

Spatial and temporal distribution of spawning aggregations of blue ling (*Molva dypterygia*) west and northwest of the British Isles

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Fisheries on blue ling in ICES Areas Vb, VI, VII, and XIIb have mostly targeted spawning aggregations. ICES has repeatedly advised that blue ling are susceptible to sequential depletion of spawning aggregations and that closed areas to protect spawning aggregations should be maintained and expanded where appropriate. Information from a range of sources, including fishers, is analysed, and five main spawning areas are identified: (i) along the continental slope northwest of Scotland (ICES Division VIa); (ii) on, around, and northwest of Rosemary Bank (VIa); (iii) on the southern and southwestern margins of Lousy Bank (Vb); (iv) on the northeastern margins of Hatton Bank (VIb); and (v) along the eastern and southern margins of Hatton Bank (VIb). From the information available, it is suggested that, for management purposes, peak spawning be considered to take place at depths of 730–1100 m between March and May inclusive in VIa and Vb, and during March and April in VIb. Based largely on this information, the European Commission (EC) introduced in 2009 protection areas for spawning aggregations of southern blue ling in European Union (EU) waters within ICES Division VIa.

Keywords: blue ling, closed area, spawning aggregation.

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Introduction

In the Northeast Atlantic, blue ling (*Molva dypterygia*) is distributed from the Barents Sea along the coast of Norway to the west of the British Isles, around the Faroe Islands and Iceland, and off the east coast of Greenland. Blue ling in the Northeast Atlantic can be separated into two main stocks, one in ICES Division Va and Subarea XIV, and another in Division Vb, Subareas VI and VII, and Division XIIb (ICES, 2009). This paper focuses on the southern stock in Vb, VI, VII, and XIIb. Surveys west of Scotland by the Scottish Association of Marine Science (SAMS) and Germany found blue ling at depths between 300 and 1500 m, with peak abundance at 750–1000 m (Gordon and Hunter, 1994). Figure 1 shows the maximum potential distribution of the southern stock of blue ling within these depths and the main geographic features found in the area.

Compared with some deep-water fish species, blue ling are relatively fast-growing and not particularly long-lived (around 30 years). Growth rates (K) estimated from the von Bertalanffy

studies of blue ling sampled around the Faroes and Shetlands are 0.20 for males and 0.13–0.17 for females (Rainer, 1987). The species is a typical gadoid, being highly fecund (1–3.5 million eggs per female; Gordon and Hunter, 1994). From its life-history characteristics, blue ling would be expected to be less vulnerable to fishing than other deep-water species, but they are highly vulnerable because fisheries in all parts of the Northeast Atlantic have generally targeted spawning aggregations.

Total international landings of southern blue ling peaked at around 30 000 t in the 1970s, 20 000 t in the mid-1980s as the fishery expanded, and again at 10 000 t around 2000 (ICES, 2009), when new fleets entered the fishery in an attempt to build a track record before the introduction of European Union (EU) total allowable catches (TACs) and licensing in 2003 [European Commission (EC) Regulations 2340/2002 and 2347/2002, respectively]. Subsequently, EU TACs have gradually reduced, and total international landings in 2008 were the lowest since 1972. French trawlers have consistently accounted for a large

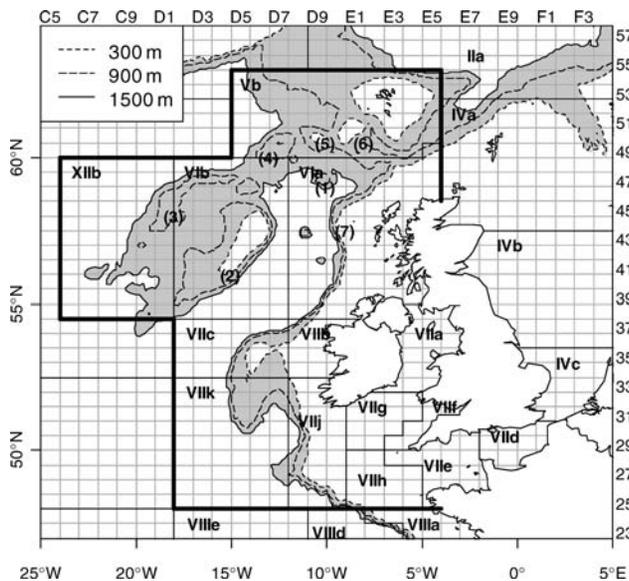


Figure 1. Potential distribution of the southern stock of blue ling in ICES Areas Vb, VI, VII, and XIIb and the location of the main geographic features referred to in text [numbers in parenthesis indicate the following banks: (1) Rosemary, (2) Rockall, (3) Hatton, (4) Lousy, (5) Bill Bailey, and (6) Faroe]. The continental slope is also shown (7).

proportion of the total international landings (50% in 2008; ICES, 2009).

Current ICES advice calls for no directed fisheries for southern blue ling and measures to be implemented to minimize catches in mixed fisheries (ICES, 2008a). ICES has repeatedly advised that blue ling are susceptible to sequential depletion of spawning aggregations and therefore that closed areas to protect spawning aggregations should be maintained and expanded where appropriate (ICES, 2004a, 2006, 2008a). Before the present study, management measures to protect spawning aggregations had not been introduced, largely because previous attempts to collate information on the spatial and temporal distribution of such aggregations had been unsuccessful, because of concerns by fishers regarding the commercial sensitivity of fishing locations (ICES, 2004b, 2007) and the paucity of fisheries-independent survey data.

The aim of this paper is to analyse, collate, and present available information on the spatial and temporal distribution of spawning aggregations of southern blue ling in both EU and international waters within ICES Areas Vb, VI, VII, and XIIb. The study is based on new and historical data from a range of sources, including information from fishers. The data remain sparse, however, and it has been necessary to develop a methodological approach suitable for a stock that is highly data-poor compared with those of most commercially exploited gadoid stocks on the continental shelf.

Material and methods

Our initial approach was to extract and explore information from the EU logbook data, on the assumption that landings from trips targeting spawning aggregations included substantially greater quantities of blue ling than trips targeting other species. Logbook data were available from French deep-water trawlers (1998–2006), UK (England and Wales) trawlers (1982–2006),

UK vessels landing in Scotland (2001–2005), and Faroese vessels (mostly trawlers) (2000–2007). A preliminary investigation of the quantity of blue ling in rectangle/month landing records (landings and fishing effort at the trip level were not available for all fleets) indicated that rectangle/month records in which blue ling were caught fell into two general categories: those where substantial quantities (mostly >10 t) of blue ling were landed, and those where landings of blue ling were much smaller, for instance as bycatch. In the absence of information on the location and extent of spawning from fisheries-independent surveys (survey data are sparse and generally do not cover the spawning season of blue ling), the assumption was made that the spatial (by ICES rectangle) and temporal (by month) distributions of rectangle/month records where landings exceeded 10 t provide insights into the duration of spawning and the geographic location of spawning aggregations.

Results from logbooks were compared with vessel monitoring by satellite (VMS) data from trips where landings exceeded 10 t, where available, to validate the use of the selected rectangle/month records and to improve the spatial resolution of indicated spawning aggregations. Information on fisheries on spawning aggregations obtained from logbooks and VMS was then compared with knowledge obtained as part of the EC-funded Framework 6 project “POORFISH” through a questionnaire designed and distributed in six countries to obtain expert opinion from a small cross section of fishery stakeholders, including fishers, producer organizations, scientists, senior scientific advisors, fishery managers, and non-governmental organizations (NGOs). A range of information was requested, including comments on the spatial and temporal extent of spawning aggregations and fisheries. In all, 50 questionnaires were distributed and eight replies were received; four from fishers, one from a fishers’ organization, and three from fisheries scientists.

The results from logbook data and the “POORFISH” questionnaires were compared with the information on observations of spawning blue ling made during a UK Fisheries Research Services (FRS; now Marine Scotland) trawl survey west and northwest of Scotland in May 2007, from 26 Russian surveys and exploratory fishing expeditions carried out in the same general area between 1976 and 1990 [summarized in working documents submitted to the ICES Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP) by VIV and his colleagues in 2003, and by VIV in 2008], and on a UK Department for Environment, Food and Rural Affairs (Defra) Fisheries Science Partnership (FSP) trawl survey carried out in February/March 2004 (Large *et al.*, 2004). The FSP was established in 2003 to build relationships between fishers and scientists and to involve fishers in the co-commissioning of science, and is funded by Defra.

Results

Temporal and spatial patterns of fisheries on spawning aggregations deduced from logbook data

Temporal patterns in monthly landings of southern blue ling (Figure 2) indicate that French trawler landings peaked later (April) in VIa than in VIb (March), whereas landings from Vb gradually increased throughout the year to peak in November. The reasons for the latter are not clear, but the same trend is evident when monthly landings of blue ling are presented as a proportion of monthly total catches. Historically, landings from Vb

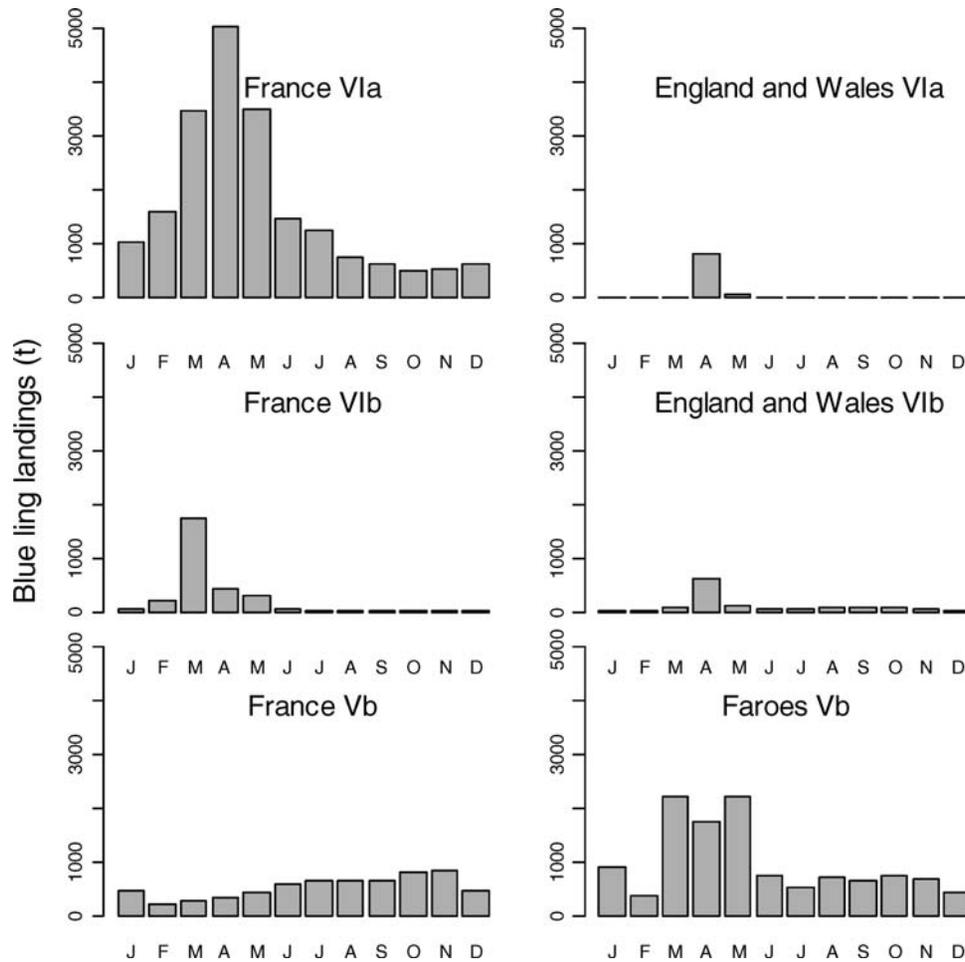


Figure 2. Monthly blue ling landings by French trawlers fishing in ICES Areas Vb, VIa, and VIb (data source French EU logbooks, 1998–2006 combined), UK (England and Wales) trawlers fishing in ICES Areas VIa and VIb [data source UK (England and Wales) EU logbooks, 1982–2006 combined], and Faroese vessels fishing in ICES Division Vb (2000–2007 combined).

were much smaller than from VIa and VIb, and this trend may reflect other factors, e.g. changes in species directivity. Landings from other ICES Areas, such as VII, were negligible.

The pattern in monthly landings by UK (England and Wales) trawlers is that landings peaked in April in both VIa and VIb. Landings from other areas, such as Vb and VII, were negligible. Although based on a long time-series of logbook data, these patterns are largely driven by comparatively few trips with large landings of blue ling mostly in the late 1990s and taken from a few ICES rectangles. The pattern in monthly landings from Vb by Faroese vessels (mostly trawlers) indicates a pronounced peak in landings from March to May.

Spatial plots of trawl landings of southern blue ling by ICES rectangle, based on rectangle/month records where landings exceeded 10 t (Figure 3), show that French landings peaked in rectangles along the continental slope northwest of Scotland and north of Rosemary Bank in VIa and, to a lesser extent, in isolated rectangles in VIb and Vb (Figure 3a). UK (Scotland) landings peaked along the continental slope and north of VIa, in central areas of VIb on and around Rockall Bank, and, to a lesser extent, east of Hatton Bank in VIb (Figure 3b). UK (England and Wales) landings were taken mostly from just six rectangles, particularly 43E0 (continental slope northwest of Scotland) in

VIa and 45D2 (eastern Hatton Bank) in VIb (Figure 3c). Detailed information on the spatial distribution of Faroese landings was not available, but fisheries on spawning aggregations are reported to take place on the southwestern margins of Lousy Bank, Bill Bailey Bank, and Faroe Bank (JR, pers. obs.).

VMS data

VMS data were provided by the UK's Defra in raw, uninterpreted form. The Secretary of State for the Environment, Food and Rural Affairs does not accept any liability whatsoever as to the interpretation of the data or any reliance placed thereon. The VMS 2-h transmission records for UK (England and Wales) trips where landings of southern blue ling exceeded 10 t were available from 2000 on (Figure 4a), and broadly corresponded to the spatial distribution of UK (England and Wales) trips targeting blue ling, as mapped using data from EU logbooks (Figure 3c). The only exceptions are trips carried out on the continental slope northwest of Scotland that took place in the late 1990s before VMS was introduced. Figures 4b and 4c show in greater spatial detail the areas with the most VMS records.

VMS transmission records for UK (Scotland) trawl trips where >10 t of blue ling were caught were available for 2007 and early 2008 (Figure 4d). These data suggest that spawning aggregations

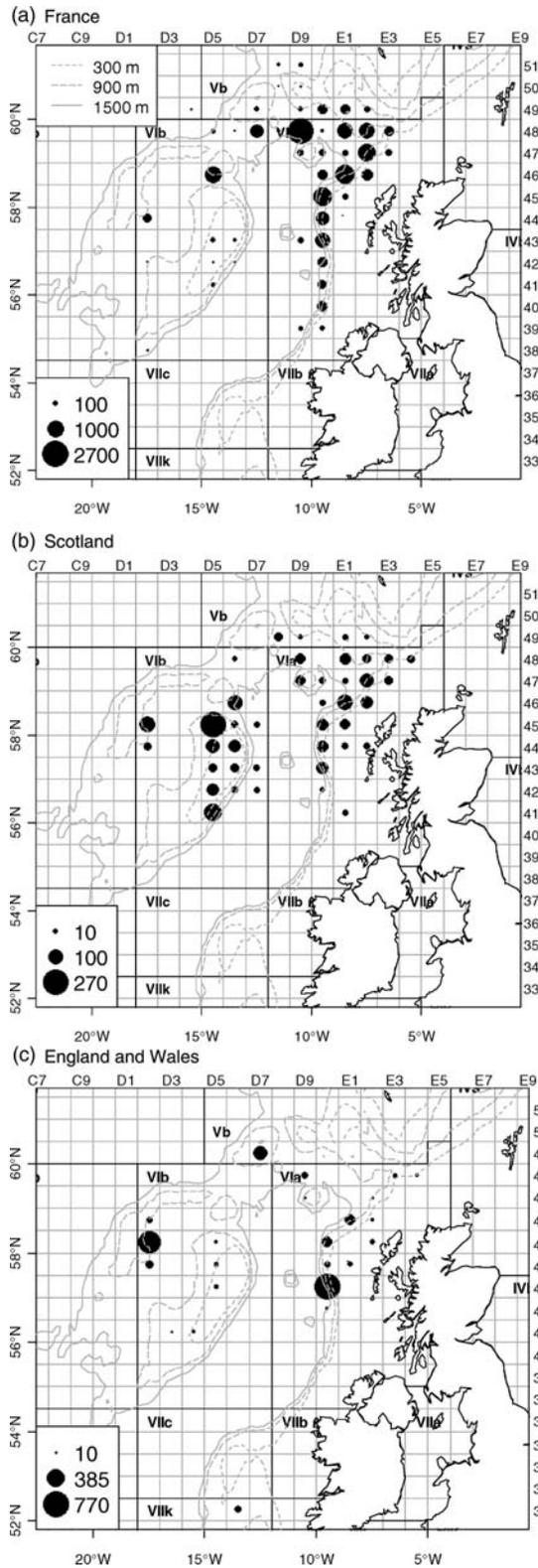


Figure 3. Trawl landings of blue ling by rectangle, based on rectangle/month records where landings of blue ling exceeded 10 t, for (a) French trawlers February–June 1998–2006 combined; (b) UK (Scotland) vessels (all gears) January–June 2001–2005; and (c) UK (England and Wales) trawlers February–June 1982–2006 (note: for the last, the two rectangles with the largest catches are each the result of single trips).

of blue ling tend to be fished along the continental slope north and northwest of Scotland, northwest of Rosemary Bank in VIa, on the northwest margins of Faroe Bank (mainly ICES Rectangle 51E1), and on George Bligh Bank (50D9), both in Vb. Although significant quantities of blue ling were caught during these trips, they may also include other fishing activity where blue ling would not be caught, e.g. east of Shetland.

Information collected from POORFISH questionnaires

Although only four fishers responded to the questionnaire, their views were considered important because the number of fishers historically involved in the fishery was likely quite small (probably fewer than 50), and previous attempts to engage fishers in dialogue, for example, by scientists attending the ICES WGDEEP, had been unsuccessful. Information on the spatial extent of targeted fisheries on spawning aggregations recorded on questionnaires is summarized in Figure 5. Two main spawning areas were identified: (i) along the continental slope northwest of Scotland and around Rosemary Bank in VIa, and (ii) on the eastern and southern margins of Hatton Bank in VIIb and XIIb. The areas identified are quite large and coarsely defined (at the ICES rectangle level) and, as such, include areas with a depth outside the range of spawning depths reported separately in questionnaires (maximum range 500–1100 m).

Information collected on the time of spawning and/or fisheries (Figure 6) broadly suggests that the maximum temporal limits of spawning are February–June on the continental slope northwest of Scotland (ICES Division VIa), and March–May on the offshore grounds east of Hatton Bank (ICES Division VIb). When questioned on year-on-year variation in the timing of spawning, some responders indicated that they did not know whether the timing of spawning varied by year, and others commented that any interannual variation observed was small.

Defra FSP trawl survey of February/March 2004 and FRS trawl survey of May 2007

Catch numbers of blue ling and the proportion of spawning fish (defined as running males and females, and females with hyaline, i.e. transparent, eggs) in blue ling catches at each fishing ground fished (Figure 7) demonstrate that, in February/March 2004, spawning blue ling were present east and southeast of Hatton Bank, at the Little Rose and Rosemary Banks, and on the continental slope northwest of Scotland.

During an FRS survey in May 2007, few spawning blue ling were caught (nine fish in total) on the continental slope (47E2, 59°07'N 07°42'W, depth 1000 m) and Rosemary Bank (47E0, 59°06'N 09°55'W, depth 900 m). No spawning fish were recorded at other grounds fished [Rockall Bank, ICES Rectangle 42D6, and at the Anton Dohrn seamount, 43D8 (E. Jones, FRS, pers. comm.)].

Russian exploratory fishing trips

The distribution of the main spawning grounds of blue ling in international waters west and northwest of Scotland, as indicated by the results of 26 Russian surveys and exploratory fishing expeditions carried out between 1976 and 1990, is shown in Figure 8. Spawning concentrations of blue ling of commercial importance were found on the southwest slope of Lousy Bank (60°02'–60°07'N 13°03'–13°30'W) at depths of 700–950 m, and on the northeast slope of Hatton Bank (59°08'–59°17'N

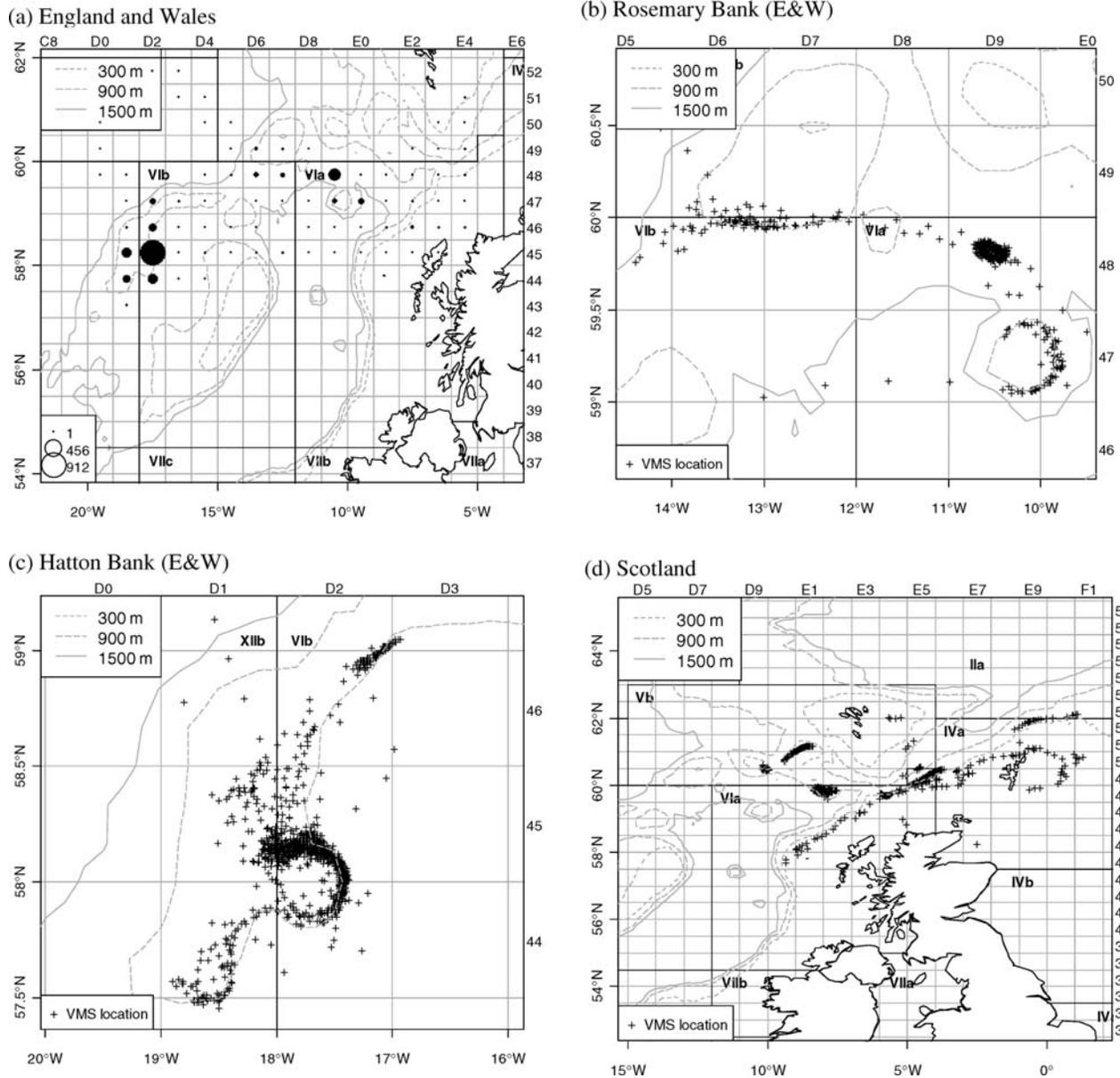


Figure 4. VMS 2-h transmission records for UK trawlers for trips where landings of blue ling exceeded 10 t showing (a) the number of records by ICES rectangle for England and Wales vessels fishing February–May 2000–2001, (b) the location of transmission records for England and Wales (E&W) trips on and northwest of Rosemary Bank (47D9, 47E0), and (c) on and around Hatton Bank, respectively, and (d) for Scotland trawlers for trips in 2007 and early 2008.

15°00′–16°04′W) at depths of 750–850 m. Further background information is given below.

Discussion and conclusions

Location of spawning aggregations

We collated and now present new information from a range of sources on the geographic location of spawning aggregations of southern blue ling. Five main areas are shown to be important: (i) along the continental slope northwest of Scotland in VIa (EU waters); (ii) on, around, and northwest of Rosemary Bank mainly in VIa (EU waters); (iii) on the southern and southwest margins of Lousy Bank in VIb and Vb (NEAFC Regulatory Area/EU waters/Faroese waters); (iv) on the northeast margins

of Hatton Bank (NEAFC Regulatory Area); and (v) along the eastern and southern margins of Hatton Bank in VIIb and XIIb (NEAFC Regulatory Area). All are shown in Figure 9.

For most areas, VMS data from trips considered to have targeted spawning aggregations are currently the most informative indicator of their spatial location and extent. There is also some evidence from UK (Scotland) logbooks that spawning blue ling may aggregate on and around Rockall Bank (Figure 3b) and on the northwest margins of Faroe Bank, and from Scottish VMS on Bill Bailey Bank (Figure 4d). However, this was not corroborated by information collected from fishers. Consequently, we suggest that these locations not be regarded as spawning areas until further information is available to confirm the presence of spawning.

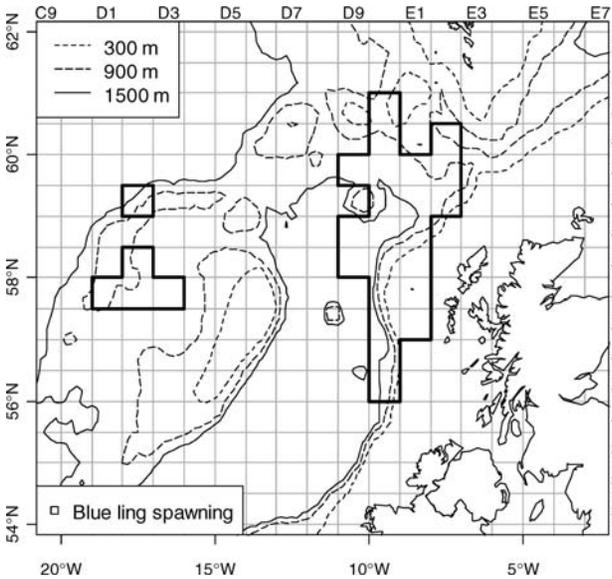


Figure 5. Spatial distribution of spawning grounds of southern blue ling, as identified/indicated by replies to POORFISH questionnaires.

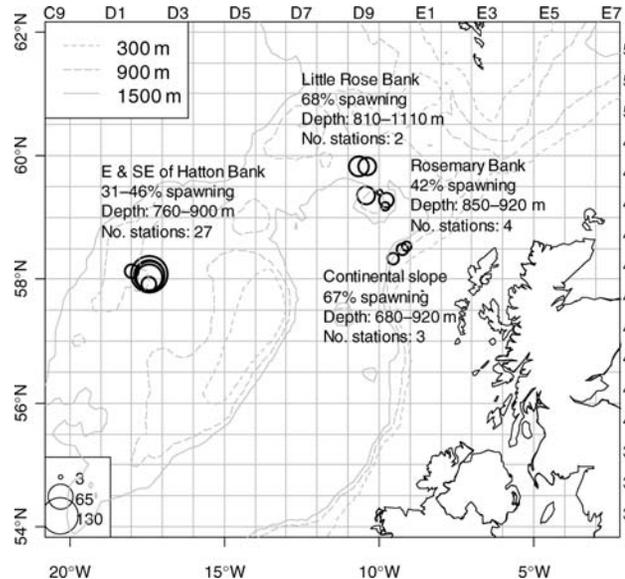


Figure 7. Catch numbers of blue ling per hour by station, FV “Farnella” FSP survey 2004, and the percentage of spawning fish in catches made at each ground fished.

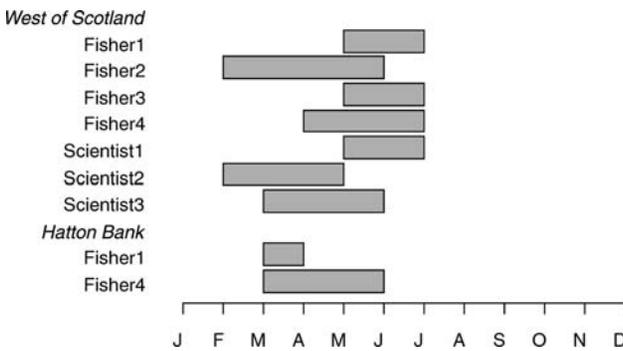


Figure 6. Summary of responses on the timing of spawning of southern blue ling from POORFISH questionnaires.

The five areas above are reasonably consistent with the limited information found in the scientific literature. Spawning blue ling were found on an Irish Marine Institute trawl-survey station carried out in April 1993 on the Hebridean Terrace (ICES Rectangle 45EO; ICES, 2004b, 2007); along the continental slope northwest of Scotland during a RV “Walter Herwig” trawl survey in February/March (Rainer, 1987); on Faroer Bank, Bill Bailey Bank, and Lousy Bank from February to May (Magnusson *et al.*, 1997); and on the northern slope of Rockall, the southern slopes of Lousy and Bill Bailey Banks, the eastern slope of Rosemary Bank, and on the northern part of the Hebridean Slope (59°43’N 6°38’W; Ehrich, 1983).

Seasonality of spawning

The seasonal information on landings presented here and the sparse information available in the scientific literature (Klimenkov *et al.*, 1977; Shibanov *et al.*, 1978) and in grey literature, mainly Russian papers submitted as working documents to ICES WGDEEP (ICES, 2004b, 2005, 2008b), suggest that the maximum temporal bounds of spawning are from February to June and that spawning may be slightly later in VIa than in VIb.

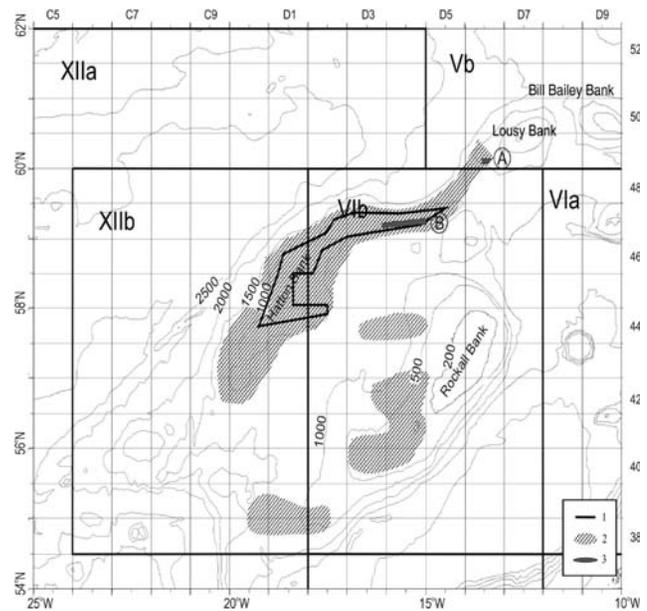


Figure 8. Distribution of the main spawning grounds of southern blue ling, according to data from Russian investigations and the Russian fishery. 1, the boundary of the closed area established by NEAFC for conservation of cold-water corals; 2, the area of the general distribution of blue ling; 3, the spawning grounds of blue ling on the southwestern slope of Lousy Bank (Area A) and the northeast slope of Hatton Bank (Area B).

We note that there is evidence of spawning as early as December in Faroese waters, but the grounds were not specified (Shibanov *et al.*, 1978). It is important to mitigate the impact on other fisheries of any management measures introduced to protect spawning aggregations of blue ling. Management measures could, therefore, be focused to address times of peak spawning rather than the entire spawning period. Although there is limited

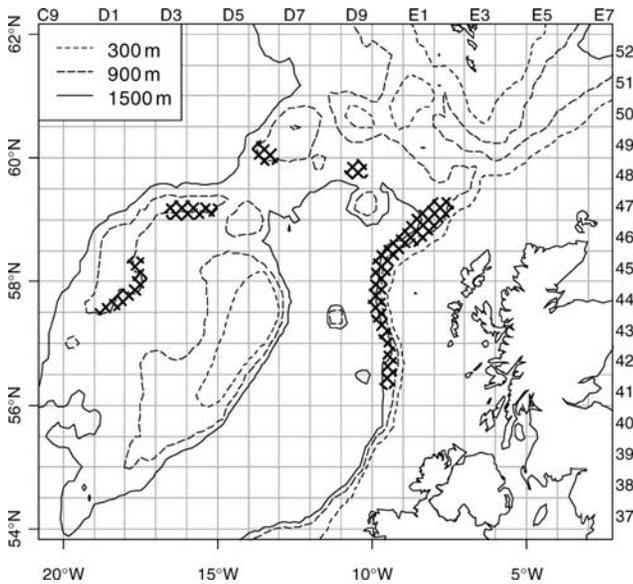


Figure 9. Distribution of the main spawning grounds of southern blue ling: (1) along the continental slope northwest of Scotland in VIa; (2) on, around, and northwest of Rosemary Bank, mainly in VIa; (3) on the southern and southwest margins of Lousy Bank in VIb and Vb; (4) on the northeast margins of Hatton Bank; and (5) on the eastern and southern margins of Hatton Bank in VIb and XIIb.

information available on the timing of peak spawning in each area, from the seasonal pattern in French and Faroese landings (Figure 2) and information reported by fishers (Figure 6), peak spawning could be considered, for management purposes, to be between March and May inclusive in VIa and Vb and during March and April in VIb.

Depth of spawning

The maximum depth range of spawning reported in POORFISH questionnaires was 500–1100 m, but most fishers were of the view that blue ling spawn between 730 and 1100 m. In the scientific and grey literature, there is only one record of spawning outside this depth range (1200 m at Lousy Bank, in a Russian working paper submitted to the ICES WGDEEP meeting in 2009). Therefore, based on all information currently available, it is likely that spawning takes place mainly within the depth range 730–1100 m.

Relevance of the results to fishery management

Many deep-water fisheries around the world have followed a boom-and-bust trajectory largely because reliable information on stock status and fisheries production potential has lagged considerably behind exploitation (Large *et al.*, 2003). The blue ling is one of the few deep-water species in the Northeast Atlantic that is not slow-growing and very long-lived, so if management measures can be introduced to protect spawning aggregations, they may support one of the better short-term opportunities to test the hypothesis that deep-water stocks can recover from overexploitation, providing that appropriate management measures are in place. Such measures could include reductions in the TAC and fishing effort from current levels.

Based on information from the EU POORFISH project and additional information collated by ICES WGDEEP in 2008, all

of which is presented here, the EC introduced in 2009 protection areas for spawning aggregations of southern blue ling in ICES Division VIa from March to May (EC Regulation No. 43/2009). The spatial and temporal boundaries of these protection areas were based on the best information available at the time, but it was recognized that the areas were provisional and required fine-tuning (or addition) as and when further information became available.

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