2016 Mackerel and Horse Mackerel Egg Survey

Preliminary Results

by

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Introduction

The mackerel and horse mackerel egg survey is an ICES-coordinated international study in the north east Atlantic conducted during the first half of 2016. This study is a combined plankton and fishery investigation formed by a series of individual surveys which have taken place triennially since the late 1970s and is coordinated by the ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS).

The main objective of this series of individual cruises from January until July is to produce both an index and a direct estimate of the biomass of the north east Atlantic mackerel stock and an index for the southern and western horse mackerel stocks. The results have been used in the assessment for mackerel since 1977 and from 1992 for horse mackerel. The mackerel and horse mackerel egg survey is still the main source of data providing fisheries independent information for these stocks.

The general method is to quantify the freshly spawned eggs in the water column on the spawning grounds. To be able to establish a relationship between eggs and biomass of the spawning stock, the fecundity of the females must also be determined. This is undertaken by sampling ovaries before and during spawning. The potential fecundity is counted from whole mount volumetric subsamples using a dissecting microscope while atresia is counted histologically from slides. Realised fecundity is estimated as potential fecundity minus atresia. The realised fecundity is used in combination with the calculated number of freshly spawned eggs in the water to estimate the spawning stock biomass.

To provide reliable estimates of spawned eggs and fecundity an extensive coverage of the spawning area is required both in time and space. The spawning of the southern horse mackerel stock and mackerel starts in late December off the Portuguese coast. Spawning proceeds further north along the continental shelf edge as water temperature increases during late winter and spring. In the past peak spawning of mackerel has normally occurred in April-May in the area of the Sole Banks with an extension to the Porcupine Bank. Whilst the distribution and timing of peak western horse mackerel spawning has remained fairly stable during recent surveys the same cannot be said for NEA mackerel. The most recent surveys in 2010 and 2013 saw peak mackerel spawning in February – March with 2013 also demonstrating a shift in the geographical centre of spawning further south within the southern Biscay region. Away from these areas mackerel spawning is now observed over a large region of the Northeast Atlantic both on and off the continental shelf, ranging as far west as Hatton Bank and as far north as Iceland and the Faroe Islands as well as the Shetland Islands in the Northeast.

This survey report presents the preliminary results of the 2016 mackerel and horse mackerel egg survey provided for WGWIDE in August 2016. The survey report and the analysis will be finalized during the next WGMEGS meeting in April 2017. Although every effort was made to ensure that WGWIDE were provided with the most recent and accurate data-set, WGMEGS cannot guarantee that there will not be changes prior to the analysis being finalised. This is due to the extremely large numbers of plankton and fecundity samples to be analysed following the surveys as well as the tight deadline set by WGWIDE for delivering these estimates. This has resulted in a very limited time within which to process the 2016 MEGS data.

Survey effort

As a consequence of the long spawning period and the large survey area involved, the mackerel and horse mackerel egg surveys have always relied on broad international participation. In 2016 a total of 19 individual cruises were carried out with a total of 367 survey days, with the contribution of Spain (IEO: 46 days at sea, AZTI: 41 days), Scotland (75 days), the Netherlands (56 days), Ireland (55 days), Portugal (30 days), Germany (27 days), Iceland (14 days) and the Faroe Islands (13 days).

During WGMEGS in 2015 discussions took place to address the issue of current survey effort and specifically concerns surrounding gaps in the proposed survey plan resulting both from the departure of Norway from the MEGS survey in 2014 as well as bringing the sampling start date forward in the western area by 2 weeks to ensure that the start of spawning was captured. These were discussions that had been initiated earlier in the year at a meeting in London that was attended by members of WGMEGS and also the pelagic RAC to discuss the results of the 2015 winter surveys and their subsequent impact on the survey design for the 2016 MEGS survey. These discussions resulted in 4 additional surveys being proposed to fill in the gaps. Scotland, the Netherlands, Ireland and Denmark were the four countries who stepped forward in partnership with their national pelagic fishing associations to complete these additional surveys which would be undertaken on commercial pelagic trawlers. Three of these would be incorporated into the scheduled 2016 survey program whilst the fourth Irish survey would be tasked with providing additional survey information concerning potential western horse mackerel spawning activity in August, after the nominal end date of spawning. The retrieved eggs from this survey are still to be analyzed. Consequently the results from this survey are not available and cannot be included in the 2016 western horse total annual egg production estimate. They will instead be presented at WGMEGS in 2017. Significant issues associated with securing a suitable vessel resulted in the Danish industry survey being cancelled and so in the end only Scottish and Dutch industry surveys were added to the standard 2016 schedule. Overall this still resulted in a net increase in survey effort in 2016 (363) when compared to 2013 (334).

Survey design

The aim of the triennial egg survey is to determine the annual egg production (AEP). This is calculated using the mean daily egg production rates per pre-defined sampling period for the complete spawning area of the Northeast Atlantic Mackerel and Horse Mackerel Stocks. To achieve this, one plankton haul per each half rectangle (separated by approximately 15 nm) is conducted on alternating transects covering the complete spawning area. The 2016 egg survey was designed in order to maximise both the spatial and temporal coverage in each of the sampling periods. Given the very large area to be surveyed this design minimises the chances of under/overestimation of the egg production (ICES 2008).

The 2016 survey plan was split into 8 sampling periods (Table 1). The first period (January/February) was scheduled to be covered by a single extended Daily egg production (DEPM) survey, conducted by Portugal in ICES subarea IXa only, with fuller coverage starting in period 2 (early February). No sampling was scheduled to take place in subarea IXa thereafter. Sampling of the western area commenced in period 2, and included coverage of the west of Scotland, west of Ireland, Biscay, and the eastern Cantabrian Sea. Surveying in the Cantabrian sea ended at the end of period 5. In periods 6 and 7 the surveys were designed to identify a southern boundary of spawning and to survey all areas north of this boundary.

Maximum deployment of effort in the western area was during periods three, four and five. Historically these periods would have coincided with the expected peak spawning of both mackerel and horse mackerel. In recent years mackerel peak spawning has moved earlier in the year. As a result the period 2 survey was moved forward in time by two weeks compared to 2013, to start at the beginning of February.

Due to the expansion of the spawning area which has been observed since 2007 the emphasis was even more focused on full area coverage and delineation of the spawning boundaries. Cruise leaders had been asked to cover their entire assigned area using alternate transects and then use any remaining time to fill in the missed transects.

Table 1. Participating countries, vessels, areas covered, dates and sampling periods of the 2016 surveys.

Country	Vessel	Area	Dates	Period
Portugal	Noruega	West Portugal	Mar 11th – Apr 1st	3
		Cadiz, southern Portugal	April 9th – May 1st	4
Ireland	Celtic Explorer	Celtic sea, Biscay, Cantabrian sea	February 2nd – 22nd	2
	Corystes	West of Ireland, west of Scotland	June 2nd – 22nd	6
	Atlantic Challenge	West of Ireland, west of Scotland	August 10th – 22nd	8
Scotland	Altaire	West of Scotland, west of Ireland	February 22nd – 29th	2
	Altaire	West of Scotland, west of Ireland	March 1st – 7th	3
	Altaire	West of Scotland, west of Ireland	April 13th – 27th	4
	Scotia	West of Scotland, west of Ireland	May 7th – 29th	5
	Altaire	West of Scotland, west of Ireland, Celtic sea, Biscay	June 27th – July 20th	7
Spain (IEO)	Vizconde de Eza	Cantabrian sea, Galicia	March 7th – April 2nd	3
	Vizconde de Eza	Cantabrian sea, Galicia	April 8th – 28th	4
Spain (AZTI)	Ramon Margalef	Biscay	March 19th – April 7th	3
	Ramon Margalef	Biscay, Cantabrian sea	April 30th – May 20th	5
Germany	Walther Herwig	Celtic sea, west of Ireland	March 25th – April 8th	3
	Walther Herwig	Celtic sea, west of Ireland	April 11th – 16th	4
Netherlands	Tridens	Biscay, Celtic sea	April 12th – May 4th	4
	Atlantic Lady	Biscay, Celtic sea	May 11th – 24th	5
	Tridens	Biscay, Celtic sea	June 1st – 21st	6
Iceland	Bjarni Saemundsson	Faroes & Shetland	May 3rd – 15th	5
Faroes	Magnus Heinason	Faroes	May 26th – 30th	5
	Magnus Heinason	Shetland	May 31st – June 6th	6

Processing of samples

The analysis of the plankton and fecundity samples were carried out according to the sampling protocols as described in the WGMEGS Survey Manual v2.0 (ICES, in prep) & Fecundity manual v11.0 (ICES, 2016).

A total of 2194 plankton samples were collected and sorted. Mackerel and horse mackerel eggs were identified and the egg development stages determined. Depending on the vessel facilities and the experience of the participants this was done either during the cruise or back in the national institutes.

Double micropipette samples and slices from ovaries of mackerel were taken during each survey. Additional samples were collected during periods 3 and 4 by participants in an effort to carry out DEPM analysis. Fecundity sampling for horse mackerel only took place during the expected peak spawning periods, 6 and 7. After each survey the ovary screening and fecundity samples were sent to different European research institutes for histological and whole mount analysis to determine the realised fecundity (potential fecundity minus atresia). Fecundity samples have to be analysed in the laboratory upon return from sea and the procedures for analyses are time consuming. The last samples were collected in July and because of the narrow time frame only a selection of the fecundity samples have been analysed up to this date. As for previous surveys it was planned to analyse the samples from sampling period 1-3 for the preliminary estimate. However, due to a lack of samples from period 1, the below estimate is based on samples from period 2 and 3 only, - as was also the case for the preliminary fecundity estimate in 2013 (Table 4).

Potential fecundity counts are based on whole mount samples taken from maturing females which had not started spawning. To select these samples we used a histological screening procedure followed by a whole mount screening procedure on the selected samples. The histological screening was also used to detect atretic oocytes in the samples. Samples with atretic cells were marked and used for the atresia estimation. A whole mount evaluation allows identifying whether there is any mismatch between the histological and whole mount reading. In this case both evaluations performed on the same samples agreed. Four institutes are involved in the histological screening, while whole mount analyses is carried out by 6 different institutes.

Horse mackerel is considered to be an indeterminate spawner and therefore since 2007 IPIMAR has adopted the DEPM methodology for horse mackerel in the southern area. The egg survey design in the western area is directed at the AEP method for mackerel which produces an estimate of SSB. Fecundity samples for horse mackerel were taken during the survey in the western areas in order to develop a modified DEPM approach for estimating the biomass of the horse mackerel stocks.

None of the DEPM ovary samples have been analysed yet.

Survey coverage and mackerel egg production by period

Period 1 – In this period only Portugal were due to survey. This DEPM survey is mainly targeting the southern horse mackerel stock and is designed for this purpose, but it provides mackerel egg samples as well. Due to difficulties in securing a vessel no sampling was undertaken within period 1. Sampling was eventually split into two time periods corresponding to 15 days in period 3 and 16 days in period 4. The survey is usually undertaken between Cadiz and the Galicia, however this year no sampling was completed off Galicia and coverage stopped at the northern coast of Portugal. Despite the vessel problems 393 stations were sampled, almost double the number collected in 2013 when again there were issues obtaining a vessel, but which compares well with the 414 samples collected in 2010.

Period 2 - Period 2 marks the commencement of the western area surveys. Subsequent to the results from both the 2010 and the 2013 MEGS surveys and also the winter surveys in 2014 - 2015 the start of period 2 was once again moved forward, commencing at the beginning of February. This was in order to try and capture spawning activity early in the season. Sampling was undertaken by Ireland (Celtic Sea, Biscay and eastern Cantabrian sea), and Scotland (West of Ireland and West of Scotland) (Fig. 1.1 & Annex 1). The mackerel migration appears to have been later and also slower in 2016 than in recent years and as a consequence low levels of spawning were found west of Ireland and to the west of Scotland towards the end of the period, with no mackerel eggs being found south of 52.45°N (Fig. 1.1 & Annex 1) . The eggs that were recorded were close to the 200m contour line. Survey coverage was good with 173 stations sampled, only 9 interpolations, and 17 replicate samples.

Period 3 – In period 3 the German vessel was operating to the West of Ireland, Celtic Sea and northern Biscay. Northwest Ireland and the West of Scotland were initially to be covered by a Danish vessel. Difficulties in securing a suitable vessel resulted in this survey having to be abandoned. Scotland was able to cover this area by moving the start of period 3 forward by one week thus placing the second week of their survey within period 3. The Bay of Biscay, Cantabrian Sea and Galicia were covered by Spain (IEO and AZTI). Egg numbers were quite low in the northern part of the survey area, Celtic sea, west of Ireland and west of Scotland (Fig. 1.2 & Annex 1). In Biscay and the Cantabrian Sea IEO and AZTI recorded a number of stations with large egg numbers (Fig. 1.2 & Annex 1). This was very similar to that recorded in 2013 for this area and time period. Poor weather and vessel issues resulted in a significant survey days being lost by AZTI. 320 stations were sampled and there were 31 interpolations. There were 33 replicate samples which were predominantly completed in the Cantabrian Sea.

Period 4 – This period was due to be covered by four surveys. The Dutch vessel was scheduled to operate in the southern Celtic Sea and northern Biscay with the West of Ireland being covered by the German vessel. West of Scotland was to be covered by Scotland with IEO completing the coverage in southern Biscay and the Cantabrian Sea (Fig. 1.3 & Annex 1). Serious winch problems were encountered by the German vessel at the start of their survey resulting in their having to completely withdraw from the plankton survey although some additional time was spent trawling for adult fish for fecundity samples prior to the vessel heading home for repairs. The German survey area was subsequently reallocated to Scotland and the Netherlands, both of which were surveying in the adjacent areas to the North and South of the German survey respectively. Once again low to moderate levels of eggs were recorded throughout the area, with the highest concentrations still being found close to the 200m contour line (Fig. 1.3 & Annex 1). The exception was a number of stations with high counts recorded by IEO in the Cantabrian Sea, and stations west of Ireland. Scotland also recorded a number of stations on their northern boundary with high egg numbers. 333 stations were sampled and there were 34 interpolations. 10 replicate samples were taken and these were collected from the Cantabrian Sea.

Period 5 – In period 5, the entire spawning area from the Cantabrian sea to the West of Scotland, and up to Faroese waters at around 61°N was planned to be surveyed by AZTI, the Netherlands, Scotland and Iceland. Due to issues with vessel availability the Faroe Islands, who were scheduled to survey in period 6, had to split their survey time between periods 5 and 6. In period 5 they surveyed to the north of the Icelandic area and extended coverage to 62°N. Several stations with significant numbers of stage 1 eggs were recorded in the Cantabrian Sea but throughout Biscay and into the southern Celtic sea numbers were generally low to moderate (Fig. 1.4 & Annex 1). This pattern continued west of Ireland to around 54°N, with spawning remaining on and around the Shelf edge. North of this however spawning activity fanned out massively both westwards and northwards (Fig. 1.4 & Annex 1). Due to the massive area Scotland had to survey the Scottish vessel was forced to limit its western survey boundary to 19°W. In this area significant numbers of eggs were found and consequently it was not possible to delineate the northwestern boundary. North of this significant spawning continued to be observed in the Icelandic survey area, up as far as the Faroe Islands. The western boundary in this area was closed off, however the Faroese vessel surveying late in the period was still encountering large numbers of eggs at 62°N, and so this boundary was also not secured. In total 424 stations were sampled and there were 122 interpolations. Twelve replicate samples taken.

Period 6 – During period 6 northern Biscay, from 46°N and also the Celtic sea were covered by the Netherlands while Ireland covered west of Ireland and also west of Scotland. The remaining component of the Faroese survey covered the area to the NW of Scotland. Low levels of spawning were observed all along the survey area from Biscay in the south all the way North to the West of Scotland (Fig. 1.5 & Annex 1). Surveying of the offshore areas around the Rockall Bank and Trough, which during period 5 had yielded high spawning concentrations over the whole region now returned only low numbers albeit the western boundary at Hatton Bank continued to record low numbers of stage 1 eggs at 18°W (Fig. 1.5 & Annex 1) . The largest spawning concentrations for this period were concentrated to the North and Northwest of Scotland with moderate levels of continuous spawning also being observed up to and on the survey boundary at 59°45N 15°45W. The result of this was that the north and northwestern survey boundaries were once again not secured. 319 stations were sampled with 107 interpolations. Only one replicate station was completed.

Period 7 – This period was covered entirely by Scotland sampling on alternate transects in the area from 46°15N in the South to the most northern transect on 59°15N.The southern boundary of sampling was delineated at 46°N and only very low levels of spawning were observed during this period and mainly to the west of Ireland (Fig. 1.6 & Annex 1). 144 stations were sampled with 59 interpolations. There were three replicate stations completed. All the spawning activity was confined to the continental shelf and shelf edge and the survey was successful in delineating all spawning boundaries.

Period 8 – This period is in addition to the standard schedule and comprises one survey that is being completed by Ireland. It is tasked with surveying the areas west of Ireland and Scotland (Fig. 1.7 & Annex 1) and to report on any spawning activity that is observed in August and past the nominal end date of the end of July. 88 stations were completed and there were no interpolations and no replicates. The results will not be available for WGWIDE in 2016 but will be presented at WGMEGS in 2017.

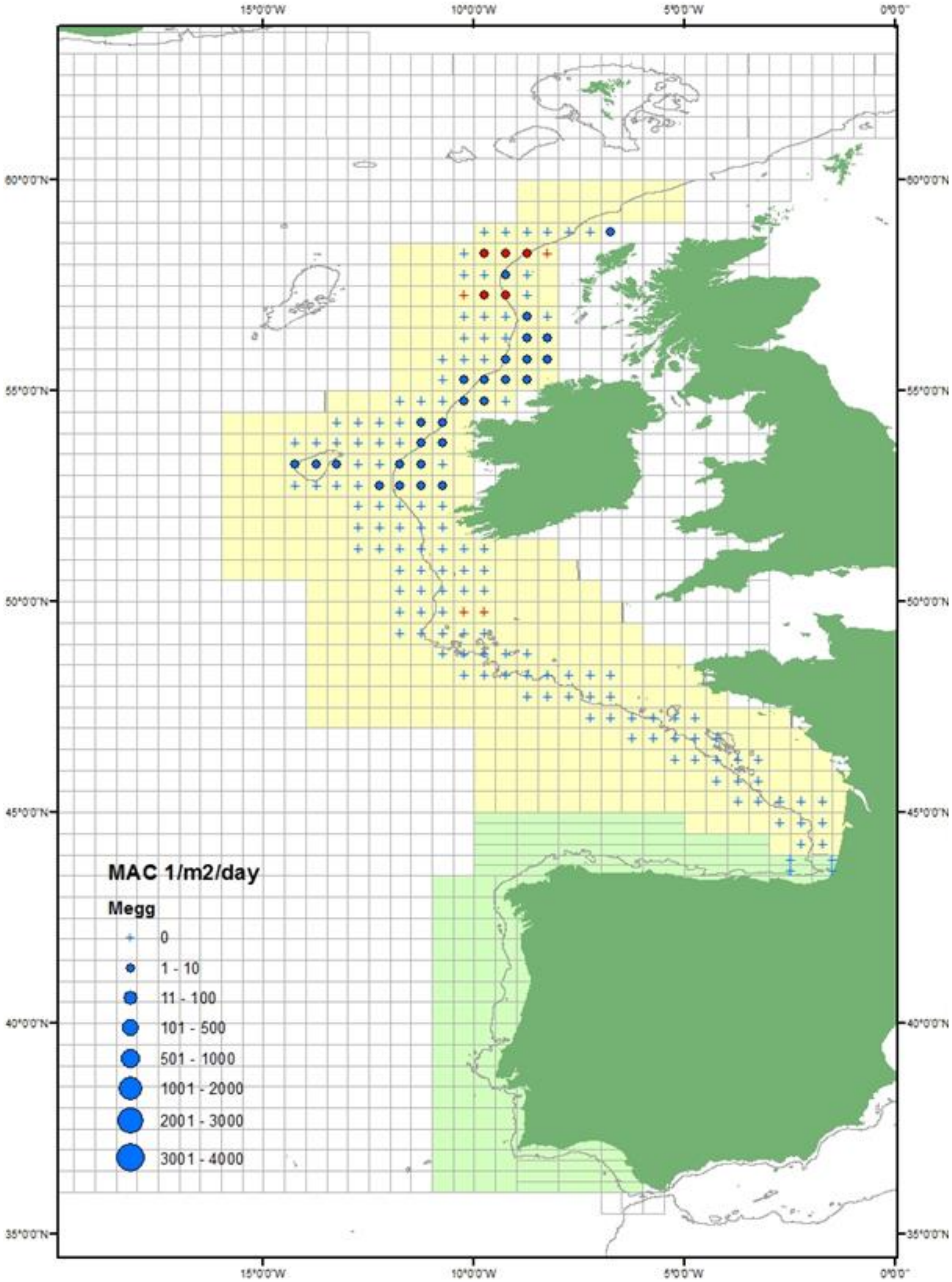

Figure 1.1: Mackerel egg production by half rectangle for period 2 (February 5th to 29th). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses interpolated zero

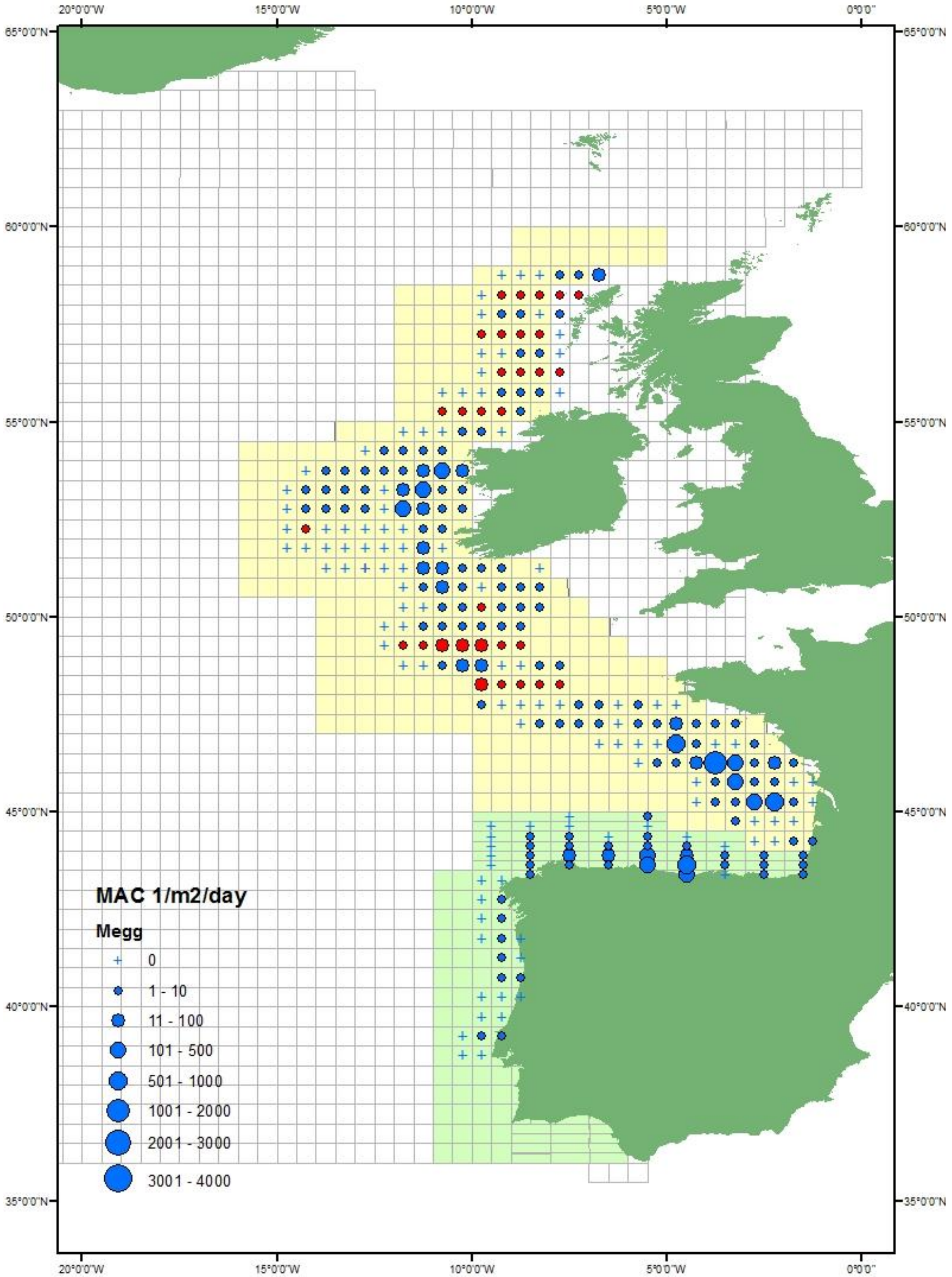

Figure 1.2: Mackerel egg production by half rectangle for period 3 (March 1st – April 8th). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses interpolated zeroes.

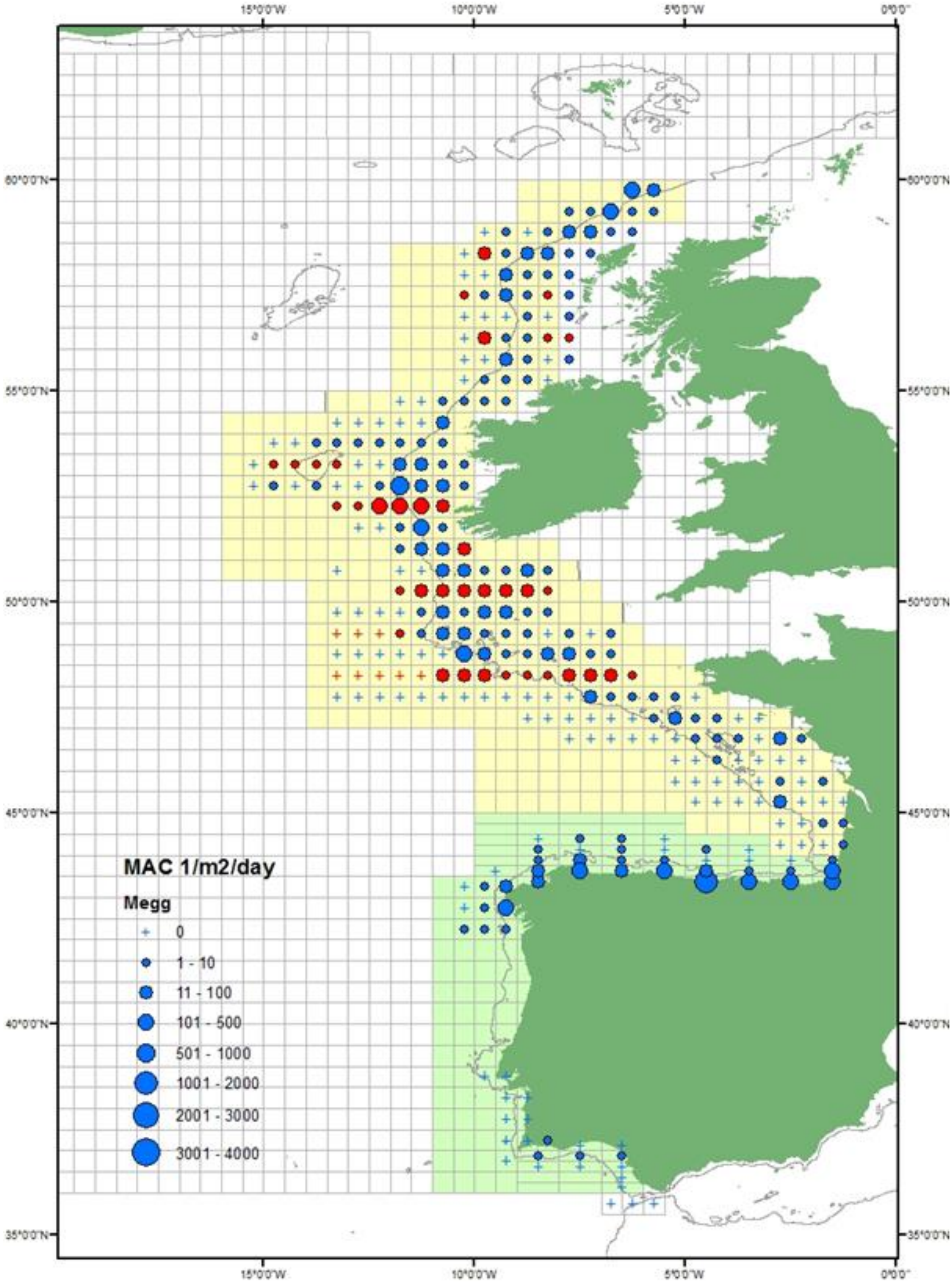

Figure 1.3: Mackerel egg production by half rectangle for period 4 (April 9th – 1st May). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses interpolated zeroes.

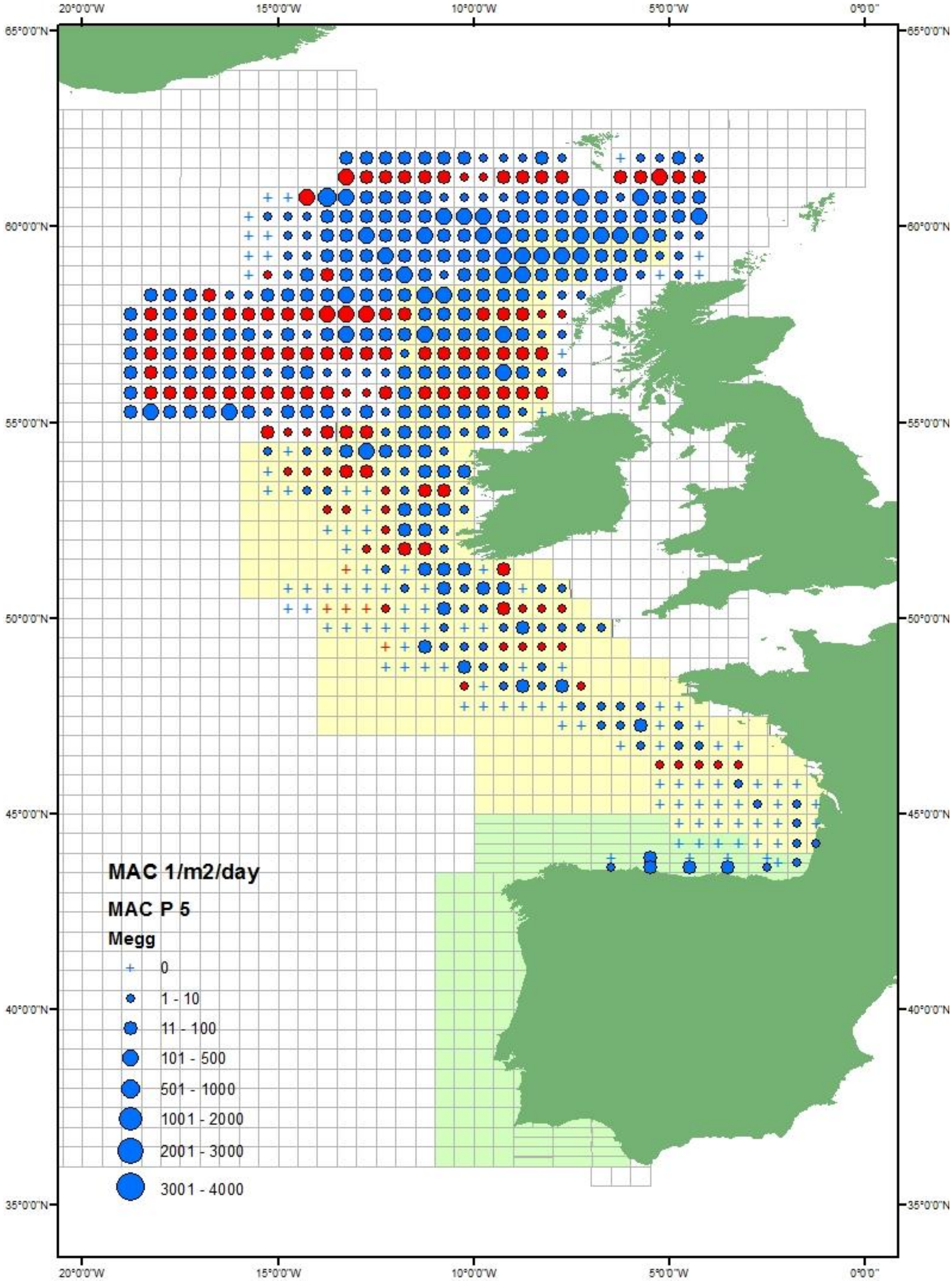

Figure 1.4: Mackerel egg production by half rectangle for period 5 (May 2nd – 30th). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses interpolated zeroes.

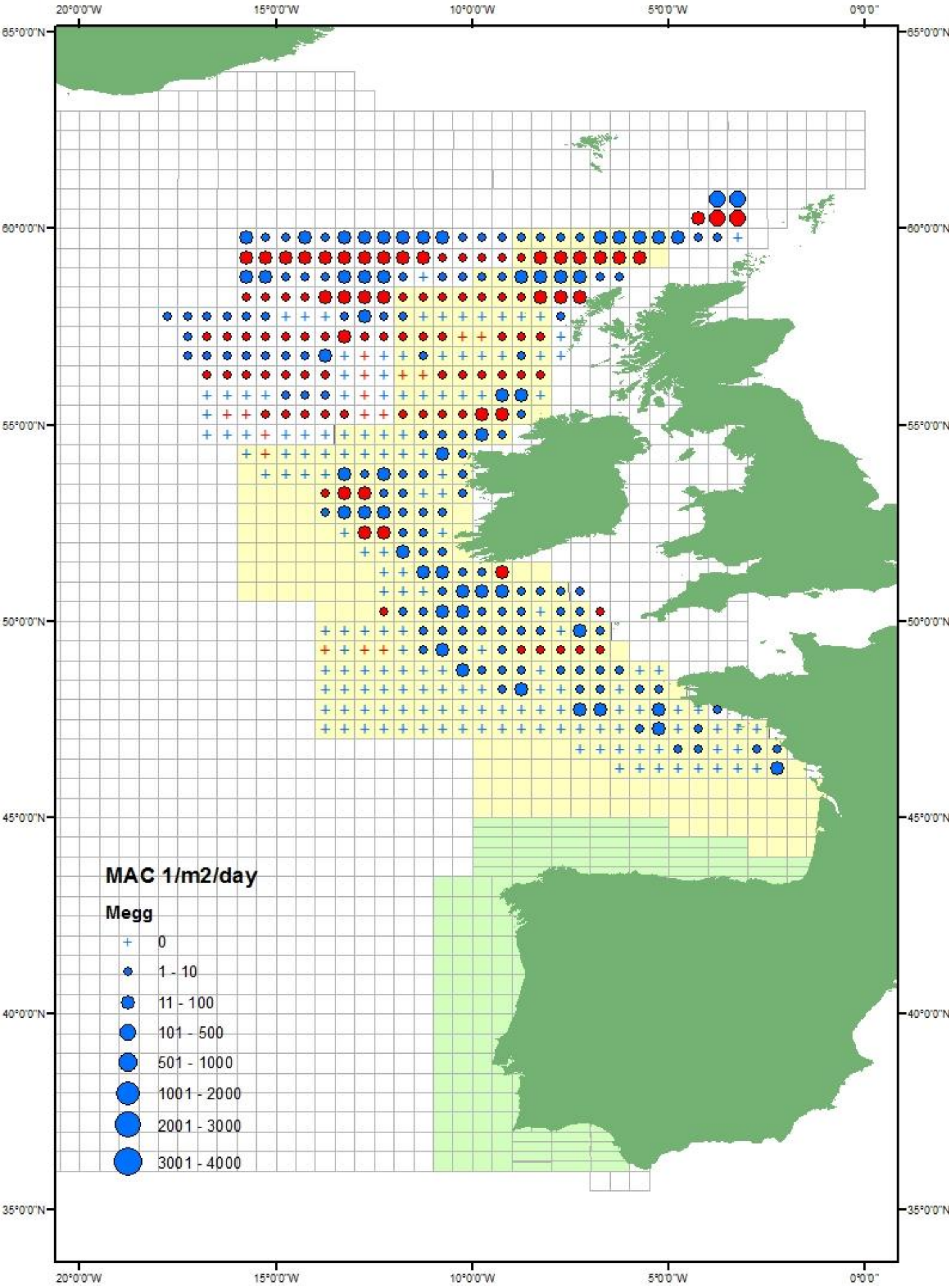

Figure 1.5: Mackerel egg production by half rectangle for period 6 (May 31st – June 21st). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses interpolated zeroes.

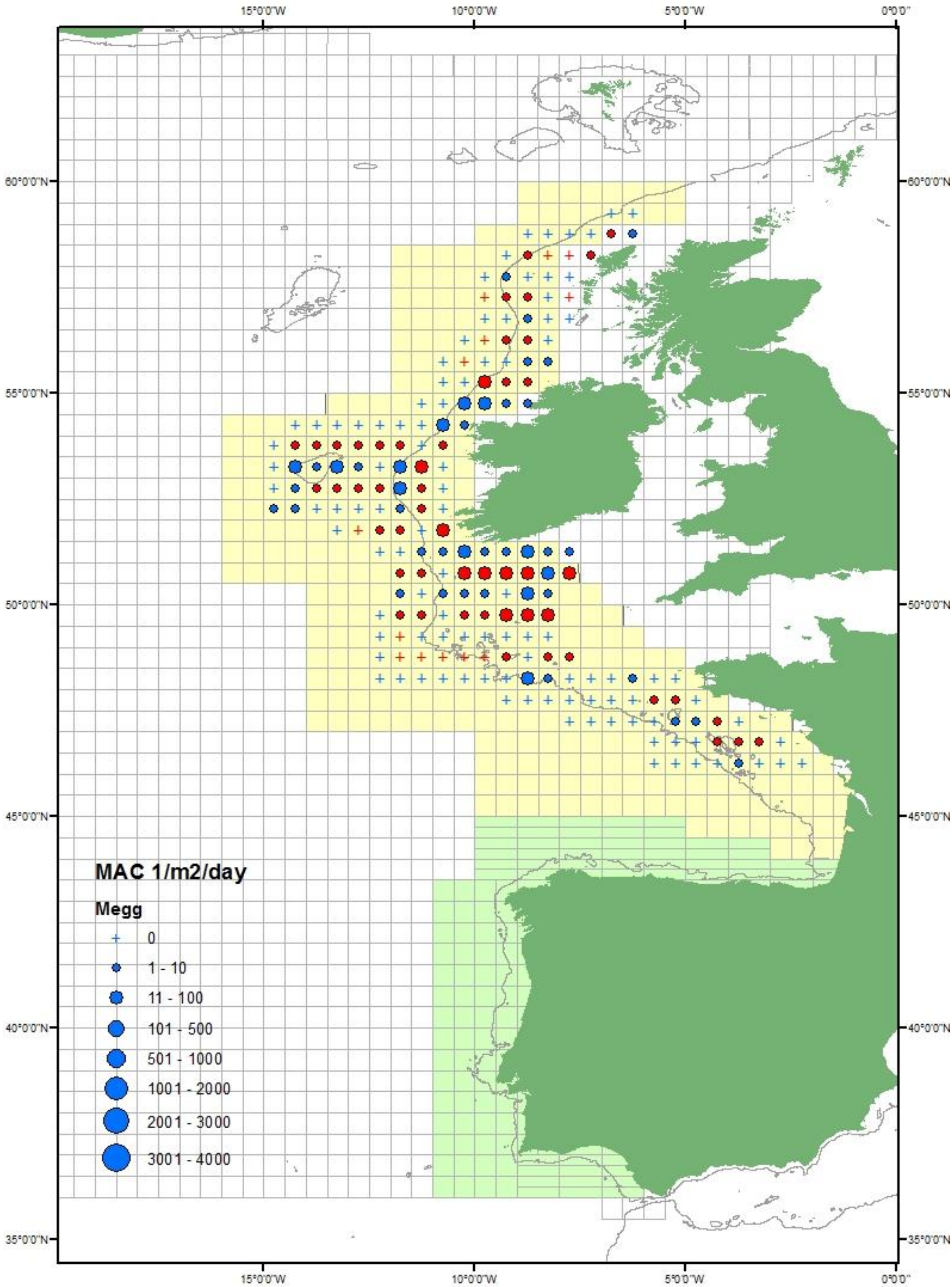

Figure 1.6: Mackerel egg production by half rectangle for period 7 (June 27th – July 19th). Filled blue circles represent observed values, filled red circles represent interpolated values, blue crosses represent observed zeroes, red crosses interpolated zeroes.

Results - MACKEREL

Stage 1 Egg production in the Western Areas

2010 provided an unusually large spawning event early in the spawning season, 2013 yielded an even larger spawning event indicating that spawning was probably taking place well before the nominal start date of 10th February (day 42) (Fig. 2.1). In 2016 the first survey commenced on February 5th which is five days prior to the nominal start date. This year however mackerel migration was later and slower than that recorded in the previous two surveys. Early peak spawning was not repeated and instead occurred during period 5 (May) (Fig. 2.1 & Table 2). It is also important to note that during this period the vast majority of spawning was taking place in northern offshore waters far west of Scotland and Faroe Islands (Fig. 1.4). During this period the northern and northwestern boundaries were not delineated and it is highly likely that additional spawning was missed.

The nominal end of spawning date of the 31st July is the same as was used during previous survey years and the shape of the egg production curve for 2016 does not suggest that the chosen end date needs to be altered. The provisional total annual egg production (TAEP) for the western area in 2016 was calculated as **1.91 * 10^{15}** (Table 2). This is a 20% reduction on the 2013 TAEP estimate which was 2.37 * 10^{15}.

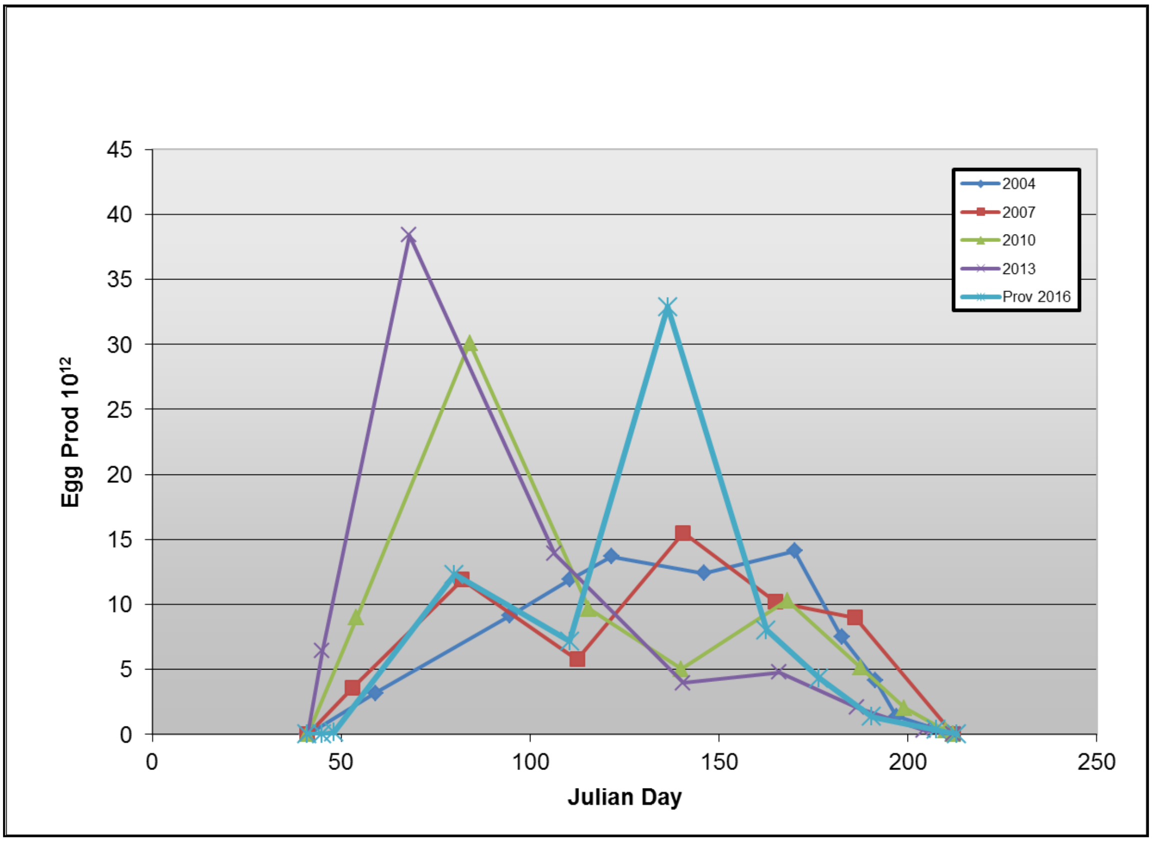

Figure 2.1: Provisional annual egg production curve for mackerel in the western spawning component. The curves for 2004, 2007, 2010 and 2013 are included for comparison.

Table 2. Western estimate of mackerel total stage I egg production by period using the histogram method for 2016.

Dates	Period	Days	Annual stage I egg production * 10^{15}
	1	No sampling	
Feb 5th – Feb 29th	2	25	0.003
March 1st – April 8th	3	39	0.48
April 9th – April 30th	4	22	0.16
May 1st – May 30th	5	30	0.99
May 31st – June 21st	6	22	0.18
June 22nd – June 27th	6 – 7	6	0.07
June 28th – July 19th	7	22	0.03
Total			1.91
CV			31%

Stage 1 Egg production in the Southern Areas

The start date for spawning in the southern area was the 15th February (Table 3) and this is 5 days later than the start date that was used in 2013. This is due to the delay to the start of the Portuguese survey in subarea IXa. Sampling instead within subarea IXa took place within periods 3 and 4. Conversely, surveying in the Cantabrian Sea where the majority of spawning occurs within the Southern area commenced 5 days earlier than in 2013 on the 8th March. The same end of spawning date of the 17th July was used again this year and the spawning curve suggests that there is no reason for this to change (Fig. 2.2). As in 2013 the survey periods were not completely contiguous and this has been accounted for (Table 3). The provisional total annual egg production (TAEP) for the southern area in 2016 was calculated as **2.34 * 10^{14}**(Table 3). This is a 70% reduction on the 2013 TAEP estimate which was 7.79 * 10^{14} . In contrast to recent surveys there is no obvious peak of spawning in the southern area in 2016 (Fig. 2.2).

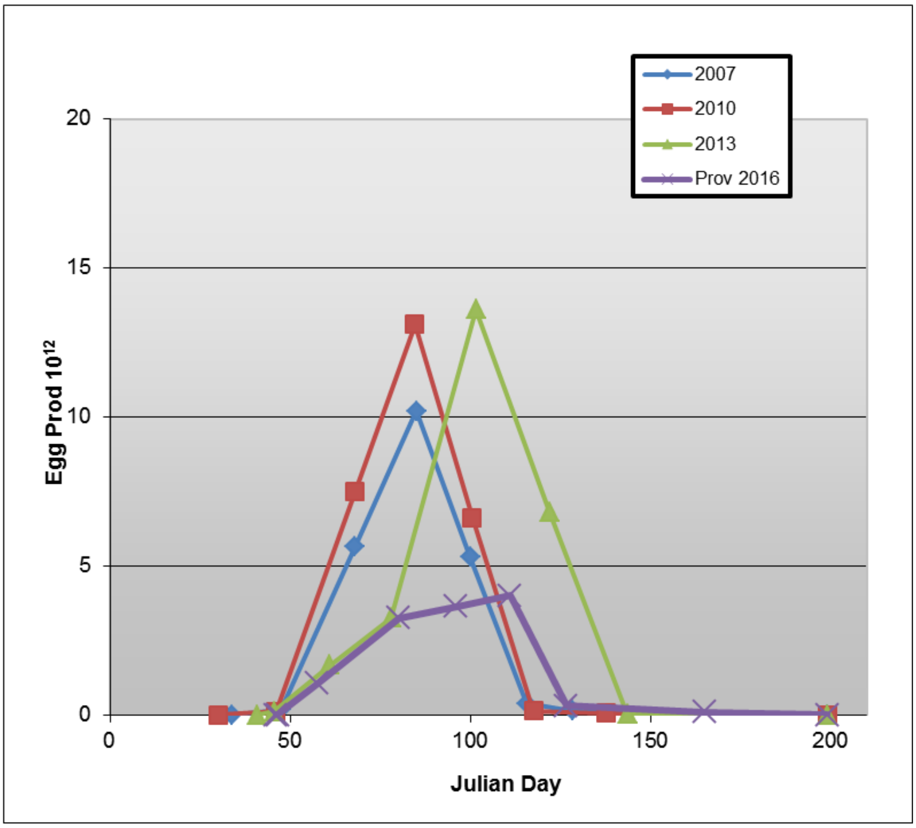

Figure 2.2: Provisional annual egg production curve for mackerel in the southern spawning component for 2013. The curves for 2007, 2010 and 2013 are included for comparison.

Table 3: Southern estimate of mackerel total stage I egg production by period using the histogram method for 2016.

Dates	Period	Days	Annual stage I egg production x 10^{14}
	1	No sampling	
15 Feb – 16 Feb	2	2	0
17 Feb – 7 Mar	2 - 3	20	0.21
8 March – 1 April	3	25	0.82
2 April – 8 April	3 - 4	7	0.26
9 April – 1 May	4	23	0.92
2 May – 9 May	5	8	0.03
10 June – 17 July	Post 5	69	0.1
Total			2.34
CV			129%

Total egg production

Total annual eggs production (TAEP) for both the western and southern components combined in 2016 is **$2.14*10^{15}$.** (Fig. 2.3). This is a decrease in production of **29%** compared to 2013 but is similar to 2007 (Fig. 2.3).

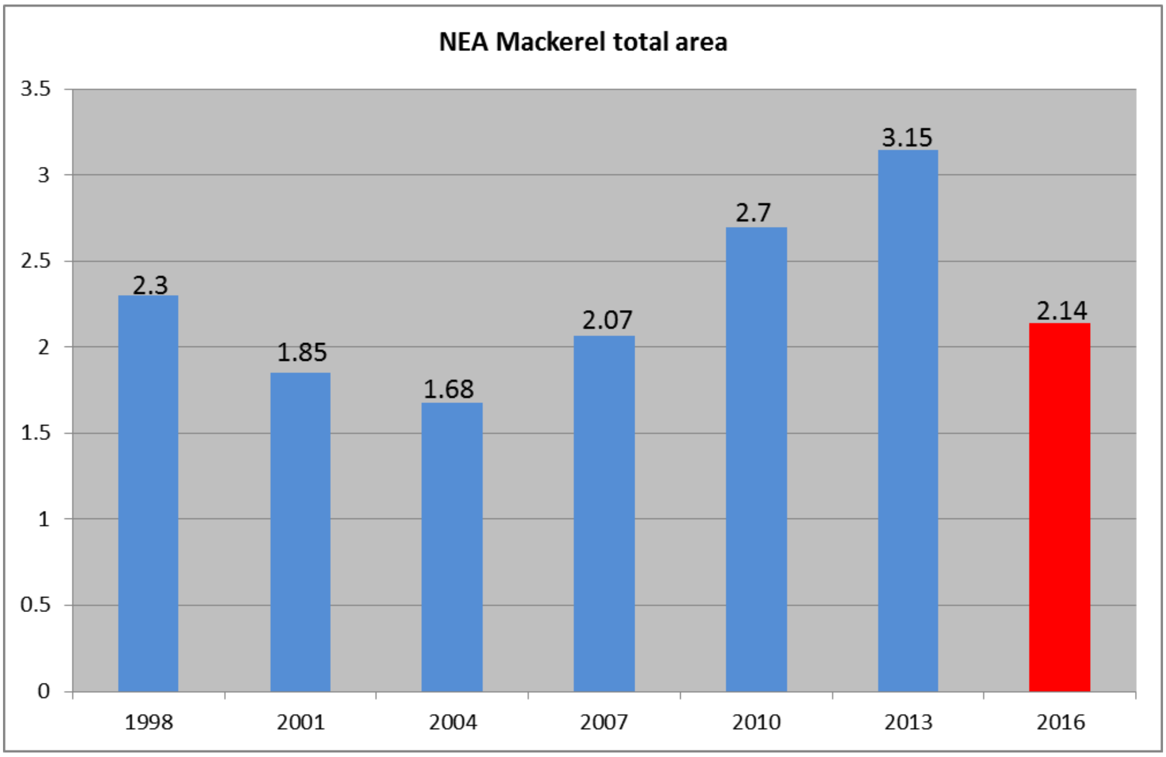

Figure 2.3: Combined mackerel TAEP estimates ($*10^{15}$) - 1998 – 2016.

Fecundity estimates

Potential fecundity

For the 2016 preliminary estimate of potential fecundity 66 samples were available, which was 9% of all the samples screened for period 2 and 3. This number was lower than in 2013 (90 samples were available for the preliminary results in 2013). Most of the samples from period 3 showed spawning markers and only 1 sample from period 3 was available for potential fecundity estimation.

In 2013 it was decided that the relative fecundity estimate should be based on the median (p50) among the institutes rather than the mean (ICES, 2014).

The preliminary relative fecundity in 2016 was similar to the final relative fecundity in 2013 (1224 and 1257, respectively) (Table 4).

Table 4. Potential relative fecundity (n/g fish) by institute and total.

Institute	Mean	N	sd	min	max	Median	95%CI
Institute 1	1300	7	363	670	1874	1253	1031-1569
Institute 2	1627	9	346	1001	2261	1628	1401-1853
Institute 3	1094	13	204	813	1394	1052	983-1205
Institute 4	1212	12	252	863	1657	1198	1069-1355
Institute 5	1122	13	328	843	2161	1066	944-1300
Institute 6	1422	12	274	1015	1966	1387	1267-1577
Total general	1275	64	333	670	2261	1224	1174-1318

Fulton K and gonadal somatic index were used to see any differences in the fish condition compared to 2013 (Figure 3). Fulton K is similar to 2013, but GSI is lower for the same period in 2016 compared to 2013.

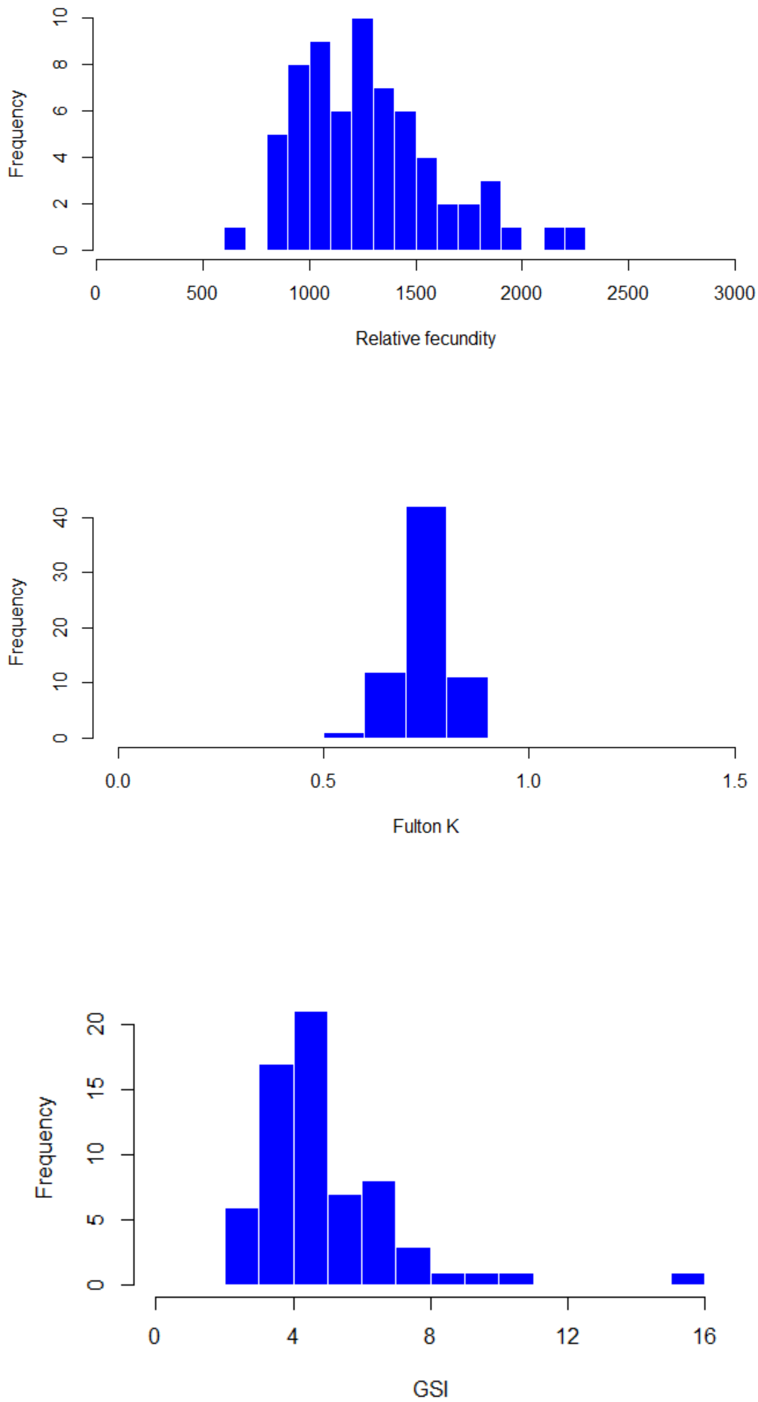

Figure 3. Frequency histogram of relative fecundity (n/g fish; upper panel), fish condition (Fulton K; middle panel) and gonadal somatic index (GSI; lower panel).

Atresia

Atresia is the loss of oocytes by reabsorption before spawning. Because the histology screening before the whole mount analysis is time consuming it has not been possible for this preliminary report to analyse samples for the intensity of atresia. The histological screening however gives an estimate on the prevalence of atresia, which is a good indicator of the level of atresia.

Prevalence of atresia is in this survey defined as the percentage of spawning fish which have early stage atresia (early alpha-atresia). Among the 491 fish with spawning markers in the histological screening, 28% were found to have early atresia (Table 5). This is on the same level as previous surveys (Table 5, 20-38%).

Realised fecundity

Realised fecundity is defined as the potential fecundity minus the loss by atresia. The loss by atresia is a function of both intensity of atresia and prevalence of atresia. No results on the intensity of atresia are available yet. The average loss of atresia from the surveys going back to 2001 was used to calculate realised fecundity (Table 5). In this period the relative loss by atresia ranged from 6-9% (average 7%).

The preliminary realised fecundity estimate for 2016 was calculated to be 1138 oocytes/gram fish. This is similar to the 2013 preliminary estimate (1161 n/g), but lower compared to the final 2013 realised fecundity (Table 5).

Table 5. Mackerel fecundity and atresia by assessment year.

	Assessment year					
Parameter	2001	2004	2007	2010	2013	2016 prel.
Fecundity samples (n)	187	205	176	74	132	66
Atresia samples (n)	290	348	416	511	735	-
Rel. Pot. fecundity (n/g)	1097	1127	1098	1140	1257*	1224*
Prevalence of atresia	0.2	0.28	0.38	0.33	0.22	0.28
G. mean intensity of atresia (n/g)	40	33	30	26	27	-
Pot. fecundity lost per day (n/g)	1.07	1.25	1.48	1.16	0.80	-
Pot. fecundity lost (n/g)	64	75	89	70	48	-
Rel. pot. fecundity lost (%)	6	7	9	6	4	-
Realized fecundity (n/g)*	1033	1052	1009	1070	1209	1138

*Median relative potential fecundity.

Biomass estimation

Total spawning stock biomass (SSB) was estimated using the fecundity estimate of 1138 oocytes/g female, a sex ratio of 1:1 and a raising factor of 1.08 (ICES, 1987) to convert pre-spawning to spawning fish. This gave an estimate of spawning stock biomass of:

- 3.543 million tonnes for western component (2013: 4.2).
- 0.443 million tonnes for southern component (2013: 1.4).
- 3.986 million tonnes for western and southern components combined (2013: 5.6)

Results – HORSE MACKEREL

Horse mackerel egg production by period

Period 2 – No horse mackerel eggs were found in this period (Fig. 4.1).

Period 3 – In period 3 horse mackerel spawning starts in the Cantabrian, but numbers of eggs found are very low (Fig. 4.2).

Period 4 – Horse mackerel was spawning in the Cantabrian Sea as well as in the Celtic Sea and northern Bay of Biscay (Fig. 4.3). Numbers of eggs were low and were only found around the 200m depth contour.

Period 5 – Horse mackerel spawning continues in the Cantabrian Sea, Celtic Sea and northern Bay of Biscay, but in low numbers around the 200m depth contour (Fig. 4.4).

Period 6 – This period shows an increase in horse mackerel egg production with increased numbers in the Celtic Sea and northern Bay of Biscay (Fig. 4.5). Spawning also occurs around Rockall and away from the 200m depth contour (Fig. 4.5). A few eggs are found on the most southern transect, but in low numbers.

Period 7 – Eggs are found from the northern Bay of Biscay to west of Scotland (Fig. 4.6) High egg numbers are found in the Celtic Sea and Rockall (Fig. 4.6).

Period 8 – 88 stations were completed west of Ireland and also west of Scotland during the survey and 25 of these contained no eggs whatsoever. A quick look at the egg samples has revealed in total around 65 stage 1 horse mackerel eggs for the entire survey.

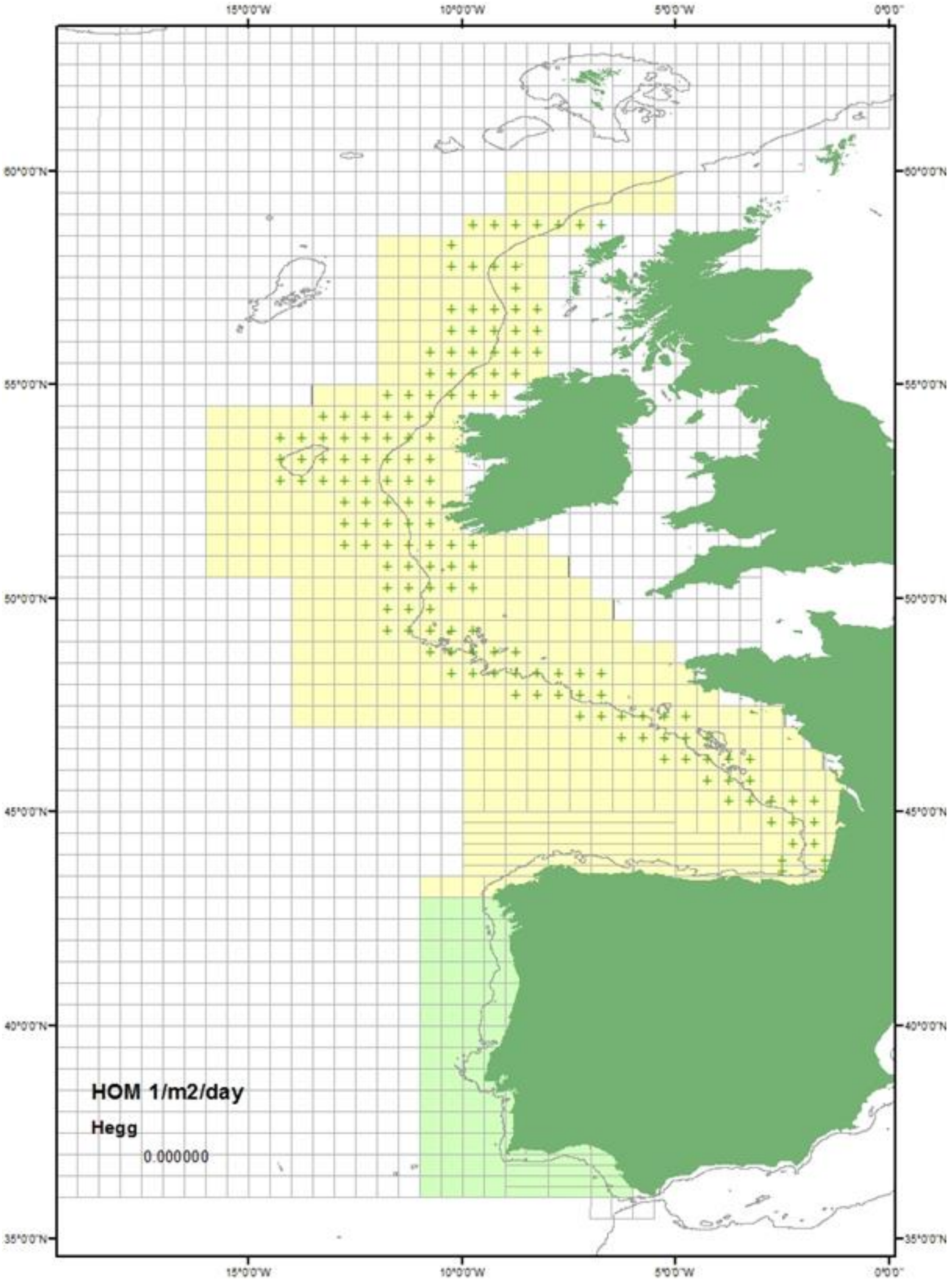

Figure 4.1: Horse mackerel egg production by half rectangle for period 2 (February 5th to 29th). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses interpolated zeroes.

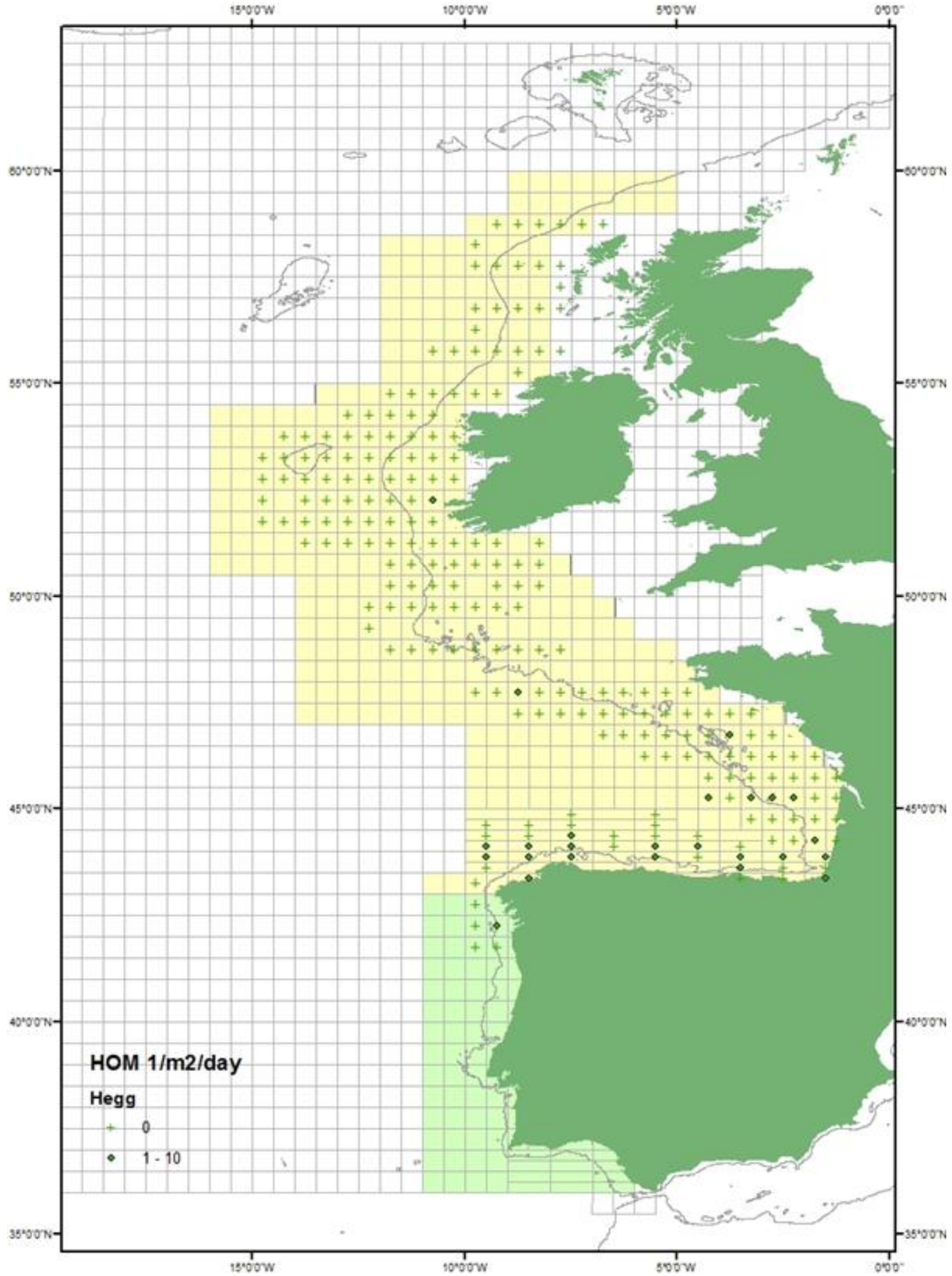

Figure 4.2: Horse mackerel egg production by half rectangle for period 3 (March 1st – April 8th). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses interpolated zeroes.

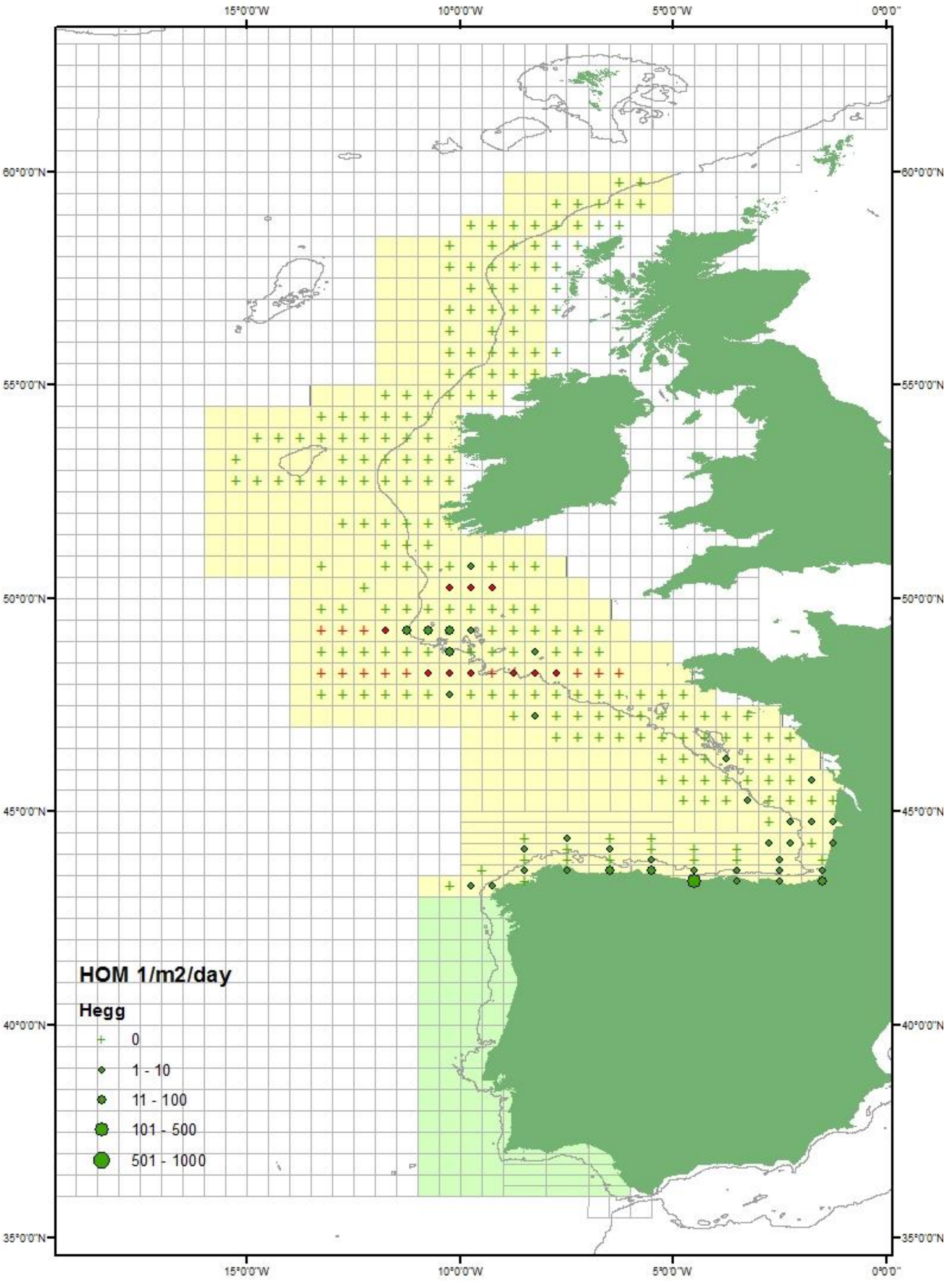

Figure 4.3: Horse mackerel egg production by half rectangle for period 4 (April 9th – 1st May). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses interpolated zeroes.

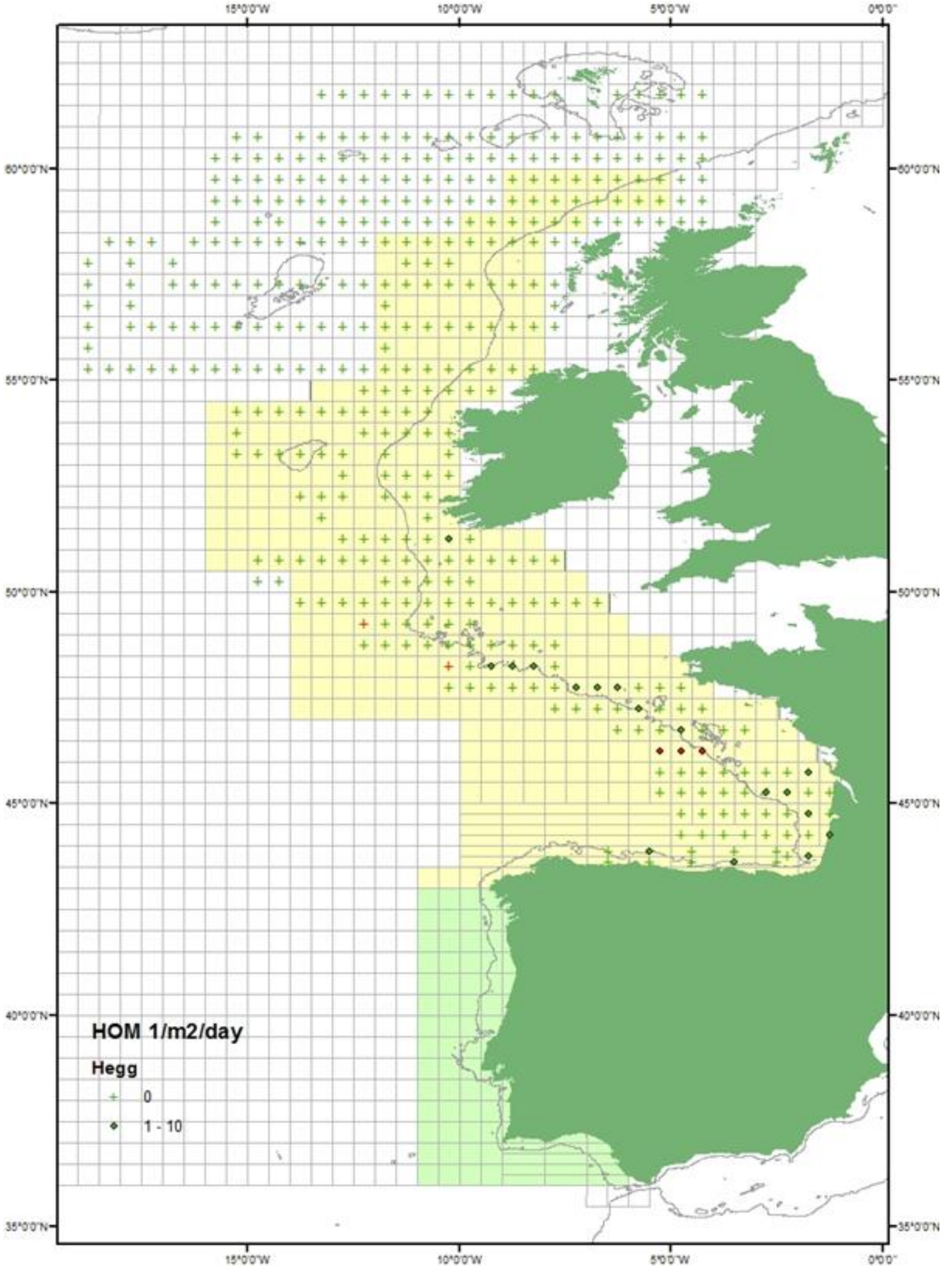

Figure 4.4: Horse mackerel egg production by half rectangle for period 5 (May 2nd – 30th). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses interpolated zeroes.

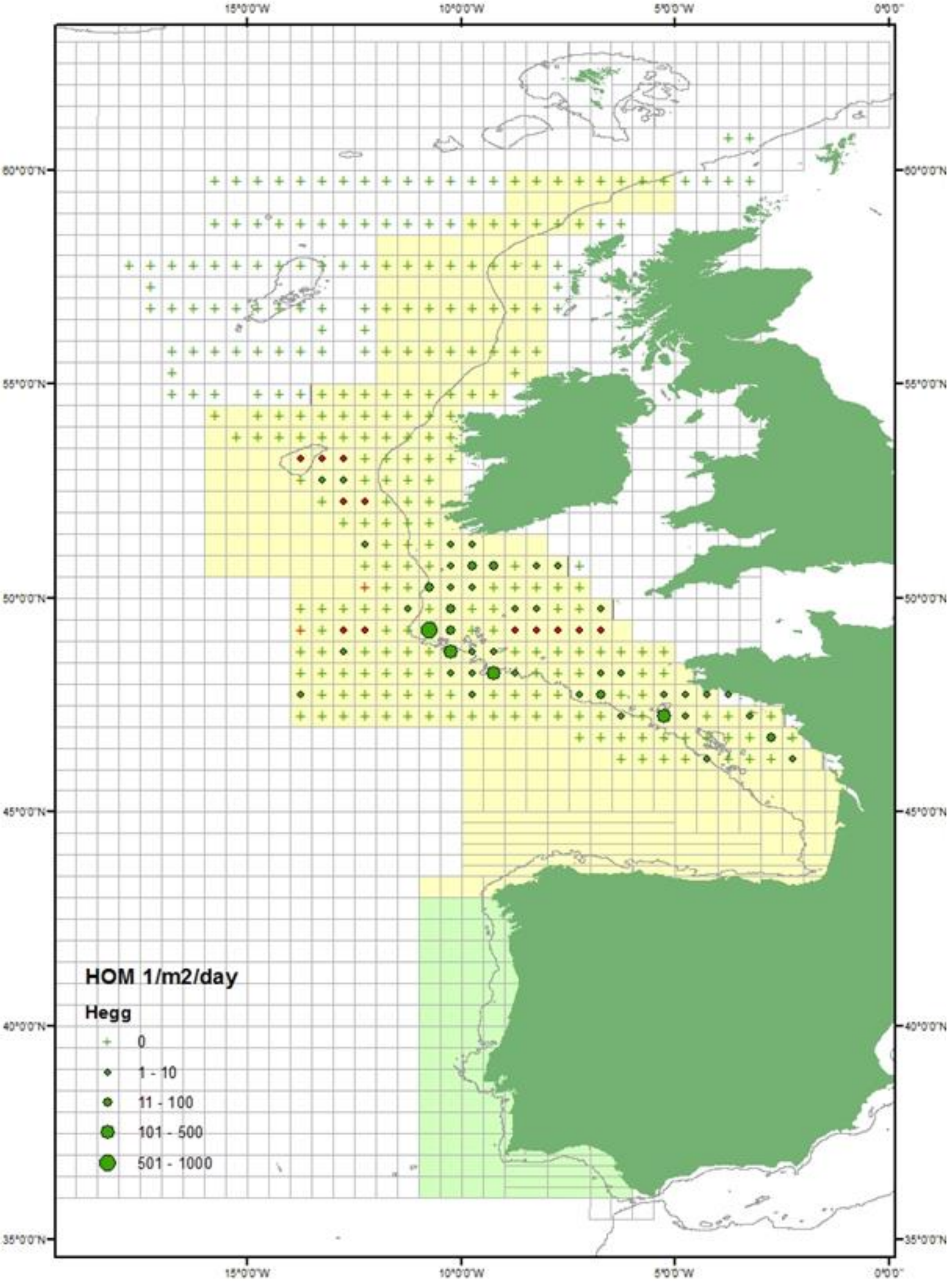

Figure 4.5: Horse mackerel egg production by half rectangle for period 6 (May 31st – June 21st). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses interpolated zeroes.

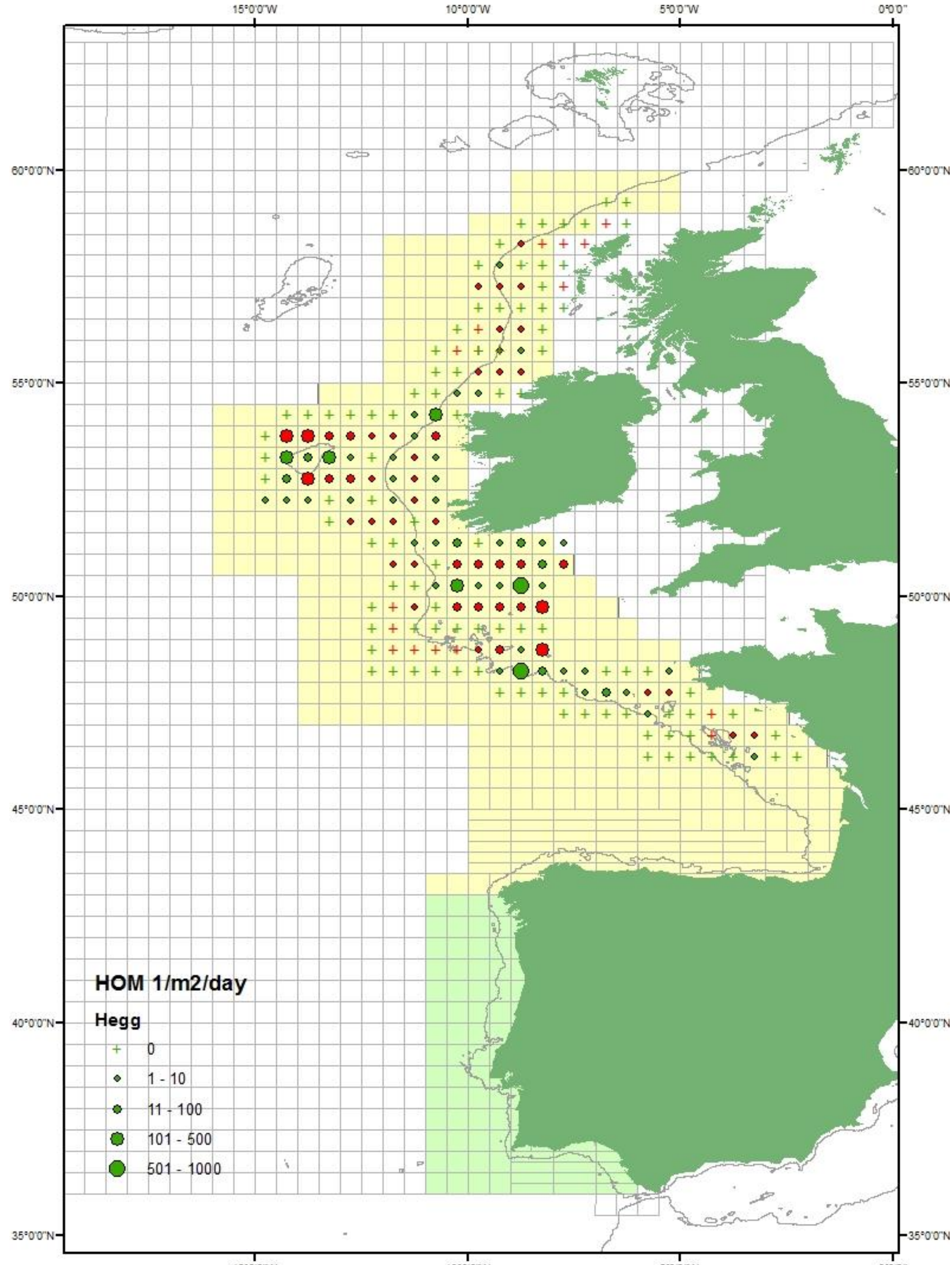

Figure 4.6: Horse mackerel egg production by half rectangle for period 7 (June 27th – July 19th). Filled green circles represent observed values, filled red circles represent interpolated values, green crosses represent observed zeroes, red crosses interpolated zeroes.

TAEP results – Western Horse Mackerel

Period number and duration are the same as those used to estimate the western mackerel stock, as are the dates defining the start and end of spawning (Table 6). The shape of the egg production curve does not suggest that those dates should be altered for 2016 (Fig. 5.1) although there is a possibility, currently being investigated that some spawning may continue after the end of July. Results from the period 8 survey were not available yet and are not included in this WD. The total annual egg production was estimated at **3.31 x 10^{14}**. This is a decrease of almost **17%** on 2013 which was 3.97 × 10^{14} and is the lowest estimate of annual egg production ever recorded for this species.

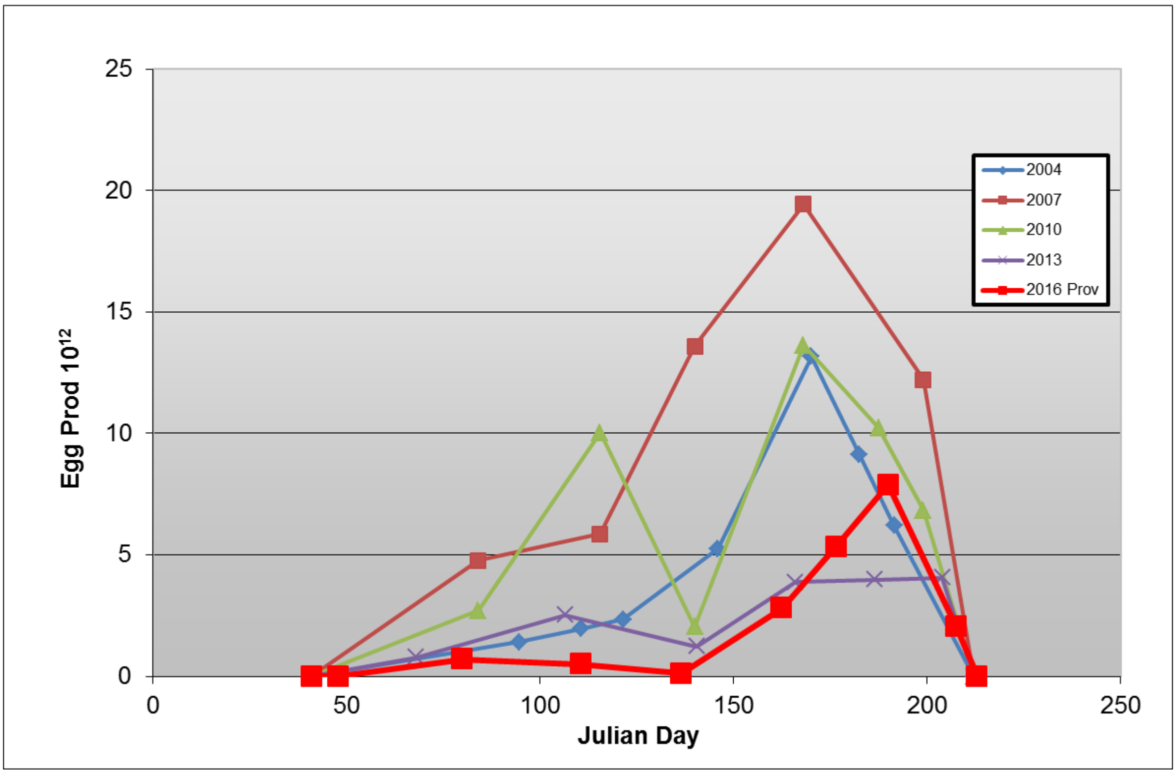

Figure 5.1: Provisional annual egg production curve for western horse mackerel. The curves for 2004, 2007, 2010, and 2013 are included for comparison.

Table 6: Western estimate of horse mackerel total stage I egg production by period using the histogram method for 2016

Dates	Period	Days	Annual stage I egg production x 10^{15}
	1	No sampling	
Feb 5th – Feb 29th	2	25	0.000
March 1st – April 8th	3	39	0.025
April 9th – April 30th	4	22	0.013
May 1st – May 30th	5	30	0.004
May 31st – June 21st	6	22	0.064
June 22nd – June 27th	6 – 7	6	0.032
June 28th – July 19th	7	22	0.169
July 20th – July 31st	Post 7	12	0.024
Total			0.331
CV			36%

Fecundity investigations

This year for horse mackerel only DEPM ovary samples were collected in periods 6 and 7, during peak of spawning. Since horse mackerel fecundity is at this moment not used for estimating the spawning stock biomass the focus of the fecundity analysis has been on mackerel. Therefore, at this time no horse mackerel fecundity results are ready to be presented. All samples will be analysed and results presented at the 2017 WGMEGS meeting.

DEPM results –Western Horse Mackerel

The horse-mackerel egg data of the DEPM survey are still under revision. Data are expected to be analyzed and results will be presented at the 2017 WGMEGS meeting.

Discussion

Since 2004 and subsequent to demands for up-to-date data for the assessment, WGMEGS has endeavored to provide an estimate of NEA mackerel biomass and western horse mackerel egg production within the same calendar year as the survey and in time for the assessment meetings taking place. This report represents the preliminary results of the 2016 egg survey. WGMEGS cannot guarantee that there will be no changes prior to the presentation of the final survey results at WGMEGS in April 2017. However, despite the tight deadline all plankton samples were analyzed for mackerel (southern and western area) and horse mackerel (western area only) stage 1 eggs, so no samples which were taken but not analyzed are missing in the station grid. Therefore only negligible changes, if any, in the total egg production values are to be expected.

As with 2013 no fecundity samples from period 1 were available, instead samples from periods 2 and 3 were included in the potential fecundity estimate. However, only 1 sample was available from period 3 for this preliminary estimate. For the final fecundity estimate the later periods will also be included, as was done for the 2013 survey. No estimate of loss by atresia is yet available for 2016. The realised fecundity estimate is therefore based on the average atretic loss found in the period from 2001-2013. Since the atretic loss has always been a small number compared to the potential fecundity, using this average value will likely not give a large error. The prevalence of atresia for 2016 (28%) is comparable to previous survey estimates, it is thus highly likely that the atretic loss will also be at the same level. Atretic loss will however be analysed and included in the final fecundity estimate at the WGMEGS meeting in 2017.

The 2016 survey was not plagued with the prolonged periods of severe weather that disrupted large periods of the 2013 survey program. The survey did however experience several significant survey related issues that resulted in the significant delay of one survey as well as the abandonment of two others. Fortunately, in each of these cases the existing/remaining survey participants for that period were able to adequately cover the additional area without further disruption to the settled survey plan.

The previous surveys in 2010 and 2013 have been dominated by the issue of early peak of western mackerel spawning and its close proximity to the nominal start date. Both the 2013 and 2016 surveys were determined to address this issue with the result that sampling in the western area during these years commenced 2 weeks earlier than the preceding survey in an effort to capture the start of spawning. Despite compelling evidence derived from the additional winter surveys in 2015 that this situation was set to continue it has not. In 2016, peak spawning in the western area was observed in period 5 which in regards to its temporal position is similar to 2007 and also the period prior to this when peak spawning in the western area was traditionally also observed during the months of May and June. Contrastingly, the bulk of the spawning activity reported during these historical surveys resulted from several spawning hotspots on and around the continental shelf edge and usually around the Celtic Sea and Porcupine Bank region. During 2016, high levels of spawning were recorded over a far larger area of the Northeast Atlantic with a large number of the stations being reported over deepwater and well away from the continental shelf. Available surveys deployed during these periods were unable to adequately cover this area and so moderate to high numbers of stage 1 eggs were recorded on most of these northerly and western boundary stations. Spawning within this area has been observed since 2007 however only at low concentrations. It was accepted that north and northwesterly unaccounted for spawning was a reality but contributed only a tiny proportion of the TAEP in the western area. In 2016 and with the large decrease in the southern mackerel component it seems certain that most of the fish remained in northerly latitudes for most of the season. It is unclear how much spawning was missed from the northwesterly area in 2016.

Western horse mackerel continues its decline with an even lower egg production estimate than was observed in 2013 and at the time that was the lowest recorded estimate for this survey. An additional survey has just been completed in August 2016 that was tasked specifically to gather information on the prevalence of western horse mackerel spawning after the nominal end date of spawning and the results from this will be presented to WGMEGS in April 2017. Preliminary results seem to suggest that the numbers of horse mackerel eggs are very low in August, thus supporting the nominal end date of the survey.

The MEGS group is confident that this survey accurately reflects the spawning patterns as exhibited by both species as it is presented in this working document. Despite the inability to secure a northern spawning boundary for western mackerel during periods 5 and 6 the survey group is confident that the resulting fraction of spawning missed is a minor one and that the survey has indeed been successful in capturing the bulk of spawning activity.

References

ICES, 2014. Report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). ICES CM 2014/SSGESST:14. 116 pp.

ICES, 2016. WGMEGS Manual for the AEPM and DEPM estimation of fecundity in mackerel and horse mackerel. WGMEGS–AEPM & DEPM. Series of ICES Survey Protocols, SISP 5. 84 pp

Annex

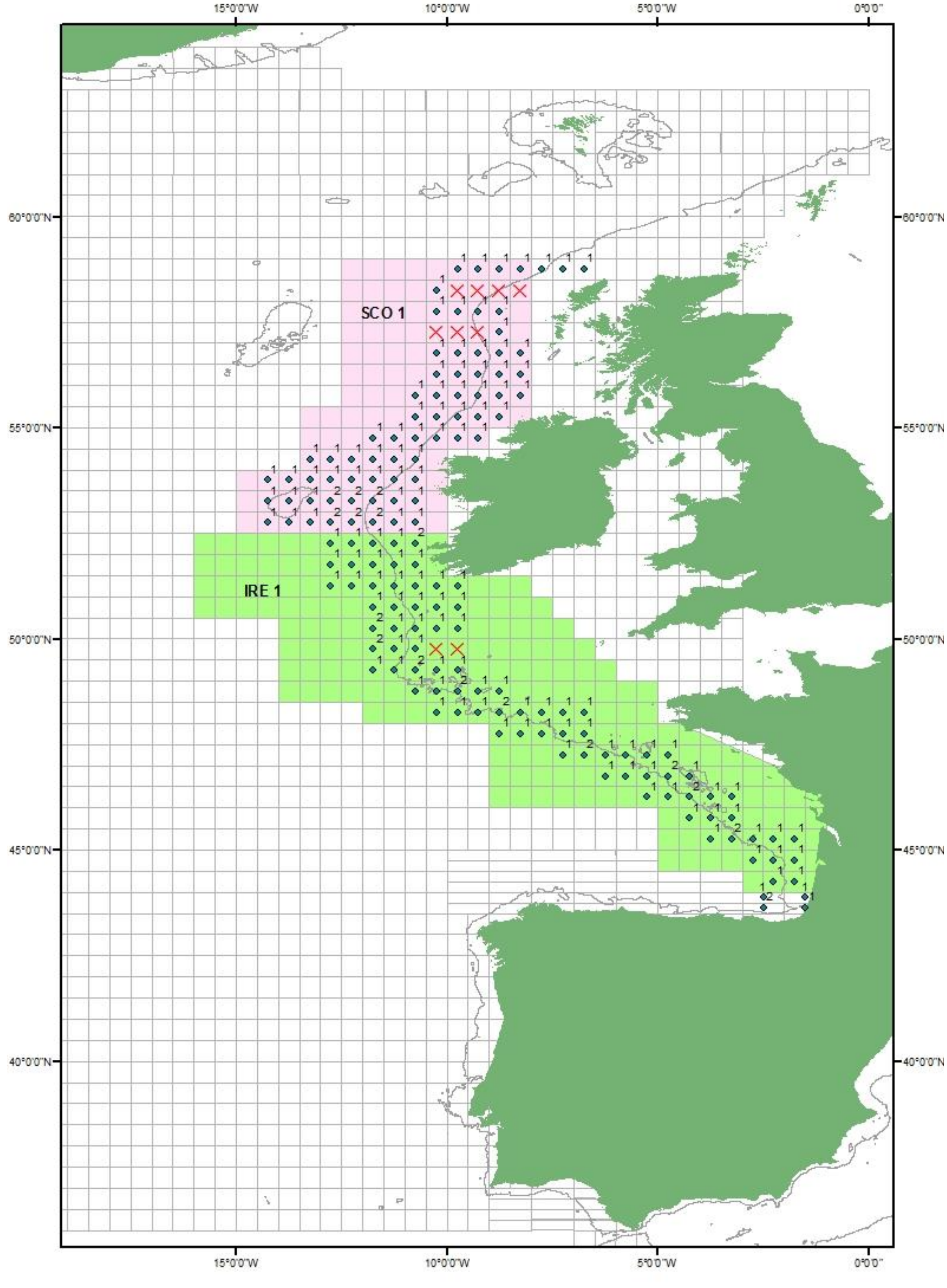

Figure 1.1: Number of observations per rectangle in period 2 (February 5th to 29th) and the country assigned areas (shaded) - X represents interpolated rectangles.

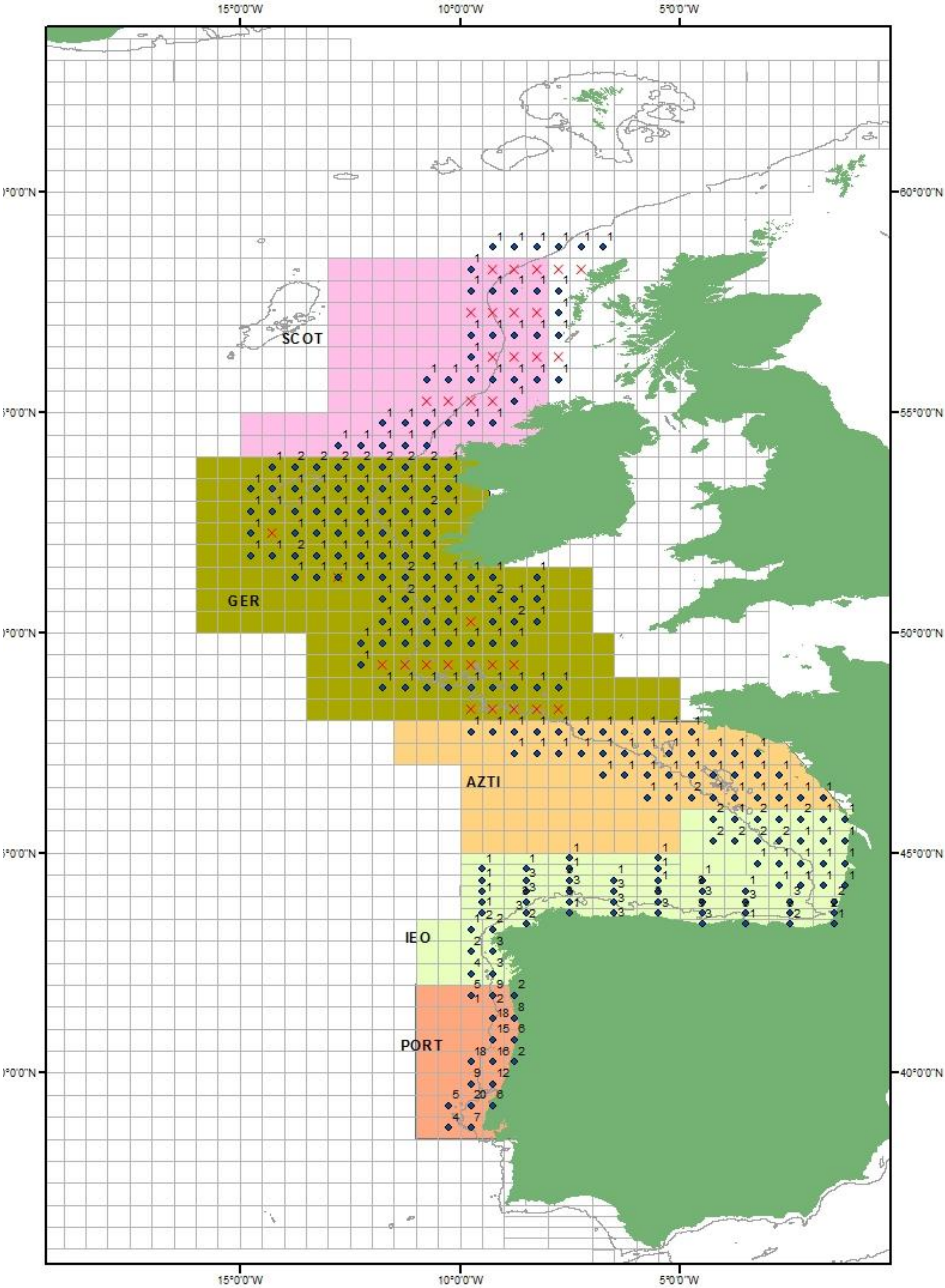

Figure 1.2: Number of observations per rectangle in period 3 (March 1st – April 8th) and the country assigned areas (shaded) – X represents interpolated rectangles.

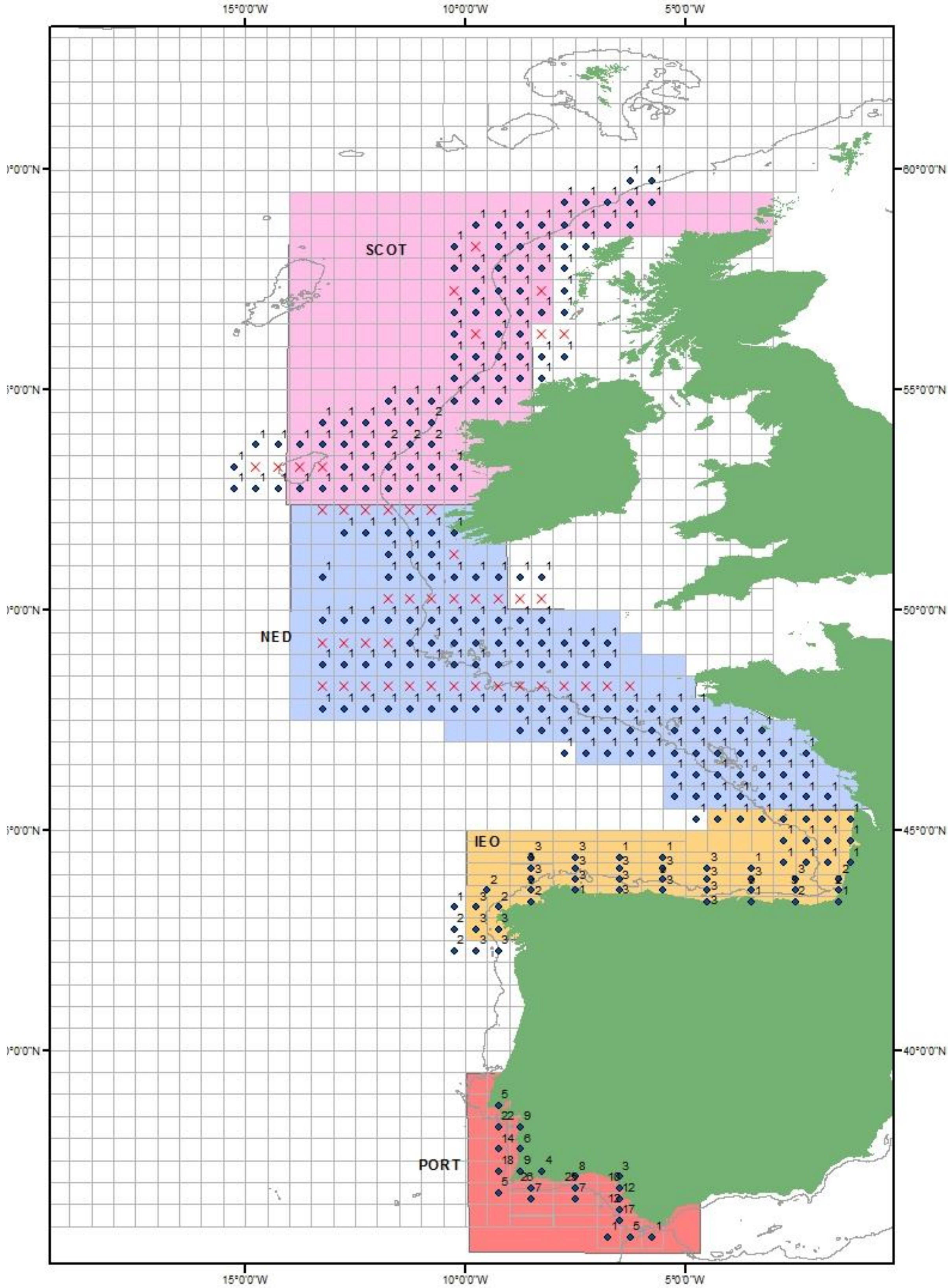

Figure 1.3: Number of observations per rectangle in period 4 (April 9th – 30th) and the country assigned areas (shaded) – X represents interpolated rectangles.

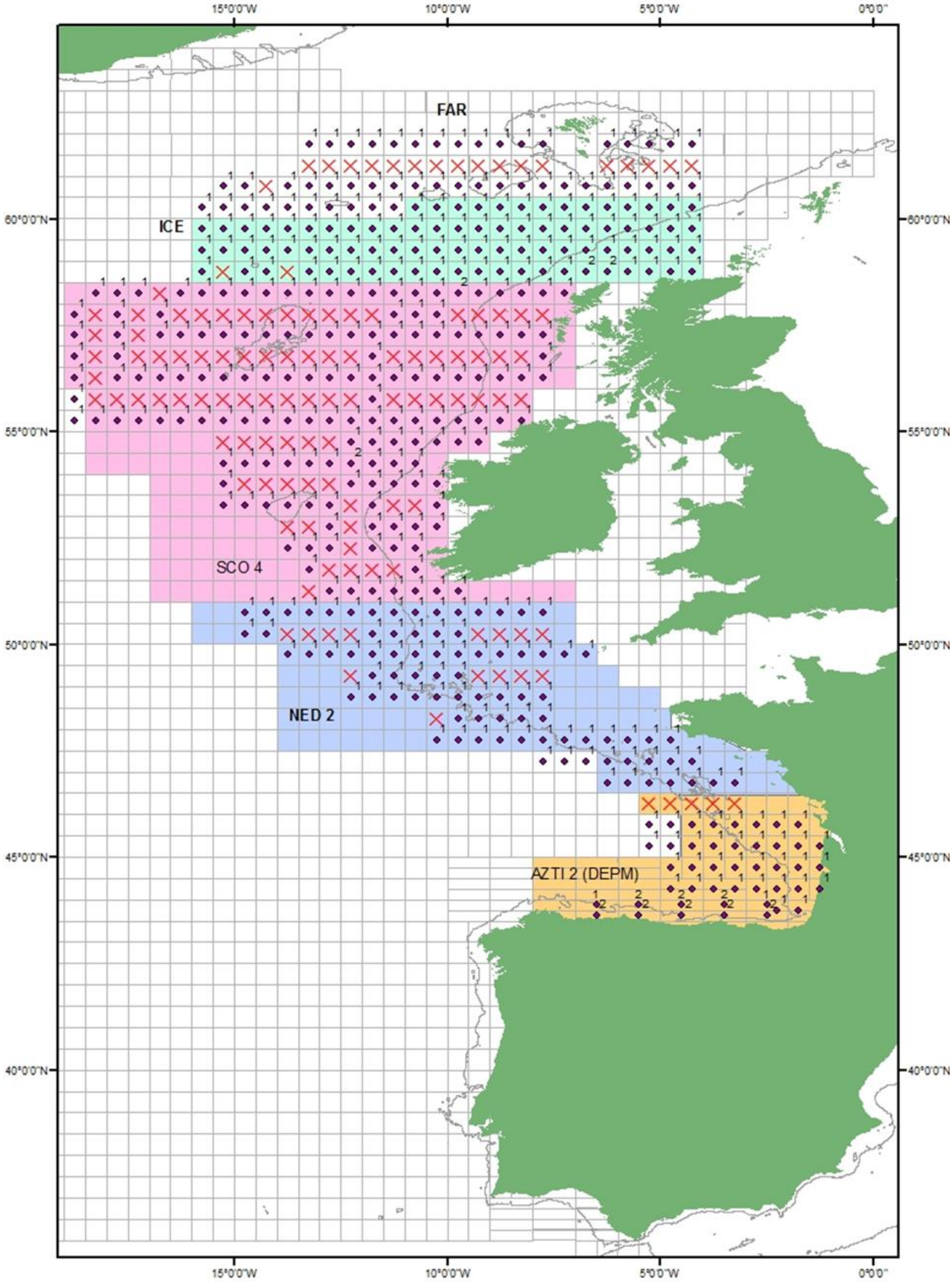

Figure 1.4: Number of observations per rectangle in period 5 (May 1st – 30th) and the country assigned areas (shaded) – X represents interpolated rectangles.

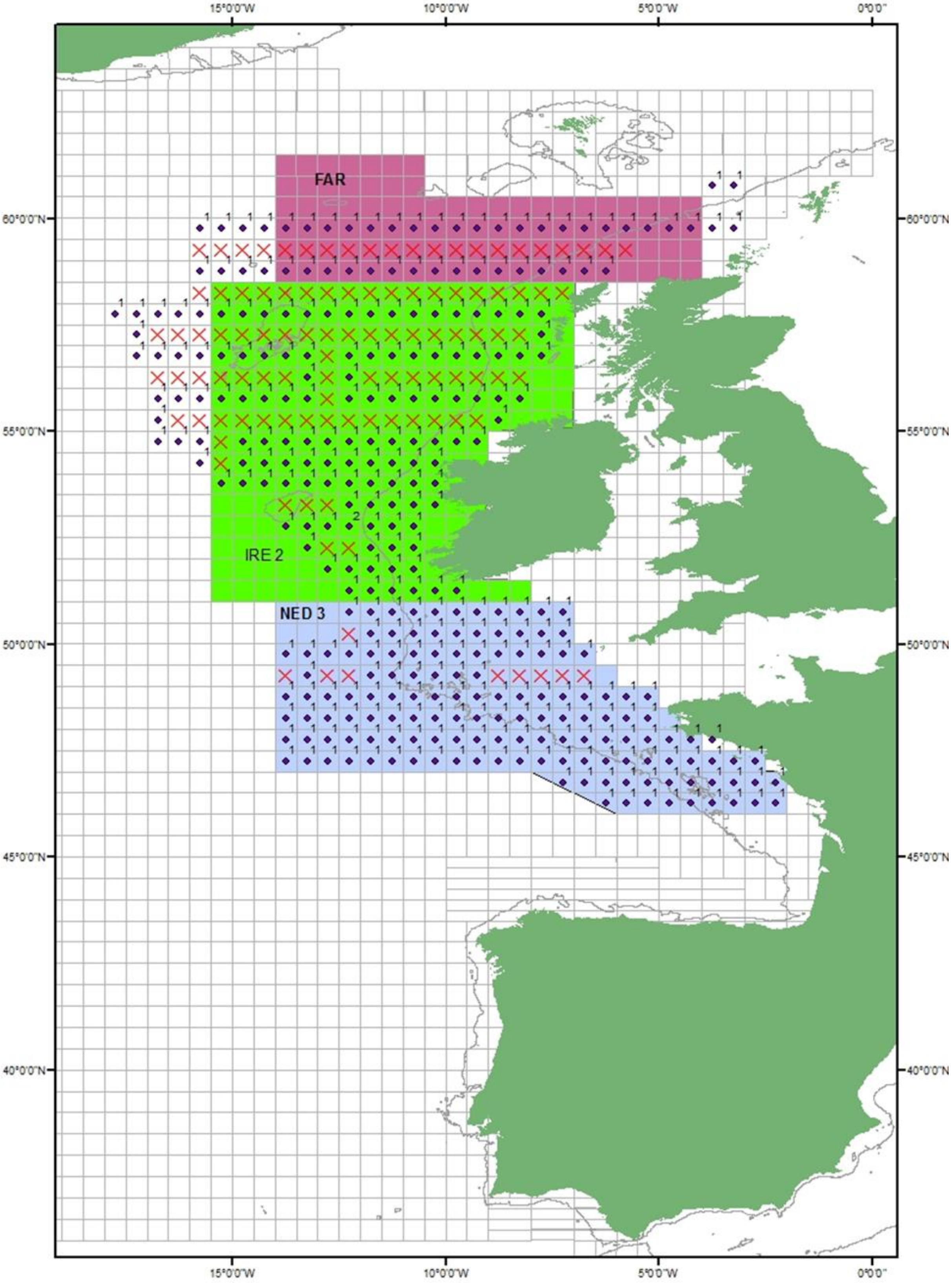

Figure 1.5: Number of observations per rectangle in period 6 (May 31st – June 26th) and the country assigned areas (shaded) – X represents interpolated rectangles

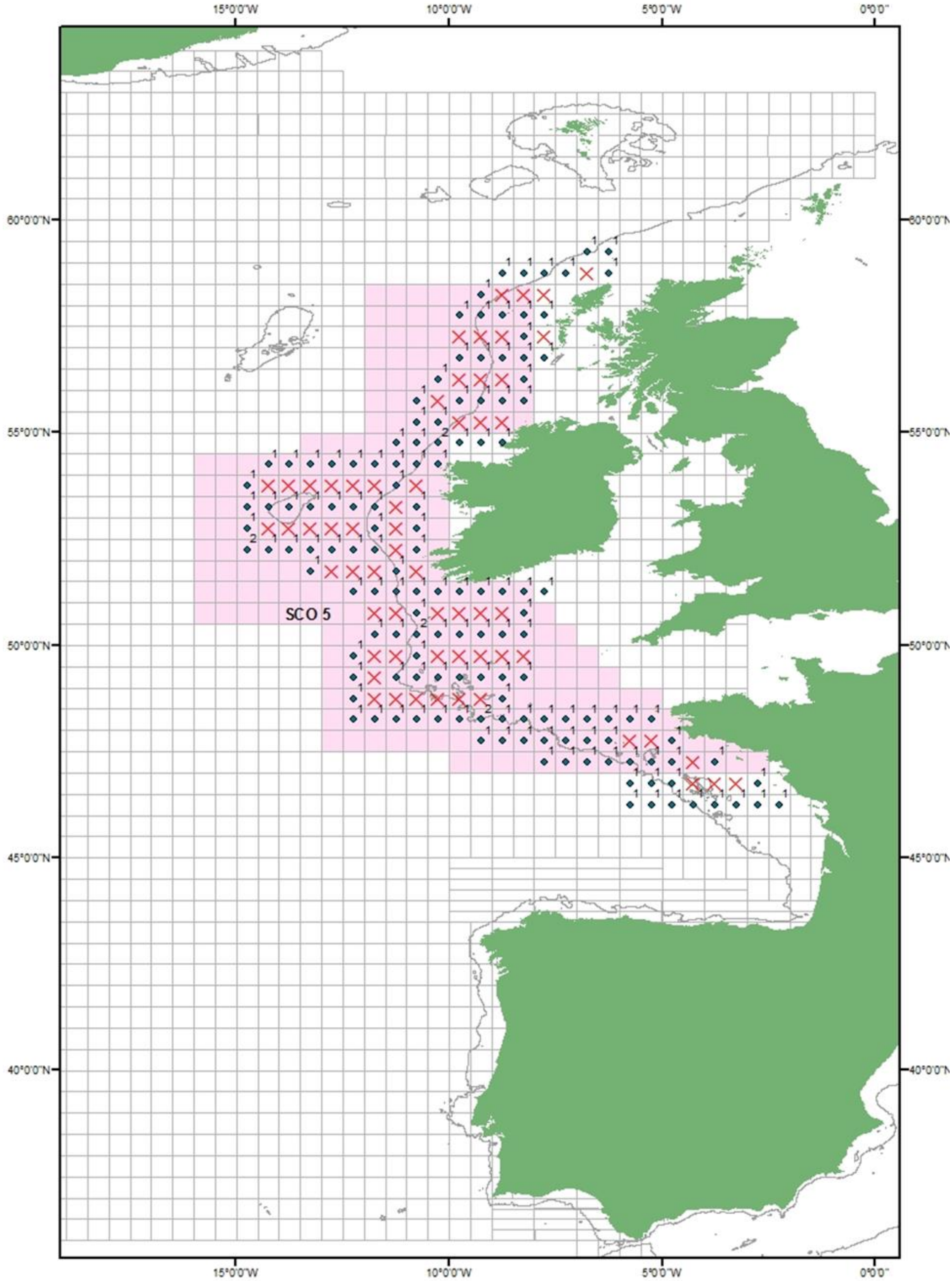

Figure 1.6: Number of observations per rectangle in period 7 (June 27th – July 19st) and the country assigned areas (shaded) – X represents interpolated rectangles

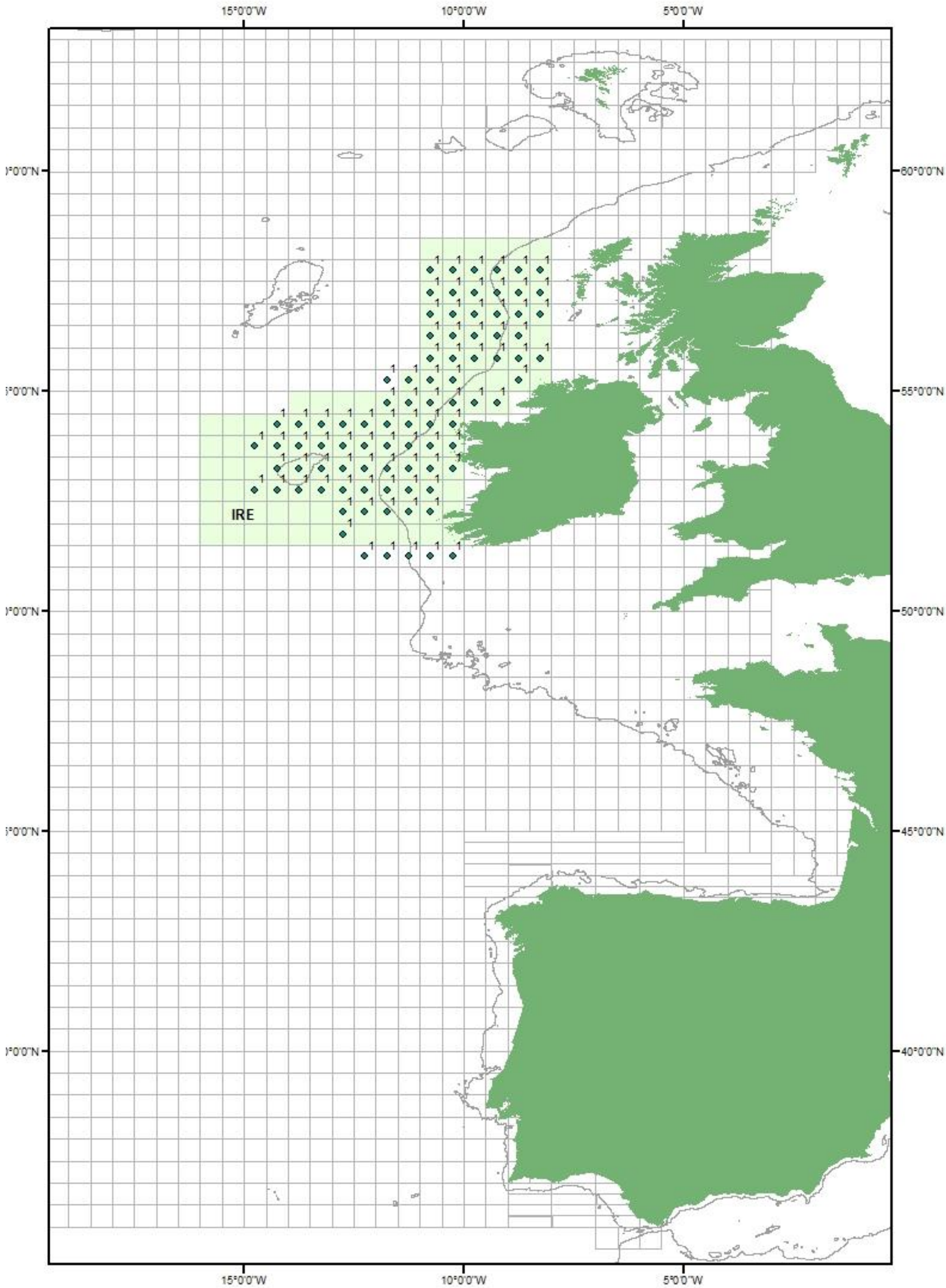

Figure 1.7: Number of observations per rectangle in period 8 (August 10th – 22nd) and the country assigned areas (shaded).