ICES REPORT 2012

ICES Advisory Committee

ICES CM 2012/ACOM:65

Ref. WGNSSK

Updated assessment of sandeel in IV, Area 1.May update of the WGNSSK report March 2012

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Recommended format for purposes of citation:

Rindorf, A. And Vinther, M. ICES. 2012. Updated assessment of sandeel in IV, Area 1. May update of the WGNSSK report March 2012. ICES CM 2012/ACOM:65. 26 pp.
https://doi.org/10.17895/ices.pub.19280933

Contents

1 Updated assessment of sandeel in IV, Area 1 (WGNSSK Feb. 2011)

The ICES assessment and advice, March 2012 (ICES, 2012a), estimates of a low TAC (23 000 t) of sandeel in Area for 2012, due to very low 2010 and 2011 year classes. Information for the 2011 year-class is entirely based on observation from a dredge survey, December 2011. However, bad weather conditions during the 2011 survey might have biased the estimate of the 2011 year-class and may indicate the relevancy of an analysis of Real Time Monitoring (RTM) for 2012 (ICES, 2012a). This document presents the results of the 2012 RTM in Area 1 and an update of the assessment.

Further information on the stock areas and assessment model can be found in the Stock Annex of WGNSSK (2012) and in the benchmark report (ICES, 2010).

1.1 Data and Methods

The aim of Real Time Monitoring of sandeel is to provide an improved estimate of stock abundance of sandeel through using observations of catch per unit effort (CPUE) from the fishery in April as a stock abundance index to update the 2012 assessment. CPUE at age in April has a high correlation with stock numbers if sampling is sufficient (ICES, 2012b). The period prior to 2001 is excluded on this basis.

CPUE is estimated from estimates of total catch weight and the effort used in obtaining this catch. Effort is measured as number days absent from harbour for the individual fishing trips, standardised to an average vessel size of 200 GT:

$$\overline{CPUE} = \frac{\sum_1^N Catch_i}{\sum_1^N Daysabsent_i * \left(\frac{GT_i}{200}\right)^{0.449}}$$

Where *N* is the number of trips, *Catch* is the catch in tonnes on a given trip, *Daysabsent* is the number of days absent on a given trip, GT is the gross tonnage of the vessel and 0.449 is the average effect of vessel size as measured over the past 10 years (2002 to 2011) using data from all months and the method described in ICES (ICES, 2010). Effort (days absent), vessel GT and total catch weight of sandeel by trip are obtained from log book data extracted from the Danish AgriFish Agency’s database.

In the most recent 5 years, a number of large vessels (>700 GT) have entered the April fishery. Their effort was low in the first years, and in total, they have participated in the fishery for less than half the total period. It is therefore not currently possible to evaluate whether they affect the accuracy of the RTM, and the vessels >700 GT are excluded in 2012. This decision should be re-evaluated when more data become available.

Age distribution of the catch is obtained from at least 100 samples of the catch taken in the harbor by the Danish AgriFish Agency. Additional samples taken at sea by the industry from every third haul, with detailed information on catch position and time were used when available to estimate the age distribution of the catch. However, samples taken by the industry are supplemented by samples taken in the harbour to ensure that the sample age composition is unbiased.

The remaining data used for the stock assessment is unaltered from that given by ICES (2012), including information on mean weight, proportion mature at age and natural mortality.

1.1.1 Spatial distribution of landings and biological samples

Danish landings in April by ICES rectangle are shown in table 1.1. One rectangle (39F1) contributed more than 75% of the landing weights. This is also the square which in the previous 10 years has supported the highest landings of all rectangles in 8 years. Biological samples are available from all squares. Distribution of effort from VMS is seen in Figure 1.1.

1.1.2 Estimation of effort and CPUE

Effort in April was just above half of the average in the previous 5 years as the fishery did not start until April 15th. The CPUE in tonnes/day absent remained at the high level seen in recent years and was slightly above that in the previous 5 years (41.3 t/day in 2012, 38.8 t/day on average from 2007–2011) (Figure 1.2).

1.1.3 Estimation age composition of catches

Visual inspection of the age-length distributions showed no difference between samples taken by the Danish AgriFish Agency and the industry. In total, 22 900 sandeel were length measured and age information was obtained from 6500 individuals. The catches in the Doggerbank area were dominated by 3-year olds and 1-year olds were only found in significant numbers in the catches in the eastern half of area 1 (Figure 1.3). The abundance indices for the RTM (Table 1.2) clearly reflect the dominance of age 3 sandeel and low catches of age 1 and age 2. This is in accordance with the age composition seen in the 2011 dredge survey catches (Table 1.2, Figure 1.4).

1.2 SMS with RTM

Settings of the SMS model was identical to that of the key run given in WGNSSK 2012, with the exception of the addition of the RTM series of CPUE in numbers at age 1, 2, 3 and 4+ per day absent in April. Details about the assessment and dredge survey and consistency analysis are given in the Stock Annex of WGNSSK 2012 (ICES, 2012b) and the benchmark report (ICES, 2010).

1.2.1 Data analysis

Based on the results from the Benchmark assessment (ICES, 2010) the SMS-effort model was used to estimate fishing mortalities and stock numbers at age by half year, using data from 1983 to 2011 and the RTM CPUE in April 2012. For details about the SMS model and model settings, see the Stock Annex.

The diagnostics output from SMS are shown in Table 1.3. The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is as expected rather constant over the three year ranges used, showing a stable relationship between effort and F for the full assessment period. The "age catchability" ("F, age effect" in the table) shows a change in the fishery pattern where the fishery was mainly targeting the age 2+ sandeel in the beginning of the period, to a fishery mainly targeting age 1 and age 2 in the most recent years.

The CV of the dredge survey (Table 1.3) is moderate (0.53) for age 0 and high (1.25) for age 1, indicating a reasonable consistency between the results from the dredge survey and the overall model results. The residual plot (Figure 1.5) shows no clear bias for this relatively short time series thought there has been a consistent underestimation of the survival of the 2010 year class which has positive residuals (more caught in survey than expected) both in the dredge and RTM series.

The CV of the RTM April CPUE (Table 1.3) is low (0.32) for age 1 and moderate to high (0.69) for age 2, 3 and 4+, indicating a good consistency between the results from the RTM April CPUE of age 1 and the overall model results. The residual plot (Figure 1.5) shows no clear bias for this relatively short time series. However, there is a clear tendency age 2 and 3 residuals to be either both positive or both negative. This is possibly related to year effects on the availability of sandeel to the fishery in April. The residuals of ages 2 and 3 in 2012 are particularly large, indicating a substantially greater CPUE in the fishery than expected from the model abundance..

The model CV of catch at age is low (0.262) for age 1 and age 2 in the first half of the year and medium or high for the remaining ages and season combinations (Table 1.3). The residual plots for catch at age (Figure 1.6) confirm that the fit is generally poor except for age 1 and 2 in the first half year. There is a cluster of negative residuals (observed catch is less than model catch) for age 4+ in most recent years, but for age 1 – age 3 there is no obvious bias in first half year catches in most recent years. The estimated recruitment in 2011 is the third lowest in the time series and follows directly after the lowest recruitment ever (2010).

1.2.2 Final assessment

The output from the assessment is presented in Tables 1.4 (fishing mortality at age by year), 1.5 (stock numbers at age) and 1.6 (Stock summary).

1.2.3 Historic Stock Trends

The stock summary (Figure 1.7 and Table 1.6) show results virtually identical to those given in the default assessment in WGNSSK 2012 (ICES, 2012b Figure 1.8).

1.2.4 Recruitment estimates

Recruitment estimates are given in the summary table (Table 1.6). Based on results from the dredge survey and RTM, the recruitment in 2011 is estimated at 33 billion. This is the third lowest estimate for the entire time series and follows directly after a very poor 2010 year class (26 billion, lowest on record). These poor year classes are not caused by lack of SSB, as SSB in both years has been above B_{lim} with a high probability. Two consecutive years of such bad recruitment has never previously been observed. The second lowest value of biennial recruitment was around twice the current and was recorded in the years 1986 and 1987, following the strongest year class on record (1985). For comparison, the 2009 year class was the 3rd largest on record. Hence, the recruitment success could potentially be depressed by the large biomass of older fish. However, it is equally possible that other effects are the cause.

1.2.5 Short-term forecasts

Input

Input to the short term forecast is given in Table 1.7. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in the second half year of 2012 is the geometric mean of the recruitment 1983–2010 (202 billion at age 0). The exploitation pattern and Fsq is taken from the assessment values in 2011. As the SMS-model assumes a fixed exploitation pattern since 1999, the choice of years is not critical. Mean weight at age in the catch and in the sea is the average value for the years 2008-2011. The maturity estimate in 2012 is obtained from the dredge survey in December 2011. For 2013 the long term average proportion mature is applied. Natural mortality is the fixed M applied in the assessment.

ICES (2012) gives more details about the forecast methodology.

Output

The short term forecast of the run including RTM shows that even with a TAC of 0 tonnes will not be consistent with a SSB at B $MSY_{trigger}$ at 215 000 tonnes (Table 1.8). For comparison, the default run given in ICES (2012b) resulted in a TAC of 23 000 tonnes.

1.2.6 Biological reference points

B_{lim} is set at 160 000 tons and B_{pa} at 215 000 tons. B $MSY_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeels in IV can be found in ICES (2012b).

1.2.7 Quality of the assessment

The number of RTM trips, total landings and biological sampling in 2012 are sufficient for calculating accurate CPUE at age. CPUE from the commercial fishery might however result in seriously biased abundance indices. As for most other abundance indices, it is assumed that catchability remains constant during the time series. This is probably not the case in for the RTM as it reflects commercial fisheries where the main effort is used on fishing grounds with the highest CPUE. This is probably the case for 2012 and for the years since 1999 used in the index. For 2012, more than 75% of the total landings were from one ICES rectangle where the catch was mainly consisting of age 3 sandeel. This resulted in a very high proportion of age 3 sandeel in the total catch, and a very low CPUE of age 1 and age 2. Whether this observation fully reflect the sandeel population is difficult to conclude. However, the historical fit between CPUE and stock abundance is good for age 1 and rather poor for the older ages. Without further information, the models procedure to weight data seems appropriate and the results therefore seem valid.

1.2.8 Status of the Stock

The stock has recovered from the low levels of SSB estimated for 2000–2006, due to recent recruitments around the long term mean and a decrease in F from around 1.0 in the period 1999–2004 to around 0.5 since 2005. Recruitment in 2009 is estimated to be twice the long term mean but recruitment in both 2010 and 2011 is less than 10% of the recruitment in 2009. SSB has been above B_{pa} since 2007 but is now expected to fall below Bpa in 2012.

1.3 Sources

ICES. 2010. ICES. 2010. Report of the Benchmark Workshop on Sandeel (WKSAN). ICES CM 2010/ACOM:57

ICES. 2012a. Sandeel in Division IIIa and Subarea IV. ICES Advice, 2012. Book 6 (Section 6.4.21)

ICES. 2012. ICES. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 27 April–03 May 2012. ICES CM 2012/ACOM:13

Table 1.1 Total catch and number of samples by ICES rectangle

Rectangle	Ton	Number of samples
37F2	855	7
38F1	935	7
39F1	20069	81
39F2	50	1
39F7	104	2
40F4	3593	82
40F5	17	4

Table 1.2. Sandeel in Area-1. Abundance indices

a) Real Time Monitoring CPUE (1000' individuals per day absent)

	Age			
Year	1	2	3	4+
1999	4434	580	833	32
2000	-1	-1	-1	-1
2001	5942	409	47	13
2002	7649	1097	106	10
2003	217	1430	71	9
2004	3287	27	70	6
2005	920	243	10	11
2006	4778	173	45	4
2007	5431	1412	74	23
2008	7232	787	150	17
2009	2791	2494	327	92
2010	9470	239	225	39
2011	457	5997	280	65
2012	483	459	3213	94

b) Dredge survey CPUE (number / hour)

	Age		
Year	0	1	2
2004	931	171	7
2005	2266	53	10
2006	1481	236	7
2007	3443	95	29
2008	429	345	31
2009	3733	92	34
2010	424	1959	142
2011	652	872	581

Table 1.3. Area-1 Sandeel updated with RTM. SMS settings and statistics.

```
objective function (negative log likelihood):  30.9621
Number of parameters: 59
Maximum gradient: 9.51453e-005
Akaike information criterion (AIC):   179.924
Number of observations used in the likelihood:
                           Catch    CPUE     S/R Stomach     Sum
                            290      68      28       0     386

objective function weight:
                         Catch  CPUE   S/R
                         1.00  1.00  0.01

unweighted objective function contributions (total):
               Catch    CPUE    S/R    Stom.  Penalty     Sum
              29.6     1.2    10.4     0.0 0.00e+000    41.2


contribution by fleet:
----------------------
Dredge survey 2004-2011     total:   4.701   mean:   0.294
RTM April. 1999-            total:  -3.489   mean:  -0.067

F, season effect:
-----------------
age: 0
    1983-1988:   0.000 1.000
    1989-1998:   0.000 1.000
    1999-2011:   0.000 1.000
age: 1 - 4
    1983-1988:   0.498 0.500
    1989-1998:   0.467 0.500
    1999-2011:   0.403 0.500

F, age effect:
--------------
               0      1      2      3      4
1983-1988:  0.027  0.285  1.234  2.098  2.098
1989-1998:  0.055  0.850  1.376  1.567  1.567
1999-2011:  0.059  1.810  2.263  2.088  2.088

Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                       0      1      2      3      4
1983-1988 season 1:  0.000  0.290  1.255  2.134  2.134
          season 2:  0.016  0.085  0.370  0.629  0.629

1989-1998 season 1:  0.000  0.727  1.176  1.340  1.340
          season 2:  0.005  0.037  0.060  0.068  0.068

1999-2011 season 1:  0.000  0.755  0.945  0.872  0.872
          season 2:  0.009  0.133  0.167  0.154  0.154


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0              1.102
 1       0.262   0.736
 2       0.262   0.736
 3       0.700   1.348
 4       0.700   1.348
```

Table 1.3 (continued). Area-1 Sandeel updated with RTM. SMS settings and statistics.

Survey catchability:

--------------------	age 0	age 1	age 2	age 3	age 4
Dredge survey 2004-2011	2.201	1.594			
RTM April. 1999-		4.562	4.838	3.123	3.123

sqrt(Survey variance) ~ CV:

---------------------------	age 0	age 1	age 2	age 3	age 4
Dredge survey 2004-2011	0.53	1.25			
RTM April. 1999-		0.32	0.69	0.69	0.69

Recruit-SSB	alfa	beta	recruit s2	recruit s
Area-1 Hockey stick -break.:	1370.383	1.600e+005	0.773	0.879

Table 1.4. Area-1 : Annual Fishing mortality (F) at age

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.009	0.235	0.958	1.613	1.613	0.596
1984	0.010	0.266	1.083	1.823	1.823	0.675
1985	0.009	0.270	1.096	1.840	1.840	0.683
1986	0.003	0.205	0.828	1.381	1.379	0.517
1987	0.005	0.143	0.584	0.986	0.986	0.364
1988	0.004	0.207	0.836	1.395	1.393	0.522
1989	0.003	0.669	1.012	1.135	1.133	0.840
1990	0.005	0.608	0.922	1.038	1.036	0.765
1991	0.013	0.470	0.722	0.822	0.823	0.596
1992	0.009	0.692	1.052	1.187	1.185	0.872
1993	0.004	0.282	0.429	0.485	0.484	0.355
1994	0.003	0.265	0.403	0.455	0.454	0.334
1995	0.006	0.463	0.704	0.794	0.793	0.584
1996	0.006	0.471	0.717	0.809	0.808	0.594
1997	0.013	0.407	0.626	0.714	0.715	0.517
1998	0.005	0.522	0.793	0.892	0.890	0.658
1999	0.010	1.208	1.431	1.315	1.314	1.319
2000	0.009	0.968	1.147	1.054	1.053	1.058
2001	0.026	1.438	1.722	1.597	1.599	1.580
2002	0.002	1.151	1.353	1.236	1.233	1.252
2003	0.008	0.873	1.033	0.949	0.948	0.953
2004	0.004	0.994	1.172	1.073	1.071	1.083
2005	0.000	0.425	0.498	0.453	0.452	0.462
2006	0.001	0.625	0.734	0.669	0.667	0.679
2007	0.000	0.262	0.307	0.279	0.278	0.285
2008	0.001	0.434	0.509	0.464	0.462	0.472
2009	0.002	0.606	0.713	0.651	0.649	0.659
2010	0.001	0.413	0.485	0.442	0.441	0.449
2011	0.001	0.520	0.610	0.556	0.554	0.565
arith. mean	0.006	0.555	0.844	0.969	0.968	0.700

Table 1.5. Area-1 : Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-

year

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4
1983	629293	16646	56737	2597	279
1984	146720	238888	4811	10034	332
1985	945952	55638	67224	758	980
1986	154520	359083	15641	10545	167
1987	72890	58969	107370	3206	1583
1988	375898	27773	18455	26813	1003
1989	177407	143418	8288	3750	4055
1990	233854	67700	29531	1463	1491
1991	332794	89053	14558	5591	611
1992	72659	125745	20912	3178	1484
1993	304738	27565	25013	3490	829
1994	451748	116204	7720	7262	1436
1995	109435	172421	33063	2299	2974
1996	709655	41666	41630	7551	1353
1997	105865	270111	9985	9392	2217
1998	199045	40031	66829	2372	3070
1999	245796	75867	9245	14202	1287
2000	388932	93181	9613	1085	2410
2001	475155	147656	14495	1458	706
2002	22153	177177	14239	1209	248
2003	189032	8468	24507	1864	252
2004	79815	71818	1430	4119	459
2005	246157	30433	11180	217	904
2006	156026	94213	7679	3104	398
2007	311537	59670	20153	1734	998
2008	124056	119285	17176	6597	1109
2009	692434	47465	29829	4716	2634
2010	26387	264572	10260	6826	2142
2011	32726	10094	67171	2871	3132
2012		12522	2356	16916	1924

Table 1.6. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), landings weight (Yield) and average fishing mortality.

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1-2
1983	629293	698743	512209	349232	0.596
1984	146720	1508407	210206	467609	0.675
1985	945952	1004859	590486	424114	0.683
1986	154520	2283933	318312	382735	0.517
1987	72890	1601795	1065834	357671	0.364
1988	375898	778011	628532	398271	0.522
1989	177407	814398	228949	445695	0.840
1990	233854	699726	364905	283040	0.765
1991	332794	1067916	318756	347096	0.596
1992	72659	1305549	346211	564298	0.872
1993	304738	543237	300561	124082	0.355
1994	451748	816469	185872	209538	0.334
1995	109435	1774455	425059	410513	0.584
1996	709655	682857	400584	298702	0.594
1997	105865	2170786	232382	431808	0.517
1998	199045	908104	560976	371117	0.658
1999	245796	634501	226461	427691	1.319
2000	388932	700058	120095	284521	1.058
2001	475155	814901	142865	513068	1.580
2002	22153	1177098	124235	596049	1.252
2003	189032	213690	156439	121863	0.953
2004	79815	407486	56497	195274	1.083
2005	246157	308811	121736	100835	0.462
2006	156026	667418	114314	231448	0.679
2007	311537	559235	219977	108600	0.285
2008	124056	1039330	300785	237447	0.472
2009	692434	660963	261227	291247	0.659
2010	26387	1919474	218824	300954	0.449
2011	32726	722737	425435	311134	0.565
2012			265833*		
arith. mean	284998	991508	312617	331233	0.704
geo. mean**	201782				

using weights from 2011

****period 1983–2010**

Table 1.7. Input values for preliminary short term forecast

Age	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2012) (millions)	201782	12522	2356	16916	1924
Exploitation pattern 1st half		0.404	0.505	0.466	0.466
Exploitation pattern 2nd half	0.001	0.011	0.014	0.013	0.013
Weight in the stock 1st half (gram)		5.84	10.14	13.03	15.20
Weight in the catch 1st half (gram)		5.84	10.14	13.03	15.20
weight in the catch 2nd half (gram)	2.69	5.71	8.63	10.81	13.76
Proportion mature(2012)	0	0.03	0.77	0.98	1
Proportion mature(2013)	0	0.02	0.83	1	1
Natural mortality 1st half		0.46	0.44	0.31	0.28
Natural mortality 2nd half	0.96	0.58	0.42	0.37	0.36

Table 1.8. Sandeel in Area-1 with RTM. Forecast for 2012 for various levels of F.

Basis: Fsq=F(2011)= sum of half yearly Fs = 0.467; Yield(2011)=310; Recruitment(2011)=33; Recruitment(2012)= geometric mean (GM 83-10) = 202 billion; SSB(2012)=266						
F multiplier	Basis	F (2012)	Landings (2012)	SSB (2013)	%SSB change*	%TAC change**
0	F=0	0	0	205	-23%	-100%
0.25	Fsq*0.25	0.117	32	183	-31%	-90%
0.5	Fsq*0.5	0.234	61	164	-38%	-80%
0.75	Fsq*0.75	0.350	87	147	-45%	-72%
1	Fsq*1	0.467	110	132	-51%	-65%
1.25	Fsq*1.25	0.584	131	118	-56%	-58%
1.5	Fsq*1.5	0.701	150	106	-60%	-52%
1.75	Fsq*1.75	0.817	167	95	-64%	-46%
2	Fsq*2	0.934	182	86	-68%	-42%

***SSB in 2013 relative to SSB in 2012**

**** TAC in 2012 relative to landings in 2011**

Table 1.9. Sandeel in Area-1 with RTM. Number of samples taken in the RTM period since 1997

Year	Number of samples
1997	16
1998	16
1999	46
2000	7
2001	53
2002	77
2003	86
2004	192
2005	83
2006	185
2007	196
2008	144
2009	148
2010	60
2011	58
2012	184

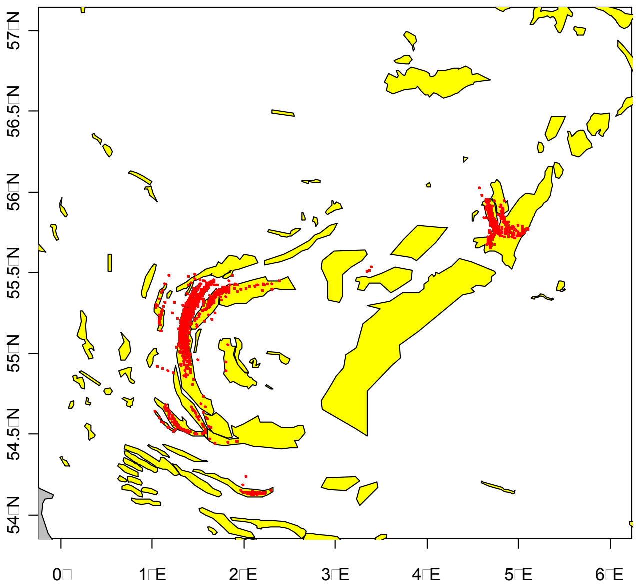

Figure 1.1. VMS signals from vessels with speed 2-4 knots, landing sandeel in April 2012

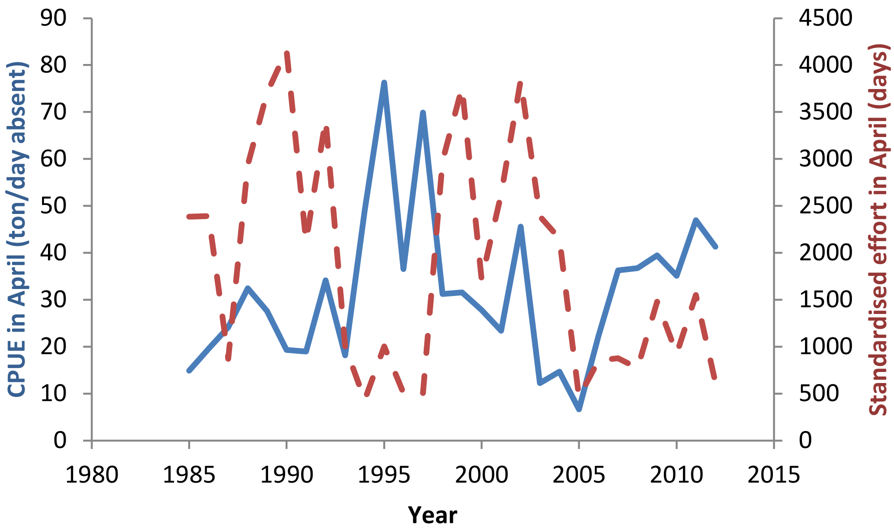

Figure 1.2. CPUE in April (blue solid line) and effort in April (red broken line).

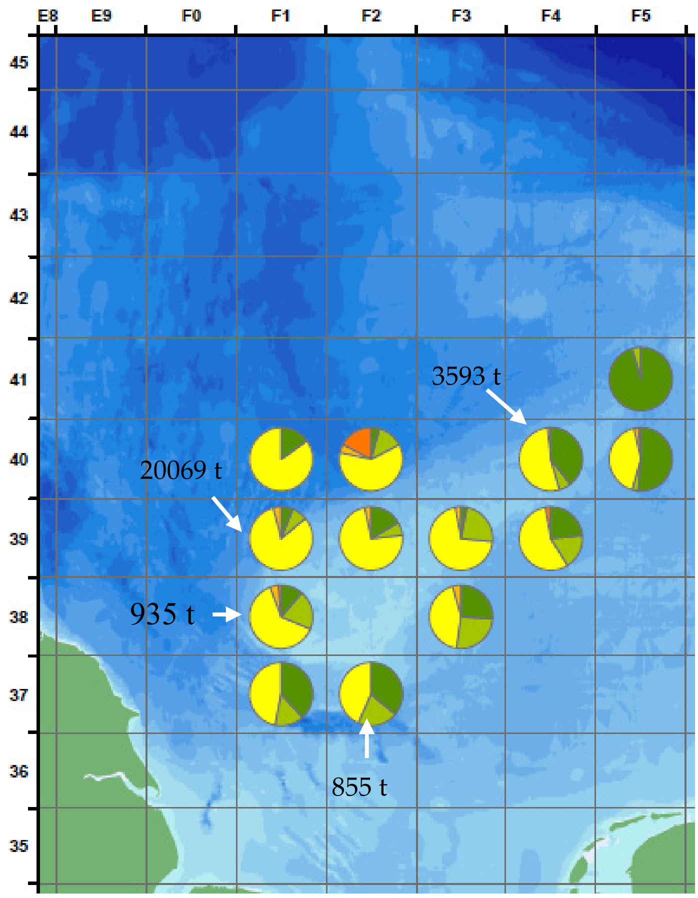

Figure 1.3. Age distribution of catch samples (in numbers) taken in different squares. Age 1: Dark green, age 2: light green, Age 3: yellow, Age 4+: orange shades. Total catch indicated in squares where the total catch exceeded 50ton.

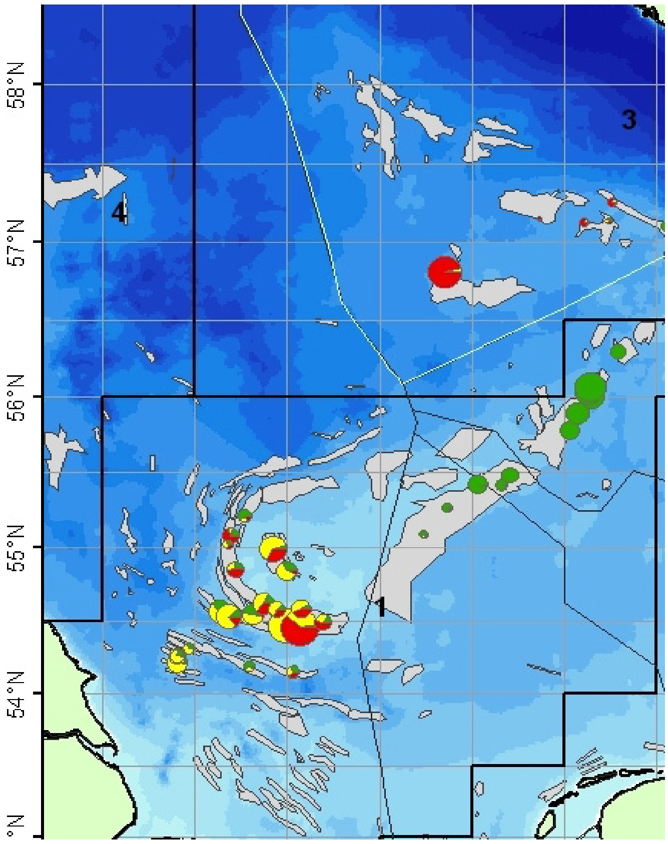

Figure 1.4. Age distribution of dredge samples (in numbers) taken in different squares. Age 0: Dark green, age 1: yellow, Age 2+: red. Note that the survey is performed in 2011, so Age0 are age 1 in the previous plot from 2012.

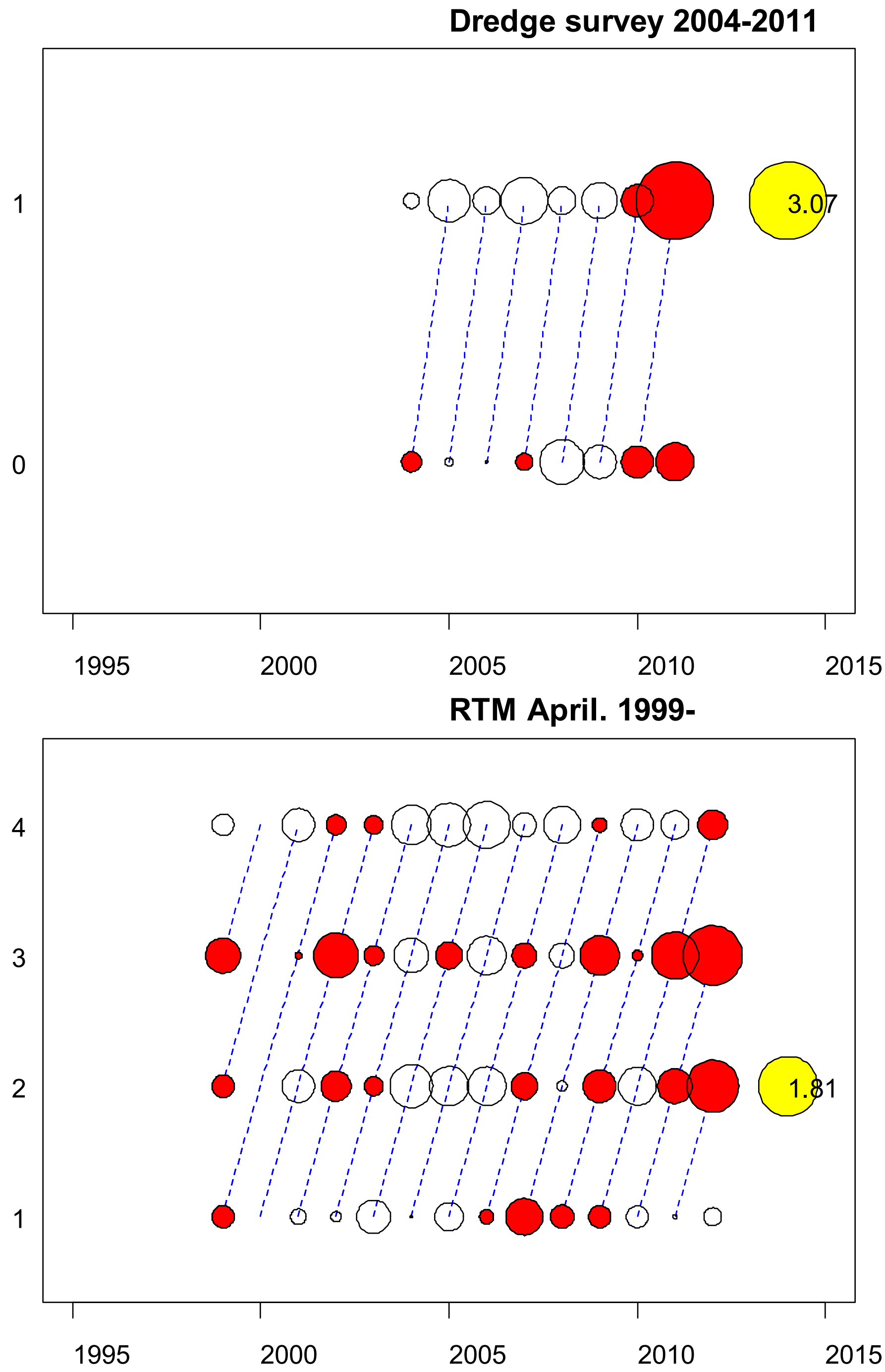

Figure 1.5. Dredge survey and RTM April residuals (log(observed CPUE) - log(expected CPUE). 'Red' dots show a positive residual.

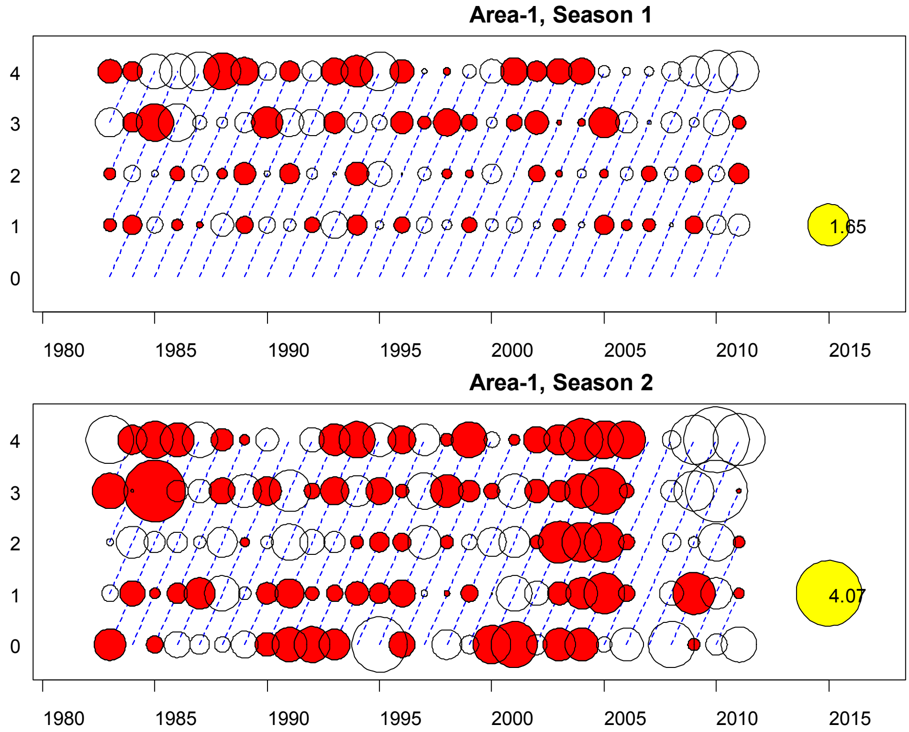

Figure 1.6. Catch at age residual (log(observed catch) - log(expected catch). 'Red' dots show a positive residual.

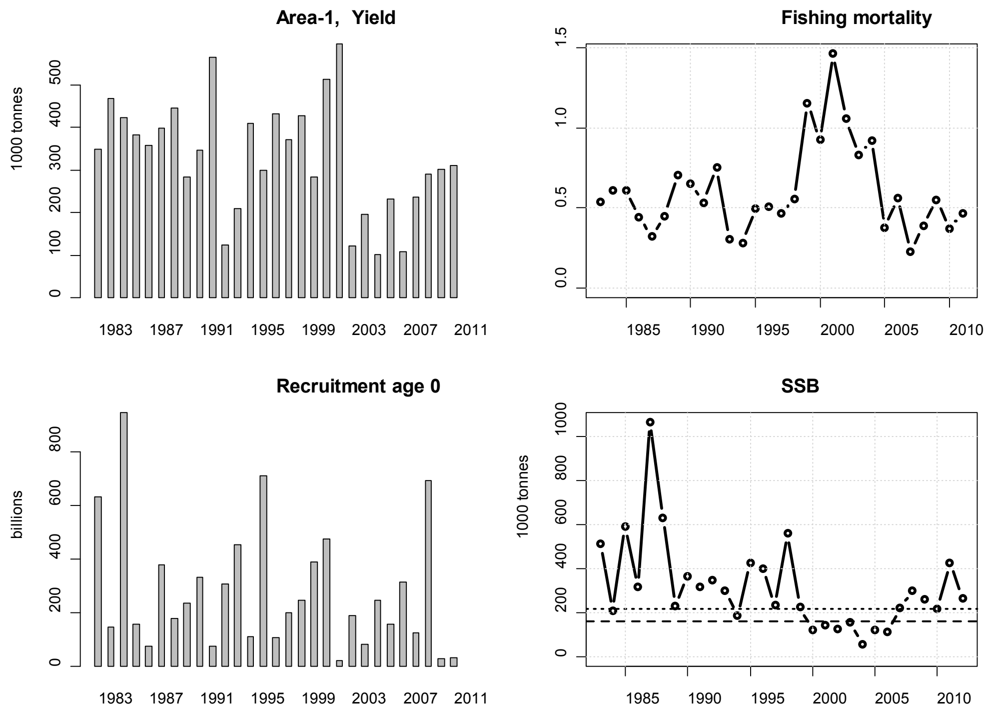

Figure 1.7. Stock summary.

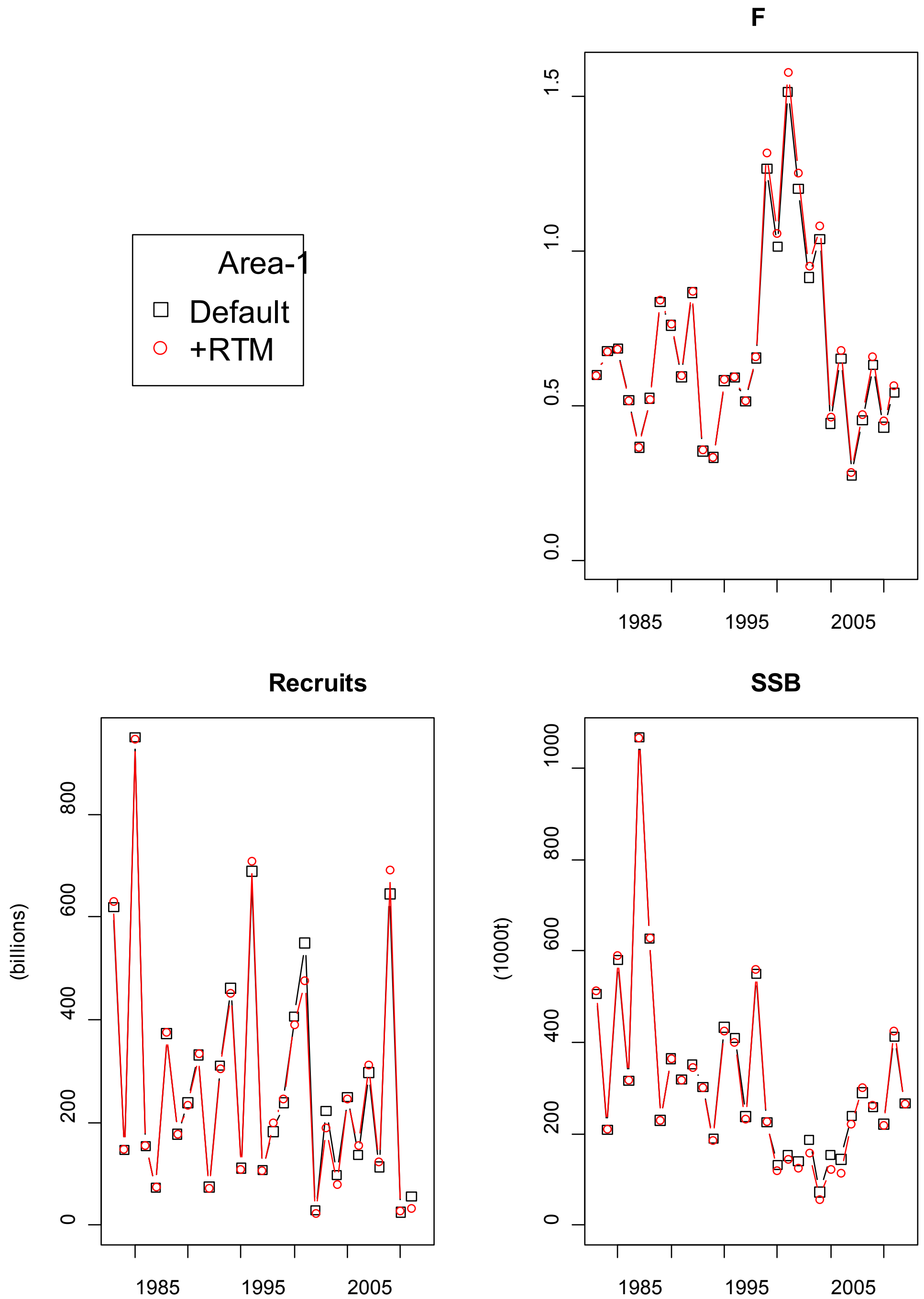

Figure 1.8. Comparison of run with RTM (red) and run without RTM (black).

Annex 1 Technical Review

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Review of Updated assessment of sandeel in IV, Area 1 (WGNSSK, Feb. 2011)

This document details an updated assessment of sandeels, through the addition of a real time monitoring (RTM) catch per unit effort (CPUE) index. The benchmark assessment conducted in 2010 (WKSAN) states that the pre-season dredge survey is sufficient to provide TAC advice in most years, without requiring RTM. It does leave the door open to incorporating RTM, if necessary, as was apparently the case this year due to poor weather conditions during the dredge survey.

The methods described in this document are clear, well documented, and well justified.

The results are in fact, very simple. The RTM CPUE index mirrors the dredge survey index (Table 1.2). This could also be shown using a more effective figure. The 2009 cohort is the largest on record for both indices and is followed by two of the three lowest on record. The assessment is the same as was previously conducted with the addition of the RTM index. Given that the new information added (the RTM index) does not appear to differ from the dredge survey index, we would not expect results of the assessment to differ significantly. That is exactly what is shown in Figure 1.8. The changes, which are not great, actually show the stock experienced a larger F and a smaller number of recruits in 2011.

Results of the short term forecast are as expected given the presence of two extremely weak recruitment years. Abundance is significantly reduced due to the presence of these cohorts in the fishery, greatly impacting the TAC.

I have a few additional cautions. First, as was noted, the RTM uses a fishery dependent index, which often have inherent problems. As fishers know where and how to get fish, changes in abundance may not be as apparent with fishery dependent abundance indices to as great an extent as with fishery independent indices. Increases or decreases in fishery dependent indices may actually mask much greater changes in actual abundance. Second, it is important in the long term to understand if the large vessels (>700 GT) added to the fishing fleet do have an impact on the index. The justification for not investigating this at this point is sound, but this will need to be addressed in the future.

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Additional research should be conducted to better understand the factors impacting recruitment in this fishery. Knowing whether critical environmental factors caused the decline in two cohorts of recruitment or whether the decline was a result of extremely high levels of recruitment in previous years will greatly improve both the knowledge of the stock's dynamics and the ability to manage the stock.

In conclusion, the addition of the work in this document was well conceived, executed, and explained. Results indicate that the stock summary is virtually identical to that presented in the earlier assessment (Figure 1.8), because the RTM CPUE index mirrored the dredge survey (Table 1.2).

Best regards,

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Courtesy Associate Professor