6 Horse Mackerel: Divisions 27.4.a (Q1 and Q2), 27.3.a (excluding Western Skagerrak Q3 and Q4), 27.4.b, 27.4.c and 27.7.d

6.1 ICES Advice Applicable to 2018

In 2012 the North Sea horse mackerel (NSHM) was classified as a category 5 stock, based on the ICES approach to data-limited stocks (DLS). Since then, a progressive reduction of TAC was advised by ICES, from 25500 tonnes in 2013-2014 to 15200 tonnes in 2015-2016. This reduction in the advised catch was supported by the analysis of information from the North Sea International Bottom Trawl Survey (NS-IBTS) traditionally used in the assessment, but also new information from the Channel Ground Fish Survey (CGFS) since 2014. Despite the considerable increase showed by the CGFS in 2015 survey, due to the high uncertainty in the two survey indices, catch in 2017 was advised to continue at 15200 tonnes. However, new information indicated a 16.7% discards of NSHM in 2015 in non-directed fisheries. This new information is taken into account in the catch advice for 2017. The advice landings were 15200 tonnes and the advice total catch was 18247 tonnes.

In 2017 this stock was benchmarked and the NS-IBTS and CGFS survey indices where modelled together. The resulting joint index was considered a proper indication of trend in abundance over time and the NSHM stock was upgraded to category 3. The joint survey index showed in 2016 a continuation of the increasing trend started in 2013. The application of the HCR 3.1 (ICES, 2012, comparison of the two latest index values with the three preceding values multiplied by the recent advised catch) resulted in an increase higher than 20% in the catch advice for 2018 in comparison to advice for 2017. Accordingly the uncertainty cap was applied. In addition, Length Based DLS methods indicated that the F was in 2016 slightly above the F_{MSY} proxy, and stock size relative to reference points was unknown. Therefore, the precautionary buffer was also applied to the advice, since it hadn´t been applied since 2014. This resulted in a catch advice for 2018 and 2019 no more than 17517 tonnes. Considering the 13.35% average discards, were advice not being higher than 15179 tonnes.

6.2 Fishery of North Sea horse mackerel stock

Based on historical catches taken by the Danish industrial fleet for reduction into fishmeal and fish oil in the 1970s and 1980s, approximately 48% of the EU North Sea horse mackerel TAC was taken by Denmark. Catches were taken in the fourth quarter mainly in Divisions 27.4.b and 27.7.d. The 1990s saw a drop in the value of industrial fish, limited fishing opportunities and steep increases in fuel costs that affected the Danish quota uptake. In 2001, individual quota scheme for a number of species was introduced in Denmark, but not for North Sea horse mackerel. This lead to a rapid restructuring and lower capacity of the Danish fleet, which in combination with the above mentioned factors led to a decrease of the Danish North Sea horse mackerel catches.

Since the 1990's, a larger portion of catches has been taken in a directed horse mackerel fishery for human consumption by the Dutch freezer-trawler fleet. This is possible because Denmark has traded parts of its quota with the Netherlands for other species. However due to the structure of the Danish quota management setup only a limited amount of quota can be made available for swaps with other countries. These practical implications of the management scheme largely explain the consistent underutilisation of the TAC over the period 2010-2013 (approximately 50%). However, following the sharp reduction in TAC in 2014 uptake increased significantly to above 80% in 2015 and 100% in 2016 (see Figure 6.2.1), although an important part of these catches were discards (16.7% and 10% respectively). In 2017 the 80% of the TAC was used, with an 8.3% discards.

Catches taken in Divisions 27.3.a and 27.4.a during the two first quarters and all year in Divisions 27.4.b, 4.c and 27.7.d are regarded North Sea horse mackerel (Section 5, Table 5.4.1). The catches were relatively low during the period 1982—1997 with an average of 18000 tonnes, but increased between 1998 (30500 tonnes) and 2000 (45130 tonnes). From 2000 to 2010, the catches varied between 24149 and 45883 tonnes. Since 2014 a steep decline in catches is observed, both due to the reduction in the TAC since 2014 but also the underutilization of the quota. In 2017 the catch was 14579 tonnes, with an 82% of total catch being caught in area 27.7.d.

Over the period 1985-2001 most catches were taken in the area 27.4.b (Figure 6.2.3). However, since 2002 the proportion of catches from area 27.7.d increased steadily until 2013, when the 92% of total catches were fished in this area (Figure 6.2.2). Germany, UK and Netherlands accounted for most of the landings, that were taken in quarter 1, but especially in quarter 4 (Figure 6.2.3). Most of the discards were reported in area 7d, more importantly during quarters 3rd and 4th, by the French bottom-trawl fleet. Discarding in the target pelagic fisheries is considered negligible. New information in 2015 from bottom-trawl fisheries not directed at horse mackerel indicated an overall discard rate of 16.7% for the stock as a whole, while in 2016 this rate is 10%. Complete discard information for earlier years has not been submitted to ICES. However, information from national discard reports for the non-directed bottom-trawl fisheries indicates a similar level of discarding in earlier years.

6.3 Biological Data

6.3.1 Catch in Numbers at Age

In 2017, as already occurred in 2016, there has been a marked reduction in the coverage of biological sampling. Only the 38% of landings was sampled, in comparison to 2013 and 2014 when 71% and 63% were sampled respectively (section 5 figure 5.9.1). In addition, this low coverage was carried out mostly by the Dutch fleet in quarter Q4 and divisions 27.7.d and 27.4.c. Despite most landing catch was taken from this area and quarter (81.9% of landings in division 27.7.d and 75% in quarter Q4, Figure 6.3.1) still part of landings were fished in other areas and quarters. In order to avoid a biased perception of the age distribution of catches over the year and areas, this partial and uneven sampling effort should be avoided in future years.

Annual catch numbers at age by area for year 2017 are shown in table 6.3.1. Due to the low level of sampling effort out of area 27.7.d., there is not enough information to represent age distribution in those areas, and hence, the one observed in 27.7.d is taken as the basis to separate catch by age. Catch-at-age for the whole period 1995-2017 are given in, table 6.3.2 and in Figure 6.3.2. These data show that since 2005 the age distribution of catches has experienced a reduction, with a decrease in the range of ages of importance in total catches. In parallel to the rejuvenation of catches, the comparison of catch-at-age data after 1998 by area (Figure 6.3.3) shows that since 2010 commercial catches have increased in area 27.7.d in comparison to the areas 27.3.a and 4a,b and c where the opposite pattern was found. Since 2015, commercial catches are focused mostly on cohort 2014 that was the main component of catches both in and out of the area 27.7.d at age 1 in year 2015, age 2 in 2016 and age 3 in 2017. Ages 1 and 2 appear with moderate importance in the total catch.

Although 2015 cohort seems to be clear in the catch-at-age distribution, in general cohort structure is not clearly detectible in the data. This may partly be due to the shifts in distribution of the fishery. In addition, it may partly be due to age reading difficulties, which are a known to be encountered (e.g. Bolle *et al*., 2011). Most clearly detectable is the relatively large 2001 year class, although it is not clearly present in the catch in all years. There are indications that environmental circumstance may be an important factor (possibly stronger than stock size) contributing to spawning success in horse mackerel. This is for example illustrated by the largest year classes (1982 and 2001) observed in the Western stock which incidentally were produced at the lowest observed stock sizes. Since 2001 is considered to have been a relatively strong year class in the Western stock as well, it is plausible that circumstances in the North Sea were similar to those in Western areas and also allowed for relatively high spawning success in the North Sea.

Lastly, potential mixing of fish from the Western and North Sea stock in area 27.7.d and 27.7.e in winter may also confuse the cohort signals. For example, the large recruitment in the Western stock may have led to more of these fish being located in the North Sea stock area as age 1 fish in 2002. With the intention of clarifying the mixing among the North Sea and the Western horse mackerel stocks, and how this may affect to the age distribution of catches. In 2015 was conducted by IMARES and the Pelagic Freezer-trawler Association (PFA). The results of this project were not conclusive because of the low sample size and some technical glitches in the sequencing. The chemical analysis generated some new insights but also some more questions on the variability that could be expected between years and seasons. Currently more genetic samples are being taking by PFA in different areas of the North East Atlantic. In addition, catch sampling carried out by several pelagic fishery companies is being explored to give information on the separation between North Sea and Western horse mackerel. Until the mixing of both stocks is clarified and catch-at-age data can be clearly segregated the development of analytical assessment will be limited.

6.3.2 Mean weight at age and mean length at age

The mean weight and mean length-at-age in the commercial catches of 2017 are presented in tables 6.3.3 and 6.3.4 respectively by quarter and area. As explained for the distribution of catch-at-age by area, due to the biased sampling coverage in 2017 for several ages mean weight and length in quarters Q2-Q3 in areas 27.3.a, 24.7.a-b-c are assumed the same than in quarter Q1-Q4 in area 27.7.d.

The mean annual weight and length over the period 2000-2016 are presented in table 6.3.2 and figures 6.3.4 and 6.3.5 respectively. Despite there are no strong differences over this period, since 2006 there seems to be a slight but steady increase in both weight and length until 2015, when a declining pattern is observed. It may be hypothesized that this is due to density-dependent effects, due to the relatively successful recruitment of 2015.

6.3.3 Maturity-at-age

Peak spawning in the North Sea falls in May and June (Macer, 1974), and spawning occurs in the coastal regions of the southern North Sea along the coasts of Belgium, the Netherlands, Germany, and Denmark.

There is no information available about the maturity-at-age of the North Sea Horse mackerel stock.

6.3.4 Natural mortality

There is no specific information available about natural mortality of this stock.

6.4 Data Exploration

6.4.1 Catch curves

The log-catch numbers were plotted by cohort to estimate the negative gradient of the slope and get an estimate of total mortality (Z). Fully selected ages 3 to 14 from the 1992 – 2016 period provide complete data for the 1992 to 2006 cohorts (Figure 6.4.1). The estimated negative gradients by cohort (Figure 6.4.2) indicate an increasing trend in total mortality for the period examined, with a marked increment in the cohorts 2005 and 2006. However, due to the low quality of the signals for some cohorts these Z estimates has to be considered with caution.

An analysis of the catch number at age data carried out in 2011 showed that only the 1vs.2, 2vs.3, 7vs.8 and 8vs.9 age groups were positively and significantly correlated in the catch. This analysis was not updated this year but these results suggest limitations in the catch-at-age data.

6.4.2 Assessment models and alternative methods to estimate the biomass

In 2002 Ruckert *et al.* estimated the North Sea horse mackerel biomass based on a ratio estimate that related cpue data from the IBTS to cpue data of whiting (*Merlangius merlangus*). The applied method assumes that length specific catchability of whiting and horse mackerel are the same for the IBTS gear. Subsequently, they use the total biomass of whiting derived from an analytical stock assessment (MSVPA) to estimate the relationship between cpue and biomass.

At the 2014 WGWIDE some exploratory model fits were attempted with the JAXass model, using the data available. The JAXass (JAX assessment) model is a simple statistical catch-at-age model fitted to an age-aggregated index of (2+) biomass, total catch data and proportions at age from the catch. It is based on Per Sparre's "separable VPA" model, an ad hoc method tested for the first time at WGWIDE in 2003, and later 2004. A new analysis using this model was also done in 2007 using an IBTS index. In 2014 the model has been coded in ADMB (Fournier *et al*., 2012) and updated with an improved objective function (dnorm), extra years of data and new methods for calculating the index (see above).

Difficulties in fitting an assessment model for this stock include:

- Unclear stock boundaries

- Difficulty aging horse mackerel

- Lack of strong cohort signals in CAA data.

- Scientific index derived from a survey not specifically designed for horse mackerel and not covering one of the main fishing grounds for the stock (VIId)

Catches taken in area 27.7. d are close to the management boundary between the (larger) western horse mackerel stock and the NS horse mackerel stock. It is quite possible that given changes in oceanographic condition, or changes in abundance of either of the two stocks, that some proportion of the catches taken in area 27.7.d actually originated from the western horse mackerel stock. Nevertheless, all assessment models used in the MSE assume that 100% of fish caught in area 27.7.d belong to the North Sea horse mackerel stock. This is in agreement with stock and management definitions.

6.4.3 Survey data

6.4.3.1 Egg Surveys

No egg surveys for horse mackerel have been carried out in the North Sea since 1991. Such surveys were carried out during the period 1988—1991. SSB estimates are available historically. However, they were calculated assuming horse mackerel to be a determinate spawner. Horse mackerel is now considered an indeterminate spawner. Therefore egg abundance could only be considered a relative index of SSB. The mackerel egg surveys in the North Sea do not cover the spawning area of horse mackerel.

6.4.3.2 IBTS Survey Data

Many pelagic species are frequently found close to the bottom during daytime (which is when the IBTS survey operates) and migrate upwards predominantly during the night they are susceptible to semi-pelagic fishing gear and to bottom trawls (Barange *et al.* 1998). Eaton *et al.* (1983) argued that horse mackerel of 2 years and older are predominantly demersal in habit. Therefore, in the absence of a targeted survey for this stock, the IBTS is considered a reasonable alternative. IBTS data are also used in the assessment of the southern horse mackerel stock.

IBTS data from quarter Q3 were obtained from DATRAS and analysed. Based on a comparison of IBTS data from all 4 quarters in the period 1991—1996, Ruckert *et al.* (2002) showed that horse mackerel catches in the IBTS were most abundant in the third quarter of the year. In 2013 WGWIDE considered that using an ‘exploitable biomass index’ estimated with the abundance by haul of individuals larger than 20 cm is the most appropriate for the purpose of interpreting trend in the stock.

To create indices, a subset of ICES rectangles was selected. Rectangles that were not covered by the survey more than once during the period 1991—2012 were excluded from the index area. In 2012, WGWIDE expressed concern that the previously selected index area did not sufficiently cover the distribution area of the stock, especially in years that the stock would be relatively more abundant and spread out more. Ruckert *et al.* (2002) also identified a larger distribution area of the North Sea stock. Based on the above, 61 rectangles were identified to be included in the index area as shown in Figure 6.4.3.

6.4.3.3 The French Channel Groundfish Survey (CGFS) in Q4

In order to improve data basis for the North Sea horse mackerel assessment, alternative survey indices have been explored. Previous indices used had only cover the North Sea distribution of the stock, while the majority of catches in recent years have come from the eastern English Channel (27.7.d). We evaluated the potential contribution of the French Channel Ground Fish Survey in 27.7.d (CGFS) in Quarter 4. The CGFS is carried out since 1990 and has frequent captures of horse mackerel. Though this survey is conducted in a different quarter to the North Sea IBTS, the observed seasonal migration patterns of horse mackerel indicate that fish move into the channel following quarter Q3, so the timing is considered appropriate.

In 2015, the RV “Gwen Drez” was replaced by the RV “Thalassa” to carry out the CGFS survey. In 2014 an inter-calibration process was conducted to quantify the differences in catchability for a large number of species. ICES reviewed this inter-calibration exercise and found a number of drawbacks that may undermine the reliability of the estimated conversion factors. The main concerns were:

- The analyses were limited in the number of tows. Considering that a number of these tows could be zeros for one of the two vessels and possibly resulting in highly uncertain estimates.
- Lack of length-specific correction factor.
- At a standardized depth of 50 m and above, wing spread estimates for the R/V Thalassa as measured by the MARPORT sensor were deemed erroneous, which may question the validity of estimated area swept by the net on the R/V Thalassa and the effect it may have on correction factors for species caught at depth at 50m and greater.
- A number of tow locations including areas outside 27.7.d were excluded. Changing the depth range of a survey can add serious bias in the calibration and the current approach seems to be ignoring this issue.
- Correction coefficients were not measured without error.

However, these limitations were considered by WGWIDE to be of minor importance for the North Sea horse mackerel since:

- Despite being still a low sample size the North Sea horse mackerel was present in all the 32 paired hauls.
- There are no important differences in size distribution (Figure 6.4.4).
- The analysis with and without the areas excluded in the new sampling design did not show important differences (ICES, 2017).
- cpue or North Sea horse mackerel for hauls deeper than 50 m was relatively low (Figure 6.4.5), and it is expected than the potential problems in determining the conversion factor bellow that depth range would have a relatively minor impact in the estimated abundance.

For these reasons it was finally decided to continue using the CGFS survey, standardizing the time-series of abundance for the period 1990-2015 with the estimated conversion factor 10.363.

6.4.3.4 Norht Sea horse mackerel benchmark exercise

In January 2017, a benchmark process was conducted for NSHM (ICES, 2017). Based on capacity to model the overdispersion and the high proportion of zero values in the survey catch data the hurdle models was concluded the best option of all the model alternatives tested. The log-likelihood ratio test, the AIC and the evidence ratio statistic supported that the model that best represented the data was a hurdle model with Year and Survey as explanatory factors (including the interaction term) in the count model (GLM-negative binomial), and Year and Survey (without the interaction) in the zero model (GLM-binomial).

The probability of having a cpue zero was modelled by a logistic regression with a GLM-binomial distribution model:

$$logit(\pi_i) = Intercept_{zero} + Year_{i,zero} + Survey_{i,zero}$$

Where π_i is the mean probability of having a cpue zero as a function Year and Survey.

The expected cpue of North Sea horse mackerel, conditional to not having a zero in hurdle models (not having a false zero in zero inflated models) was modelled with a GLM-negative binomial distribution model:

$$\log(CPUE_i) = Intercept_{count} + Year_{i,count}\ x\ Survey_{i,count}$$

This model was used to synthesise the information from both the GCFS and IBTS and predict the average annual cpue index per haul as an indicator of trends in stock abundance both for the juvenile (<20cm) and exploitable (>20cm) substocks. The contribution of the two surveys to the combined index is weighted taken into consideration their respective surface coverage as well as the mean wing spread. This index model allowed upgrading the NSHM to a category 3 stock within the ICES classification.

6.4.4 Summary of index trends

The survey index for both the small and exploitable substocks experienced a marked decline in the early-mid 2000s (Figure 6.4.6; table 6.4.1). This reduction was due in part to the decline of the average abundance by haul over time, but also to the increase of hauls with zero catch of horse mackerel, from 26% in 1998 to the highest observed value of 72% in 2013 (Figure 6.4.7). Since 2014 a slight decrease in zero hauls was observed in juveniles group (smaller than 20 cm). Since 2013, in addition to the decline of zero hauls, the mean cpue in the non-zero hauls has increased. After an increase in 2016, the abundance survey index for the exploitable substock has shown a marked decline in 2017. This pattern has been mostly due to the decline of the survey index estimated for the CGFS in comparison to the value in 2016 (Figure 6.4.8). The survey index of the juvenile substock, that also showed an increasing pattern since 2013, seems to be stabilized since 2014 in the CGFS, but in the IBTS is in 2017 at the lowest level since 1992. Due to this compensation by the CGFS, the abundance index for juveniles, show a less steep decline than the exploitable substock index. The size distribution in both the CGFS and the IBTS suggest the entrance of a moderate new cohort in 2017 (between 4-7cm in the IBTS and 7-11cm in the CGFS) age 0 (Figures 6.4.9 and 6.4.10).

However, despite the index of abundance of individuals smaller than 20 cm could be considered a recruitment index, it has to be considered with caution. Preliminary examinations of how the juvenile (0–19cm) indices relate to subsequent exploitable abundance (20+ cm) do not indicate strong linkages. The very high juvenile indices in the early 2000s in the IBTS were not subsequently picked up in the exploitable component. Hence while increases in the juvenile indices are encouraging, whether these lead to increases in the exploitable component of the stock need to be confirmed in the future with observations in the 20+ cm indices.

6.4.5 Data Limited Stock methods and MSY proxy reference points

As part of the ICES approach to provide advice within the MSY framework for stocks of category 3 and 4, different Data Limited methods to estimate MSY proxy reference points for the North Sea horse mackerel were explored. This analysis and results were presented in a separate working document (Pérez-Rodríguez, 2017). After exploring the compliance with each method assumptions and assessing the data availability the group decided that the Length Based Indicators would be the only DLS method to be applied to the NSHM.

Despite this length based method will have to be applied in the future to a longer time-series of catch length frequencies, only length data have been collected for 2016 and 2017. The estimates of F/F_{MSY} proxy indicate that fishing mortality seems to be, both in

2016 and 2017, slightly above F_{MSY} for the North Sea horse mackerel, with F/F_{MSY}=1.082 and 1.073 respectively (Figure 6.4.11).

6.4.6 Ongoing work

To improve the knowledge base for North Sea horse mackerel about the degree of connection and migrations in between the North Sea and the Western Stock, catch sampling carried out by several pelagic fishery companies is being explored to give information on the separation between North Sea and Western horse mackerel. To improve the abundance indicators the potential application of a commercial fishery search time index will be explored. Horse mackerel is fished while it is very close to the bottom in relatively dispersed, small schools. The fishery is mostly executed using long hauls and there may be extensive search time involved. Handled in an appropriate statistical framework, taking into account the nature of the fishery and other factors such as seasonality and alternative fishing opportunities, the search time and catch rates could provide for an indication of changes in stock size over time. Catch rates in areas 27.7.e, 27.7.d and southern North Sea will be analysed from skippers' private logbooks.

6.5 Basis for 2019 Advice. ICES DLS approach.

Stock advice for NSHM is biannual. In 2017 the advice for years 2018 and 2019 was provided. The joint abundance survey index indicated a continuation in the increasing trend observed since 2013. This increase was due mostly to the increment observed in the CGFS survey index. Despite that, as mentioned in the previous section, the joint survey index for 2017 has shown a sudden change and steep decline due to the drop of the CGFS survey index, WGWIDE decided to continue with the current advice of 17517 tonnes for 2019.

The fisheries in the area have largely been focused on the smaller fish in 2015, 2016, 2017 and it is expected that this will continue in 2018 and 2019. With this pattern of exploitation, mostly immature individuals are caught which might hinder the recovery of the stock by removing an important portion of the recent year classes before they enter the spawning stock.

6.6 Management considerations

In the past, Division 27.7.d was included in the management area for Western horse mackerel together with Divisions 27.2.a, 27.7.a–c, 27.7.e–k, 27.8.a, 27.8.b, 27.8.d, 27.8.e, Subarea 6, EU and international waters of Division 5.b, and international waters of Subareas 12 and 14. ICES considers Division 27.7.d to be part of the North Sea horse mackerel distribution area. Since 2010, the TAC for the North Sea area has included Divisions 27.4.bc and 27.7.d. Considering that a majority of the catches are taken in Division 27.7.d, the total of North Sea horse mackerel catches are effectively constrained by the TAC since the realignment of the management areas in 2010.

Catches in Divisions 27.3.a (Western Skagerrak) and 27.4.a in quarters 3 and 4 are considered to be from the Western horse mackerel stock, while catches in quarters 1 and 2 are considered to be from the North Sea horse mackerel stock. Catches in area 27.4.a and 27.3.a are variable. In recent years only Norway has had significant catches in this area, but these are only taken in some years.

6.7 References

Aitchison, J. 1955. On the distribution of a positive random variable having a discrete probability mass at the origin. J Am Sta Assoc 50:901–908.

Barange, M., Pillar, S. C., and Hampton, I. 1998. Distribution patterns, stock size and life-history strategies of Cape horse mackerel Trachurus trachurus capensis, based on bottom trawl and acoustic surveys. South African Journal of Marine Science, 19: 433–447.

Bolle, L.J., Abaunza, P., Albrecht, C., Dijkman-Dulkes, A., Dueñas, C., Gentschouw, G., Gill, H., Holst, G., Moreira, A., Mullins, E., Rico, I., Rijs, S., Smith, T., Thaarup, A., Ulleweit, J. 2011 . Report of the Horse Mackerel Exchange and Workshop 2006. CVO report: 11.007.Eaton, D. R. 1983. Scad in the North-East Atlantic. Laboratory Leaflet, Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research, Lowestoft, 56: 20 pp.

Eaton, D. R. 1983. Scad in the North-East Atlantic. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft (56): 20pp.

Fletcher, D., 2008. Confidence intervals for the mean of the delta-lognormal distribution. Environ Ecol Stat (2008) 15:175–189.

ICES. 2012. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp.

ICES. 2017. Report of the Benchmark Workshop on Widely Distributed Stocks (WKWIDE), 30 January–3 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:36. 196 pp

Macer, C.T. 1974. The reproductive biology of the horse mackerel *Trachurus trachurus* (L.) in the North Sea and English Channel. J. Fish Biol., 6(4): 415-438.

Pennington, M., 1996. Estimating the mean and variance from highly skewed marine data. Fishery Bulletin 94:498-505.

Pérez-Rodríguez, A. 2017. Use of Length Based Indicators to estimate reference points for the North Sea horse mackerel. Working Document to WGWIDE, 6pp.

Punt, A. E., Smith, D. C., and Smith, A. D. M. 2011. Among-stock comparisons for improving stock assessments of data-poor stocks: the “Robin Hood” approach. – ICES Journal of Marine Science, 68: 972–981.

Rückert, C., Floeter, J., A. Temming. 2002: An estimate of horse mackerel biomass in the North Sea, 1991-1997. - ICES Journal of Marine Science, 59: 120-130.

6.8 Tables

Table 6.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2017.

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.99	44.35	96.06	10.51	0	151.91
2	0.9	40.45	87.61	9.59	1579.74	1718.29
3	2.73	122.35	265.02	29	6243.76	6662.86
4	0.4	17.94	38.85	4.25	4502.28	4563.72
5	0.25	11.08	24	2.63	3308.95	3346.91
6	0.15	6.87	14.89	1.63	1229.79	1253.33
7	0.11	4.99	10.8	1.18	2074.86	2091.93
8	0.1	4.45	9.63	1.05	1604.79	1620.02
9	0.04	1.75	3.78	0.41	558.59	564.58
10	0.01	0.49	1.06	0.12	261.55	263.23
11	0.02	1.02	2.2	0.24	297.05	300.53
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.01	0.49	1.06	0.12	261.55	263.23
15	0.01	0.49	1.06	0.12	261.55	263.23
Sum	5.72	256.7	556.04	60.84	22184.47	23063.76
2Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	16.65	24.39	17.35	411.9	828.12	1298.41
2	15.18	22.24	15.83	375.67	755.27	1184.19
3	45.93	67.28	47.87	1136.4	2284.7	3582.19
4	6.73	9.86	7.02	166.61	334.96	525.18
5	4.16	6.09	4.34	102.93	206.94	324.46
6	2.58	3.78	2.69	63.83	128.32	201.19
7	1.87	2.74	1.95	46.31	93.1	145.97
8	1.67	2.44	1.74	41.29	83.02	130.17
9	0.66	0.96	0.68	16.22	32.61	51.13
10	0.18	0.27	0.19	4.55	9.15	14.35
11	0.38	0.56	0.4	9.45	18.99	29.77
12	0	0	0	0	0	0

13	0	0	0	0	0	0
14	0.18	0.27	0.19	4.55	9.15	14.35
15	0.18	0.27	0.19	4.55	9.15	14.35
Sum	96.37	141.15	100.44	2384.26	4793.5	7515.73

3Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	59.57	59.57
1	0	0	70.95	111.67	1329.97	1512.59
2	0	0	64.71	101.85	1212.97	1379.53
3	0	0	195.75	308.08	3669.25	4173.08
4	0	0	28.7	45.17	537.94	611.81
5	0	0	17.73	27.9	332.34	377.98
6	0	0	10.99	17.3	206.08	234.38
7	0	0	7.98	12.55	149.52	170.05
8	0	0	7.11	11.19	133.33	151.64
9	0	0	2.79	4.4	52.38	59.57
10	0	0	0.78	1.23	14.7	16.72
11	0	0	1.63	2.56	30.5	34.68
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.78	1.23	14.7	16.72
15	0	0	0.78	1.23	14.7	16.72
Sum	0	0	410.69	646.39	7757.96	8815.04
4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	391.05	391.05
1	0	0	6.18	1874.01	15901.14	17781.33
2	0	0	5.64	4425.6	12187.97	16619.21
3	0	0	17.06	11524.87	36654.11	48196.04
4	0	0	2.5	1611.53	2872.44	4486.47
5	0	0	1.55	250.28	1730.29	1982.11
6	0	0	0.96	0	1722.52	1723.48
7	0	0	0.7	0	413.71	414.4
8	0	0	0.62	0	542.37	542.99
9	0	0	0.24	0	263.86	264.1
10	0	0	0.07	0	0	0.07
11	0	0	0.14	0	173.56	173.7

12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.07	0	0	0.07
15	0	0	0.07	0	0	0.07
	0	0	786.34	999.45	80108.12	81893.91

1-4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	450.61	450.61
1	17.64	68.73	190.55	2408.1	18059.23	20744.25
2	16.09	62.69	173.79	4912.7	15735.95	20901.21
3	48.66	189.63	525.7	12998.35	48851.82	62614.16
4	7.13	27.8	77.07	1827.55	8247.61	10187.17
5	4.41	17.18	47.62	383.74	5578.52	6031.46
6	2.73	10.65	29.53	82.76	3286.72	3412.39
7	1.98	7.73	21.42	60.04	2731.19	2822.36
8	1.77	6.89	19.1	53.54	2363.51	2444.81
9	0.69	2.71	7.5	21.03	907.44	939.38
10	0.19	0.76	2.11	5.9	285.41	294.37
11	0.4	1.58	4.37	12.25	520.09	538.69
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.19	0.76	2.11	5.9	285.41	294.37
15	0.19	0.76	2.11	5.9	285.41	294.37
Sum	102.09	397.85	1102.97	22777.77	107588.92	131969.6

Table 6.3.2. Numbers at age (millions), weight at age (kg) and length at age (cm) for the North Sea horse mackerel 1995-2017 in the commercial fleet catches.

MILLIO

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	1.8	4.6	12.6	2.3	12.4	70.2	12.8	60.4	13.8	15.7	52.4	5	3.4	1.7	34.1	3.3	8.1	9.5	7.6	15.4	49.7	3.6	20.7
2	3.1	13.8	27.2	22.1	31.5	78	36.4	16.8	56.2	17.5	29.8	23.7	15.5	8.8	13.9	22.5	23.3	24.3	10	15.3	23.8	65.2	20.9
3	7.2	11	14.1	36.7	23.1	28.4	174.3	19.3	23.4	34.4	27.8	61.5	22.8	36.1	28.4	10.7	76.5	20.4	21.3	8.7	10.1	15.9	62.6
4	10.3	11.9	14.9	38.8	17.6	21.4	87.8	11.9	33.2	14.5	12.6	40.9	82.6	16.7	22.1	15.7	37.3	40.2	22.2	30.2	5.8	9.8	10.2
5	12.1	9.6	14.6	20.8	23.1	31.3	18.5	5.6	26.9	27.8	16.7	73	71.2	36.4	17.3	23.7	14.6	25.8	27.1	13.8	7.2	7.7	6
6	13.2	12.5	12.4	12.1	26.2	19.6	11.5	5.8	10.6	20.2	5.2	23.4	30.5	36.1	16.3	15.9	9.9	20.8	6	7.1	3.8	5.7	3.4
7	11.4	8	10.1	14	20.6	19.5	18.3	5.5	6.3	10.6	2.9	13.7	23.9	27.3	21.5	27.6	5.8	3.1	7.2	2.7	3.3	2.5	2.8
8	12.6	6.6	8.6	10.8	21.8	9	14.7	10.5	9.6	3.8	2.4	5.9	17.3	21.9	47.1	5.6	6	5	4.3	3.4	1.4	5.1	2.4
9	7.3	1.5	2.5	8.3	12.9	11.5	10.2	6.3	10.9	5.4	3.8	1.6	7.9	10.2	11.2	6.3	3.4	4.6	4	0.9	1.6	1.2	0.9
10	5.9	5.3	0.8	4	8.2	9	10	6.8	1.5	11	5.8	1.4	1.7	7.5	9.3	8.3	10.1	1.5	5.4	1	0.9	0.1	0.3
11	0	0.3	0.3	2.7	2.1	7	9.6	5.1	3.4	6.2	2.3	0.2	0.6	1.9	7.2	2.9	6.9	0.5	3.7	1.3	0.2	0.1	0.5
12	8.8	1.3	0.3	0.7	0.4	3.1	5.4	3	3.3	4.5	4.1	1.7	0.2	2.1	3.7	0.3	3.6	0.1	1	0.4	0.9	0.4	0
13	0.2	8.9		1.8	1.4	1.6	3.7	2.2	2.3	6.2	2.5	0.6	0.7	0.4	0.3	0.3	0.8		0.6	0	0.2	1.4	0
14	4.4	8	1.4	0.3	3.8		2	1.3	3.4	2.3	9.9	1	0.7	2.4	0.9	0.2	0.3	0.2	0	0.2	0.2	0.5	0.3
15+				5.1	4	12.2	5.8	2.7	4.7	8.5	9.6	0.8		1	6.1	1.1	0.5		0.1	0.1			0.3

KG	WEIGHT																						
AGE	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	0.076	0.107	0.063	0.063	0.063	0.075	0.067	0.066	0.075	0.076	0.07	0.074	0.615	0.063	0.074	0.077	0.061	0.069	0.077	0.078	0.062	0.07	0.06
2	0.126	0.123	0.102	0.102	0.102	0.1	0.09	0.096	0.105	0.105	0.087	0.098	0.081	0.096	0.087	0.101	0.092	0.09	0.099	0.11	0.099	0.093	0.086
3	0.125	0.143	0.126	0.126	0.126	0.137	0.094	0.129	0.122	0.122	0.104	0.116	0.104	0.109	0.113	0.118	0.096	0.118	0.112	0.113	0.13	0.115	0.113
4	0.133	0.156	0.142	0.142	0.142	0.152	0.117	0.155	0.136	0.146	0.133	0.124	0.115	0.125	0.134	0.137	0.115	0.142	0.138	0.135	0.15	0.126	0.131
5	0.146	0.177	0.16	0.16	0.16	0.165	0.159	0.171	0.164	0.174	0.159	0.141	0.13	0.145	0.152	0.155	0.145	0.152	0.166	0.144	0.169	0.158	0.173
6	0.164	0.187	0.175	0.175	0.175	0.192	0.183	0.195	0.18	0.198	0.197	0.178	0.163	0.161	0.182	0.183	0.166	0.172	0.18	0.177	0.196	0.155	0.189
7	0.161	0.203	0.199	0.199	0.199	0.194	0.198	0.216	0.193	0.224	0.238	0.212	0.192	0.193	0.195	0.206	0.193	0.183	0.2	0.184	0.26	0.162	0.177
8	0.178	0.195	0.231	0.231	0.231	0.216	0.201	0.227	0.212	0.229	0.248	0.247	0.197	0.221	0.258	0.199	0.193	0.188	0.216	0.201	0.29	0.235	0.188
9	0.165	0.218	0.25	0.25	0.25	0.244	0.237	0.228	0.24	0.256	0.259	0.236	0.257	0.286	0.253	0.241	0.305	0.212	0.223	0.222	0.265	0.246	0.222
10	0.173	0.241	0.259	0.259	0.259	0.283	0.246	0.253	0.27	0.29	0.287	0.286	0.255	0.295	0.322	0.227	0.334	0.204	0.226	0.22	0.312	0.359	0.233
11	0.317	0.307	0.3	0.3	0.3	0.286	0.26	0.303	0.24	0.3	0.335	0.237	0.517	0.273	0.422	0.284	0.345	0.275	0.242	0.264	0.262	0.369	0.257
12	0.233	0.211	0.329	0.329	0.329	0.354	0.286	0.293	0.298	0.297	0.349	0.261	0.279	0.309	0.447	0.234	0.408	0.195	0.263	0.287	0.318	0.379	
13	0.241	0.258	0.367	0.367	0.367	0.316	0.287	0.317	0.356	0.301	0.338	0.267	0.339	0.375	0.383	0.288	0.474		0.262	0.252	0.351	0.242	
14	0.348	0.277	0.299	0.299	0.299		0.295	0.32	0.316	0.338	0.373	0.302	0.414	0.277	0.362	0.315	0.415	0.187	0.559	0.408	0.235	0.39	0.214
15+	0.348	0.277	0.36	0.36	0.36	0.35	0.336	0.389	0.353	0.402	0.375	0.404		0.389	0.46	0.351	0.475		0.339	0.273		0.378	0.26

CM LENGTH

AGE	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	19.2	19.2	19.2	19.2	19.2	19.1	19.5	19.4	20.3	19.8	18.1	20.1	19.9	20	20.3	20.8	19.2	19.9	20.9	20.4	19.8	20	19.1
2	22	22	22	22	22	21.5	21.5	21.7	22.3	22.2	21.5	22	20.8	21.6	21.6	22.6	21.7	21.7	22.4	22.9	22.9	22	21.3
3	23.5	23.5	23.5	23.5	23.5	23.9	21.9	23.8	23.7	23.6	22.9	23.4	22.5	23.2	23.2	23.9	23	23.5	23.5	23.6	24.6	23.6	23.3
4	24.8	24.8	24.8	24.8	24.8	24.9	23.4	25.4	24.6	25.2	24.7	24.1	23.6	24.1	24.6	25	24.5	25	25.3	24.8	25.8	24.8	24.1
5	25.5	25.5	25.5	25.5	25.5	26	26.7	26.3	26.2	26.6	25.9	25.4	24.4	25.6	25.8	25.7	25.9	25.7	27	25.4	26.6	26.4	26.7
6	26.4	26.4	26.4	26.4	26.4	27.6	27.5	27.4	27.3	27.5	27.7	27	26.6	26.3	27.2	27.1	27.6	27	27.1	27.3	28.2	26.1	27.5
7	27.2	27.2	27.2	27.2	27.2	28.1	28.1	28.6	28.2	28.8	29.8	28.6	27.8	28.1	28.1	28.3	27.7	27.1	28.3	27.5	30.4	27.5	27.5
8	29.2	29.2	29.2	29.2	29.2	28.6	28.5	29.3	29	29.2	30.4	29.8	28.1	28.8	30.6	28.4	27.8	27	28.9	28	31.7	30.2	28
9	29.5	29.5	29.5	29.5	29.5	29.9	29.8	29.4	29.9	30.4	30.8	30.8	30.1	31.2	31.1	30.2	31.9	28.6	29.2	28.8	30.5	30.5	29.1
10	29.5	29.5	29.5	29.5	29.5	31.2	30.2	30.3	30.9	31.4	31.8	31.5	31	31.8	32.5	30	32.5	28	29.5	29.2	32.5	34.7	29.5
11	30.6	30.6	30.6	30.6	30.6	31.5	30.7	31.4	30.7	31.9	33.8	31.2	39.5	31.6	35	32.2	33.2	30.1	30	30.7	31.5	35.2	31.1
12	32.1	32.1	32.1	32.1	32.1	33.6	32	31.6	31.9	31.7	35.6	30.8	31.5	32.2	35.3	30.8	34.6	27.5	30.4	30.6	32.3	35.5	
13	33.3	33.3	33.3	33.3	33.3	33.3	31.7	32.4	32.8	31.9	34	32.1	33.4	33.9	34	31.8	36.4		32.1	30	32.5	31.5	
14	31.1	31.1	31.1	31.1	31.1		32.1	32.4	32.5	33	34.4	32.5	34.5	32.3	34.2	33	36	27.5	38.5	36	30.5	36.1	30.5
15+	32.5	32.5	32.5	32.5	32.5	33.8	33.4	34.3	33.6	34.8	35.2	35.3		35.1	36.1	34.5	36.9		34.2	32.5		36.1	31.5

Table 6.3.3. North Sea Horse Mackerel stock. Mean weight at age (kg) in the catch by quarter and area in 2017.

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.06	0.06	0.06	0.06	0	0.06
2	0.086	0.086	0.086	0.086	0.058	0.081
3	0.114	0.114	0.114	0.114	0.087	0.108
4	0.13	0.13	0.13	0.13	0.112	0.127
5	0.172	0.172	0.172	0.172	0.151	0.168
6	0.19	0.19	0.19	0.19	0.159	0.184
7	0.175	0.175	0.175	0.175	0.163	0.173
8	0.188	0.188	0.188	0.188	0.178	0.186
9	0.222	0.222	0.222	0.222	0.225	0.223
10	0.233	0.233	0.233	0.233	0.233	0.233
11	0.257	0.257	0.257	0.257	0.277	0.261
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.214	0.214	0.214	0.214	0.214	0.214
15	0.26	0.26	0.26	0.26	0.26	0.26
2Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.06	0.06	0.06	0.06	0.06	0.06
2	0.086	0.086	0.086	0.086	0.086	0.086
3	0.114	0.114	0.114	0.114	0.114	0.114
4	0.13	0.13	0.13	0.13	0.13	0.13
5	0.172	0.172	0.172	0.172	0.172	0.172
6	0.19	0.19	0.19	0.19	0.19	0.19
7	0.175	0.175	0.175	0.175	0.175	0.175
8	0.188	0.188	0.188	0.188	0.188	0.188
9	0.222	0.222	0.222	0.222	0.222	0.222
10	0.233	0.233	0.233	0.233	0.233	0.233
11	0.257	0.257	0.257	0.257	0.257	0.257
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.214	0.214	0.214	0.214	0.214	0.214

15	0.26	0.26	0.26	0.26	0.26	0.26

3Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	0.06	0.06	0.06	0.06
2	0	0	0.086	0.086	0.086	0.086
3	0	0	0.114	0.114	0.114	0.114
4	0	0	0.13	0.13	0.13	0.13
5	0	0	0.172	0.172	0.172	0.172
6	0	0	0.19	0.19	0.19	0.19
7	0	0	0.175	0.175	0.175	0.175
8	0	0	0.188	0.188	0.188	0.188
9	0	0	0.222	0.222	0.222	0.222
10	0	0	0.233	0.233	0.233	0.233
11	0	0	0.257	0.257	0.257	0.257
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.214	0.214	0.214	0.214
15	0	0	0.26	0.26	0.26	0.26
4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	0.06	0.06	0.059	0.074
2	0	0	0.086	0.092	0.088	0.089
3	0	0	0.114	0.115	0.117	0.115
4	0	0	0.13	0.141	0.148	0.14
5	0	0	0.172	0.18	0.198	0.183
6	0	0	0.19	0	0.206	0.132
7	0	0	0.175	0	0.215	0.13
8	0	0	0.188	0	0.208	0.132
9	0	0	0.222	0	0.219	0.147
10	0	0	0.233	0	0	0.078
11	0	0	0.257	0	0.234	0.164
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0.214	0	0	0.071
15	0	0	0.26	0	0	0.087

1-4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0.06	0.06	0.06	0.06	0.059	0.075
2	0.086	0.086	0.086	0.088	0.081	0.087
3	0.114	0.114	0.114	0.114	0.109	0.117
4	0.13	0.13	0.13	0.133	0.131	0.135
5	0.172	0.172	0.172	0.174	0.174	0.167
6	0.19	0.19	0.19	0.19	0.187	0.178
7	0.175	0.175	0.175	0.175	0.182	0.179
8	0.188	0.188	0.188	0.188	0.191	0.257
9	0.222	0.222	0.222	0.222	0.222	0.291
10	0.233	0.233	0.233	0.233	0.233	0.359
11	0.257	0.257	0.257	0.257	0.255	0.369
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0.214	0.214	0.214	0.214	0.214	0.379
15	0.26	0.26	0.26	0.26	0.26	0.37

Table 6.3.4. North Sea Horse Mackerel stock. Mean length (cm) at age in the catch by quarter and area in 2017.

	Number/1000					
1Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	19.1	19.1	19.1	19.1	0	19.1
2	21.3	21.3	21.3	21.3	18	20.7
3	23.4	23.4	23.4	23.4	21.5	23
4	24.1	24.1	24.1	24.1	22.9	23.8
5	26.6	26.6	26.6	26.6	25.7	26.4
6	27.5	27.5	27.5	27.5	26.3	27.3
7	27.4	27.4	27.4	27.4	26.8	27.3
8	28	28	28	28	27.8	28
9	29.1	29.1	29.1	29.1	29.6	29.2
10	29.5	29.5	29.5	29.5	29.5	29.5
11	31.1	31.1	31.1	31.1	32.5	31.4
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	30.5	30.5	30.5	30.5	30.5	30.5
15	31.5	31.5	31.5	31.5	31.5	31.5
2Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	19.1	19.1	19.1	19.1	19.1	19.1
2	21.3	21.3	21.3	21.3	21.3	21.3
3	23.4	23.4	23.4	23.4	23.4	23.4
4	24.1	24.1	24.1	24.1	24.1	24.1
5	26.6	26.6	26.6	26.6	26.6	26.6
6	27.5	27.5	27.5	27.5	27.5	27.5
7	27.4	27.4	27.4	27.4	27.4	27.4
8	28	28	28	28	28	28
9	29.1	29.1	29.1	29.1	29.1	29.1
10	29.5	29.5	29.5	29.5	29.5	29.5
11	31.1	31.1	31.1	31.1	31.1	31.1
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	30.5	30.5	30.5	30.5	30.5	30.5

15	31.5	31.5	31.5	31.5	31.5	31.5
3Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	19.1	19.1	19.1	19.1
2	0	0	21.3	21.3	21.3	21.3
3	0	0	23.4	23.4	23.4	23.4
4	0	0	24.1	24.1	24.1	24.1
5	0	0	26.6	26.6	26.6	26.6
6	0	0	27.5	27.5	27.5	27.5
7	0	0	27.4	27.4	27.4	27.4
8	0	0	28	28	28	28
9	0	0	29.1	29.1	29.1	29.1
10	0	0	29.5	29.5	29.5	29.5
11	0	0	31.1	31.1	31.1	31.1
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	30.5	30.5	30.5	30.5
15	0	0	31.5	31.5	31.5	31.5
4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	0	0	19.1	19.2	19.1	19.1
2	0	0	21.3	21.9	21.6	21.6
3	0	0	23.4	23.4	23.6	23.5
4	0	0	24.1	24.8	25.3	24.7
5	0	0	26.6	28.5	27.5	27.5
6	0	0	27.5	0	28.1	18.5
7	0	0	27.4	0	28.7	18.7
8	0	0	28	0	28.5	18.8
9	0	0	29.1	0	28.4	19.2
10	0	0	29.5	0	0	9.8
11	0	0	31.1	0	29.5	20.2
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	30.5	0	0	10.2
15	0	0	31.5	0	0	10.5

1-4Q						
Ages	**27.3.a**	**27.4.a**	**27.4.b**	**27.4.c**	**27.7.d**	**Total**
0	0	0	0	0	0	0
1	19.1	19.1	19.1	19.1	19.1	19.1
2	21.3	21.3	21.3	21.5	20.7	21.3
3	23.4	23.4	23.4	23.4	23	23.3
4	24.1	24.1	24.1	24.3	24.1	24.1
5	26.6	26.6	26.6	27.1	26.6	26.7
6	27.5	27.5	27.5	27.5	27.4	27.5
7	27.4	27.4	27.4	27.4	27.6	27.5
8	28	28	28	28	28.1	28
9	29.1	29.1	29.1	29.1	29	29.1
10	29.5	29.5	29.5	29.5	29.5	29.5
11	31.1	31.1	31.1	31.1	31	31.1
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	30.5	30.5	30.5	30.5	30.5	30.5
15	31.5	31.5	31.5	31.5	31.5	31.5

Table 6.4.1. North Sea Horse Mackerel. cpue Indices of abundance (individuals/hour) for juvenile (<20cm) and exploitable (>20cm) substocks, estimated as a combined index for the NS-IBTS Q3 (North Sea only, no 27.7.d included) and the Channel Ground Fish Survey in Q4 (CGFS, 27.7.d). The survey indices are derived from the prediction of a hurdle model fit to data over the period 1992-2017.

	Juvenile substock (<20cm)			Exploitable substock (>20cm)		
Year	**Index**	**CI_low**	**CI_high**	**Index**	**CI_low**	**CI_high**
1992	4865	2293	9237	1498	663	2915
1993	1917	959	3415	565	291	974
1994	3288	1593	6067	1322	635	2368
1995	2232	1107	4115	1621	669	3401
1996	1178	447	2480	1080	482	1987
1997	3350	1516	6253	714	336	1286
1998	858	414	1573	436	201	806
1999	1475	794	2433	517	257	905
2000	1139	516	2333	289	137	570
2001	3431	1580	7437	508	245	916
2002	2999	1515	5386	501	240	937
2003	2116	1190	3499	381	179	726
2004	1064	559	1844	428	199	754
2005	987	530	1727	759	366	1370
2006	502	271	880	834	422	1523
2007	665	375	1107	411	197	787
2008	394	224	695	209	101	458
2009	758	416	1265	104	47	212
2010	1611	863	2981	234	106	459
2011	569	317	1091	282	136	583
2012	354	189	705	185	93	437
2013	1062	572	1882	146	64	335
2014	1609	909	2747	430	193	876
2015	2257	1220	4527	580	261	1146
2016	1752	959	2976	803	376	1557
2017	973	505	1714	131	54	282

6.9 Figures

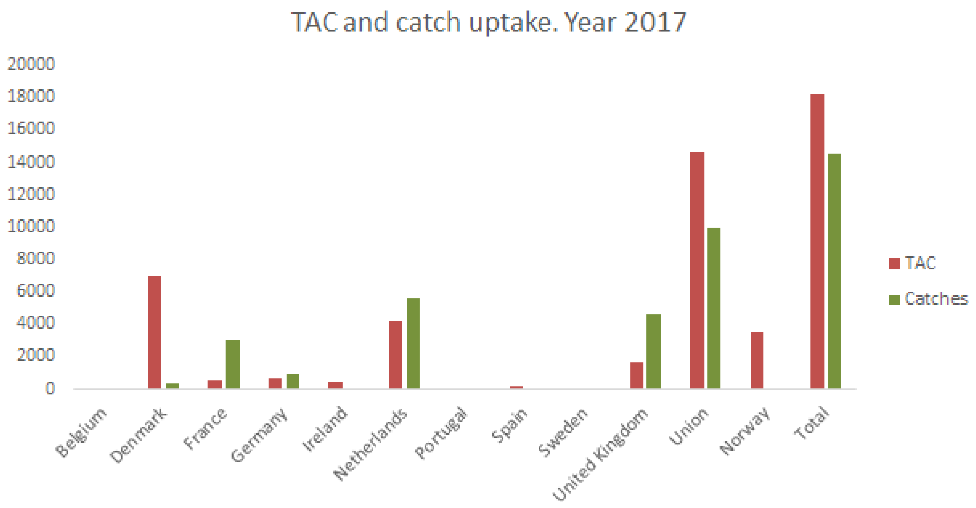


Figure 6.2.1. North Sea horse mackerel. Utilisation of quota by country.

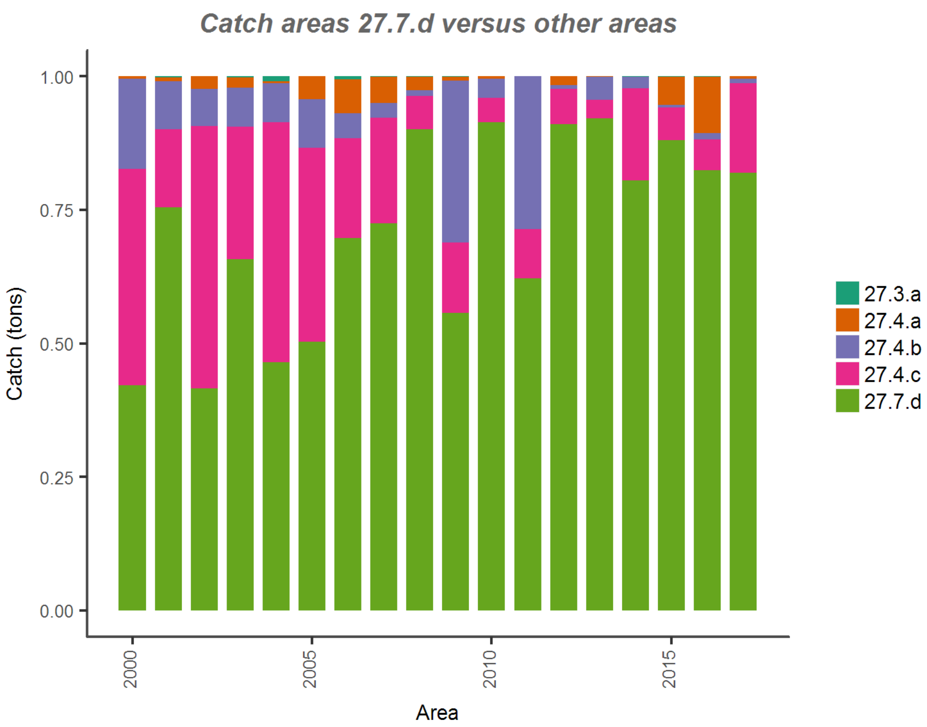


Figure 6.2.2 North Sea Horse Mackerel. North Sea horse mackerel. Catch by ICES Division for 2000–2017.

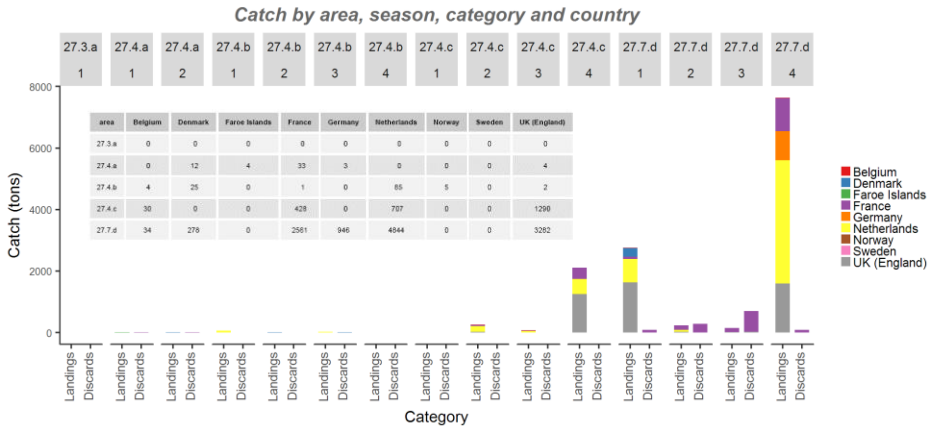


Figure 6.2.3.- North Sea Horse Mackerel. Total catch (in tonnes) by area, quarter, catch category and country. BMS landing refers to landings below minimum legal size.

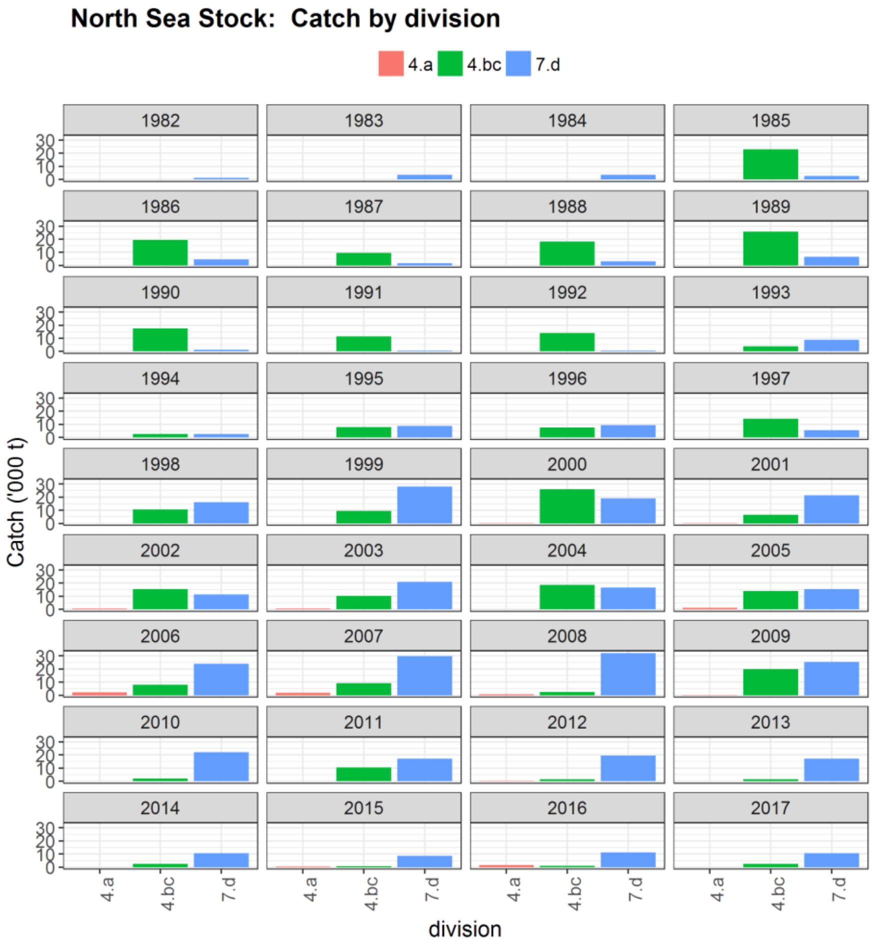


Figure 6.3.1.- North Sea Horse Mackerel. Proportion of NSHM total catch per year and station that have been sampled.

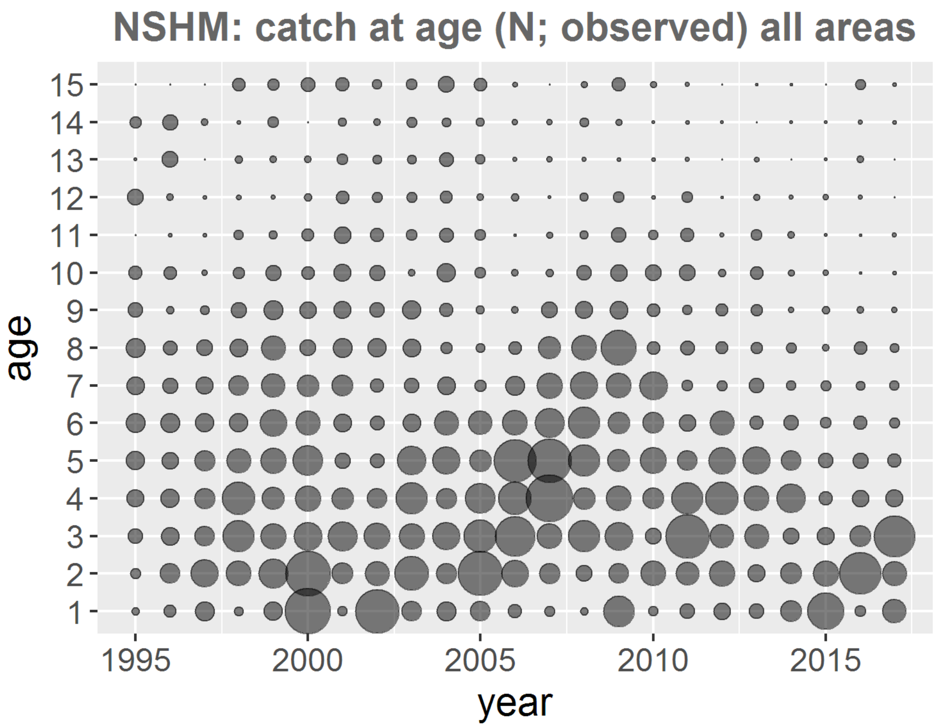


Figure 6.3.2.- North Sea horse mackerel age distribution in the catch for 1995–2017. The area of bubbles is proportional to the catch number. Note that age 15 is a plus group.

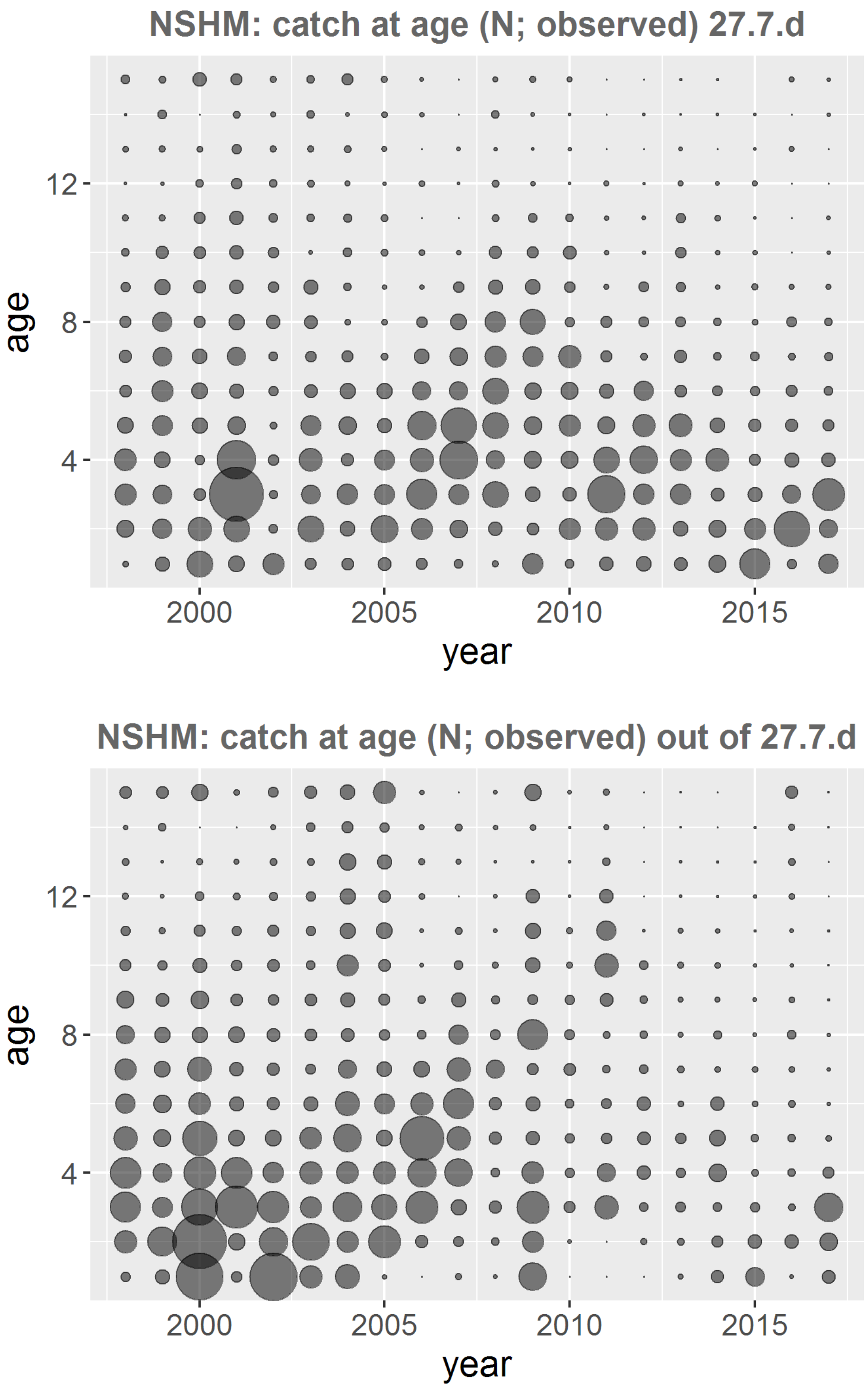


Figure 6.3.3. North Sea horse mackerel. Bubbleplots of age distribution in the catch by area for 1998-2017 for area 7.d (upper panel) and out of 7.d (bottom panel). The area of bubbles is proportional to the total catch number for the stock. Note that age 15 is a plus group.

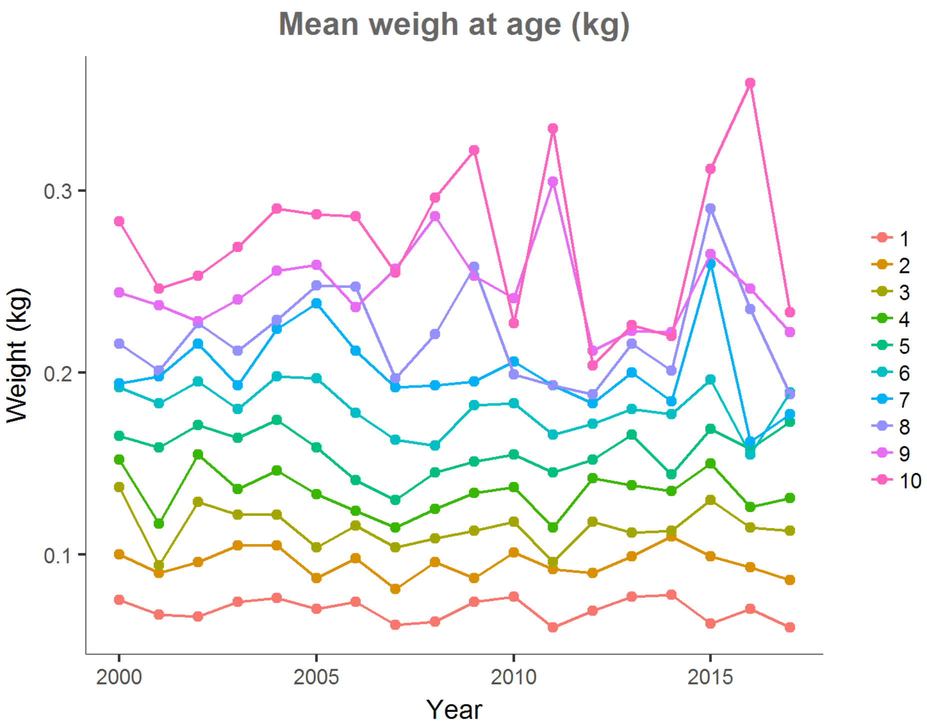


Figure 6.3.4. North Sea horse mackerel. Mean weight at age in commercial catches over the period 2000–2017

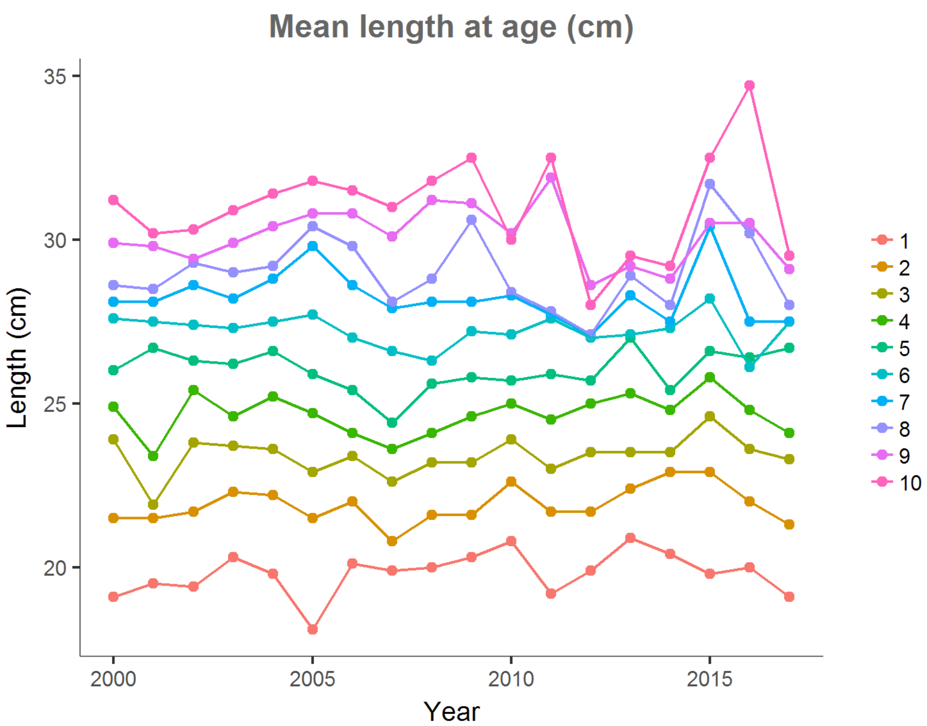


Figure 6.3.5. North Sea horse mackerel. Mean length at age in commercial catches over the period 2000–2017.

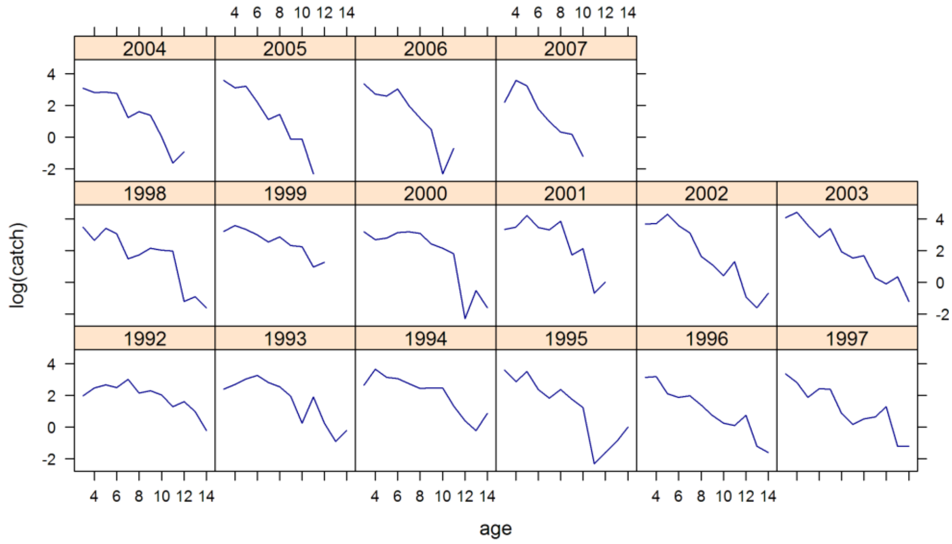


Figure 6.4.1. North Sea Horse Mackerel. Catch curves for the 1994 to 2007 cohorts, ages from 3 to 14. Values plotted are the log(catch) values for each cohort in each year. The negative slope of these curves estimates total mortality (Z) in the cohort.

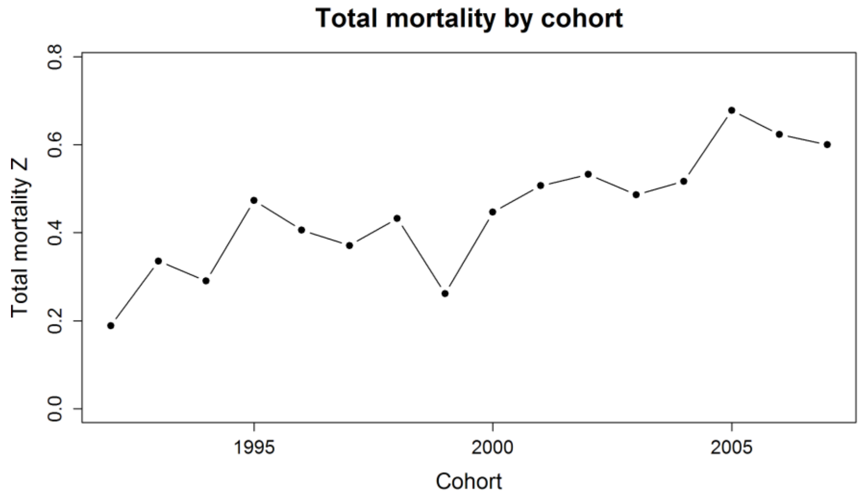


Figure 6.4.2. North Sea Horse Mackerel. Total mortality by cohort (Z) estimated from the negative gradients of the 1992–2006 cohort catch curves (Figure 6.4.1).

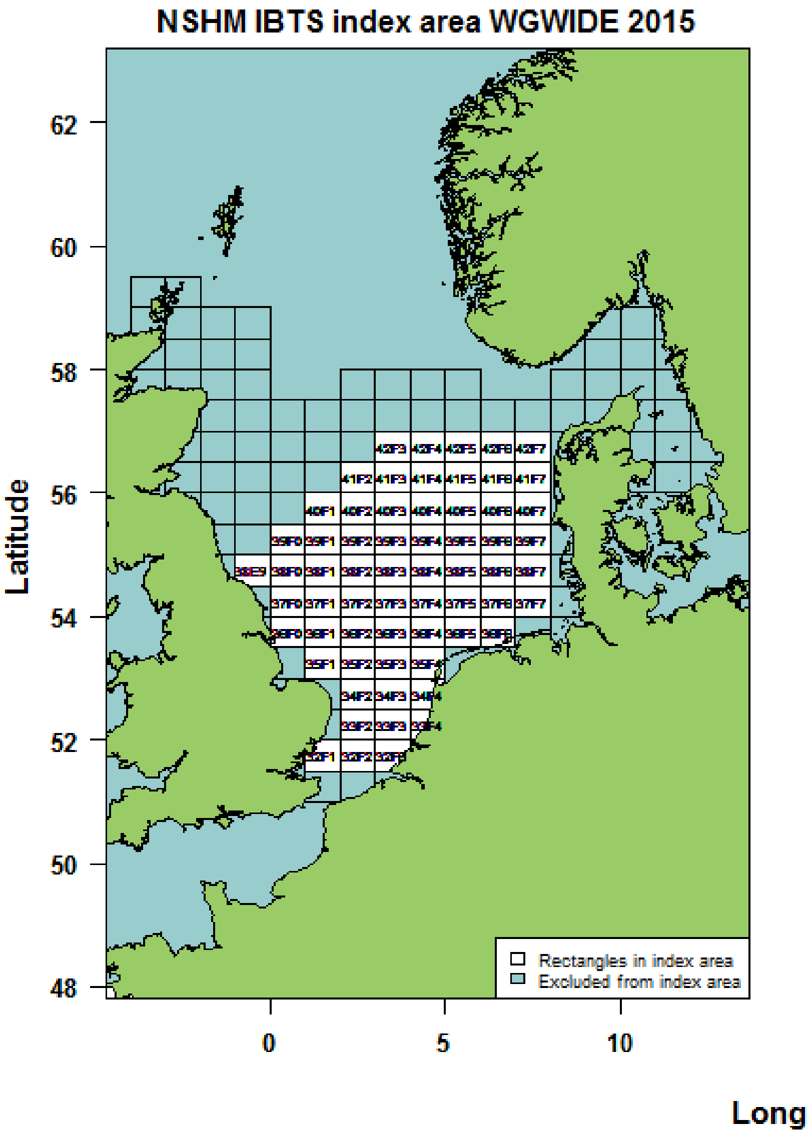


Figure 6.4.3.- North Sea horse mackerel. ICES rectangles selected in 2013 and currently used by the working group.

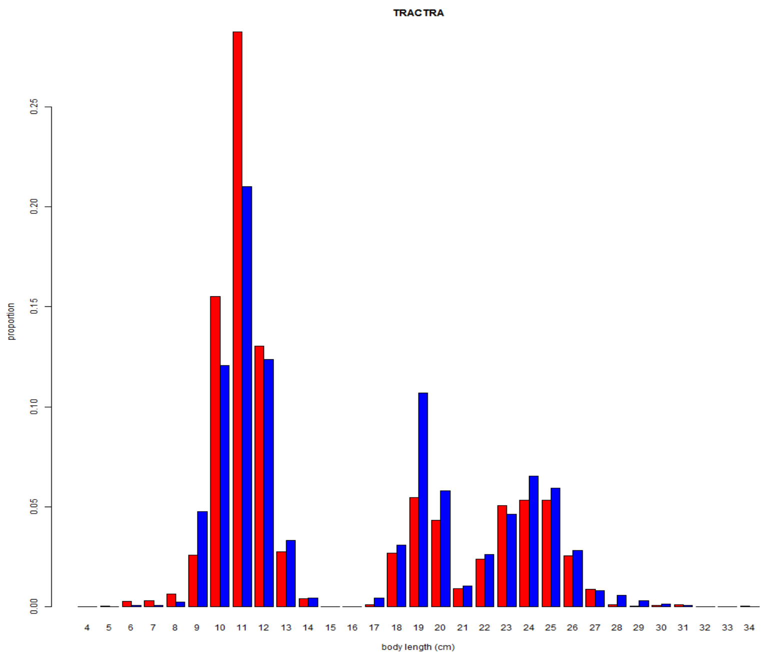


Figure 6.4.4.- North Sea horse mackerel. Size distribution of North Sea horse mackerel catches during the inter-calibration exercise conducted in 2014 between the RV Gwen Drez (red bars) and Thalassa (blue bars).

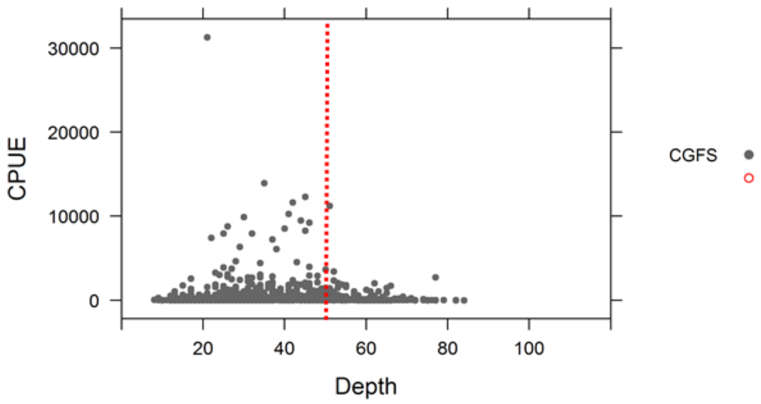
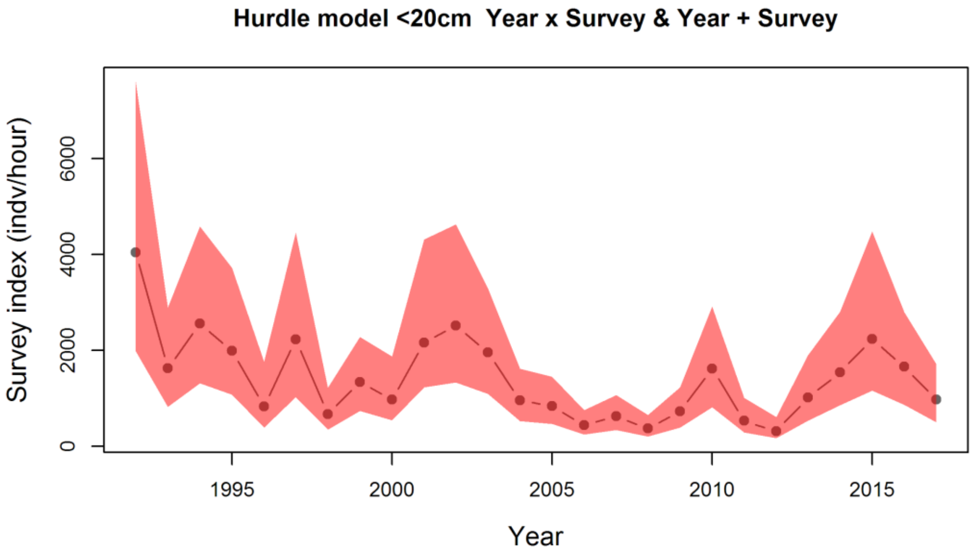


Figure 6.4.5. North Sea horse mackerel. cpue by depth for the CGFS survey from 1992 to 2017.



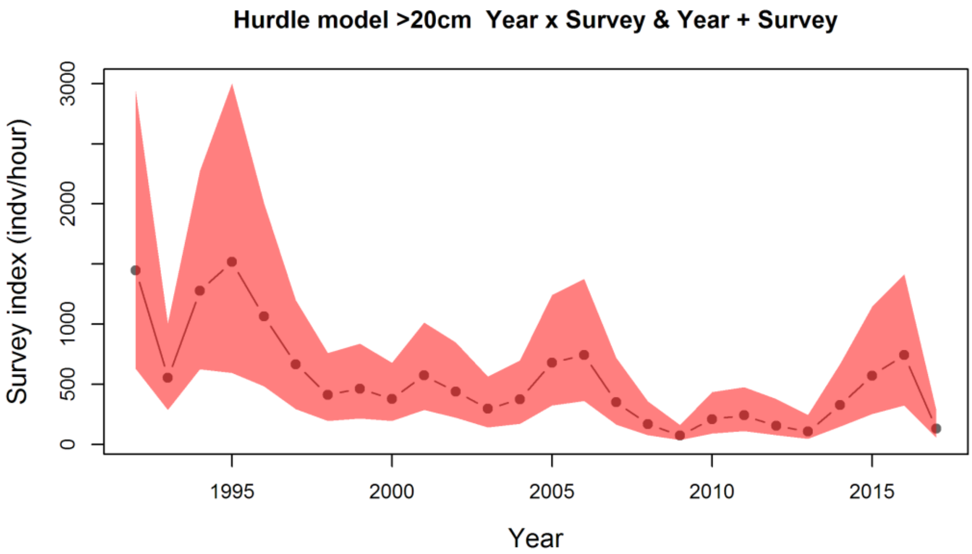


Figure 6.4.6. North Sea Horse Mackerel. Combined cpue survey index (indiv/hour) derived from the hurdle model fit to the IBTS survey in the North Sea (4.bc) and the CGFS survey in the English channel. Top: Juvenile substock (<20 cm); Bottom: exploitable substock (>20cm). The abundance index values are presented as number of individuals per hours. The confidence interval is determined by bootstrap resampling of Pearson residuals with 1000 iterations.

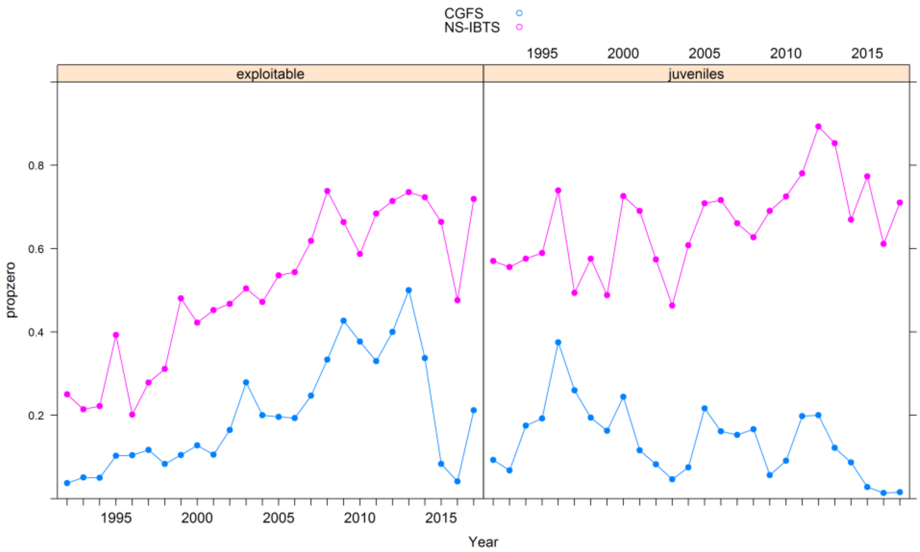


Figure 6.4.7.- North Sea horse mackerel. Proportion of hauls with zero catch for the exploitable (>20cm) and juvenile (<20 cm) substocks in the NS-IBTS (pink dotted lines) and the CGFS (blue dotted lines).

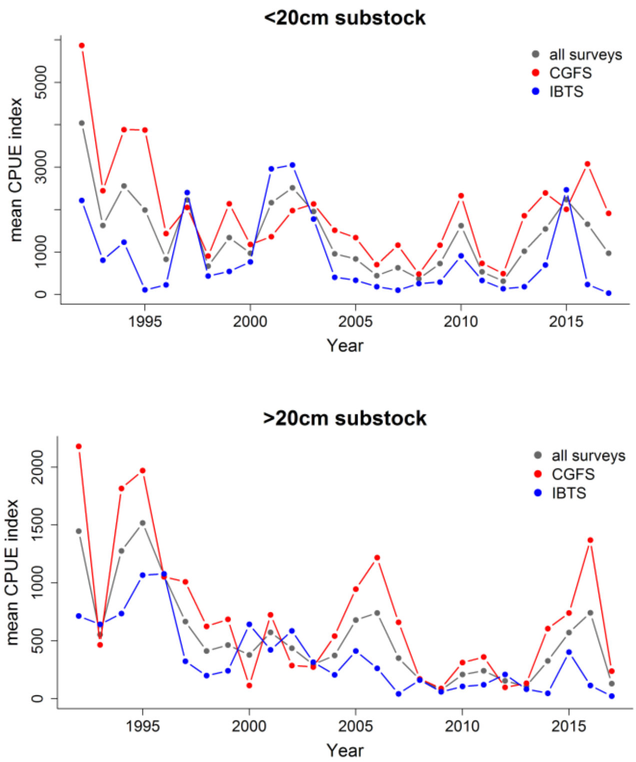


Figure 6.4.8. North Sea Horse Mackerel. Mean CPUE survey index (indiv/hour) obtained from the hurdle model fit to the IBTS survey in the North Sea (4.bc) and the CGFS survey in the English channel. Top: Juvenile substock (<20 cm); Bottom: exploitable substock (>20cm). The abundance index values are presented as number of individuals per hours.

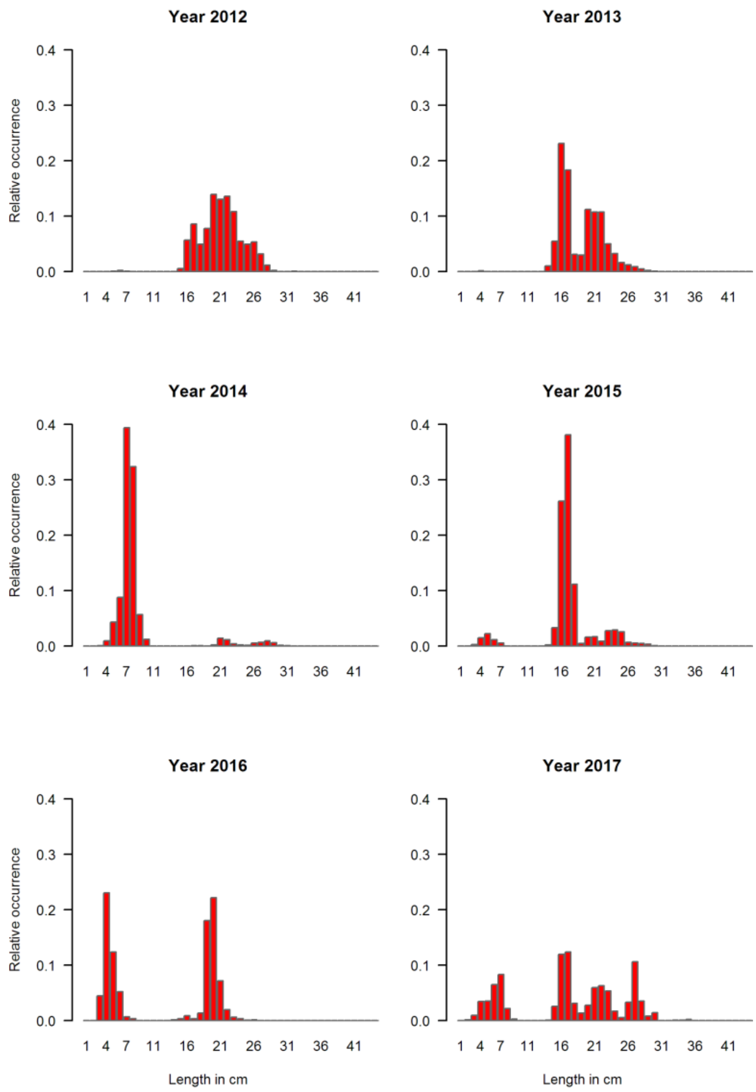


Figure 6.4.9. North Sea horse mackerel. Relative occurrence by length for the period 2012–2017 in the CGFS.

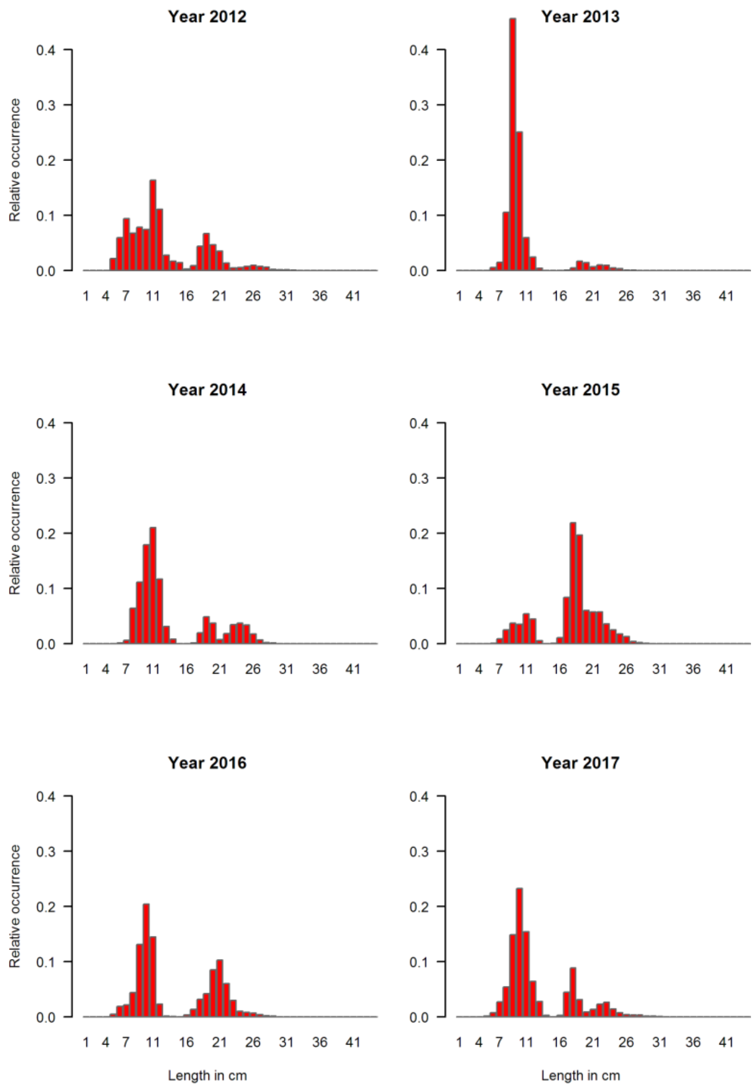


Figure 6.4.10. North Sea horse mackerel. Relative occurrence by length for the period 2012-2017 in the IBTS.

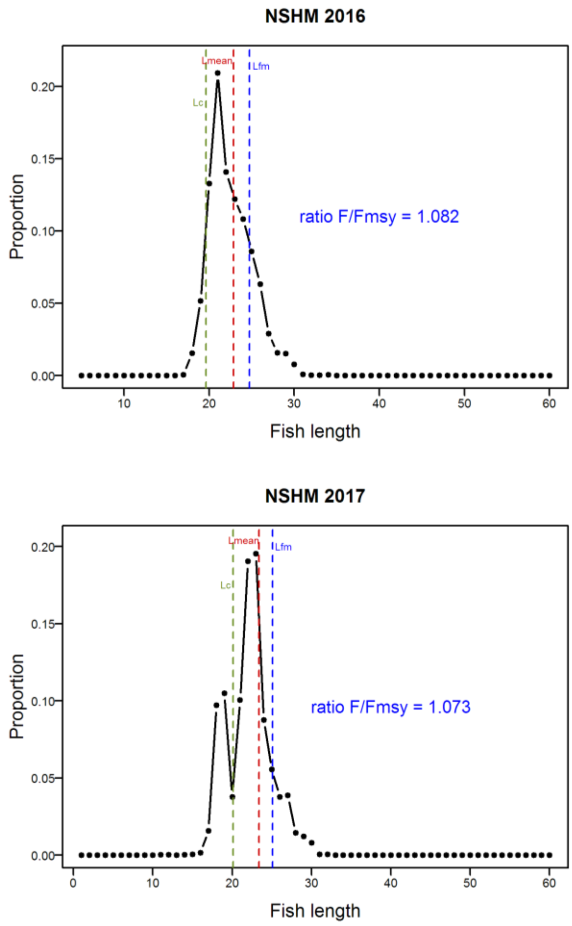


Figure 6.4.11.- Length distribution, as well as the estimated parameters Lc, Lmean, Lf=m for the Dutch fleet in 2016 and 2017.