4 North Sea Horse Mackerel: Divisions IVa (Q1 and Q2), IIIa (excluding Western Skagerrak Q3 and Q4), IVb, IVc and VIId

4.1 ICES Advice Applicable to 2014

In 2012, based on ICES approach to data-limited stocks (category 5), ICES advised for 2013 that catches of horse mackerel in Divisions IIIa and VIa first and second quarter, IVb,c, and VIId (North Sea stock) should be no more than 25500 tonnes, which represented a 20% precautionary reduction to recent catch levels. In 2013, new data on survey indices available for this stock were considered to not change the perception of the stock and therefore the advice for the fishery in 2014 was the same as the advice for 2013: no more than 25500 t. Discards are known to take place but cannot be quantified; therefore total catches could not be calculated.

The TAC for IVbc and VIId in 2014 was 31,720 tonnes.

4.2 The Fishery in 2013 on the North Sea horse mackerel stock

Catches by the Danish industrial fleet for reduction into fishmeal and fish oil formed the majority of North Sea horse mackerel catches throughout the 1970s and 1980s. Catches were taken in the fourth quarter mainly in Divisions IVb and VIId. The 1990s saw a drop in the value of industrial resources, limited fishing opportunities and steep increases in fuel costs. 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.

In 2001, an individual quota scheme was introduced in Denmark, the majority quota holder for this stock. Though this individual quota system does not directly apply to the North Sea horse mackerel fishery, it resulted in a rapid restructuring of the Danish fleet. Since then the Danish North Sea horse mackerel catches have diminished. Denmark has traded parts of its quota with the Netherlands for fishing opportunities for other species, however due to the structure of the Danish quota management set-up 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 (approximately 50% in 2010—2013) in recent years (see Figure 4.2.1).

Catches taken in Divisions IVa and IIIa during the two first quarters and all year in divisions IVb, IVc and VIId are regarded North Sea horse mackerel (Section 3, Table 3.3.1). In Section 3, Table 3.3.3 shows the reported national catches of this stock from 1997—2013. The catches were relatively low during the period 1982—1997 (not shown) with an average of 18000 tons. The catches increased between 1998 (30500 tons) and 2000 (4,400 tons). Between 2000 and 2010, the catches varied between 22255 and 46400 tons. In 2013 the catch was 18696 tons, which is 13% less than in 2012. This difference is the same as the percentage decrease in TAC. Landings by ICES division are illustrated in Figure 4.2.2 for the period 1982—2013.

4.2.1 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.

4.3 Biological Data

4.3.1 Catch in Numbers at Age

In 2013, 71% of the landings were sampled. These samples were taken by Germany, Netherlands and the UK (England) in all quarters except Q2 (<7% of the landings occur in this quarter). A total of 30 samples were collected (Section 1.3.1). Sampling coverage in 2013 has improved compared to 2012. The catch at age data remains questionable and, if an analytical assessment is to be carried out in the future, methods for distinguishing landings from the Western stock and the North Sea horse mackerel stock need to be developed.

Table 4.3.1 shows catch numbers by quarter (and annual totals) by area in 2013. Annual catch numbers at age for the whole stock for 1995—2013 are given in Table 4.3.2. Age compositions for the period 1987—1995 are also available and are plotted together with the estimates from 1995—2013 in Figures 4.3.1 and 4.3.2. However, these are based on samples taken from low numbers of Dutch commercial catches and catches from research vessels. These samples cover only a small proportion of the total catch and therefore only give a rough indication of the age composition of the stock. After 1998 catch at age data by area are available (Figure 4.3.3). Since the mid-2000s the majority of the catch has come from VIId.

Cohort structure is generally 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 VIId 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.

4.3.2 Mean weight at age and mean length at age

Tables 4.3.3 and 4.3.4 show mean weight and length at age by quarter and by area in 2013. The annual average values are also shown in those same tables.

4.3.3 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. Since there is no specific information available for the North Sea horse mackerel stock specifically, for exploratory model fits the maturity ogive used since 1998 in the assessment of the Western horse mackerel stock was used, constant over time (see text table below).

Western horse mackerel maturity ogive (>1998) used in exploratory assessments.

Age:	1	2	3	4	5	6	7	8	9	10+
Proportion Mature	0.00	0.05	0.25	0.70	0.95	1.00	1.00	1.00	1.00	1.00

4.3.4 Natural mortality

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

Two options (see text table below) were explored for inclusion in the exploratory assessments. The first being the natural mortality assumptions used in the assessment for Western horse mackerel (whmM). This stock is geographically closest to the North Sea stock and therefore possible better comparable than the Southern stock. It assumes a constant natural mortality rate of 0.15 for all ages and years, which is almost identical to estimates derived from simple maximum age methods to calculate M (results not shown here). The second option explored included the assumptions used in the assessment of the Southern horse mackerel stock (shmM). This is an age-varying M, highest on the younger ages, decreasing to 0.15 for the older ages. Despite that this stock is geographically further away than the Western stock, predation on younger ages, especially in a more confined area as the North Sea, might be expected to be higher than in a situation like the Western stock where spawning occurs in more open waters, with possibly less threat of predation.

Two alternative natural mortality at age vectors considered for use in the NS horse mackerel exploratory assessments.

Age:	1	2	3	4	5	6	7	8	9	10+
whmM	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
shmM	0.6	0.4	0.3	0.2	0.15	0.15	0.15	0.15	0.15	0.15

4.4 Data Exploration

4.4.1 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 1995 – 2013 period (when catch at age estimates are considered more representative of the whole fishery) provide complete data for the 1992 to 1999 cohorts (Figure 4.4.1). The estimated negative gradients by cohort (Figure 4.4.2) indicate an increasing trend in total mortality for the period examined, however the poor quality of the cohort signals in the data likely make these Z estimates highly uncertain.

An analysis of the catch number at age data carried out in 2011 showed that only the 1 vs 2, 2 vs 3, 7vs 8 and 8 vs 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.

4.4.2 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.

Other methods to use information from data-rich stocks to assess the biomass of data poor stocks have recently been suggested by Punt *et al.* (2011). WGWIDE suggests that these methods should be further investigated to enable stock estimates of the North Sea horse mackerel.

4.4.3 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 3 were obtained from DATRAS and analysed. Based on a comparison of IBTS data from 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 contrast to previous years, when during WGWIDE meetings, three indices were derived: (a) for fish <14 cm, (b) for fish >= 14 cm and <23 cm and (c) for fish >=23 cm, the working group in 2013 considered that using an 'exploitable biomass index' is most appropriate for the purpose of interpreting trend in the stock.

Commercial catch data show that 2-year old fish and older make up 96% of the landings, which roughly coincides with fish of >= 20 cm (see Figure 4.4.3). Index including fish of 20 cm and larger (roughly corresponding to age 2 and older) were therefore derived for the interpretation of stock trend.

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 4.4.4.

4.4.3.1 General Linear Modelling approach to index

Even though survey trawl hauls in the IBTS are supposed to be directly comparable, there still may exist differences in catchability of between vessels, especially with species for which the survey was not designed. If the proportion or the geographical distribution of the data collected by the different vessels varies among years, then the vessel effect needs to be accounted for in the computation of the abundance index.

A generalized linear model (GLM) approach accounts for the above mentioned issue in establishing the index. Catches from the survey can be modelled as a linear function of explanatory variables, which may be continuous (depth) or factors (year, vessel, gear type) and offer the possibility to specify a distribution different from the normal distribution. The abundance index (corrected for the other potential effects such as vessel effects) can then be obtained from the estimated year effects. Sensitivity tests suggested that the index is robust to the inclusion of new years of data.

In zero inflated GLMs, the zeros (absence of the species) are assumed to result of two different causes: i) the false zeros, corresponding to sampling errors (such as sampling in wrong areas, i.e. outside the distribution area of the species, or using an inadequate technique) and ii) the real zeros, corresponding to sampling in low abundance areas. The zero inflated GLM is then a combination of two models: a model for the probability of occurrence of a false zero multiplied by a model of the count data conditional to not having a false zero.

Where $E(Y_i)$ is the expected catch for the trawl haul *i*, and $var(Y_i)$ is the associated variance, π_i is the probability of having a false zero, μ_i is the expected catch, conditional to not having a false zero, and *k* is the dispersion parameter from the negative binomial distribution.

The probability of having a false zero is modelled by a logistic regression, where

$$logit(\pi_i) = I_{zero} + Depth\ Cathegory_{i,zero} + Vessel_{i,zero} + Year_{i,zero}$$

The expected number of fish, conditional to not having a false zero is modelled as negative binomial regression :

$$log(\mu_i) = I_{count} + Depth\ Cathegory_{i,count} + Vessel_{i,count} + Year_{i,count} + offset\ (\log(haul\ duration))$$

Using $\log(haul\ duration)$ as an offset is a common way of standardizing samples taken by trawl haul of different length and it comes down to modelling the CPUE of the horse mackerel in fish per hour.

The year effect from this model fit then represents an index of the relative changes in stock abundance in the index area over time (Table 4.4.1, Figure 4.4.5)

To convert abundance per length class to biomass per length class, weight per cm length class was calculated using length-weight information from a fitted function to IBTS 2003—2009 weight data:

$$W = 0.0161 * L^{2.86}$$

Where: W=weight in grams

L= length in cm.

The resulting biomass index shows very similar trends to the abundance index (Table 4.4.1, Figure 4.4.5). Index values decreased steadily over the 2000s. Since 2010 there are some signs of a slight increase in abundance/biomass, however the relative increase in the index is small in comparison to the uncertainty range.

4.4.3.2 Delta Log-Normal computation of index

As an alternative approach to deal with the skewed nature of the data together with its relatively large number of zeros, the mean annual cpue was computed assuming a lognormal distribution for the positive values only, together with an additional probability mass at zero. This type of distribution is commonly referred to as the delta-lognormal distribution, and was first discussed by Aitchison (1957). It has been used in various applications since then, and is commonly used in fisheries research (e.g. Pennington, 1996; Fletcher 2008).

The expected annual index values are computed as the product of the proportion of positive (non-zero) hauls and the cpue of the positive hauls:

$$\mu_Y = \pi \exp(\mu_X + \frac{\sigma_X^2}{2})$$

Where: π = the proportion of positive hauls in each year

μ , σ = the mean and variance of the cpue from the positive hauls each year

The proportion of positive hauls, the cpue in the positive hauls and the resultant index values are shown in Table 4.4.1 and Figure 4.4.6. The decrease in the DLN index is more consistent than the GLM index, with no slight recovery in recent years as seen in the GLM index. This is mainly due to the proportion of hauls in which horse mackerel are found decreasing steadily over time, from 74% in 1998 to the lowest observed value of 28% in 2013. Since 2008, cpue in the positive hauls only has increased. This indicates that while the distribution of horse mackerel through the survey area has reduced, in hauls where horse mackerel are encountered, they are found in a higher density than previously.

4.5 Exploratory Assessments

4.5.1 The JAXass assessment model

At the 2014 WGWIDE some exploratory model fits were attempted 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 VIId 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 VIId actually originated from the western horse mackerel stock. Nevertheless, all assessment models used in the MSE assume that 100% of fish caught in area VIId belong to the North Sea horse mackerel stock. This is in agreement with stock and management definitions.

Table 4.5.1 shows the inputs and settings used in the JAXass model. In total the model estimates 60 parameters (for the period 1992—2013):

- Annual F multipliers (*N*=22, one for each year)
- Fishery selectivity parameters (*N*=2, selectivity is time invariant i.e. one selectivity curve)
- Initial population (*N*=9, ages 2-10+ in 1995)
- Annual recruitment (*N*=22, one for each year)
- Sigmas (variances) (*N*=5, one for total catch, one for index and three for CAA)

Annual F values in the model are bound between 0.01 and 1.5. Selectivity is modelled as a logistic curve. For *age* 1 to 10, the selectivity at age (Sel_{age}) is calculated as:

$$Sel_{age} = \frac{1}{1 + e^{\alpha + age \times \beta}}$$

The objective function is the weighted dnorm likelihoods for the total catch, catch at age and IBTS data:

$$objF = wt_C \times f_C + wt_{CAA} \times f_{CAA} + wt_I \times f_I$$

Where:

$$f_C = \sum_{y=1995}^{2012} 0.5 \times \left(\ln(2\pi\sigma_C^2) + \frac{\left(\ln C_y^{obs} - \ln C_y^{exp}\right)^2}{\sigma_C^2} \right)$$

$$f_{CAA} = \sum_{a=1}^{10+} \sum_{y=1995}^{2012} 0.5 \times \left(\ln\left(2\pi\sigma_{CAA,a}^2\right) + \frac{\left(\ln CAA_{a,y}^{obs} - \ln CAA_{a,y}^{est}\right)^2}{\sigma_{CAA,a}^2} \right)$$

$$f_I = \sum_{y=1998}^{2012} 0.5 \times \left(\ln(2\pi\sigma_I^2) + \frac{\left(\ln I_y^{obs} - \ln I_y^{exp}\right)^2}{\sigma_I^2} \right)$$

C^{obs} and C^{exp} = The observed and expected total catch (*C*), over years (*y*)

CAA^{obs} and CAA^{exp} = The observed and expected catch at age (*CAA*), over years (*y*)

I^{obs} and I^{exp} = The observed and expected IBTS index (*I*), over ages (*a*) and years (*y*)

σ_C = Estimated variance in the total catch time series

σ_I = Estimated variance in the IBTS index time series

$\sigma_{CAA,a}$ = Estimated variance in the catch at age (*CAA*) time series for ages *a=1*, *a=2-9*, and *a=10*

wt_C / wt_{CAA} / wt_I = Weightings applied to the total catch / catch at age / index

The index and total catch have single sigma (variance) values for the whole time series while the CAA has one for the youngest age (a=1, high variance), one for ages 2—9 (similar variance) and one for age 10 (high variance).

4.5.2 Assessment model results

Four assessment models were fit, using either the GLM index or the DLN index and either the western or southern horse mackerel natural mortality (Figure 4.5.1).

All models fit indicate a sharp reduction in SSB since the start of the time series, with an accompanying increase in mean F. Mean F fluctuates in recent years depending on whether or not there was a Norwegian fishery in IVa. Using the GLM index instead of the DLN index leads to higher SSB and recruitment and lower mean F in 2013 relative to the past.

The alternative natural mortality values do not have a significant impact on either SSB or mean F. Rather, the southern horse mackerel M models, which have higher M on the younger ages, predict more recruits and a slightly lower selectivity of the fleet on these ages. This allows the model to account for the higher natural mortality on the younger ages. As a result the age structure in stock tends towards more young fish with Shm M.

All models under estimate total catch in the recent years and over estimate it in the past. This is because the model is not able to reconcile the sharp decreases seen in the indices with the levels of catch taken. i.e. the model estimates that more catch than observed was required to lead to the sharp reduction in the indices and that the current levels of catch are too high given the recent trends found in the index.

The diagnostics of these models (not shown) indicate significant retrospective patterns, probably due to the assumption of a constant selectivity. It is unlikely that selectivity in this fishery has remained constant over time given changes in fishery location and the frequent reliance on a few large year classes.

The results presented here, are purely exploratory. Much work is required to develop a plausible assessment model for this stock given the data issues involved.

4.6 Basis for 2014 Advice

The exploratory assessment models are not considered acceptable as a basis for advice. As in the previous two years, using an index derived from the IBTS survey can be used to inform on stock status. New methods for calculating indices have been explored. The GLM approach is considered a robust, appropriate treatment of the survey data and provides confidence bounds on the final estimates. This is considered as the best currently available index for the stock.

There remains concerns over the data and knowledge available for the management of this stock. The available survey data do not cover the main fishing grounds for this stock, even though the stock is thought to be present in the survey area at the time of the survey. Cohort signals in the catch are weak, due to aging errors, changes in fishery location and potentially due to mixing of fish from the western stock in the catch. However, the available data all suggest that the North Sea horse mackerel stock is currently at a low biomass in the North Sea, potentially increasing slightly I n the most recent years.

4.6.1 ICES DLS approach

The guidelines for data-limited stocks (DLS) for which a biomass index is available (Category 3) suggest a harvest control rule of index-adjusted status-quo catch. The advice is based on a comparison of the most recent index values (2 or 3) with the preceding values (3 or 5), combined with recent catch or landings data. Knowledge about the exploitation status also influences the advised catch.

For this stock, comparing the most recent two years with the preceding three years of the GLM biomass index estimates a 54% increase. According to the guidelines for DLS this implies an increase of landings of at most 20% in relation to the last three years average landings (23155 t), corresponding to landings of no more than 27786 t.

Comparing the most recent three years with the preceding five years of the GLM biomass index estimates a 4% increase. According to the guidelines for DLS this implies an increase of landings of 4% in relation to the last three years average landings (23155 t), corresponding to landings of no more than 24081 t.

Although the 2:3 harvest control rule indicates a potential increase in biomass >50%, the large confidence bounds indicate a high degree of uncertainty around this increase. In addition there are no clear indications that the stock is not over-exploited. The advice given for this stock in 2012 under category 5 of the ICES DLS approach (25500 t) is considered valid for 3 years unless there are clear indications of a change in stock status. WGWIDE does considers that this advice should remain valid since any potential changes in stock status are highly uncertain.

4.7 Management considerations

In the past, Division VIId was included in the management area for Western horse mackerel together with Divisions IIa, VIIa–c, VIIe–k, VIIIa, VIIIb, VIIId, VIIIe, Subarea VI, EU and international waters of Division Vb, and international waters of Subareas XII and XIV. ICES considers Division VIId to be part of the North Sea horse mackerel distribution area. Since 2010, the EU TAC for the North Sea area has included Divisions IVb,c and VIId. Considering that a majority of the catches are taken in Division VIId, 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 IIIa (Western Skagerrak) and IVa 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 IVa and IIIa are variable. In recent years only Norway has had significant catches in this area, but these are only taken in some years (see Figure 4.2.1).

4.8 References

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Table 4.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2013.

1Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0						
1	0.00	0.00	8.04	2.89	141.29	152.23
2	0.00	0.01	20.14	7.24	353.79	381.18
3	0.00	0.13	249.84	89.81	4388.38	4728.17
4	0.01	0.19	352.73	126.79	6195.53	6675.25
5	0.01	0.34	622.66	223.82	10936.61	11783.43
6	0.00	0.07	132.51	47.63	2327.41	2507.62
7	0.00	0.14	253.08	90.97	4445.17	4789.36
8	0.00	0.06	110.31	39.65	1937.61	2087.64
9	0.00	0.09	163.33	58.71	2868.77	3090.90
10	0.00	0.12	229.13	82.36	4024.54	4336.16
11	0.00	0.08	150.31	54.03	2640.18	2844.61
12	0.00	0.02	28.32	10.18	497.37	535.88
13	0.00	0.01	25.56	9.19	448.99	483.76
14		0.00	2.00	0.72	35.18	37.91
15+	0.00	0.00	4.21	1.51	73.87	79.59
Sum	0.04	1.27	2352.18	845.51	41314.70	44513.70
2Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	0.00	0.10	0.14	0.00	0.00	0.24
1	0.00	2.82	4.10	8.96	26.40	42.28
2	0.00	0.48	0.70	34.04	101.06	136.29
3	0.00	0.34	0.50	225.87	670.58	897.30
4	0.00	0.38	0.55	284.94	845.96	1131.83
5	0.00	1.52	2.21	484.50	1438.31	1926.53
6	0.00	1.01	1.47	105.75	313.87	422.09
7	0.00	0.38	0.55	196.92	584.58	782.43
8				85.83	254.82	340.65
9	0.00	0.19	0.28	127.08	377.27	504.81
10	0.00	0.57	0.83	178.29	529.26	708.94
11	0.00	0.38	0.55	116.96	347.20	465.10
12	0.00	0.38	0.55	22.04	65.41	88.38
13				19.89	59.05	78.93
14				1.56	4.63	6.19
15+				3.27	9.71	12.99
Sum	0.01	8.55	12.43	1895.89	5628.10	7544.98

Table 4.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2013. Cont.

3Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			1.09	0.05		1.14
1			31.82	55.38	157.53	244.72
2			5.46	376.98	1102.70	1485.14
3			3.88	645.98	1890.35	2540.21
4			4.28	215.47	630.12	849.86
5			17.10	0.84		17.94
6			11.39	54.37	157.53	223.29
7			4.28	0.21		4.49
8						
9			2.14	0.10		2.24
10			6.41	0.31		6.73
11			4.28	0.21		4.49
12			4.28	0.21		4.49
13						
14						
15+						
Sum			96.39	1350.12	3938.22	5384.73
4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			3.38	0.89	161.66	165.94
1			145.33	38.46	6948.78	7132.57
2			162.15	42.91	7753.05	7958.10
3			268.17	70.97	12822.63	13161.77
4			275.28	72.85	13162.45	13510.57
5			273.14	72.28	13060.27	13405.69
6			58.69	15.53	2806.41	2880.64
7			32.85	8.69	1570.81	1612.36
8			37.25	9.86	1781.07	1828.17
9			8.36	2.21	399.91	410.48
10			6.70	1.77	320.49	328.97
11			7.70	2.04	368.09	377.82
12			8.08	2.14	386.12	396.33
13						
14						
15+			0.19	0.05	9.12	9.37
Sum			1287.26	340.65	61550.85	63178.77

Table 4.3.1. North Sea Horse Mackerel stock. Catch in numbers (1000) by quarter and area in 2013. Cont.

1-4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	0.00	0.10	4.61	0.95	161.66	167.32
1	0.00	2.83	189.29	105.68	7274.01	7571.81
2	0.00	0.49	188.45	461.17	9310.60	9960.71
3	0.00	0.48	522.40	1032.62	19771.94	21327.44
4	0.01	0.57	632.84	700.05	20834.06	22167.52
5	0.01	1.85	915.11	781.44	25435.19	27133.59
6	0.00	1.08	204.06	223.28	5605.22	6033.64
7	0.00	0.52	290.76	296.79	6600.56	7188.63
8	0.00	0.06	147.56	135.34	3973.50	4256.47
9	0.00	0.28	174.11	188.11	3645.94	4008.44
10	0.00	0.69	243.07	262.74	4874.29	5380.80
11	0.00	0.46	162.84	173.24	3355.47	3692.01
12	0.00	0.39	41.22	34.57	948.90	1025.08
13	0.00	0.01	25.56	29.08	508.04	562.69
14		0.00	2.00	2.28	39.81	44.09
15+	0.00	0.00	4.40	4.83	92.71	101.94
Sum	0.05	9.82	3748.27	4432.17	112431.88	120622.17

Table 4.3.2. Catch in numbers at age (millions), weight at age (kg) and length at age (cm) for the North Sea horse mackerel 1995-2013.

millions	Catch number																		
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	1.76	4.58	12.56	2.30	12.42	70.23	12.81	60.42	13.81	15.65	52.39	5.01	3.40	1.73	34.10	3.31	8.14	9.49	7.57
2	3.12	13.78	27.24	22.13	31.45	77.98	36.36	16.82	56.15	17.54	29.82	23.72	15.46	8.84	13.91	22.52	23.30	24.31	9.96
3	7.19	11.04	14.07	36.69	23.13	28.41	174.34	19.27	23.44	34.38	27.80	61.47	22.83	36.13	28.43	10.67	76.51	20.42	21.33
4	10.32	11.87	14.93	38.82	17.59	21.42	87.81	11.90	33.21	14.51	12.58	40.86	82.64	16.72	22.06	15.70	37.27	40.24	22.17
5	12.08	9.64	14.58	20.79	23.12	31.27	18.51	5.61	26.93	27.77	16.66	72.95	71.23	36.35	17.25	23.68	14.58	25.76	27.13
6	13.16	12.49	12.38	12.10	26.19	19.64	11.49	5.83	10.59	20.17	5.19	23.38	30.52	36.10	16.28	15.93	9.93	20.82	6.03
7	11.43	7.96	10.12	13.99	20.64	19.47	18.25	5.54	6.33	10.58	2.86	13.73	23.93	27.33	21.52	27.63	5.75	3.13	7.19
8	12.64	6.60	8.64	10.79	21.75	9.00	14.70	10.48	9.56	3.82	2.43	5.86	17.27	21.90	47.13	5.62	6.03	4.99	4.26
9	7.25	1.48	2.45	8.26	12.91	11.50	10.22	6.33	10.90	5.37	3.80	1.58	7.89	10.16	11.24	6.34	3.36	4.64	4.01
10	5.87	5.31	0.75	4.01	8.21	8.96	9.98	6.75	1.51	10.95	5.76	1.36	1.66	7.52	9.28	8.30	10.13	1.53	5.38
11	0.01	0.29	0.34	2.72	2.14	6.98	9.58	5.12	3.43	6.22	2.31	0.19	0.59	1.92	7.24	2.88	6.90	0.49	3.69
12	8.84	1.28	0.25	0.71	0.43	3.07	5.35	3.02	3.29	4.47	4.13	1.69	0.21	2.10	3.65	0.30	3.61	0.11	1.03
13	0.20	8.92		1.81	1.40	1.61	3.73	2.17	2.25	6.16	2.50	0.62	0.72	0.36	0.30	0.34	0.77		0.56
14	4.37	8.01	1.38	0.31	3.78		1.95	1.29	3.40	2.25	9.86	0.96	0.65	2.42	0.90	0.23	0.33	0.17	0.04
15+				5.11	4.03	12.22	5.81	2.71	4.70	8.52	9.55	0.82		1.03	6.14	1.13	0.53		0.10

kg	weight																		
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.076	0.107	0.063	0.063	0.063	0.075	0.055	0.066	0.073	0.076	0.079	0.069	0.073	0.063	0.063	0.077	0.060	0.069	0.077
2	0.126	0.123	0.102	0.102	0.102	0.101	0.072	0.095	0.105	0.104	0.077	0.095	0.082	0.096	0.096	0.101	0.092	0.090	0.099
3	0.125	0.143	0.126	0.126	0.126	0.136	0.071	0.129	0.123	0.120	0.103	0.116	0.105	0.109	0.109	0.115	0.098	0.118	0.112
4	0.133	0.156	0.142	0.142	0.142	0.152	0.082	0.154	0.137	0.147	0.132	0.124	0.115	0.125	0.125	0.138	0.116	0.142	0.138
5	0.146	0.177	0.160	0.160	0.160	0.166	0.120	0.172	0.166	0.174	0.158	0.141	0.130	0.145	0.145	0.154	0.146	0.152	0.166

6	0.164	0.187	0.175	0.175	0.175	0.194	0.183	0.195	0.181	0.198	0.196	0.177	0.164	0.161	0.161	0.180	0.167	0.172	0.180
7	0.161	0.203	0.199	0.199	0.199	0.198	0.197	0.216	0.195	0.225	0.251	0.210	0.191	0.194	0.194	0.207	0.188	0.183	0.200
8	0.178	0.195	0.231	0.231	0.231	0.213	0.201	0.227	0.212	0.229	0.270	0.244	0.197	0.221	0.221	0.195	0.206	0.188	0.216
9	0.165	0.218	0.250	0.250	0.250	0.247	0.235	0.228	0.238	0.256	0.280	0.231	0.256	0.286	0.286	0.241	0.300	0.212	0.223
10	0.173	0.241	0.259	0.259	0.259	0.280	0.246	0.251	0.259	0.291	0.291	0.284	0.258	0.296	0.296	0.225	0.324	0.204	0.226
11	0.317	0.307	0.300	0.300	0.300	0.279	0.260	0.302	0.245	0.301	0.344	0.237	0.517	0.273	0.273	0.286	0.341	0.274	0.242
12	0.233	0.211	0.329	0.329	0.329	0.342	0.286	0.292	0.295	0.300	0.361	0.257	0.279	0.309	0.309	0.227	0.402	0.195	0.263
13	0.241	0.258	0.367	0.367	0.367	0.318	0.287	0.318	0.356	0.302	0.332	0.268	0.338	0.375	0.375	0.288	0.405		0.262
14	0.348	0.277	0.299	0.299	0.299	0.325	0.295	0.319	0.319	0.338	0.376	0.291	0.414	0.277	0.277	0.315	0.415	0.187	0.559
15+	0.348	0.277	0.360	0.360	0.360	0.332	0.336	0.390	0.380	0.401	0.367	0.402		0.389	0.389	0.358	0.473		0.339

cm	length																		
Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	19.2	19.2	19.2	19.2	19.2	19.0	18.7	17.1	20.2	19.8	20.54	19.89	20.05	20.00	20.00	20.77	19.17	19.90	20.86
2	22.0	22.0	22.0	22.0	22.0	21.5	20.4	21.4	22.4	22.2	21.49	21.94	20.83	21.62	21.62	22.60	21.70	21.67	22.37
3	23.5	23.5	23.5	23.5	23.5	23.9	20.6	22.9	23.8	23.6	23.00	23.38	22.59	23.20	23.20	23.75	23.06	23.53	23.45
4	24.8	24.8	24.8	24.8	24.8	24.9	21.3	24.9	24.6	25.2	24.69	24.13	23.64	24.11	24.11	24.98	24.48	25.02	25.25
5	25.5	25.5	25.5	25.5	25.5	26.0	25.0	26.2	26.2	26.6	25.53	25.42	24.37	25.61	25.61	25.69	25.87	25.70	26.98
6	26.4	26.4	26.4	26.4	26.4	27.8	27.4	26.6	27.3	27.5	27.77	27.01	26.58	26.33	26.33	27.02	27.54	26.96	27.10
7	27.2	27.2	27.2	27.2	27.2	28.3	28.0	27.4	28.2	28.9	30.42	28.53	27.80	28.07	28.07	28.23	28.02	27.09	28.25
8	29.2	29.2	29.2	29.2	29.2	28.6	28.4	28.2	29.0	29.2	31.19	29.84	28.12	28.77	28.77	28.17	27.71	27.05	28.87
9	29.5	29.5	29.5	29.5	29.5	30.0	29.7	29.2	29.9	30.5	31.82	30.63	30.05	31.16	31.16	30.19	31.88	28.56	29.22
10	29.5	29.5	29.5	29.5	29.5	31.3	30.2	30.8	30.8	31.5	32.32	31.55	31.15	31.79	31.79	29.91	32.45	28.04	29.53
11	30.6	30.6	30.6	30.6	30.6	31.4	30.7	32.5	30.8	32.0	34.41	31.18	39.50	31.60	31.60	32.09	33.30	30.06	30.05
12	32.1	32.1	32.1	32.1	32.1	33.7	32.0	33.8	31.9	31.8	36.16	30.75	31.50	32.24	32.24	29.57	34.49	27.50	30.39
13	33.3	33.3	33.3	33.3	33.3	33.5	31.7	33.8	32.9	32.0	34.20	32.13	33.40	33.90	33.90	31.83	35.21		32.08
14	31.1	31.1	31.1	31.1	31.1	33.4	32.1	32.4	32.7	33.0	34.90	32.15	34.50	32.33	32.33	33.00	36.00	27.50	38.50
15+	32.5	32.5	32.5	32.5	32.5	33.4	33.4	34.4	34.6	34.8	35.39	35.42		35.12	35.12	34.69	36.95		34.22

Table 4.3.3. North Sea Horse Mackerel stock. Mean weight at age (kg) in the catch by quarter and area in 2013.

1Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0						
1	0.062	0.062	0.062	0.062	0.062	0.062
2	0.080	0.080	0.080	0.080	0.080	0.080
3	0.098	0.098	0.098	0.098	0.098	0.098
4	0.118	0.118	0.118	0.118	0.118	0.118
5	0.157	0.157	0.157	0.157	0.157	0.157
6	0.171	0.171	0.171	0.171	0.171	0.171
7	0.189	0.189	0.189	0.189	0.189	0.189
8	0.209	0.209	0.209	0.209	0.209	0.209
9	0.218	0.218	0.218	0.218	0.218	0.218
10	0.225	0.225	0.225	0.225	0.225	0.225
11	0.241	0.241	0.241	0.241	0.241	0.241
12	0.285	0.285	0.285	0.285	0.285	0.285
13	0.262	0.262	0.262	0.262	0.262	0.262
14	0.559	0.559	0.559	0.559	0.559	0.559
15+	0.343	0.343	0.343	0.343	0.343	0.343
Mean	0.214	0.214	0.214	0.214	0.214	0.214
2Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	0.019	0.019	0.019	0.019	0.060	0.019
1	0.074	0.074	0.074	0.068	0.068	0.069
2	0.091	0.091	0.091	0.096	0.096	0.096
3	0.127	0.127	0.127	0.100	0.100	0.100
4	0.189	0.189	0.189	0.119	0.119	0.119
5	0.205	0.205	0.205	0.157	0.157	0.157
6	0.210	0.210	0.210	0.170	0.170	0.170
7	0.229	0.229	0.229	0.189	0.189	0.189
8				0.209	0.209	0.209
9	0.210	0.210	0.210	0.218	0.218	0.218
10	0.229	0.229	0.229	0.225	0.225	0.225
11	0.267	0.267	0.267	0.241	0.241	0.241
12	0.274	0.274	0.274	0.285	0.285	0.284
13				0.262	0.262	0.262
14				0.559	0.559	0.559
15+				0.343	0.343	0.343
Mean	0.177	0.177	0.177	0.204	0.206	0.204

Table 4.3.3. North Sea Horse Mackerel stock. Mean weight at age (kg) in the catch by quarter and area in 2013. Cont.

3Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			0.019	0.019		0.019
1			0.074	0.084	0.084	0.083
2			0.091	0.109	0.109	0.109
3			0.127	0.112	0.112	0.112
4			0.189	0.145	0.145	0.145
5			0.205	0.205		0.205
6			0.210	0.155	0.154	0.157
7			0.229	0.229		0.229
8						
9			0.210	0.210		0.210
10			0.229	0.229		0.229
11			0.267	0.267		0.267
12			0.274	0.274		0.274
13						
14						
15+						
Mean			0.177	0.170	0.121	0.170
4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			0.060	0.060	0.060	0.060
1			0.077	0.077	0.077	0.077
2			0.098	0.098	0.098	0.098
3			0.118	0.118	0.118	0.118
4			0.150	0.150	0.150	0.150
5			0.174	0.174	0.174	0.174
6			0.191	0.191	0.191	0.191
7			0.237	0.237	0.237	0.237
8			0.226	0.226	0.226	0.226
9			0.265	0.265	0.265	0.265
10			0.248	0.248	0.248	0.248
11			0.251	0.251	0.251	0.251
12			0.230	0.230	0.230	0.230
13						
14						
15+			0.300	0.300	0.300	0.300
Mean			0.187	0.187	0.187	0.187

Table 4.3.3. North Sea Horse Mackerel stock. Mean weight at age (kg) in the catch by quarter and area in 2013. Cont.

1-4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	0.019	0.019	0.049	0.058	0.060	0.060
1	0.073	0.074	0.076	0.079	0.077	0.077
2	0.086	0.091	0.096	0.106	0.099	0.099
3	0.099	0.119	0.108	0.108	0.112	0.112
4	0.121	0.165	0.132	0.130	0.139	0.138
5	0.162	0.196	0.163	0.159	0.166	0.166
6	0.180	0.208	0.179	0.168	0.180	0.180
7	0.191	0.218	0.195	0.191	0.201	0.200
8	0.209	0.209	0.213	0.210	0.217	0.216
9	0.218	0.213	0.220	0.219	0.223	0.223
10	0.225	0.229	0.225	0.225	0.226	0.226
11	0.243	0.262	0.242	0.241	0.242	0.242
12	0.281	0.274	0.273	0.281	0.262	0.263
13	0.262	0.262	0.262	0.262	0.262	0.262
14	0.559	0.559	0.559	0.559	0.559	0.559
15+	0.343	0.343	0.341	0.343	0.339	0.339
Mean	0.204	0.215	0.208	0.209	0.210	0.210

Table 4.3.4. North Sea Horse Mackerel stock. Mean length (cm) at age in the catch by quarter and area in 2013.

1Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0						
1	19.34	19.34	19.34	19.34	19.34	19.34
2	21.36	21.36	21.36	21.36	21.36	21.36
3	22.71	22.71	22.71	22.71	22.71	22.71
4	24.46	24.46	24.46	24.46	24.46	24.46
5	26.53	26.53	26.53	26.53	26.53	26.53
6	26.94	26.94	26.94	26.94	26.94	26.94
7	28.01	28.01	28.01	28.01	28.01	28.01
8	28.62	28.62	28.62	28.62	28.62	28.62
9	29.05	29.05	29.05	29.05	29.05	29.05
10	29.52	29.52	29.52	29.52	29.52	29.52
11	30.12	30.12	30.12	30.12	30.12	30.12
12	31.19	31.19	31.19	31.19	31.19	31.19
13	32.08	32.08	32.08	32.08	32.08	32.08
14	38.50	38.50	38.50	38.50	38.50	38.50
15+	34.50	34.50	34.50	34.50	34.50	34.50
Mean	28.20	28.20	28.20	28.20	28.20	28.20
2Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	12.50	12.50	12.50	12.50	19.50	12.52
1	19.53	19.53	19.53	19.97	19.98	19.90
2	20.90	20.90	20.90	21.90	21.90	21.89
3	23.60	23.60	23.60	22.75	22.75	22.75
4	27.00	27.00	27.00	24.47	24.47	24.47
5	27.25	27.25	27.25	26.53	26.53	26.53
6	27.88	27.88	27.88	26.91	26.91	26.92
7	28.00	28.00	28.00	28.01	28.01	28.01
8				28.62	28.62	28.62
9	28.50	28.50	28.50	29.05	29.05	29.05
10	28.50	28.50	28.50	29.52	29.52	29.52
11	30.00	30.00	30.00	30.12	30.12	30.12
12	30.50	30.50	30.50	31.18	31.19	31.18
13				32.08	32.08	32.08
14				38.50	38.50	38.50
15+				34.50	34.50	34.50
Mean	25.35	25.35	25.35	27.29	27.73	27.29

Table 4.3.4. North Sea Horse Mackerel stock. Mean length (cm) at age in the catch by quarter and area in 2013. Cont.

3Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			12.50	12.50		12.50
1			19.53	21.44	21.50	21.23
2			20.90	22.36	22.36	22.35
3			23.60	23.00	23.00	23.00
4			27.00	24.75	24.75	24.76
5			27.25	27.25		27.25
6			27.88	25.52	25.50	25.63
7			28.00	28.00		28.00
8						
9			28.50	28.50		28.50
10			28.50	28.50		28.50
11			30.00	30.00		30.00
12			30.50	30.50		30.50
13						
14						
15+						
Mean			25.35	25.19	23.42	25.19
4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0			19.50	19.50	19.50	19.50
1			20.89	20.89	20.89	20.89
2			22.44	22.44	22.44	22.44
3			23.85	23.85	23.85	23.85
4			25.74	25.74	25.74	25.74
5			27.45	27.45	27.45	27.45
6			27.38	27.38	27.38	27.38
7			29.09	29.09	29.09	29.09
8			29.20	29.20	29.20	29.20
9			30.72	30.72	30.72	30.72
10			29.60	29.60	29.60	29.60
11			29.40	29.40	29.40	29.40
12			29.14	29.14	29.14	29.14
13						
14						
15+			31.50	31.50	31.50	31.50
Mean			26.85	26.85	26.85	26.85

Table 4.3.4. North Sea Horse Mackerel stock. Mean length (cm) at age in the catch by quarter and area in 2013. Cont.

1–4Q						
Ages	IIIa	IVa	IVb	IVc	VIId	Total
0	12.50	12.50	17.63	19.09	19.50	19.44
1	19.52	19.53	20.56	21.06	20.87	20.86
2	21.12	20.91	22.27	22.31	22.38	22.37
3	22.76	23.35	23.30	22.98	23.48	23.45
4	24.57	26.15	25.04	24.69	25.28	25.25
5	26.60	27.12	26.82	26.61	27.00	26.98
6	27.18	27.81	27.13	26.61	27.12	27.10
7	28.01	28.00	28.13	28.04	28.27	28.25
8	28.62	28.62	28.76	28.66	28.88	28.87
9	29.02	28.67	29.12	29.07	29.23	29.22
10	29.42	28.68	29.49	29.52	29.53	29.53
11	30.11	30.02	30.08	30.11	30.04	30.05
12	30.93	30.53	30.71	31.05	30.35	30.39
13	32.08	32.08	32.08	32.08	32.08	32.08
14	38.50	38.50	38.50	38.50	38.50	38.50
15+	34.50	34.50	34.37	34.47	34.20	34.22
Mean	27.22	27.31	27.75	27.80	27.92	27.91

Table 4.4.1. North Sea horse mackerel. Relative indices of abundance and biomass derived from the IBTS Q3 data (North Sea only, no VIId included). The DLN index is derived as the product of the CPUE in the positive (non-zero) hauls and the proportion of positive hauls. The GLM index uses a zero inflated negative binomial model to predict the trend in abundance of exploitable (≥20cm) horse mackerel in the North Sea. This GLM index of abundance is converted to an index of biomass using the observed length frequency in each year together with a length-weight relationship

	DLN Index (age 2+)			GLM Index (20cm+)					
.Year	CPUE (+ve hauls)	Prop. +ve hauls	Relative1 Abundance Index	Relative1 Abundance Index	Lower CI	Upper CI	Relative1 Biomass Index	Lower CI	Upper CI
1998	8.86	0.74	1.60	0.79	0.39	1.59	1.12	0.56	2.25
1999	7.15	0.68	1.19	1.67	0.78	3.55	2.04	0.96	4.34
2000	9.43	0.64	1.48	4.03	1.78	9.13	3.80	1.68	8.61
2001	9.26	0.60	1.36	0.69	0.32	1.51	0.69	0.31	1.50
2002	8.04	0.64	1.27	1.51	0.71	3.21	1.43	0.67	3.05
2003	6.92	0.67	1.13	1.19	0.55	2.54	1.06	0.50	2.27
2004	6.99	0.67	1.14	0.74	0.35	1.60	0.72	0.34	1.55
2005	7.64	0.54	1.01	1.11	0.49	2.54	0.97	0.43	2.21
2006	8.01	0.53	1.05	0.99	0.45	2.18	0.89	0.40	1.96
2007	6.42	0.51	0.80	0.18	0.08	0.41	0.19	0.08	0.44
2008	4.94	0.50	0.61	0.70	0.27	1.82	0.83	0.32	2.15
2009	5.96	0.50	0.72	0.45	0.19	1.08	0.47	0.20	1.11
2010	6.74	0.49	0.80	0.19	0.08	0.43	0.19	0.08	0.45
2011	6.35	0.39	0.61	0.44	0.19	1.05	0.46	0.19	1.09
2012	8.09	0.32	0.64	0.47	0.19	1.20	0.43	0.17	1.09
2013	8.38	0.28	0.58	0.84	0.31	2.28	0.71	0.26	1.93

[1]Relative to the mean of the whole time series.

Table 4.5.1 North Sea horse mackerel. JAXass statistical catch at age model inputs and settings.

Setting/Data	Values/source
Total Catch	Total Landings, 1992-2013. Discards considered negligible.
Catch at age	Landings at age, 1995-2013, ages 1- 10+
Tuning indices	IBTS Q3 (GLM year effect or delta lognormal index); 1998-2013; 20cm+
Weight at age	Weight at age samples from the catch, 1992-2013
Maturity at age	Constant over time, taken from most recent western stock (whm) values
Natural mortality	Constant over time, taken from either the western (whm) or southern (shm) stock
First Age	1
Plus group (last age)	10+
First tuning year	1992
Selectivity	Two parameter (α, β) logistic, constant over years

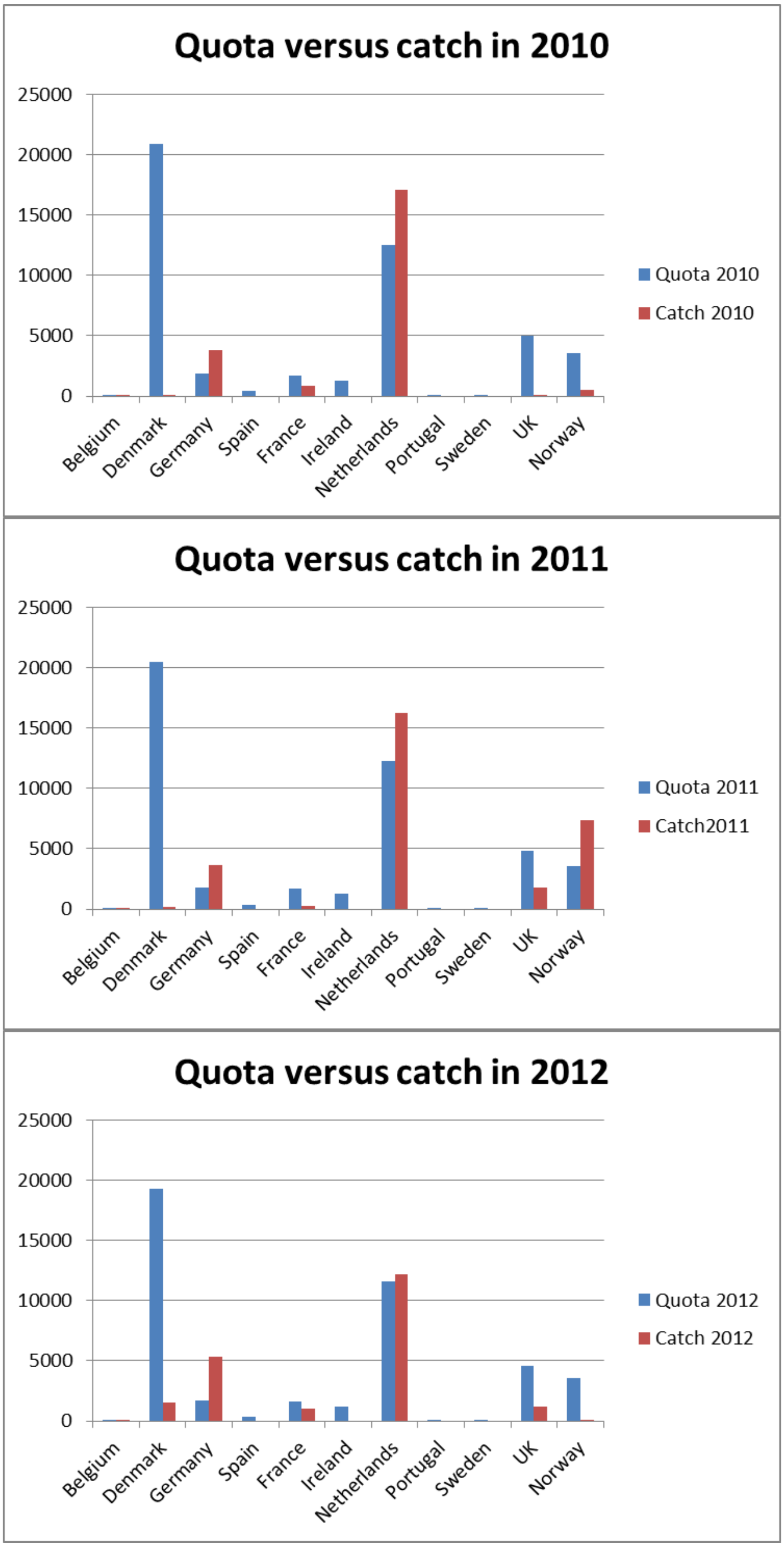


Figure 4.2.1. North Sea horse mackerel. Utilisation of quota by country. Total under-utilisation of EU quota equals 52%, 52% and 49% in 2011, 2012 and 2013 respectively.

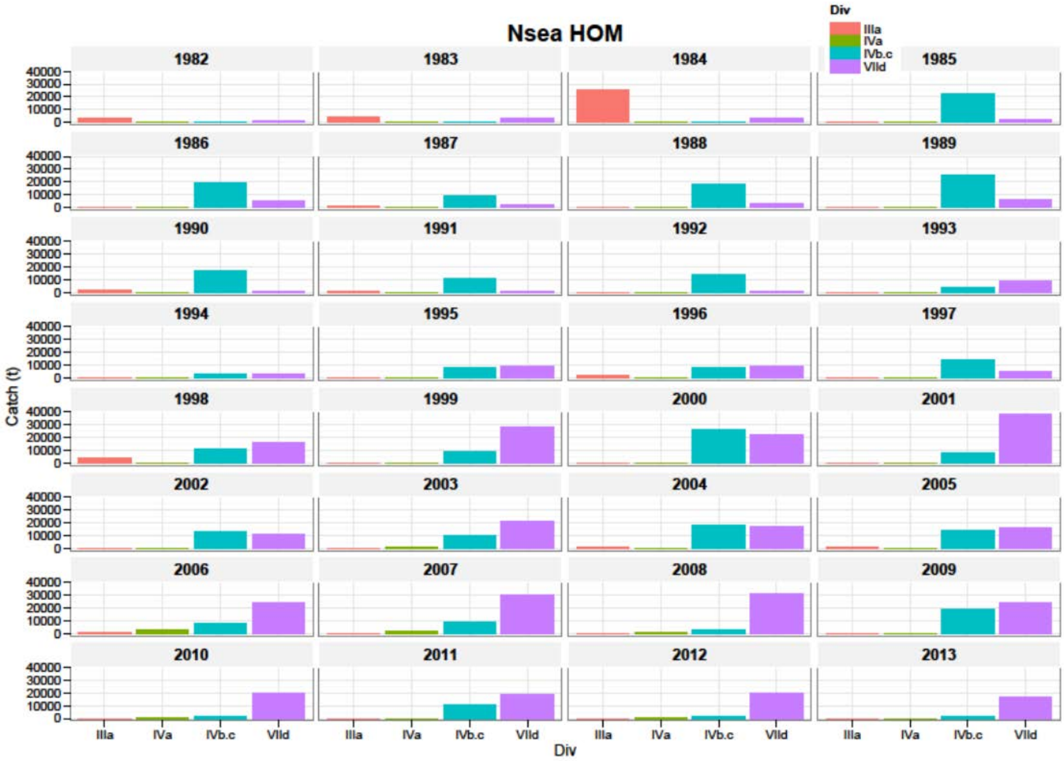


Figure 4.2.2 North Sea horse mackerel. Catch by ICES Division for 1982-2013.

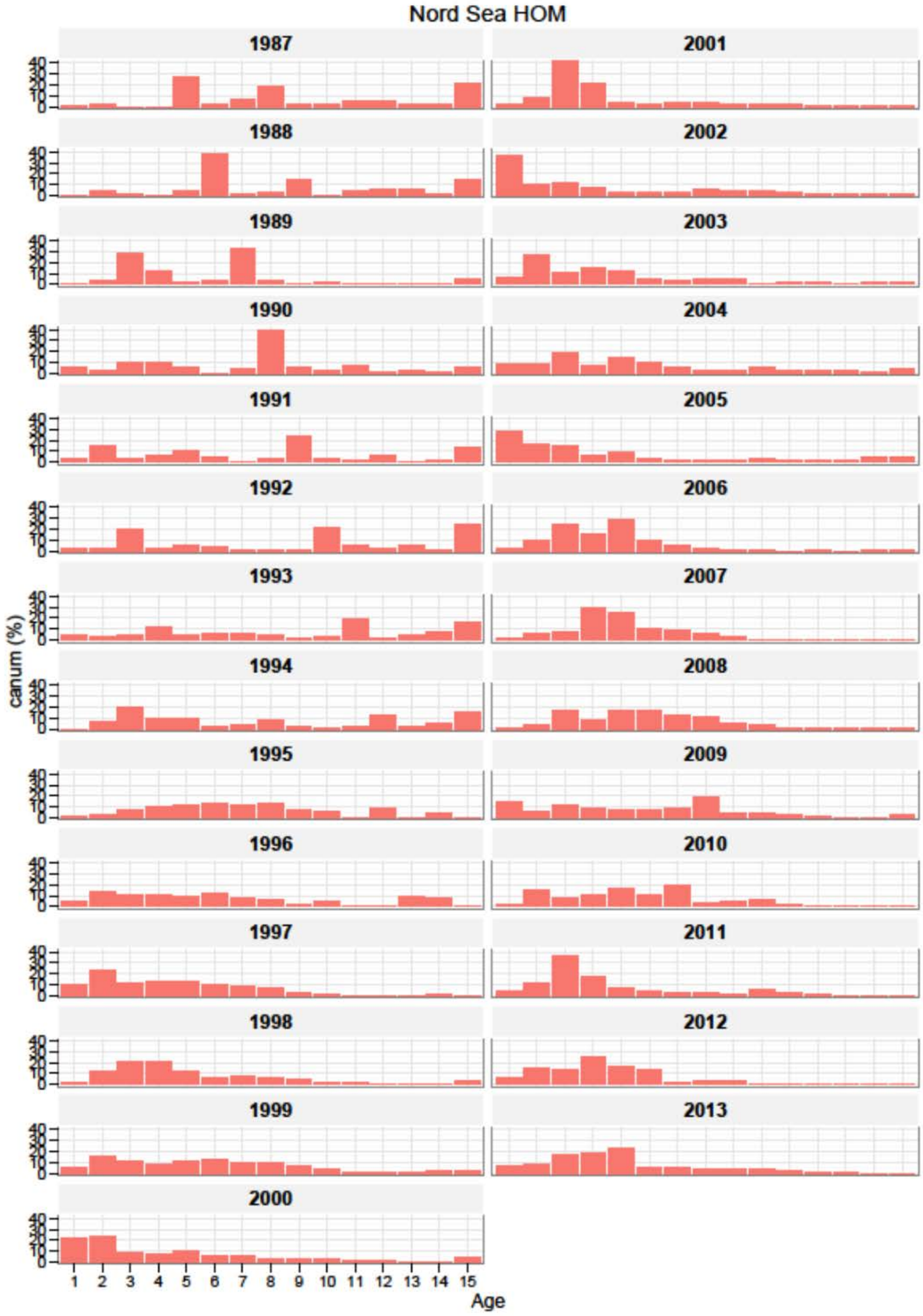


Figure 4.3.1 North Sea horse mackerel. Age distribution in the catch for 1987-2013.

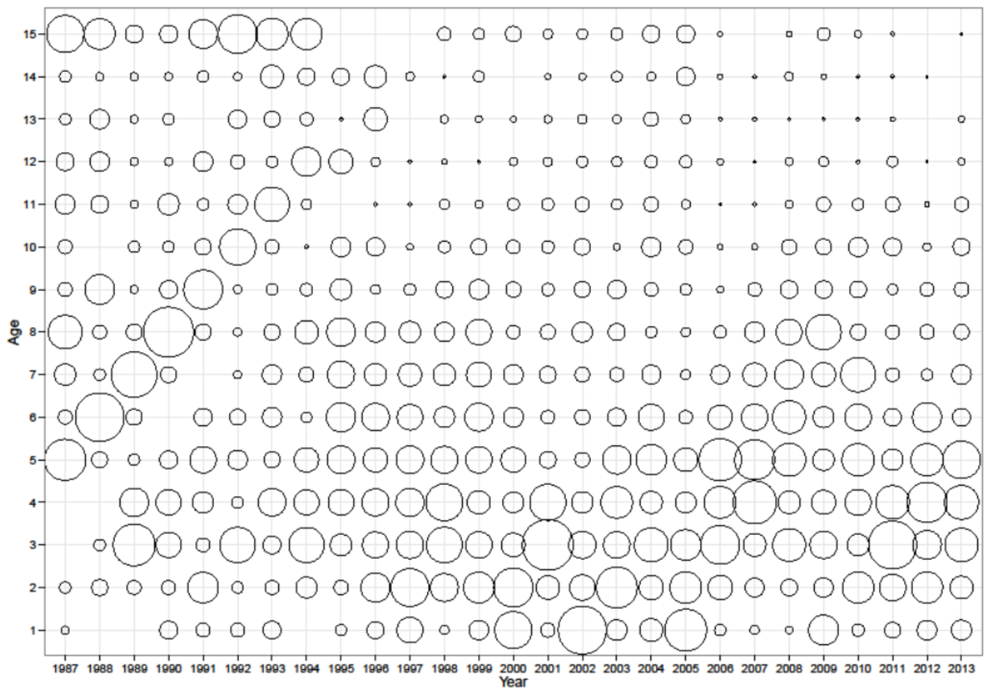


Figure 4.3.2. North Sea horse mackerel. Bubbleplot of age distribution in the catch in all areas for 1987-2013. The area of bubbles is proportional to the catch number. Note that age 15 is a plus group.

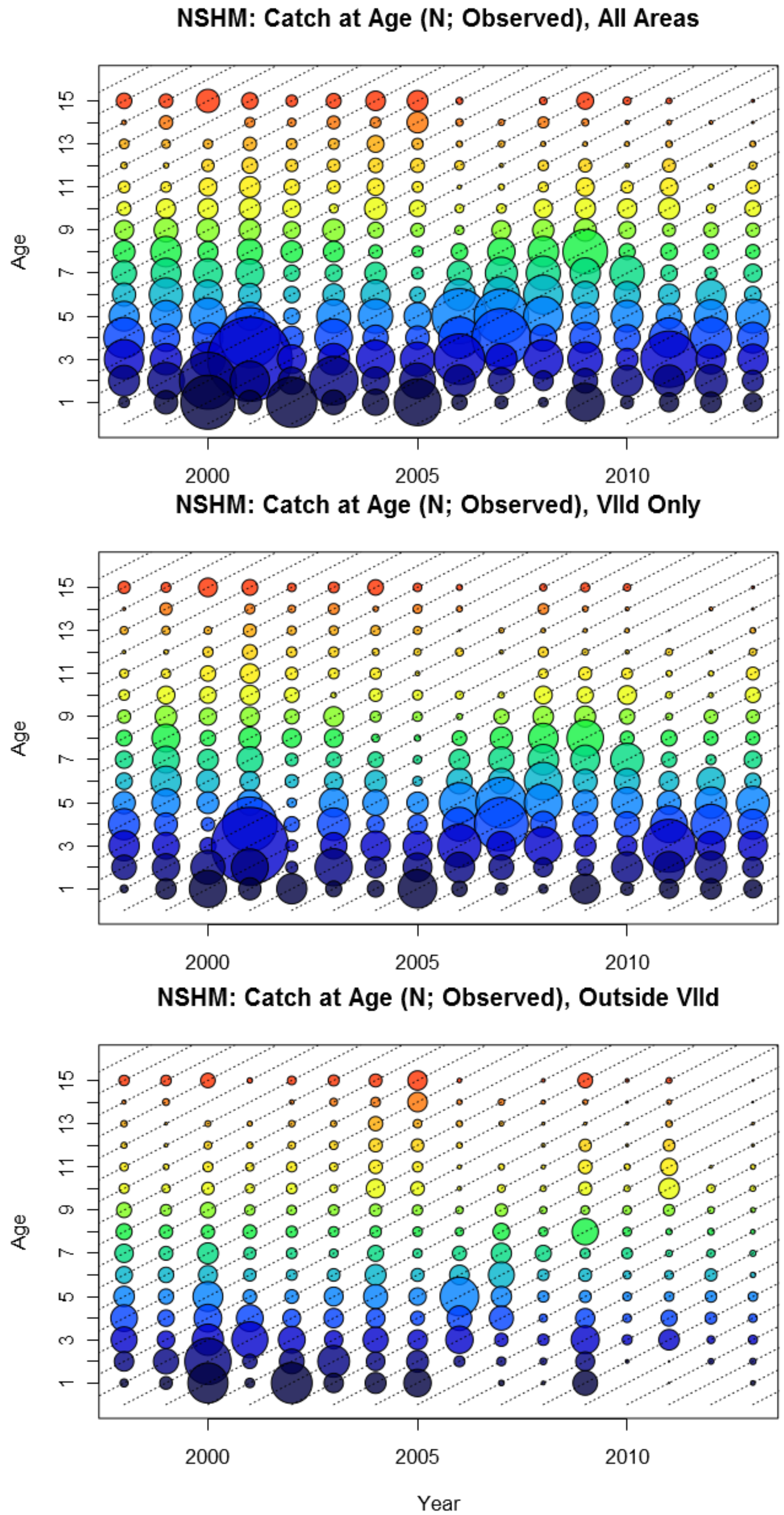


Figure 4.3.3. North Sea horse mackerel. Bubbleplots of age distribution in the catch by area for 1998-2013. The area of bubbles is proportional to the catch number. Note that age 15 is a plus group.

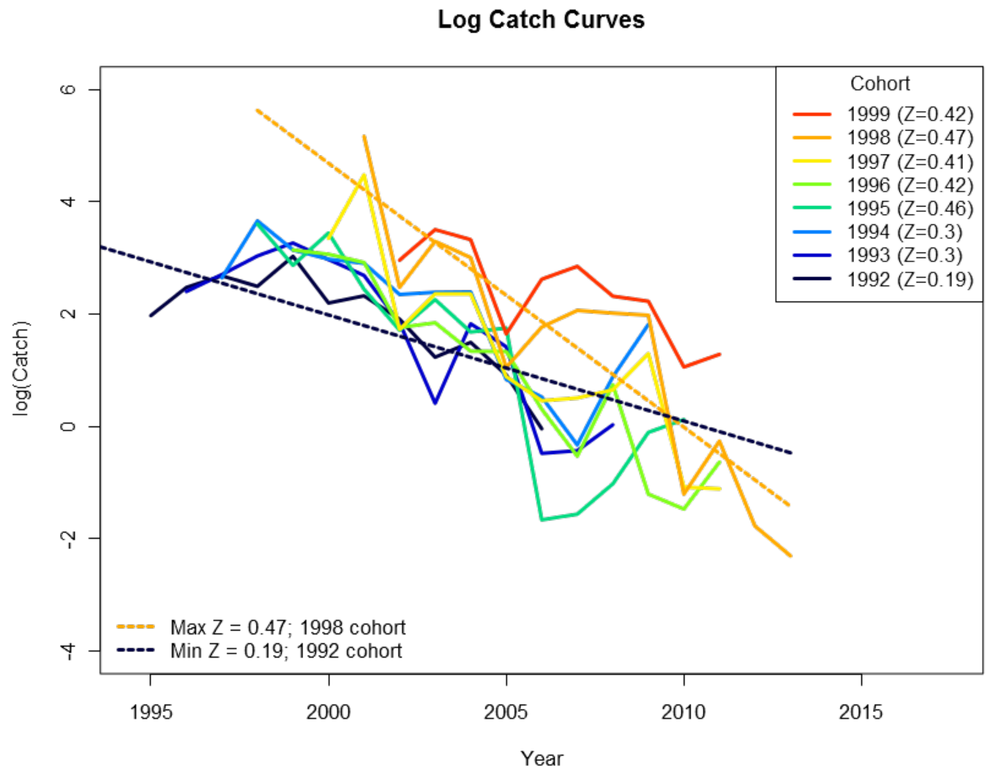


Figure 4.4.1. North Sea Horse Mackerel. Catch curves for the 1992 to 1999 cohorts, ages from 3 to 14. Values plotted are the log(catch) values for each cohort in each year. The negative slope of these curves estimates total mortality (Z) in the cohort.

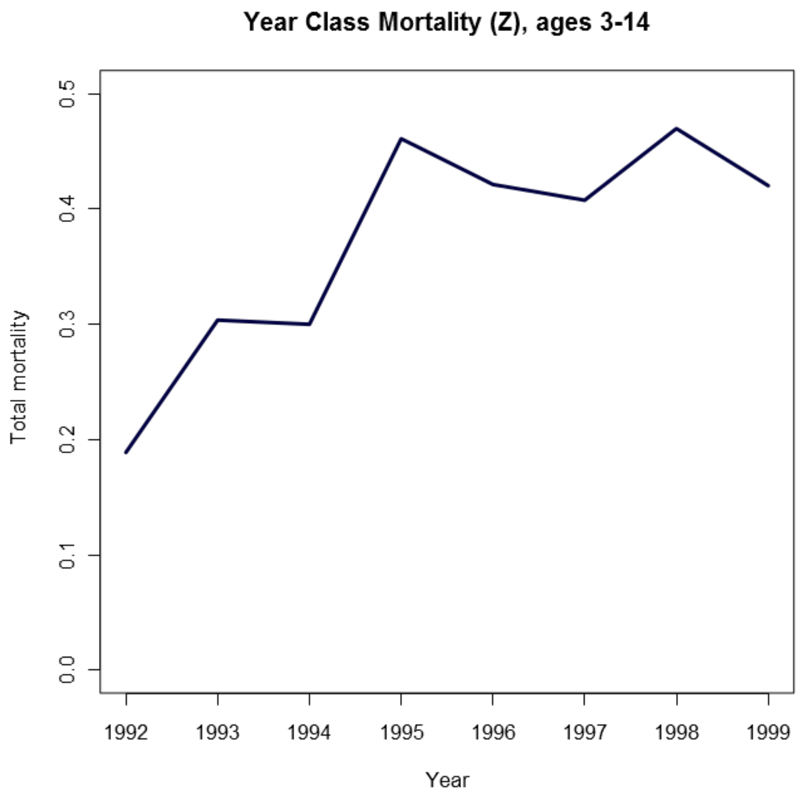


Figure 4.4.2. North Sea Horse Mackerel. Cohort total mortality (Z), negative gradients of the 1992–1999 cohort catch curves.

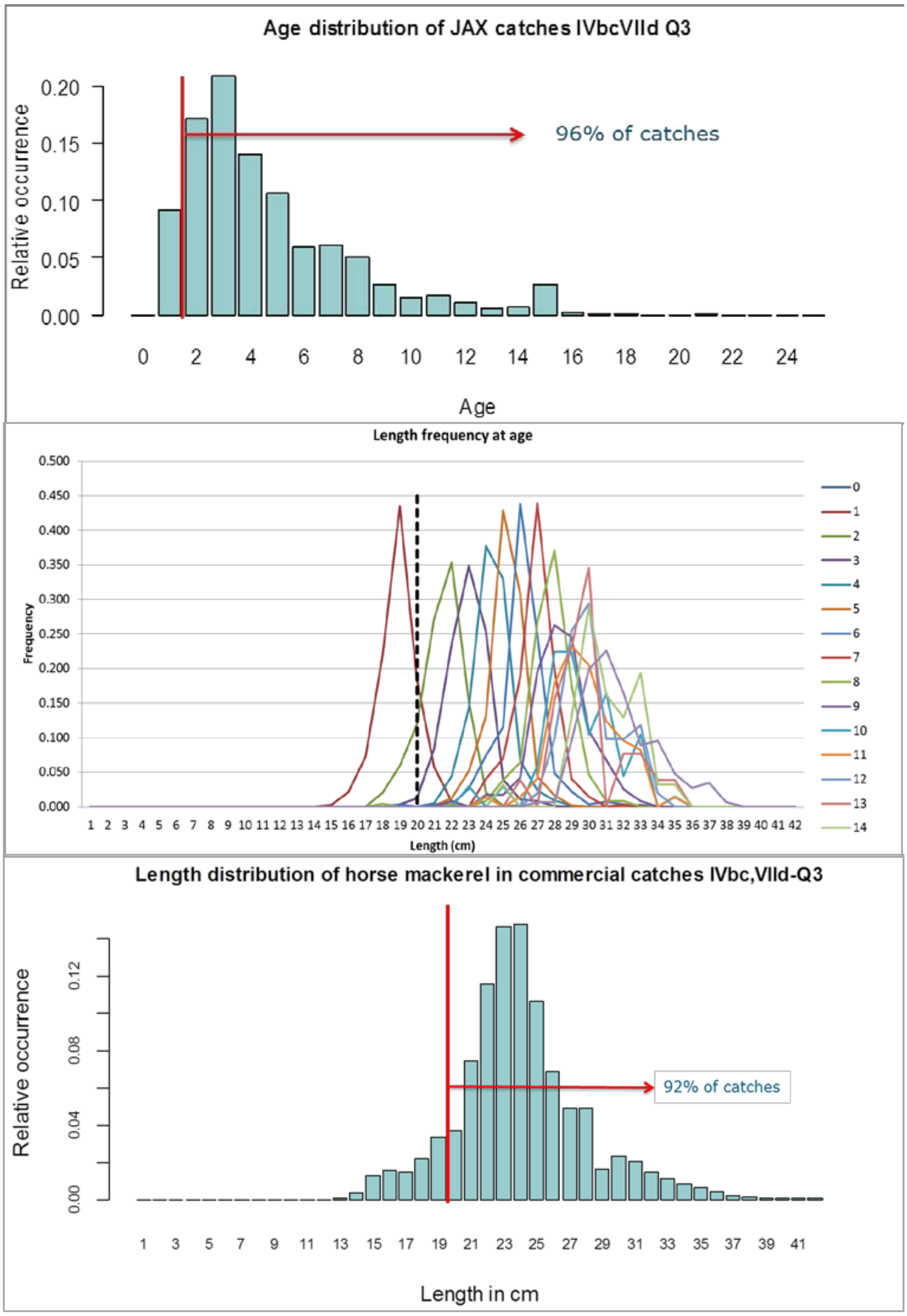


Figure 4.4.3. North Sea horse mackerel. Age distribution of commercial catches in the 3rd quarter (top), length distribution at age in the third quarter (middle) and length distribution of commercial catches in the 3rd quarter (bottom). Data are aggregated from all years up to and including 2012.

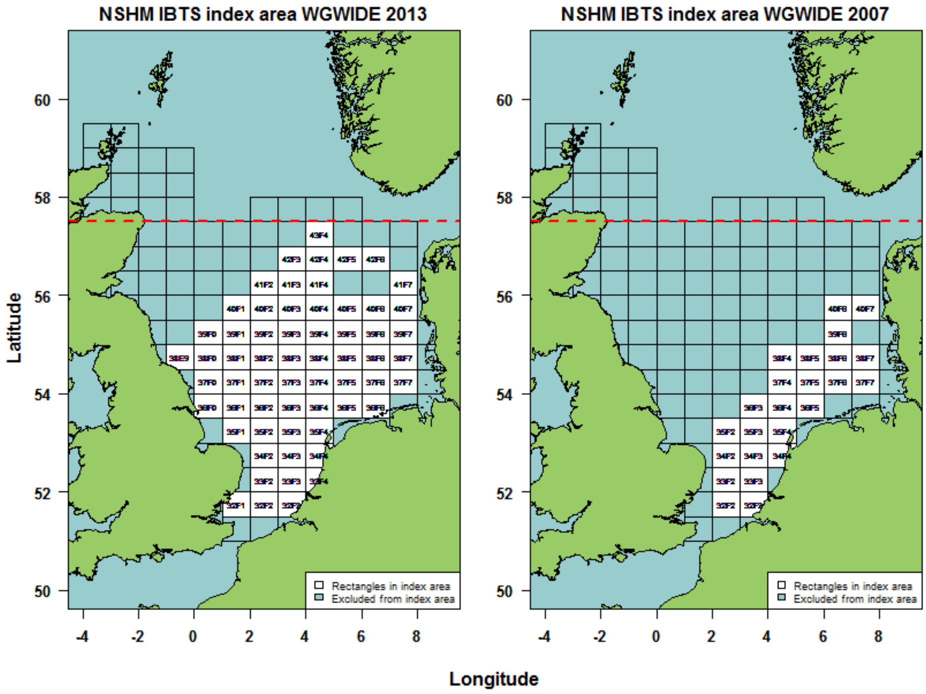
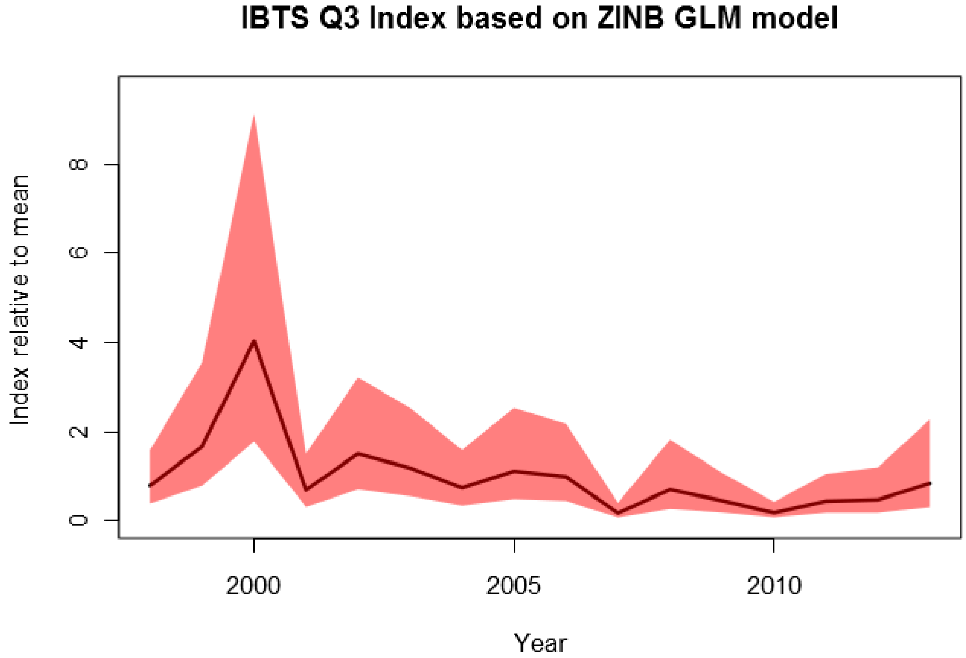


Figure 4.4.4 North Sea horse mackerel. ICES rectangles selected in 2013 and currently used by the working group (left) compared to selection for explorations in previous years (right).



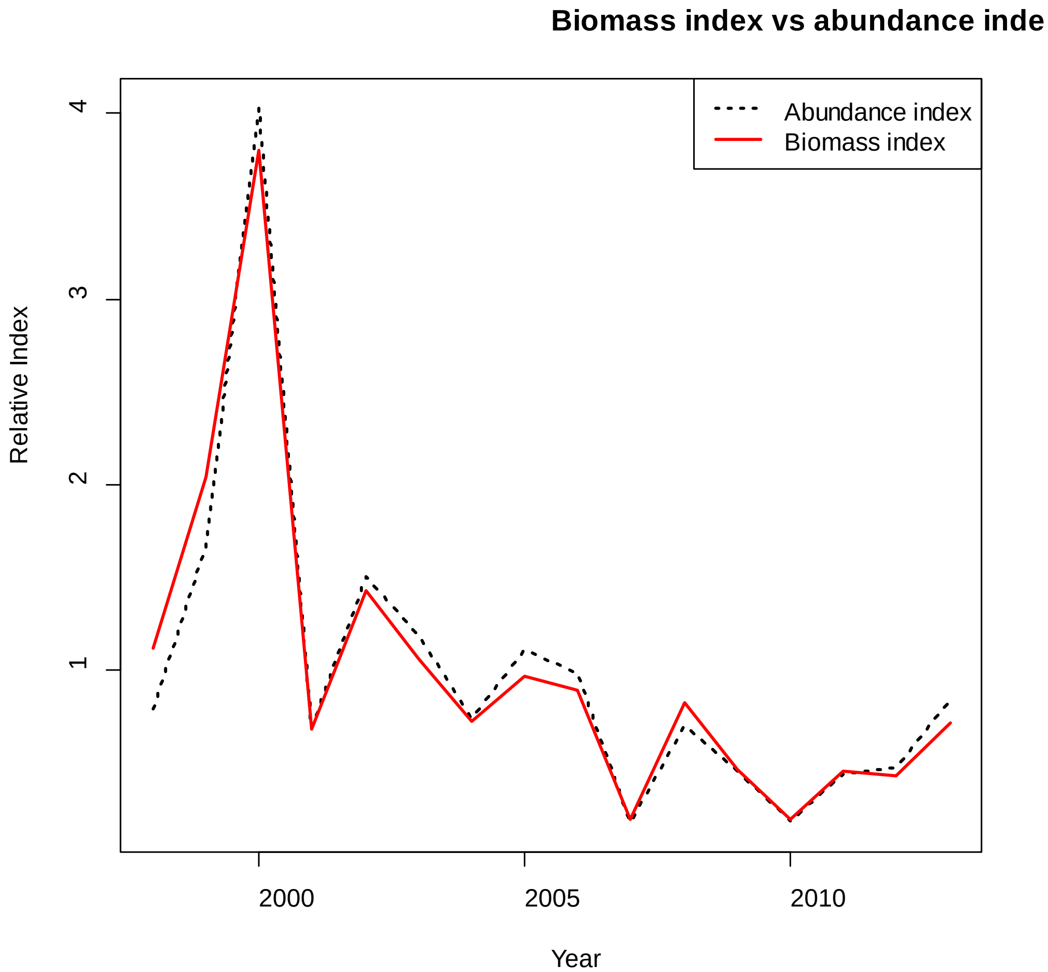


Figure 4.4.5. North Sea horse mackerel. GLM abundance indices. Top: Abundance index, the shaded area indicates the 95% confidence intervals for the estimated index values. Bottom: The abundance and biomass indices compared.

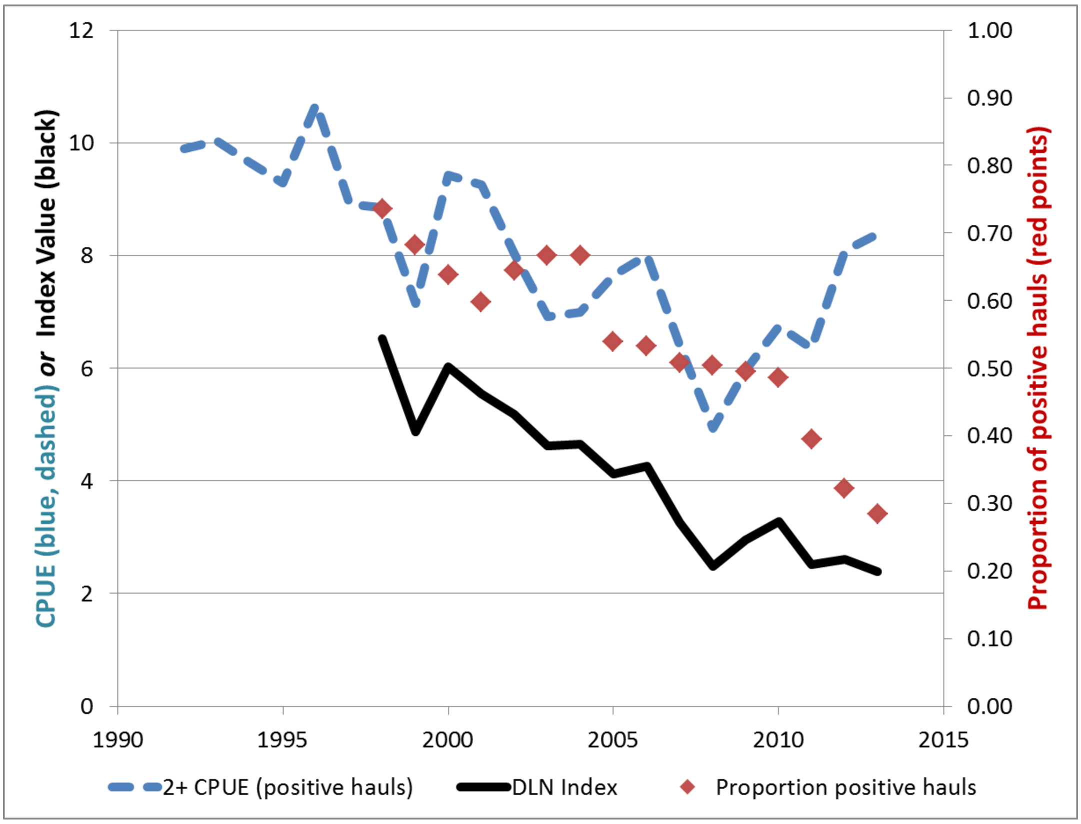


Figure 4.4.6. North Sea horse mackerel. The DLN index (black, solid) and its components: the proportion of positive (non-zero) hauls (red diamonds) and the cpue in the positive hauls (blue, dashed).

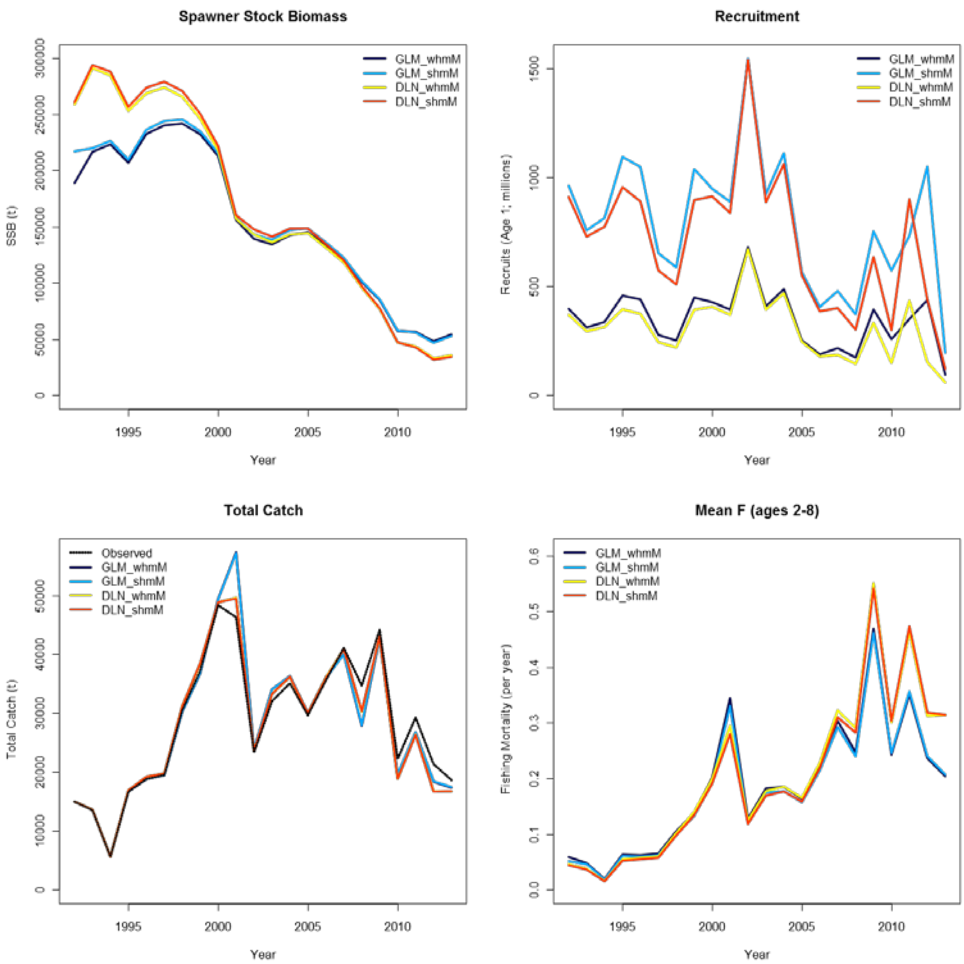


Figure 4.5.1. North Sea horse mackerel. Results of exploratory model fits using the JAXass assessment model. Spawner stock biomass (SSB, top left), Recruitment (top right), total catch (bottom left) and mean fishing mortality (ages 2-8, bottom right) for the four combinations of data used in the assessment model.