the cod spawning stock biomass (SSB) in the Kattegat still is at historically low levels, and below biomass reference points, the working group concluded that the objective to rebuild the stock is still valid. To specify the objective in detail the working group suggest to develop the objectives accordingly:

- To protect adults (decrease F and increase SSB) at age 2 and older (as cod in the Kattegat tend to mature already at age 2)
- To protect juveniles (i.e. 1 year old)

7.2 Area design and fishing impact

A change in area design must be viewed in the perspective of the range of fishing mortality and costs each design will generate. The most conservative design proposed so far is the original proposal in 2008 (Fig. 1.1), simply since this design encompasses the largest area of the cod distribution and provides the least access to fishing grounds. The working group, however, decided to base their assessment of the area design on the current regulation (Fig.1.2) in place as being an already agreed compromise between the industries need for access to fishing grounds and the ambition of the management to achieve the objective of reduced cod fishing mortality.

This report shows that Danish fishing effort in 2009 and 2011 has been redistributed into areas of lower CPUE of cod (based on modelled stock distribution from survey data), however high fishing intensity was recorded in the partially closed area in 2010. No major change is visible in Swedish effort distribution in the timeframe 2008-2011, as the permanently closed area was hardly fished by Sweden in 2008, and the Swedish effort continued in the partially closed area after the implementation of closures as Swedish fishers applied the use of sorting grid. The calculation of fishing impact shows that the area closures in combination with the general effort reduction in the Kattegat, and the use of more selective gears have reduced fishing

impact on cod to around 40% of what it was in 2008. The effect of the closures cannot, however, be disentangled from the use of selective gears since access to the otherwise closed area depends on use of selective gears.

Since the introduction of the closed area scheme in the Kattegat 2009, many new alternative trawl configurations have been introduced into legislation. The working group concluded that common definitions of minimum selectivity for cod is needed in order to clearly state what is needed in order to evaluate future gear options against common standards. Therefore, the working group suggests that definitions are needed both to avoid small fish in the entire Kattegat (as these are more widely distributed) and for large fish in the partially and seasonally closed areas (where the large cod appear to reside).

In summary, the working group concluded that the increase (in the range 45-112% as estimated by ICES) in SSB estimated for 2012 compared to the values estimated for 2009 can partly be attributed to the measures related to the implementation of closed areas. It is, however, unclear how the trends in harvest rates differ between stock units. Cod coming from spawning localities in the Kattegat can be assumed to be behaviourally different and distributed to other areas of the Kattegat than cod recruited from the North Sea. It is quite possible that the stock units we want to preserve are more confined to the closed and semi-closed areas than to other parts of the Kattegat, whereas cod recruited from the North Sea and migrating back at ages 2-3 are more widely spread and for the time being more susceptible to fishing.

As the current regulation includes both a seasonal protection and a permanent component, the assessment further is based on quarters of the year. The distribution of cod age 2 and older (2+) and comments on protection can be summarised as follows:

Quarter 1

Quarter 1 is the spawning period for cod, where age 2 and older cod contribute significantly to the spawning stock. There exist relatively good quality survey data to model cod distribution. The density of age 2+ cod is high in Kilen and in the permanently and partially closed areas. There is also a high density in the northern part of the seasonally closed area and Northwest of this area. The area design for the protection of spawning cod in the Kattegat appears to be appropriate.

There is no clear distributional pattern of juveniles. Available data indicate similar distributions as in quarter 4 (see below).

Quarter 2

There are presently no data available to model cod distribution. The historical targeted cod fishery was also continued in April, indicating similar cod aggregations as in the first quarter. Adult cod protection similar to Q1 also in April is thus justified

Quarter 3

Survey coverage is poor giving an uncertain cod distribution. Available data indicate similar distribution of age 2+ as in Quarter 4.

Quarter 4

Good trawl survey data are available to model cod distribution and complimentary survey by hydroacoustics. There is a high density of age 2+ cod in the partially and seasonally closed areas and North of the areas but also high concentration in the North-western part of Kattegat. Since implementation of the closures the distribution from the surveys indicates low density but increase in 2011 of larger cod in the partially, seasonally and permanently closed areas.

There are indications that juveniles are distributed mainly to the north-eastern Kattegat and to the south in vicinity to the Belt Sea. However, shallow areas both along the Swedish and, along the Danish coast have not been sampled at all. Also, structurally complex environments in rocky and moraine areas are excluded in the trawl surveys for obvious reasons. These areas constitute about half the surface of the Kattegat and such areas are also recognised as the most important types of nursery grounds for cod in general. We cannot therefore suggest where the juvenile cod are concentrating in the Kattegat as essential studies are missing.

7.3 Recommendation:

January- April:

b) Closed areas

Higher densities of larger, spawning cod are found in the closed areas. Recommendation: maintain the present regulation in the seasonally, partially and permanently closed areas in Kattegat (yet it is recommended that the closure period is extended to April due to historical fisheries). Maintain the present regulation in the Kilen area in the Sound.

b) Outside

To reduce the presently high discard of juvenile cod catches must be reduced. Fishery should therefore only be allowed with designs 1, 2, 4 and 5 (or gear with documented similar selectivity characteristics) in all other parts of Kattegat

May-December:

a) Closed areas

Higher density of larger cod is found in the partially closed area. Recommendation: maintain the partially closed area.

Low density of larger cod has in general been found in the permanently closed area, but survey results from December 2011 indicate an increase.

Recommendation by SLU scientists: maintain the permanently closed area. An option may be to allow access for selective gears that avoids by-catch of large cod, i.e. having retention probability of less than 10% for cod larger than 40 cm and catching less than 1,5% cod according to EC Council Reg. 1342/2008, Article 11. However, the working group could not agree on the need to apply this definition as discussed below.

Recommendation by DTU aqua scientists: The permanently closed area may be merged with the partially closed area, such that fisheries with selective gears (as discussed below) are allowed in the presently permanently closed area.

b) Outside

To reduce the presently high discard of juvenile cod catches must be reduced. Fishery should only be allowed with designs 1, 2, 4 and 5 (or gear with documented similar selectivity characteristics) in other areas of Kattegat.

Fishery in the partially and seasonally closed areas is today allowed with gear designs 4 (grid) and 5 (SELTRA 300). A larger protection of large cod is obtained by excluding design 5. This will, however, result in relatively higher catch of juvenile cod, and a loss of species like sole and plaice. The group was not in a position to quantify costs and benefits of changing the criteria for getting access to the seasonally, partially and permanently closed areas. There was no consensus in the working group on the need for changing the access criteria to those areas.

To monitor the effects of closed areas a targeted survey for cod is recommended by the working group. The current cod-survey has provided important input to this evaluation and it is recommended that this survey

continues. No S-DK joint cod survey will be carried out in 2012 due to lack of funding.

7.4 Potential contribution to Good Environmental Status (GES) from the closure

The closed areas evaluated in this report are not a general solution to achieve GES for the descriptors most affected by fishery. Fishing has several effects on the marine environment and a suite of management tools including closed areas will be needed to make sure that GES is achieved, especially for all aspects of biodiversity (MSFD Descriptor 1).

Most obviously, closed areas may contribute to the recovery of the Kattegat cod population towards GES (Descriptor 3). For stationary commercial species with local populations, the closed areas may reduce evolutionary effects of fishing and maintain genetic diversity (D3).

A rebuilt cod stock should also lead to more natural food webs with the potential for cod as a functional top-predator in the system (Descriptor4).

By protecting the sea-floor from abrasion by trawling in the permanently closed area, critical processes of benthic ecosystems are safe-guarded even though the response of these processes to fishing may not always be known (Descriptor 6).

It is recommended that Sweden and Denmark agree on common indicators and targets for GES (DIRECTIVE 2008/56/EC Article 5:2), and that these indicators are evaluated at the Kattegat scale. It is further suggested that relevant indicators from descriptors 1, 3, 4 and 6 are considered specifically when future monitoring related to the closed area for the protection of cod in the Kattegat is decided.

If management decides to change the spatial extent of the closed area or is to allow trawling during part of the year, potential effects on GES are to be considered. The permanently closed area has now been closed for 3 years and a large area not affected by trawling could develop there given a consistent management.

Appendices

Appendix 1. Cod in the Kattegat – stock identity

Appendix 2. Raw data on cod cpue from surveys

Appendix. 3. Changes in fishing mortality of Kattegat cod due to the introduction of closed areas and other management measures

Appendix 4. Statistical evaluation of the cod closures in Kattegat

Appendix 5. Assessment from hydro-acoustic surveys

Appendix 6. Documentation on trawls used in the Swedish Kattegat demersal fisheries

Appendix 7. Documentation of selective effect of gear designs used in Kattegat

Appendix 8. Analysis of the Danish fishery in restricted areas in Kattegat and the Sound initiated 1st January 2009

Appendix 9. Trends in fish species abundance in relation closures
Appendix 10. Effects of Kattegat closures on seafloor integrity

Appendix 11. Description of the Swedish control

Appendix 12. Presentation of the Danish control measures in place in relation to the Cod Avoidance Plan in 2011

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