DTU Aqua
National Institute of Aquatic Resources

Abundance and catch of sensitive non-commercial fish species in Danish waters

Morten Vinther, Tobias Mildenberger, Anna Rindorf, and Kirsten Håkansson

DTU Aqua Report no. 456-2024

DTU Aqua
National Institute of Aquatic Resources

Abundance and catch of sensitive non-commercial fish species in Danish waters

Morten Vinther, Tobias Mildenberger, Anna Rindorf, and Kirsten Håkansson

DTU Aqua Report no. 456-2024

Colophon

Title:	Abundance and catch of sensitive non-commercial fish species in Danish waters
Authors:	Morten Vinther, Tobias Mildenberger, Anna Rindorf, and Kirsten Håkansson
DTU Aqua Report no.:	456-2024
Year:	Work completed in January 2024. Report published June 2024
Reference:	Vinther, M., Mildenberger, T., Rindorf, A. & Håkansson, K. (2024). Abundance and catch of sensitive non-commercial fish species in Danish waters. DTU Aqua. DTU Aqua-rapport no. 456-2024. https://doi.org/10.11581/dtu.00000329
Cover photo:	Atlantic wolffish. Photo: Citron / CC-BY-SA-3.0
Published by:	National Institute of Aquatic Resources, Technical University of Denmark, Henrik Dams Allé, 2800 Kgs. Lyngby, Denmark
Download:	www.aqua.dtu.dk/publikationer
ISSN:	1395-8216
ISBN:	978-87-7481-392-7

DTU Aqua Reports contain results from research projects, reviews of specific topics, expositions for authorities etc. Unless stated in the colophon, the reports are not peer reviewed, which means that the content has not been reviewed by researchers outside the project group.

Contents

1. Introduction 4

2. Material and methods 5
2.1 Identification of species and thresholds 5
2.2 Commercial catches (D1C1) 5
2.3 Spatio-temporal modelling of the scientific survey data (D1C2) 5
2.4 Fishing mortality and trends 8

3. Results 9
3.1 Common skate (Dipturus spp) 9
3.2 Atlantic halibut (*Hippoglossus hippoglossus*) 10
3.3 Ling (*Molva molva*) 11
3.4 Starry ray (*Amblyraja radiata*) 12
3.5 Atlantic wolffish (*Anarhichas lupus*) 13
3.6 Anglerfish (*Lophius* spp) 14
3.7 Thornback ray (*Raja clavata*) 15
3.8 Greater forkbeard (*Phycis blennoides*) 16
3.9 Tope (*Galeorhinus galeus*) 17
3.10 Rabbit fish (*Chimaera monstrosa*) 18
3.11 Spotted ray (*Raja montagui*) 19
3.12 Starry smooth-hound and smooth-hound (*Mustelus* spp) 20
3.13 Roundnose grenadier (*Coryphaenoides rupestris*) 21
3.14 Other species 21
3.15 Baltic species under the habitats directive 22
3.16 Joint evaluation 22
3.17 Management considerations 22
3.18 References 25

Appendix 1: Density maps for 1991, 2006 and 2021 based on survey catches 27

Appendix 2: Correlation analysis for trend in abundance index 66

1. Introduction

The sea contains a significant part of Danish nature and biodiversity and is also a source of healthy food, nature experiences, renewable energy and raw materials. In order to ensure a healthy and good marine environment for the enjoyment and benefit of future generations as well as maintaining sustainable exploitation, the EU's Marine Strategy Framework Directive from 2008 specifies how we identify significant aspects of the marine environment. The significant aspects are divided into 11 descriptors: 1. Marine biodiversity, 2. Non-indigenous species, 3. Commercial fish and shellfish, 4. Food webs, 5. Eutrophication, 6. Seabed integrity, 7. Hydrographical conditions, 8. Contaminants. 9. Contaminants in seafood, 10. Marine litter and 11. Energy. For each descriptor, a number of criteria have been defined and these are examined by following the development of specific indicators. The indicators are used together with threshold values to assess whether the individual criterion is in good environmental status (on the right side of the threshold value). This report is one of a number of reports DTU Aqua has produced for the Ministry of the Environment for the Danish reporting for the marine strategy directive's descriptors.

Descriptor 1 aims to maintain biodiversity, including that of fish (European Commission, 2008). It is recommended that the list of species is developed through regional cooperation, preferably using regional seas conventions such as OSPAR (European Commission 2021).

The present report provides an update of analyses in support of Marine Strategy Directive descriptor 1. It is an update of the report ”Abundance and catch of sensitive non-commercial species in Danish waters” (Gislason et al., 2017). The methodology for estimating stock abundance from survey catch rate has been improved and data from survey and fisheries have been updated to also include the period 2017-2022.

The aim of the study was to evaluate the temporal development of bycatch (D1C1) and abundance (D1C2) of species sensitive to bottom trawling in the Baltic Sea, Kattegat, Skagerrak and the North Sea.

The report was funded by the Ministry of Environment of Denmark under the ‘Contract for Technical Assistance on the EU Marine Strategy Directive and the Regional Seas Conventions’ (MIM ID no: 355159). The Ministry of Environment has had draft reports for commenting along the way, but the choice of methods and conclusions are the sole responsibility of the authors.

2. Material and methods

2.1 Identification of species and thresholds

The method for identification and selection of sensitive fish species based on their life history characteristics and catchability follows ICES (2021) and is described in Rindorf et al. (2020) or ICES (2021). Reduced to those for which a substantial part of the population occurs in the North Sea, Skagerrak and Kattegat. Further, lumpsucker (*Cyclopterus lumpus*) was excluded here as a survey index is under development but the estimation is not yet complete. The approach to selecting species is consistent with the guidance defined in the guidance from the European Commission (2022) and approaches in ICES (2021) and the OSPAR regional convention. The thresholds are defined as the occurrence of a positive trend in abundance, consistent with the OSPAR sensitive fish indicator (https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/indicator-assessments/recovery-sensitive-fish-species/) and the HELCOM indicator for coastal fish (HELCOM 2018).

2.2 Commercial catches (D1C1)

Commercial catch statistics are available from ICES (https://www.ices.dk/data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx) Data include:

- Official Nominal Catches 2006-2021. Catch by country, species, area and year as provided by the national authorities. Source: FAO/Eurostat/ICES data compilation of catch. Version: 19-07-2023.
- Historical Nominal Catches 1950-2010. Catch by country, species, area and year. Source: FAO/Eurostat/ICES database on catch statistics. Version 26-06-2019.
- ICES Historical Landings 1903-1949. Catch by country, year, area, and species. Source: Bulletin Statistique. Version: 28-10-2014.

Data were extracted for ICES subarea 4 (the North Sea) and subarea 3 (Skagerrak, Kattegat, and the Baltic Sea) for all countries combined and separately for Denmark. In some cases, the landings from commercial fisheries have not been reported by species but instead lumped into species groups such as “rays and skates” making it impossible to estimate the historic landings of some of the individual species. An analysis of the catches of elasmobranchs in the Danish fisheries (Rindorf et al., 2023) showed that even though species identification of rays and skates has improved since 2021, species identification remains doubtful for some species of elasmobranchs, especially for the less abundant species of rays and skates. Therefore, catches of some of the species are not presented in this report.

The historical databases include in most cases just the landed weight, while the discards at sea are not included. Landings are likely to substantially underestimate true catches (landings plus discards), and as the degree of discard may vary between years, it is difficult to derive meaningful time series of catches. Danish discards were estimated from data from observer trips with catch sampling onboard commercial vessels in the period from 2002 to 2022. Recreational catches are unknown for all the species.

2.3 Spatio-temporal modelling of the scientific survey data (D1C2)

Species distribution and density estimation were based on available data from six scientific surveys in the Greater North Sea region (NS-IBTS, BITS, Norwegian shrimp survey, BTS, DYFS, SNS; Figure 2.1). The data was restricted to the well-covered and standardised period from 1991 to 2021. Data from the Norwegian shrimp survey before 2006 were excluded from this analysis due to unrepresentative sampling design and species identification. Data, except data from the Norwegian shrimp survey, are available from ICES (https://www.ices.dk/data/data-portals/Pages/DATRAS.aspx)

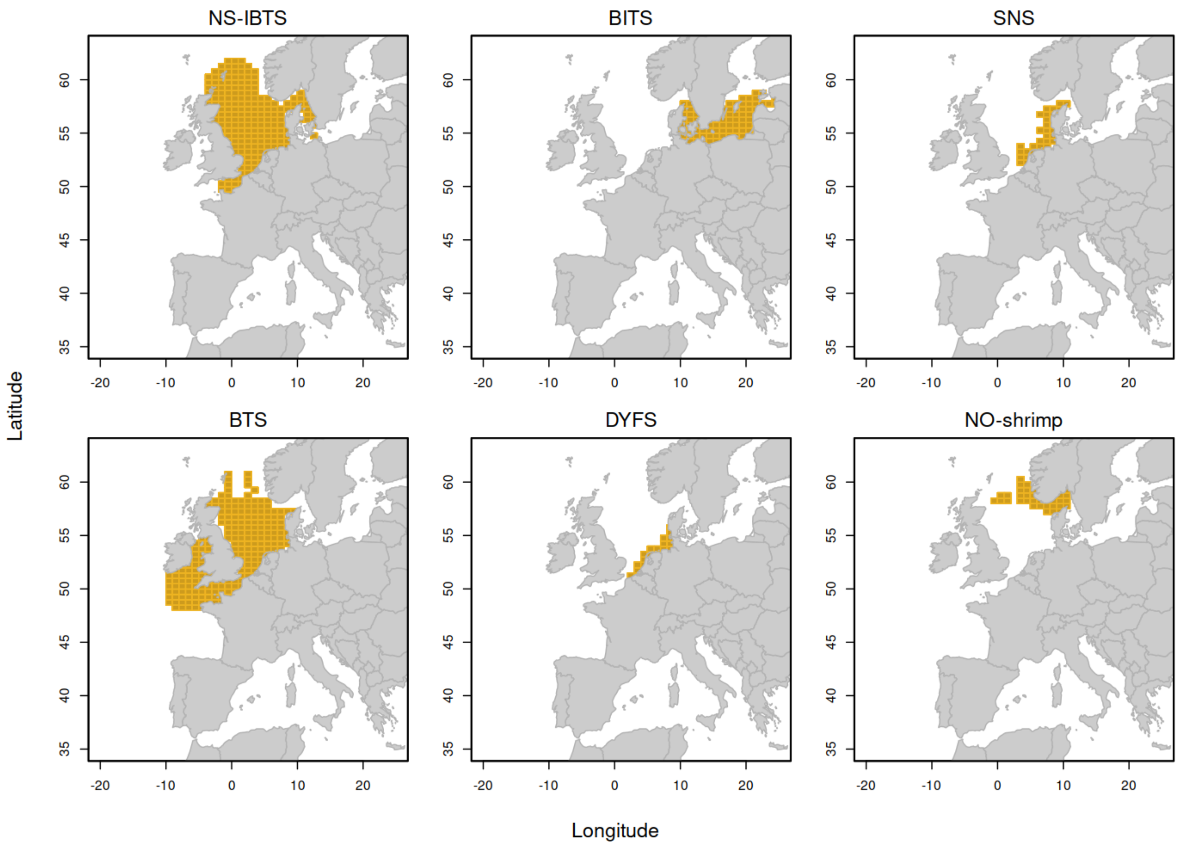

Figure 2.1. Spatial distribution of the surveys

The area with a radius of around 60km around a haul in which a species was observed at least once was defined as a suitable habitat for the species and included in the spatio-temporal analysis. Any haul in the suitable habitat in which the species was not observed was interpreted as a true zero observation, i.e. the species could have been observed but was absent. To combine the information from the various surveys and standardise for various haul duration and gears used by the survey, a spatio-temporal generalized additive model (GAM) was used. GAMs allow to estimate abundances of fish populations while correcting for confounding factors such as spatial position of the haul, depth, time of day, or swept area. GAMs allow the definition of non-linear smooth relations between the response (e.g. abundance) and explanatory variables (e.g. year, season and position of haul).

Two spatio-temporal GAMs were fitted to the survey information for each species with the following model formula:

$$g(Y_i) = f_1(Lon_i, Lat_i) + f_2(Time_i) + f_3(Time_i, Lon_i, Lat_i) + f_4(Toy_i) + \\ f_5\left(\sqrt{(Depth)}_i\right) + Gear_i + U(i)_{Ship:Gear} + offset\left(log(HaulDur_i)\right)$$

where

- Y_i refers either to the observed catch in number of individuals or to the biomass in kg in the i^{th} haul with link function (g).

- f_1 represents a fine-scale 2D Duchon spline on the geographical coordinates (longitude and latitude) of haul *i* (144 knots),
- f_2 represents a smooth function of the continuous time (number of knots equal to the number of years),
- f_3 represents a 3D Tensor product smooth of the 1D Thin plate smooth for the time domain (number of knots equal to the number of years) and 2D Duchon spline for the space domain (10 knots),
- f_4 represents a cyclic cubic regression spline for the time of year (Toy; 5 knots), f_5 represents a 1D thin plate spline for effect of the square root of the bottom depth (5 knots),
- $Gear_i$ is a parametric trawl gear effect,
- $U(i)_{Ship:Gear} \sim \mathbb{N}(0, \sigma_u)$ is a random effect for the ship:gear interaction of haul *i*, and
- offset is the logarithm of the haul duration (HaulDur) and is used as an offset in the model.

For the number of individuals, the negative binomial distribution with a log link function (g) is used. For the biomass, a delta lognormal model is used that fits the zero (presence/absence) and positive observations independently. The zero observations are fitted using the Binomial distribution with a logit link function and the positive observations using the Gaussian distribution with a log-transformed response variable and the unit link function (g).

If this complex model did not converge for a given species, the model was gradually simplified by reducing the number of knots and/or the number of the 3D tensor product smooths until the model converged.

The estimation of the density and uncertainty are based on the methodology described by Berg et al. (2014). The density was predicted for the longitude and latitude values corresponding to the centroid of a regular sized grid based on subsets of the ICES statistical sub-rectangles with 1.5'longitudinal and 1.5' latitudinal dimensions. The extensions of the grid were constrained to be within a distance of 0.5° to the location of the hauls included in the ICES DATRAS database. The depth for each of the grid cells was downloaded from the NOAA database (Figure 2-2).

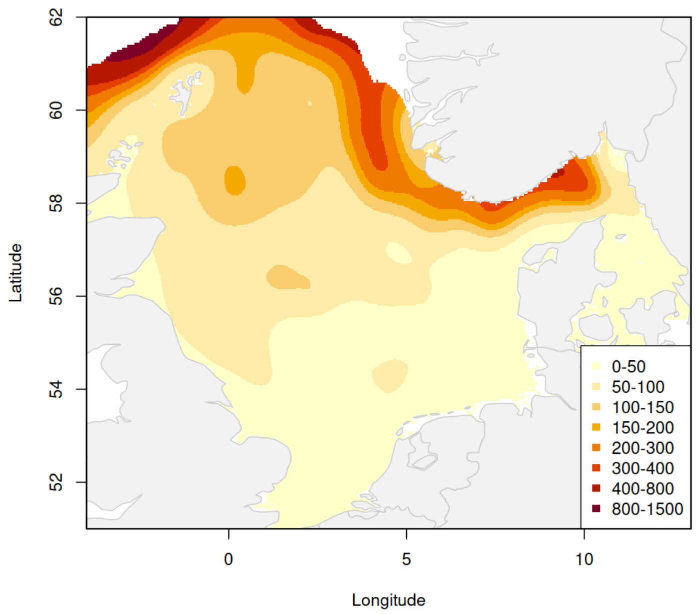

Figure 2.2. Smoothed representation of the depth.

We used the approach and R package described in Berg *et al.* (2014). The package was slightly modified to allow more flexibility with input data and work with overall biomass without an age structure. The procedure to estimate density included the following steps:

1. Divide the realised habitat into small subareas of approximately equal size.
2. Choose one haul position to be representative for each sub-area (here the one closest to the spatial centroid of all hauls in the given sub-area).
3. Take the sum of all predicted densities with the same reference gear, time of the year, depth, and haul duration for the chosen haul position.

The standard deviation, coefficient of variation (CV), and 95% confidence intervals of the density estimates were estimated based on bootstrapping. Given that n_y denotes the number of hauls in a given year, a bootstrap data set is created by resampling the data set with replacement, taking n_y hauls for each year from the data. All parameters (incl. smoothing parameters) and the abundance index is re-estimated for each bootstrap data set. The estimation of the standard deviation is based on 1000 bootstrap data sets. For more information about the prediction and bootstrapping procedure, please refer to Berg *et al.* (2014).

The predicted density in the distribution maps was categorised into nine density levels (colours) based on the concentration of the respective species, i.e. each level (colour) contains an equal proportion of the population (around 11%).

2.4 Fishing mortality and trends

Total catch divided by the biomass index, normalized to an average of 1, derived from survey data was used as a proxy for fishing mortality (F).

For each species, the presence oftrends was assessed as the Pearson correlation coefficient between year and abundance index from trawl surveys in the historic period defined as the years up to 10 years before 2017 (species where quarter 1 surveys were most appropriate) or 2016 (species where quarter 3 surveys were most appropriate) as well as in the latest 10 year period. The results of this analysis are given in Table 4.

3. Results

For each of the sensitive species, this section presents an evaluation of temporal changes in abundance and spatial distribution, together with the Danish and international catches of the species and a fishing mortality proxy.

3.1 Common skate (Dipturus spp)

The common skate complex (*Dipturus intermedius, D. flossada, D. batis*) occurs mainly in the western North Sea but has also been recorded in Skagerrak/Kattegat. It has decreased severely from historical (pre-survey) levels of abundance and is now considered to be at a very low abundance. Survey catch rates are very low (Figure 3.1) and the survey area in the North Sea and Skagerrak does not include the full depth ranges of this species group. The species must be released when caught, but catch statistics are highly uncertain due to inadequate species identification of landings (Rindorf et al., 2023). Discards and their survival are unknown, and hence total catch mortality is unknown. Two specimens have been reported from Danish observer trips and both were discarded. ICES have records of catches up to 26 t/year since 2010 with Denmark as the main fishing nation. However, these catches are considered uncertain due to likely species misclassification in the landings. EU fishing regulations have listed the common skate complex as a prohibited species to land in EU waters since 2009. This is also the case for UK waters, but not for Norwegian waters. ICES has advised zero catch for this species since 2009.

Appendix 1 provides density maps for the years 1991, 2006 and 2021 based on survey catches in biomass (Figure 4.1) and in numbers (Figure 4.3). The biomass index by year is shown in Figure 4.2.

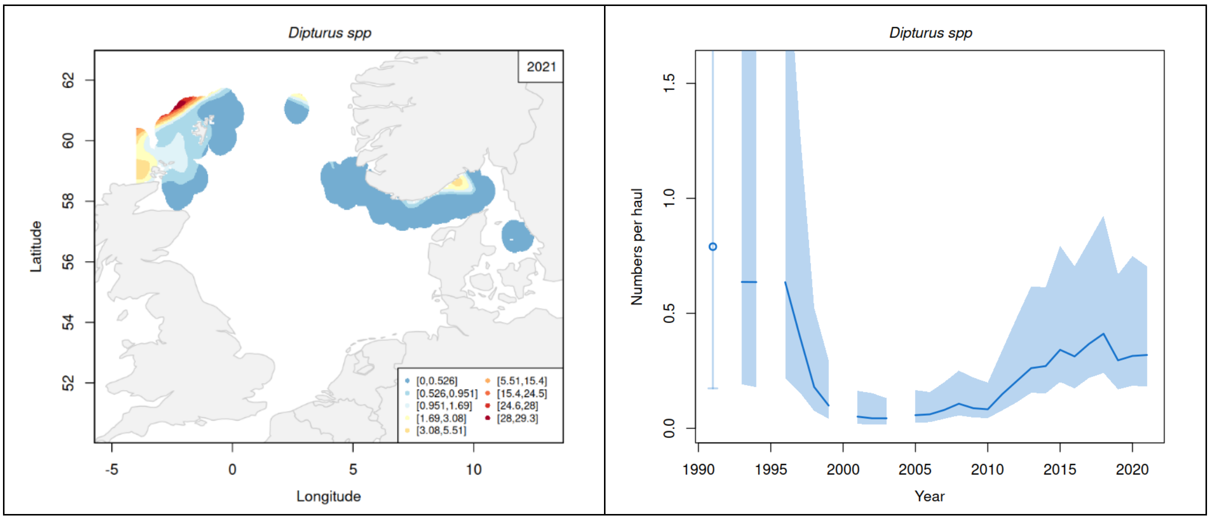

Figure 3.1. Common skate complex. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.

3.2 Atlantic halibut (*Hippoglossus hippoglossus*)

Atlantic halibut occurs in the deeper parts of the North Sea and Skagerrak. Abundance in the trawl survey has fluctuated without a trend over the time period surveyed (Figure 3.2). Catches of halibut have decreased significantly over the last 100 years with an average annual catch of 330 t/year for the most recent 10 years. Around one-third of these catches are Danish. Discards of Atlantic halibut are low (1% of catches on average). Commercial catch divided by the survey index provide a proxy for fishing mortality (Figure 3.2, bottom right). This F proxy is variable but shows a decline in fishing mortality over the years 1991-2021. Please note that F proxy used and abundance index bases on the biomass of survey catches while the abundance index show in Figure 3.2, is based on catches in numbers. The biomass index (Figure 4.5) can be found in Appendix 1. ICES does not give catch advice for this species.

Appendix 1 provides density maps for the years 1991, 2006 and 2021 based on survey catches measured as biomass (Figure 4.4) and in numbers (Figure 4.6). The biomass index by year is shown in Figure 4.5.

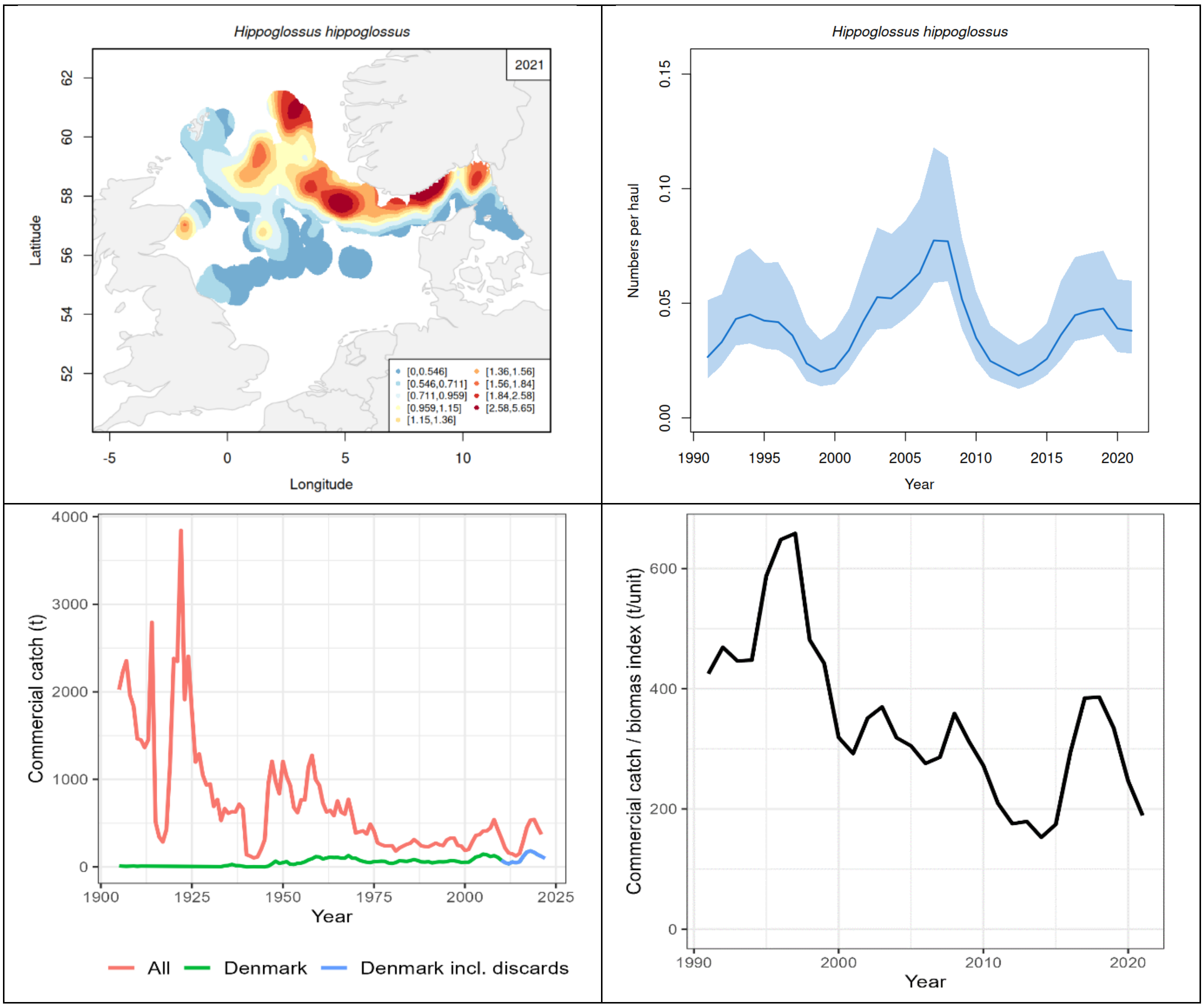

Figure 3.2. Atlantic halibut. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.3 Ling (*Molva molva*)

Ling occurs mainly in the deeper parts of the North Sea and Skagerrak. The abundance index was highest in 2017 followed by a small decline (Figure 3.3). Catches in the most recent years have been around the long term mean. Discards of this species are low (2% of the total catch in 2022). Fishing mortality (proxy) of ling has generally decreased since 2005. ICES advised in 2023 that the maximum catch in 2024 and 2025 of the ICES stock of ling in the entire Northeast Atlantic and the Arctic should be decreased by 12% compared to previous ICES advice. Realized catches of ling have generally been lower than the agreed TAC but exceeded ICES advice by an average 5% for the period 2018-2022.

Appendix 1 provides density maps for the years 1991, 2006 and 2021 based on survey catches measured as biomass (Figure 4.7) and in numbers (Figure 4.9). The biomass index by year is shown in Figure 4.8.

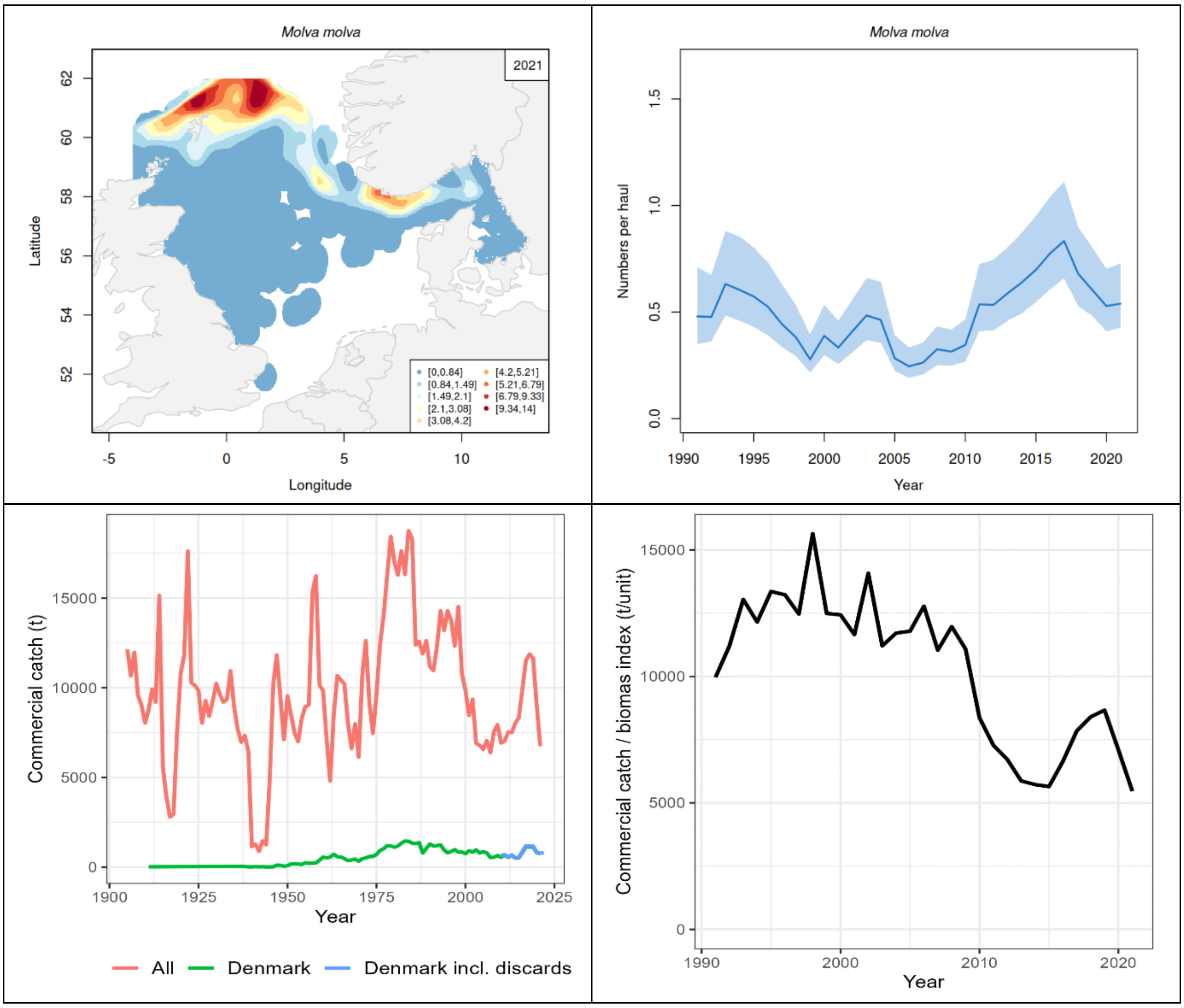

Figure 3.3. Ling. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.4 Starry ray (*Amblyraja radiata*)

Starry ray occurs in the North Sea through to the belt sea. Since year 1992, stock size has decreased steadily (Figure 3.4). According to ICES, international landings have been in the range of 0-3 t/year since 2009, while discards are substantial with discards in the range 400-3600 t/year. Denmark is the major catching (reporting) nation with around two-thirds of the total catches. EU fishing regulations have listed the starry ray as a prohibited species to land in EU waters since 2009. This is also the case for UK waters, but not for Norwegian waters. ICES has advised zero catch for this species since 2016.

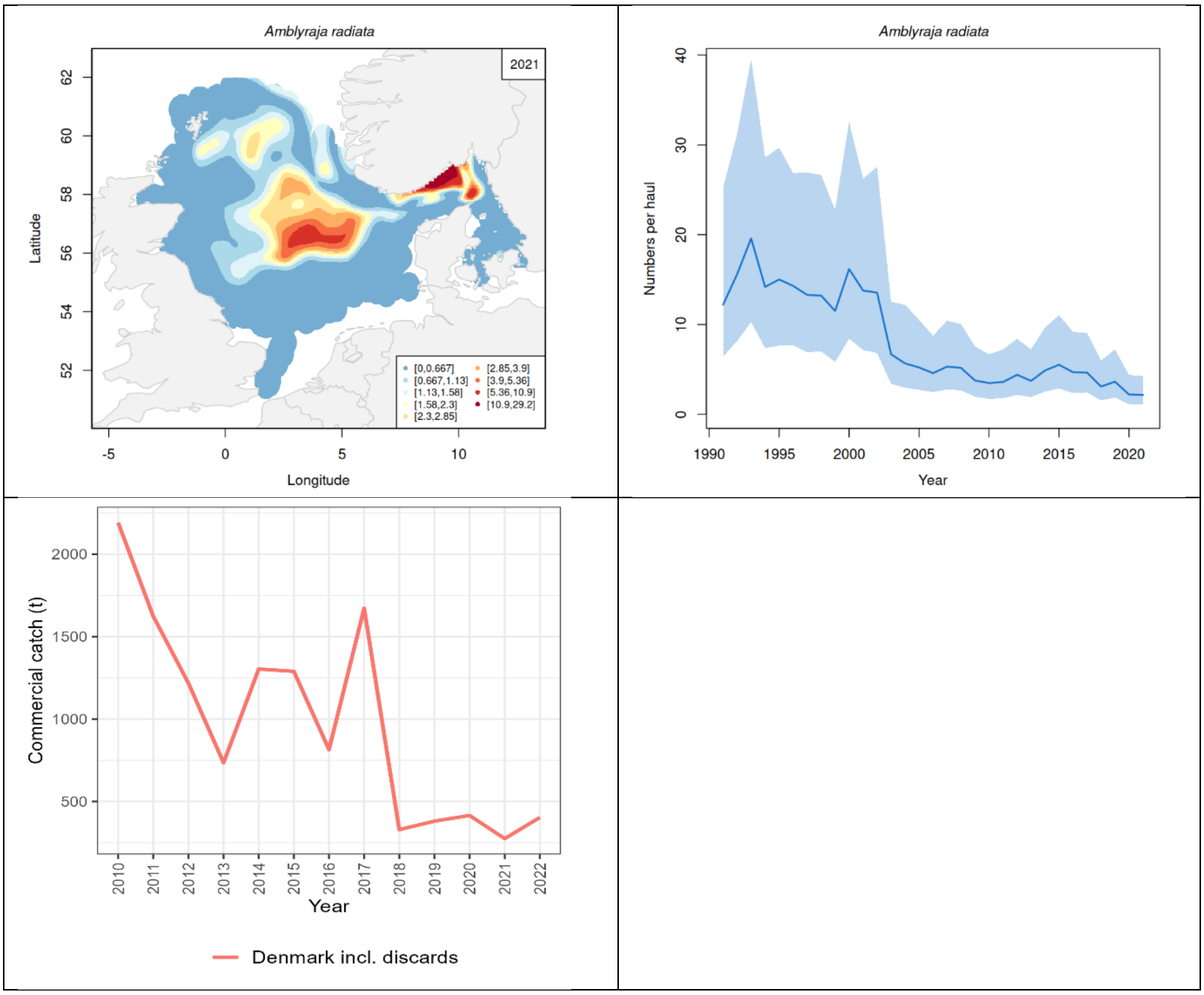

Figure 3.4. Starry ray. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers; Danish commercial catches (bottom right) within subareas 3 and 4;

3.5 Atlantic wolffish (*Anarhichas lupus*)

Atlantic wolffish has historically been found in the North Sea, Skagerrak and Kattegat all around Denmark. In later years, abundance has decreased severely but seems to have stabilized at a low level since 2005 (Figure 3.5). Catches of wolfish increased steadily from 1945 to 1992. Since then, catches have dropped significantly. The proxy for fishing mortality showed a general decline over the whole time series, Denmark has been responsible for on average 40 % of the landings in the most recent 10 years. Discards are less than 1% on average. ICES does not provide catch advice for wolffish.

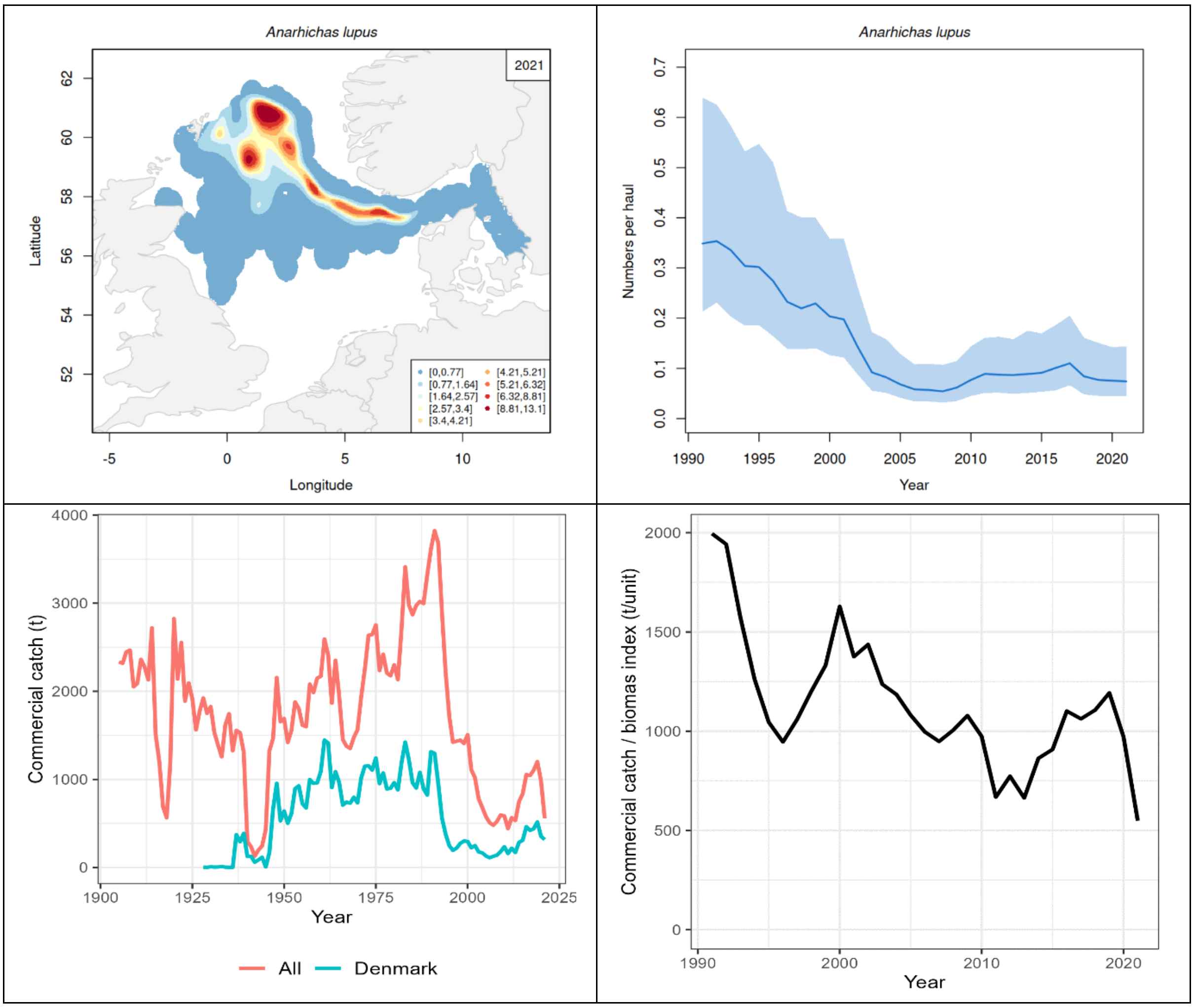

Figure 3.5. Atlantic wolffish. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.6 Anglerfish (*Lophius* spp)

The main species of anglerfish caught in the North Sea area is *Lophius piscatorius*, and a small amount (<-5%) belongs to the species *L. budegassa.* The two species are recorded together in landings. Anglerfish occurs in the deeper parts of the North Sea and Skagerrak and ICES consider that the stock area extends to the areas west of Scotland. Anglerfish landings from the North Sea area peaked in the 1990s followed by a steep decline and a small increase in the most recent years. Abundance in the trawl survey shows a general decline until 2010 followed by a small increase. Fishing mortality of anglerfish seems to have fluctuated without a significant trend. Discard of Anglerfish is negligible. ICES has advised on catch opportunities for anglerfish in the North Sea, Skagerrak and west of Scotland since 2014 and the catch advice for 2023-2024 was a 30% reduction compared with the previous ICES advice.

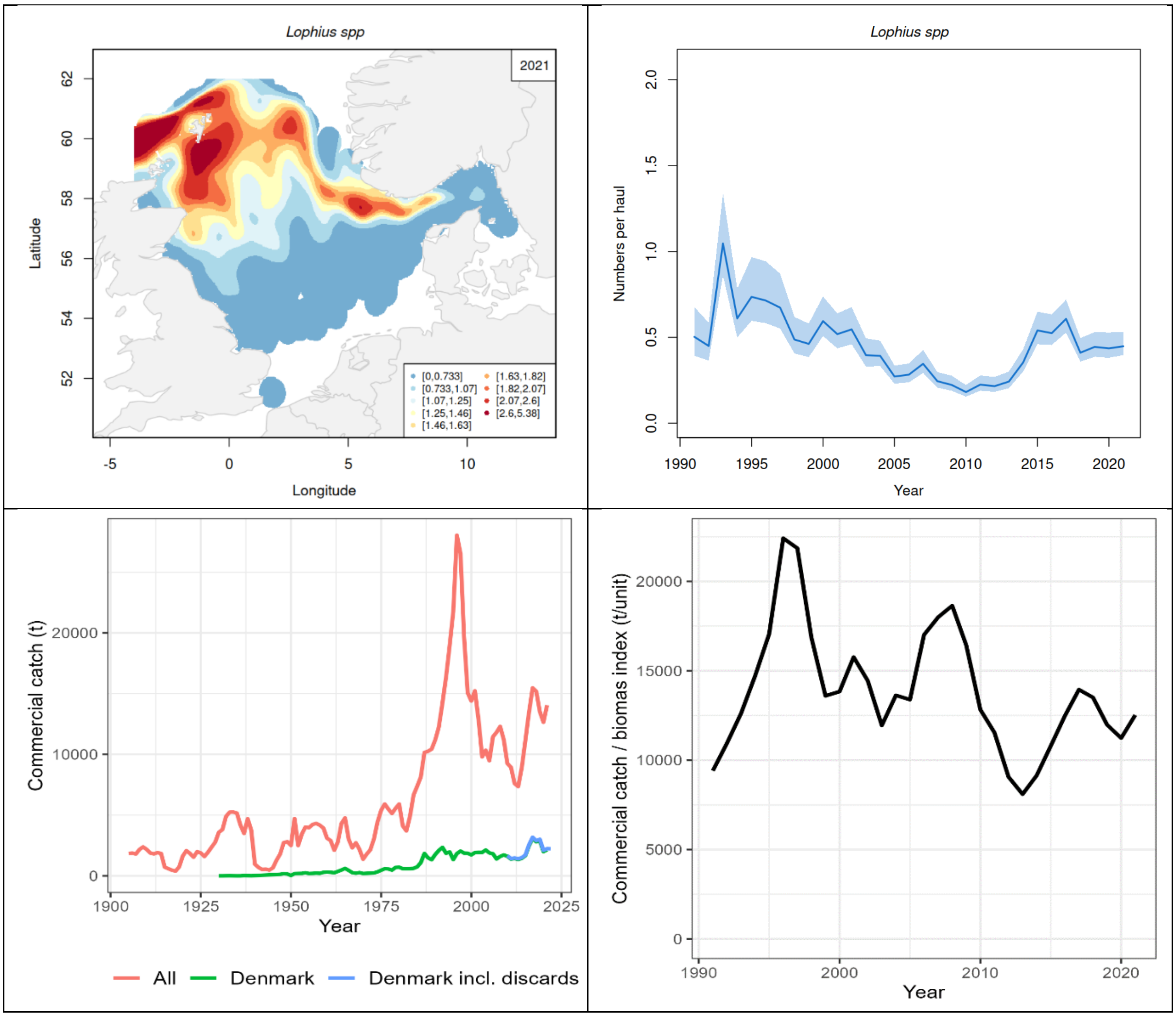

Figure 3.6. Anglerfish. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.7 Thornback ray (*Raja clavata*)

Thornback ray is found throughout the North Sea, though the densities are highest off the UK coast, especially in the Thames Estuary. In later years, abundance has increased, but the increase seems to be within historical bounds when using the longer time series (Figure 3.7). Historical information is considered unreliable before 2008 and uncertain for some countries, e.g. Denmark, after that period as well (Rindorf et al., 2023). 98% of Danish catches of this species reported on observer trips in the period from 2002-2016 were discarded (Rindorf et al. 2017). ICES has advised on catch limits at 5427 t for 2024 which is around twice the catches in the previous years, (also taking into account that the ICES stock of thornback ray includes the eastern English Channel which is not included in the catches in Figure 3.7). The proxy fishing mortalities estimated from the present data show a steep decrease, supporting an increasing stock.

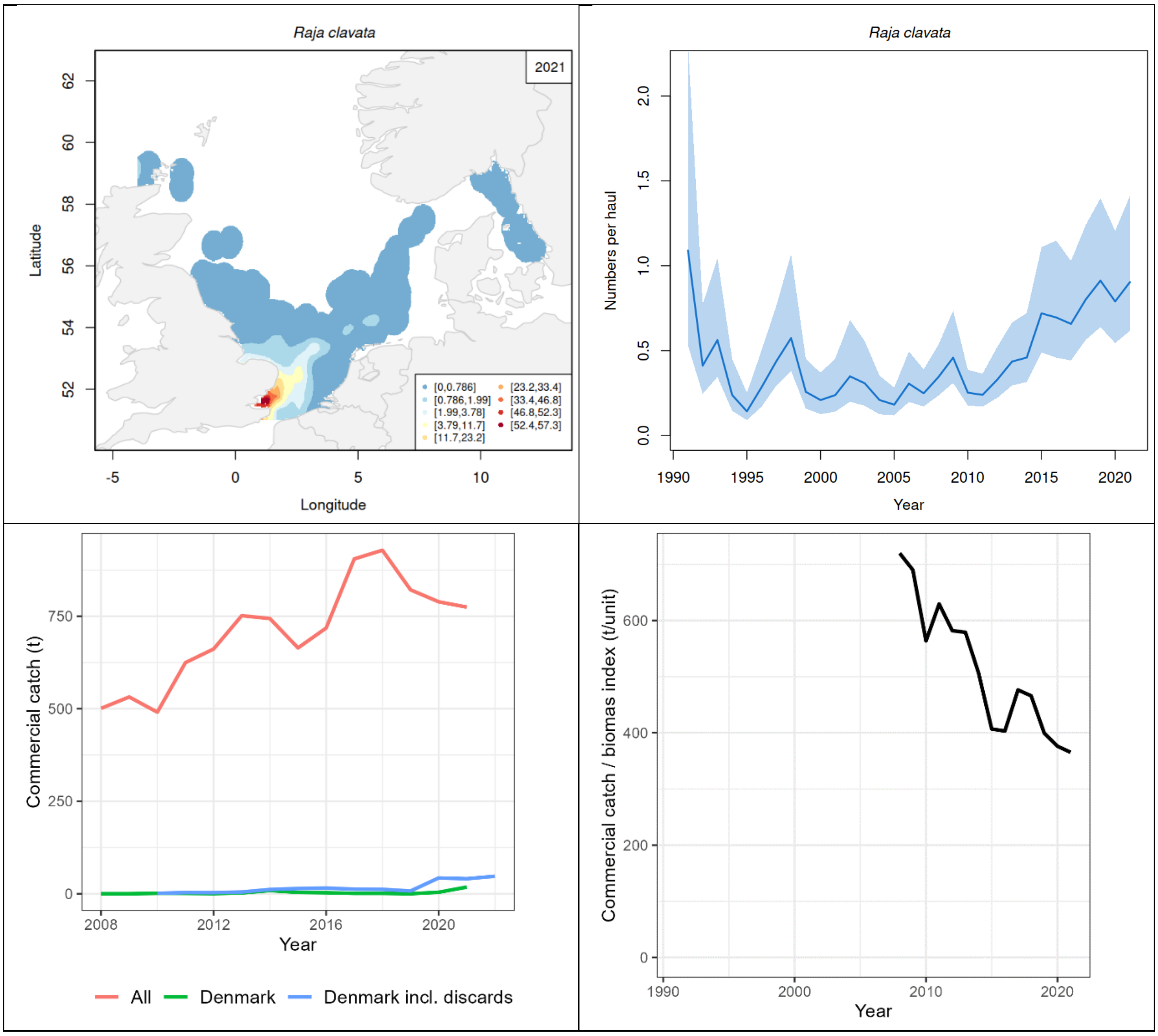

Figure 3.7. Thornback ray. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.8 Greater forkbeard (*Phycis blennoides*)

Greater forkbeard is found in the northern North Sea and along the Norwegian trench in Skagerrak, however, ICES considers the entire Northeast Atlantic as the stock area. Survey catches in the North Sea and Skagerrak show an increase in abundance (Figure 3.8), but as the stock's preferred depth is below the max depth (200-250 m) of the ICES surveys, the estimate is considered uncertain. Landings in subarea 3 and 4 since 2010 have been variable but without a trend. ICES estimate of landings in the entire stock area shows a similar picture of catches. Reported landings before 2010 were considerably lower, which might be due to the quality of the reporting. Most of the Danish catches since 2010 have been discarded, even though data show a decrease in discard in the most recent years. The proxy for fishing mortality shows a clear reduction, similar to the abundance index from surveys. ICES advice for greater forkbeard in the entire stock area in 2023 and 2024 was a 5% decrease compared to previous advice.

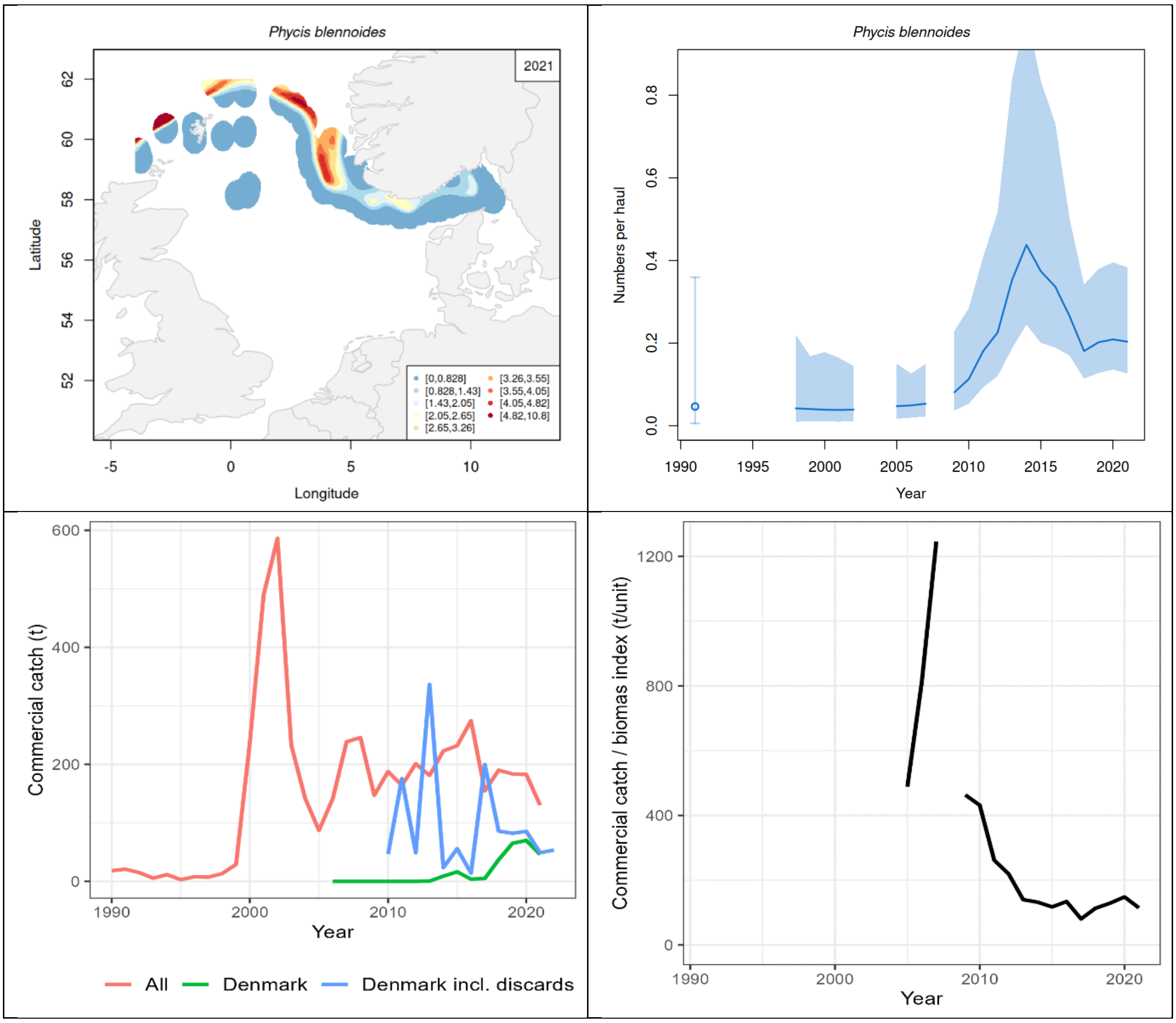

Figure 3.8. Greater forkbeard. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.9 Tope (*Galeorhinus galeus*)

Tope is found mainly in the southern and western parts of the North Sea. ICES considers that the stock is distributed throughout the Northeast Atlantic and does not provide an evaluation of the stock development. Judging from the survey catch rates in the North Sea, abundance has declined followed by a small increase since around year 2015 (Figure 3.9). Denmark lands around 25% of the tope from the North Sea and landings of tope have decreased since the mid 1990's. Catch data exist before 1990 but is considered unreliable. ICES uses catches since 2005 for the entire stock area, which show a consistence total decline in catches of around 33% over the period 2005-2022s. The ICES advice for 2024-2027 is a 20% reduction in catches compared to the previous advice.

Figure 3.9. Tope. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.10 Rabbit fish (*Chimaera monstrosa*)

Rabbit fish is a deep sea species and in the North Sea, rabbitfish occurs exclusively along the Norwegian trench. Abundance seems to have fluctuated without a trend for the stock from 1991 to around 2010 onwards followed by an increase in recent years. Landings have increased since the period 2000-2020 followed by a steep decrease in 2021. Danish landings are small, 0-3 t/year for the recent 10 years. Estimates of Danish discard (not shown) are uncertain but estimated in the range of 6-130 t/year for the recent 10 years. The index of fishing mortality shows an increase, but is considered uncertain as it is based on landings only, and a rather uncertain abundance index. ICES does not advise on stock status or catch opportunities for this species.

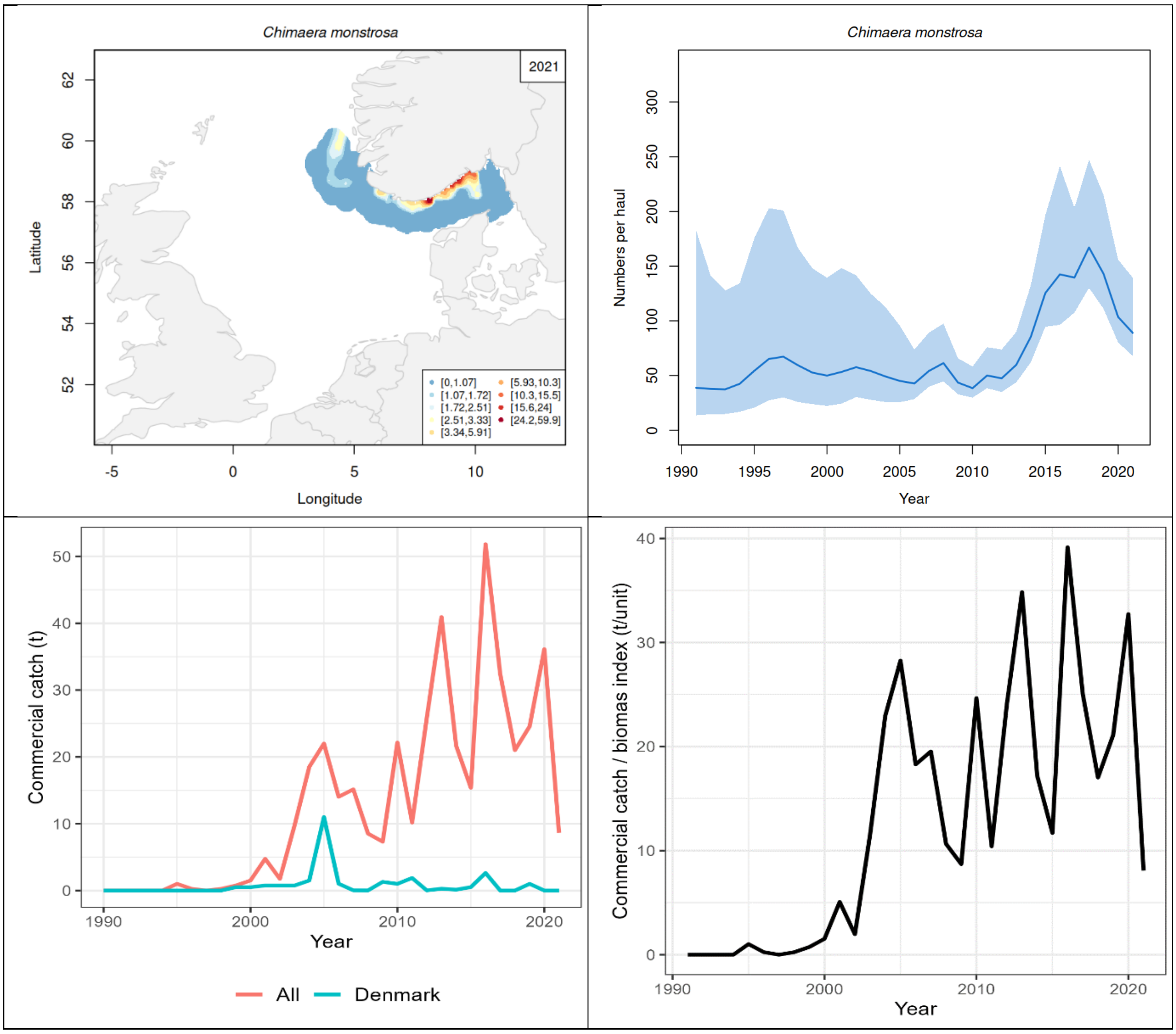

Figure 3.10. Rabbit fish. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.11 Spotted ray (*Raja montagui*)

Spotted ray occurs mainly in the southern and north-western North Sea. The stock size has increased substantially in the last twenty years, judged by the abundance index (Figure 3.11). As part of a so-called ICES "Benchmark" in 2023, landings for 1999–2008 were reconstructed based on the average proportion of spotted ray in total Rajidae landings 2009–2011 and discards were estimated from various sources. This dataset shows annual catches (landings plus discards) in the range 531-901 t, without a clear temporal trend. Given such catches and an increasing abundance index, the proxy for fishing mortality would show a significant decrease, as also found by ICES. Historical Danish catches of spotted ray are uncertain (Rindorf et al., 2023), but are considered low. Reported landings of 8 t in 2021 indicate the level of Danish catches. With the "benchmark" in 2023, ICES estimates a fishing mortality clearly below F_{MSY} and a biomass clearly above B_{MSY}. ICES advised a (maximum) catch increase of 525% compared to the previous advice.

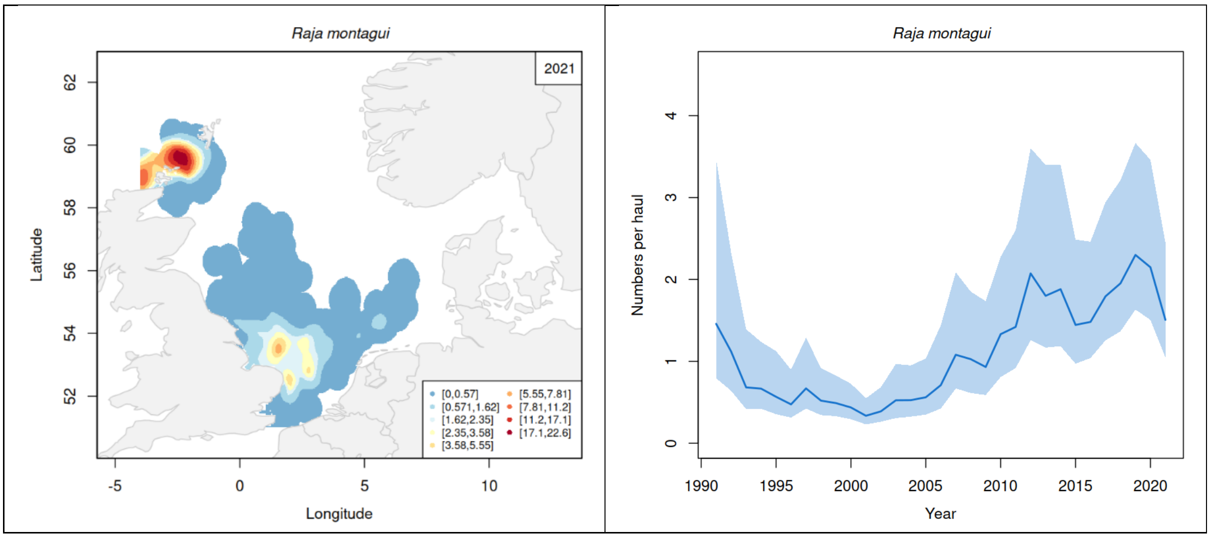

Figure 3.11. Spotted ray. Spatial distribution (left) and abundance index (right) estimated from survey catches in numbers.

3.12 Starry smooth-hound and smooth-hound (*Mustelus* spp)

Smooth-hounds, primarily the starry smooth-hound (*Mustelus asterias*), occur mainly in the western North Sea but are occasionally seen in Skagerrak and off the Danish coast (Figure 3.12). ICES considers smooth-hounds in the entire northeast Atlantic as one stock. In later years, the stock size has increased substantially, both judged from the abundance index for the North Sea and from the ICES abundance index covering a larger area. The landings statistics for the North Sea area show a steep increase but are considered uncertain. ICES estimate of landings for the entire stock area, 2005-2022, is between 3000-4000 t/year without a trend. Danish reported landings are small, less than 1 t/y reported per year, while discards are estimated between 0 and 39 t/y for the most recent 10 years, although highly uncertain. The proxy fishing mortality in Figure 3.12 is considered biased as it just includes the North Sea area. The ICES catch advice for 2024 is 116 % higher than the previous advice.

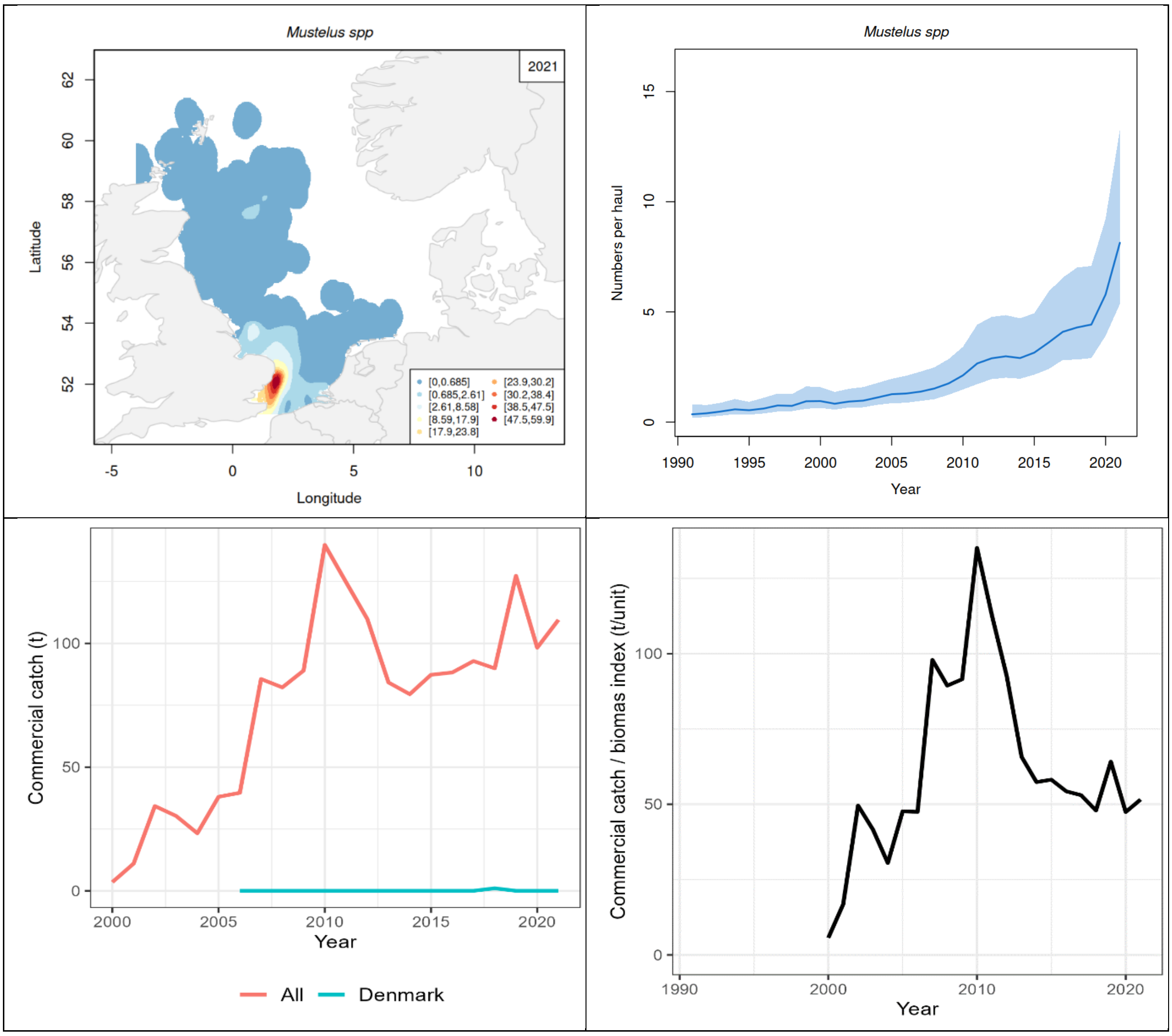

Figure 3.12. Smooth-hounds. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.13 Roundnose grenadier (*Coryphaenoides rupestris*)

Roundnose grenadier is a slow-growing deep-sea species. The species is rarely caught in ICES surveys, as these surveys do not extend to depths greater than 200m but data from the Norwegian shrimp survey covers these deeper water depths. Denmark has taken more than 95% of the historical catches of this species in the North Sea. Up to 2006, there was a targeted Danish fishery for the species. Danish landings in the recent 10 years have been less than 1.1 t/year. Discard estimates are uncertain but estimated in the range of 0-3 t/year. ICES considers the stock as depleted and has advised a zero catch since 2015.

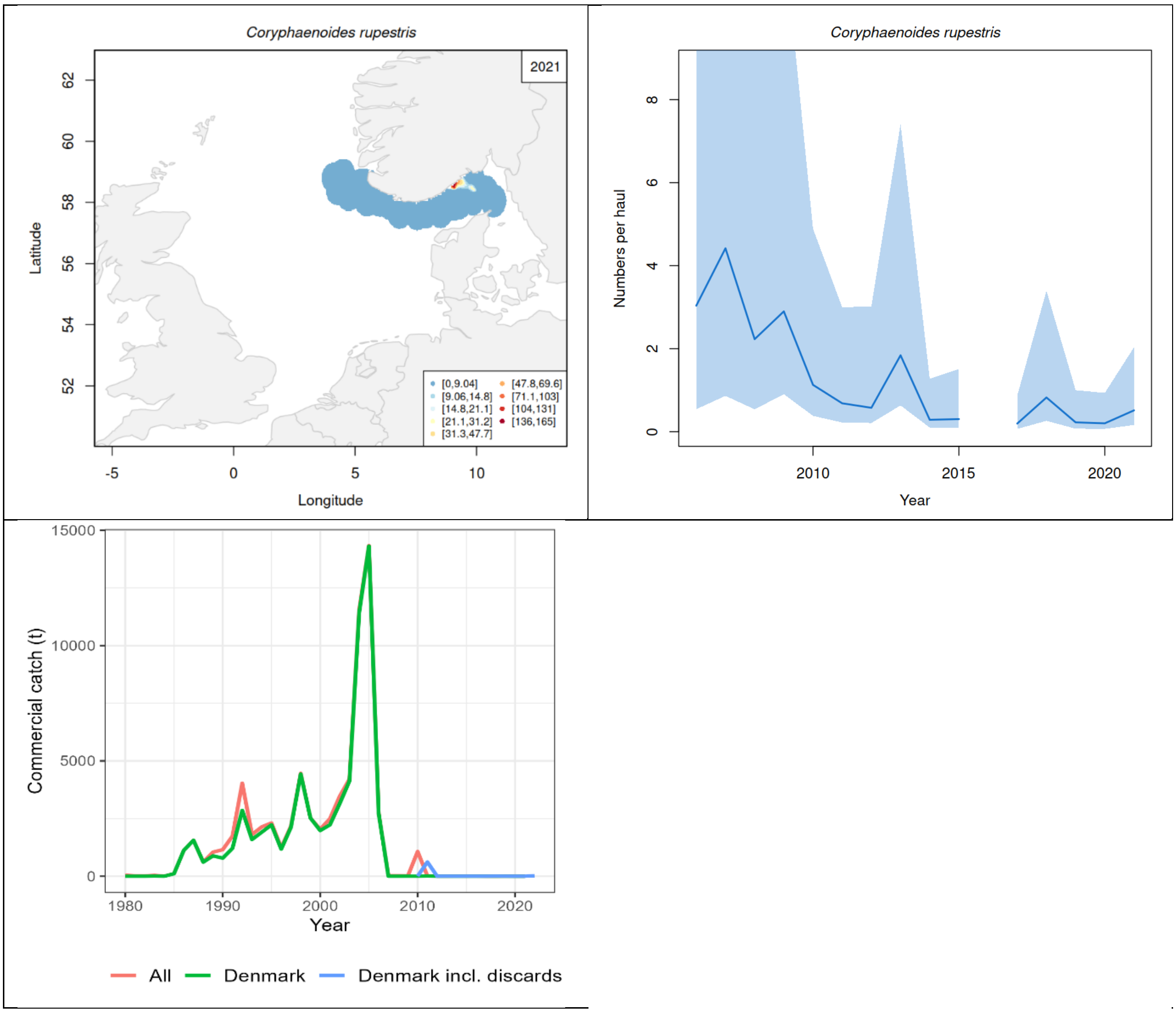

Figure 3.13. Roundnose grenadier. Spatial distribution (top left) and abundance index (top right) estimated from survey catches in numbers.; commercial catches (bottom left) within subareas 3 and 4 from all countries combined and from Denmark, with and without discards; and fishing mortality proxy, catch divided by biomass index normalized to an average of 1 (bottom right).

3.14 Other species

Sandy ray, Greenland shark, Nursehound and common stingray

No reliable information is available on catches of these species. 100% of Danish catches of sandy ray and nursehound reported on observer trips from 2002-2016 were discarded.

3.15 Baltic species under the habitats directive

European whitefish (*Coregonus maraena*) and Baltic sturgeon (*Acipenser oxyrhynchus*)

In the period from 2002 to 2016, there are no observed Danish landings or discards of Baltic sturgeon and observed catches of Coregonus spp in the Baltic sea ranged from 0 to 305 kg with a mean of 57 kg per year.

Twaite shad (*Alosa fallax*) and Allis shad (*Alosa alosa*)

Russia and Lithuania reported landings of Alosa spp in 2002 to 2010. All catches were taken in the eastern part of the Baltic Sea (outside Danish waters). Observed Danish catches in the Baltic Sea ranged from 0 to 1167 kg with a mean of 356 kg. On average, 68% of the catch was discarded, but this fraction was highly variable from year to year (ranging from 0-100%).

River lamprey (*Lampetra fluviatilis*) and Sea lamprey (*Petromyzon marinus*)

There are no reported or observed Danish landings and discard of these species in the period from 2003 to 2016 in the Baltic Sea. Estonia, Lithuania, Latvia and Russia reported small catches of River lamprey in 2009, 2011 and 2015.

3.16 Joint evaluation

For each species, the presence of trends in abundance was assessed as the Pearson correlation coefficient between year and abundance index from trawl surveys based on number. Periods of ten years were used for detecting trends, i.e. trends within the period 2003-2012 and 2013-2022. For comparison with the results presented in the 2017 report, trends were also calculated for the periods 1997-2006 and 2007-2016. Appendix 1 presents the trends and the results are summarized in Table 3.1.

Of the species where abundance indices are available, 9 out of 13 showed increasing trends in the past 10 years, and four of these (Atlantic halibut, thornback ray, tope and smoothhound) increased significantly at the 5% level while two showed significant decline (starry ray and greater forkbeard) (table 3.1). In the previous 10 year period, 7 out of 13 showed increasing trends, and four of these increased significantly while four showed significant decline (starry ray and greater forkbeard) (table 3.1). Hence, there has been no change in the number of species showing a significant increasing trend (4 out of 13, corresponding to 31%).

With the exception of the two *Alosa* species for which abundance was not assessed here, none of the species listed here have a substantial part of their distribution in the Baltic Sea and hence all evaluations pertain to the North Sea.

In conclusion, the development in species abundance was more positive in the final period than historically, but the results are highly uncertain for some species (especially roundnose grenadier).

3.17 Management considerations

As recommended by ICES, targeted catches of common skate should be zero catch and bycatch should be minimized. For several of the species, there is no scientific advice on catch rates. In most cases, this is caused by a lack of reliable catch data, but for Atlantic halibut and wolfish, commercial catches and survey catch rates are both available and there does not appear to be a reason not to provide catch advice on these species. However, ICES advice is given on request from the clients (e.g. EU Commission) and member states and hence a request from EU or a member state is required to attain catch advice also for sensitive species without current advice.

Table 3.1. Overview of identified sensitive species, whether and how ICES has evaluated stock development and the number of survey hauls containing the species. Numbers in italics denote species/area combinations where the number of hauls catching the species is insufficient to allow the estimation of temporal development in abundance. Green: significant increase, yellow: non-significant increase, orange: non-significant decrease, red: significant decrease.

Species	Danish name	Scientific name	Habitat	ICES evaluation	Trend, abundance index 1997-2006	Trend, abundance index 2007-2016	Trend, abundance index 2003-2012	Trend, abundance index 2013-2022
Common skate	Skade	*Dipturus batis*[1]	Demersal	Depleted[a*]	-0.72 (0.043)	0.95 (0.001)	0.86 (0.003)	0.36 (0.34)
Atlantic halibut	Helleflynder	*Hippoglossus hippoglossus*	Demersal	No evaluation	0.86 (0.001)	-0.77 (0.001)	-0.58 (0.076)	0.77 **(0.015)**
Ling	Lange	*Molva molva*	Demersal	Increasing[b]	-0.26 (0.47)	0.98 (0.001)	0.25 (0.49)	-0.36 (0.34)
Sandy ray	Sandrokke	*Leucoraja circularis*	Demersal	Biomass unknown[c*]				
Starry ray	Tærbe	*Amblyraja radiata*	Demersal	Decreasing[d*]	-0.81 (0.004)	0.09 (0.80)	-0.83 (0.003)	-0.75 (0.019)
Atlantic wolffish	Havkat	*Anarhichas lupus*	Demersal	No evaluation	-0.96 (0.0001)	0.93 (0.001)	0.07 (0.84)	0.51 (0.16)
Greenland shark	Grønlandshaj	*Somniosus microcephalus*	Deep sea, DK waters at the edge of distribution	Biomass unknown[e*]				
Roundnose grenadier	Skolæst	*Coryphaenoides rupestris*	Deep sea, DK waters	Stock size is below MSY $B_{trigger}$ [f*]		-0.82 (0.007)	-0.86 0.012	-0.48 (0.23)
Anglerfish	Havtaske og sort havtaske	*Lophius piscatorius and Lophius budegassa*	Demersal	Stock-size index is above MSY $B_{trigger}$ [g*]	-0.84 (0.002)	0.64 (0.047)	-0.85 (0.002)	0.32 (0.40)

Species	Danish name	Scientific name	Habitat	ICES evaluation	Trend, abundance index 1997-2006	Trend, abundance index 2007-2016	Trend, abundance index 2003-2012	Trend, abundance index 2013-2022
Thornback ray	Sømrokke	*Raja clavata*	Demersal	Spawning-stock biomass is above MSY $B_{trigger}$ [h*]	-0.57 (0.085)	0.77 (0.009)	0.30 (0.4)	0.89 (0.001)
Nursehound	Storplettet rødhaj	*Scyliorhinus stellaris*	Demersal	No evaluation				
Greater forkbeard	Skælbrosme	*Phycis blennoides*	Deep sea, DK waters	Biomass unknown[j*]	0.77 (0.043)	0.91 (0.001)	0.92 (0.003)	-0.88 (0.002)
Tope	Gråhaj	*Galeorhinus galeus*	Demersal	Biomass unknow [k*]	-0.91 (0.001)	-0.04 (0.91)	-0.91 (0.001)	0.99 (0.001)
Rabbit fish	Havmus	*Chimaera monstrosa*	Deep sea, DK waters	Biomass unknown	-0.83 (0.003)	0.77 (0.009)	-0.21 (0.55)	0.30 (0.43)
Spotted ray	Storplettet rokke	*Raja montagui*	Demersal	Spawning-stock biomass is above MSY $B_{trigger}$ [l*]	0.18 (0.61)	0.64 (0.044)	0.92 (0.001)	0.28 (0.47)
Starry smoothhound and smoothhound	Stjernehaj og glathaj	*Mustelus spp* [2]	Demersal	Increasing[m*]	0.91 (0.001)	0.97 (0.0001)	0.95 (0.001)	0.89 (0.002)
Common stingray	Pigrokke	*Dasyatis pastinaca*	Pelagic	No evaluation				

[1]*Dipturus batis* is not reliably separated from *D. lineus, D. intermedia* and *D. flossada* in trawl surveys, hence catches of the species are combined.
[2]*Mustellus asterias and M. mustellus* are not reliably separated, hence catches of the two species are combined.
[*]Total catch unknown.

3.18 References

Casper W. Berg, Anders Nielsen and Kasper Kristensen. 2013. Evaluation of alternative age-based methods for estimating relative abundance from survey data in relation to assessment models, Fisheries Research 151 (2014) 91–99. https://doi.org/10.1016/j.fishres.2013.10.005

European Commission. 2022. MSFD CIS Guidance Document No. 19, Article 8 MSFD, May 2022.

Gislason, H., Rindorf, A., Håkansson, K. and Vinther, M. 2017. Abundance and catch of sensitive non-commercial species in Danish waters.

HELCOM. 2018. Abundance of key coastal fish species, HELCOM core indicator report. July 2018.

ICES. 2021. Workshop on the production of abundance estimates for sensitive species (WKABSENS). ICES Scientific Reports. 3:96. 128 pp. https://doi.org/10.17895/ices.pub.8299

[a]ICES. 2023a. Common skate complex (Blue skate (*Dipturus batis*) and flapper skate (*Dipturus intermedius*) in Subarea 4 and Division 3.a (North Sea, Skagerrak and Kattegat). *In* Report of the ICES Advisory Committee, 2023. ICES Advice 2023, rjb.27.3a4. https://doi.org/10.17895/ices.advice.21856872

[b]ICES. 2023. Ling (*Molva molva*) in subareas 3, 4, 6–9, 12, and 14 (Northeast Atlantic and Arctic Ocean). *In* Report of the ICES Advisory Committee, 2023. ICES Advice 2023, lin.27.346-91214. https://doi.org/10.17895/ices.advice.21828360

[c]ICES. 2023. Rays and skates (Rajidae) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel). In Report of the ICES Advisory Committee, 2023, raj.27.3a47d. https://doi.org/10.17895/ices.advice.21856839.

[d]ICES. 2023. Starry ray (*Amblyraja radiata*) in subareas 2 and 4, and Division 3.a (Norwegian Sea, North Sea, Skagerrak and Kattegat). In Report of the ICES Advisory Committee, 2023. ICES Advice 2023, rjr.27.23a4, https://doi.org/10.17895/ices.advice.21857001.

[e]ICES 2017. Report of the working group on elasmobranch. ICES CM 2017/ACOM:16. http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2017/WGEF/26%20WGEF%20Report%20-%20Section%2024%20Greenland%20shark%20Somniosus%20microcephalus%20in%20the%20Northeast%20Atlantic.pdf

[f]ICES. 2022. Roundnose grenadier (*Coryphaenoides rupestris*) in Division 3.a (Skagerrak and Kattegat). In Report of the ICES Advisory Committee, 2022. ICES Advice 2022, rng.27.3a. https://doi.org/10.17895/ices.advice.19453703

[g]ICES. 2022. Anglerfish (*Lophius budegassa*, *Lophius piscatorius*) in Subareas 4 and 6, and Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat). *In* Report of the

ICES Advisory Committee, 2022. ICES Advice 2022, anf.27.3a46. https://doi.org/10.17895/ices.advice.19772359

[h]ICES. 2023. Thornback ray (Raja clavata) in Subarea 4 and in divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and the eastern English Channel). In Report of the ICES Advisory Committee, 2023. ICES Advice 2023, rjc.27.3a47d. https://doi.org/10.17895/ices.advice.21856875.

[j]ICES. 2022. Greater forkbeard (*Phycis blennoides*) in subareas 1–10, 12, and 14 (the Northeast Atlantic and adjacent waters). In Report of the ICES Advisory Committee, 2022. ICES Advice 2022, gfb.27.nea. https://doi.org/10.17895/ices.advice.19447910.

[k]ICES. 2023. Tope (*Galeorhinus galeus*) in subareas 1-10, 12 and 14 (the Northeast Atlantic and adjacent waters). In Report of the ICES Advisory Committee, 2023. ICES Advice 2023, gag.27.nea.
https://doi.org/10.17895/ices.advice.21856626.

[l]ICES. 2023. Spotted ray (*Raja montagui*) in Subarea 4 and Divisions 3.a and 7.d (North Sea, Skagerrak, Kattegat, and eastern English Channel). In Report of the ICES Advisory Committee, 2023. ICES Advice 2023, rjm.27.3a47d. https://doi.org/10.17895/ices.advice.21856905.

[m]ICES. 2023. Smooth-hound (Mustelus spp.) in subareas 1–10, 12, and 14 (Northeast Atlantic and adjacent waters). In Report of the ICES Advisory Committee, 2023. ICES Advice 2023, sdv.27.nea. https://doi.org/10.17895/ices.advice.21857163.

Rindorf A, Gislason H, Burns F, Ellis JR, Reid D. 2020. Are fish sensitive to trawling recovering in the Northeast Atlantic? J Appl Ecol. 2020;57:1936–1947. https://doi.org/10.1111/1365-2664.13693

Rindorf, A, EH Nielsen, LM Wulf Jacobsen, M Storr-Paulsen, M Vinther, K Håkansson and T Mildenberger 2023. DNA based monitoring of sharks, skates and rays, and risk-based evaluation of by-catch in Danish fisheries. DTU Aqua Report no. 429-2023

Appendix 1: Density maps for 1991, 2006 and 2021 based on survey catches

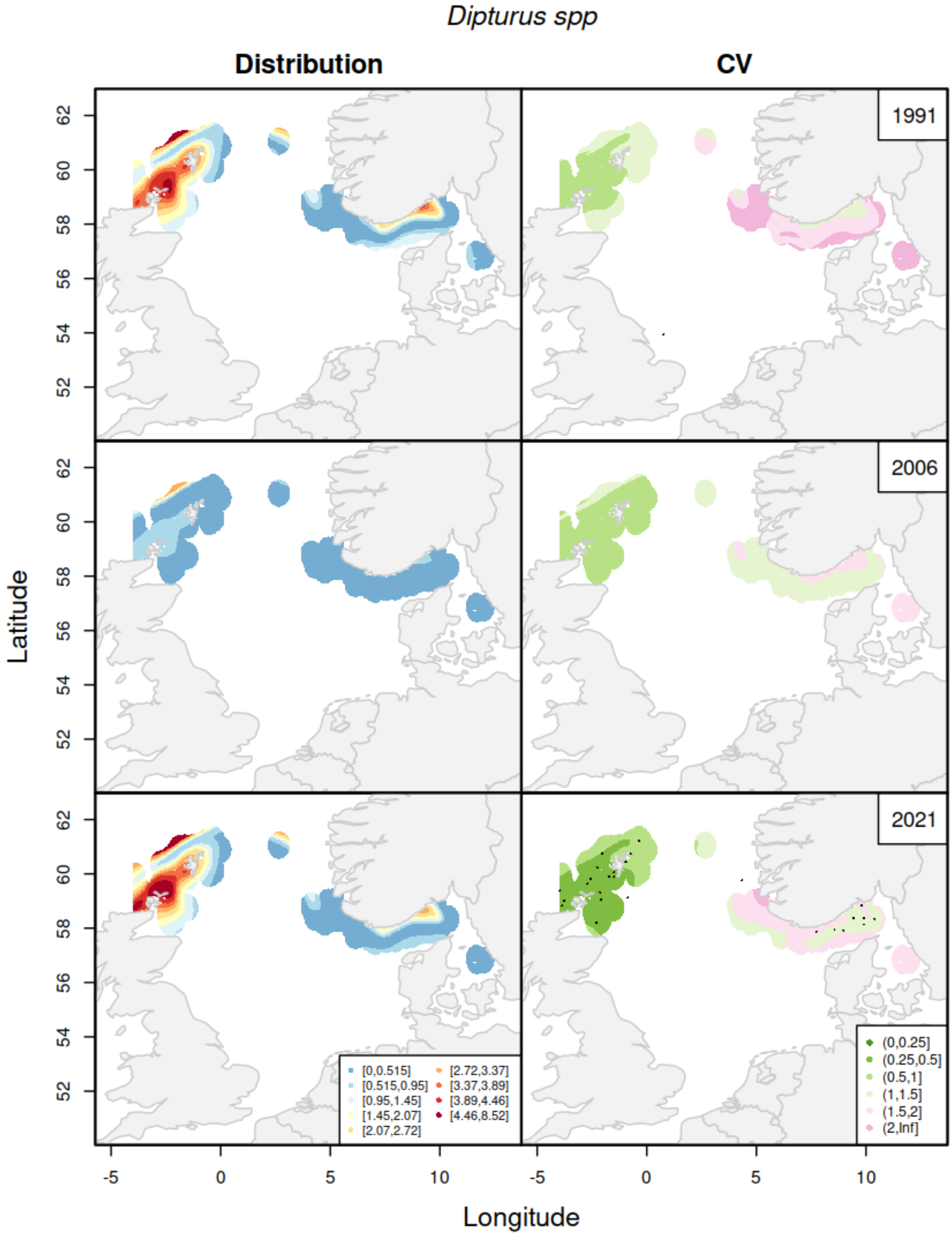

Figure 4.1. Common skate complex. Spatial distribution based on survey catches in biomass (kg).

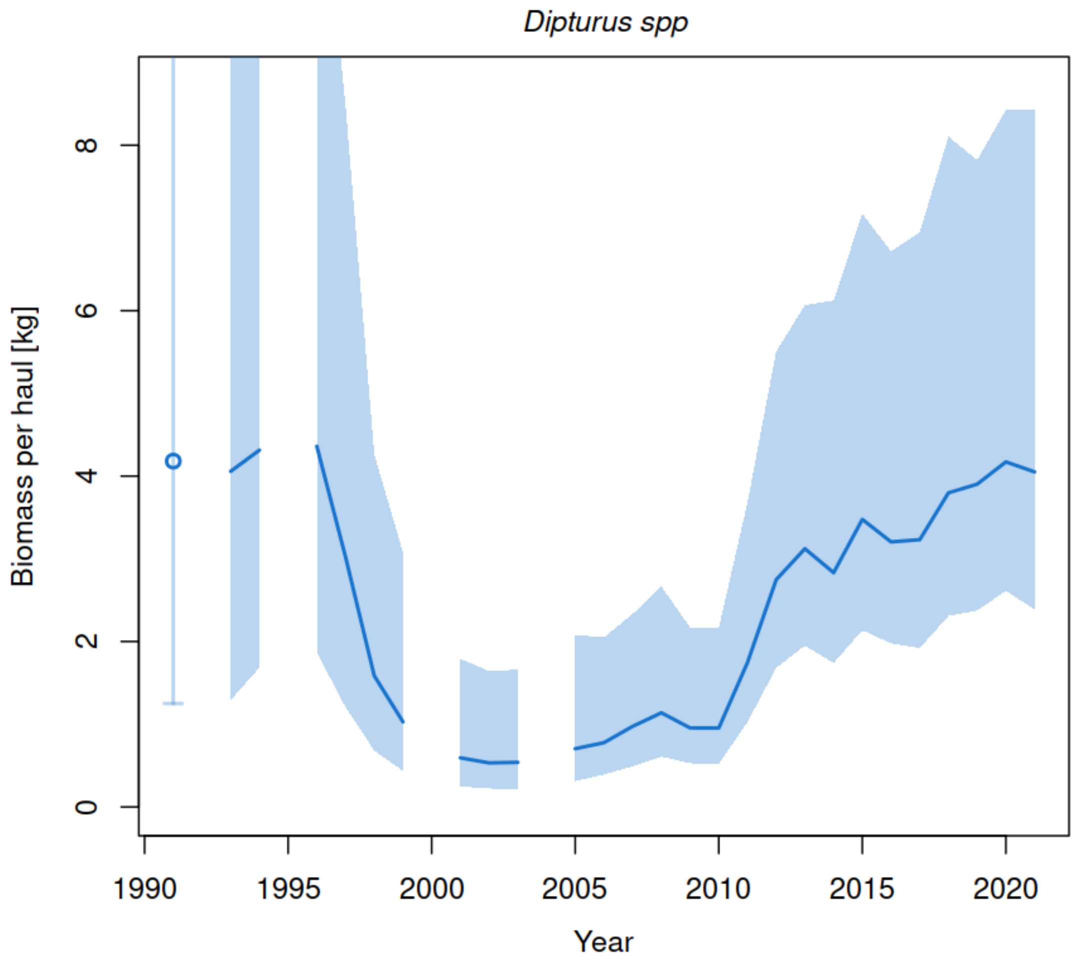

Figure 4.2. Common skate complex. Abundance index based on survey catches measured in biomass.

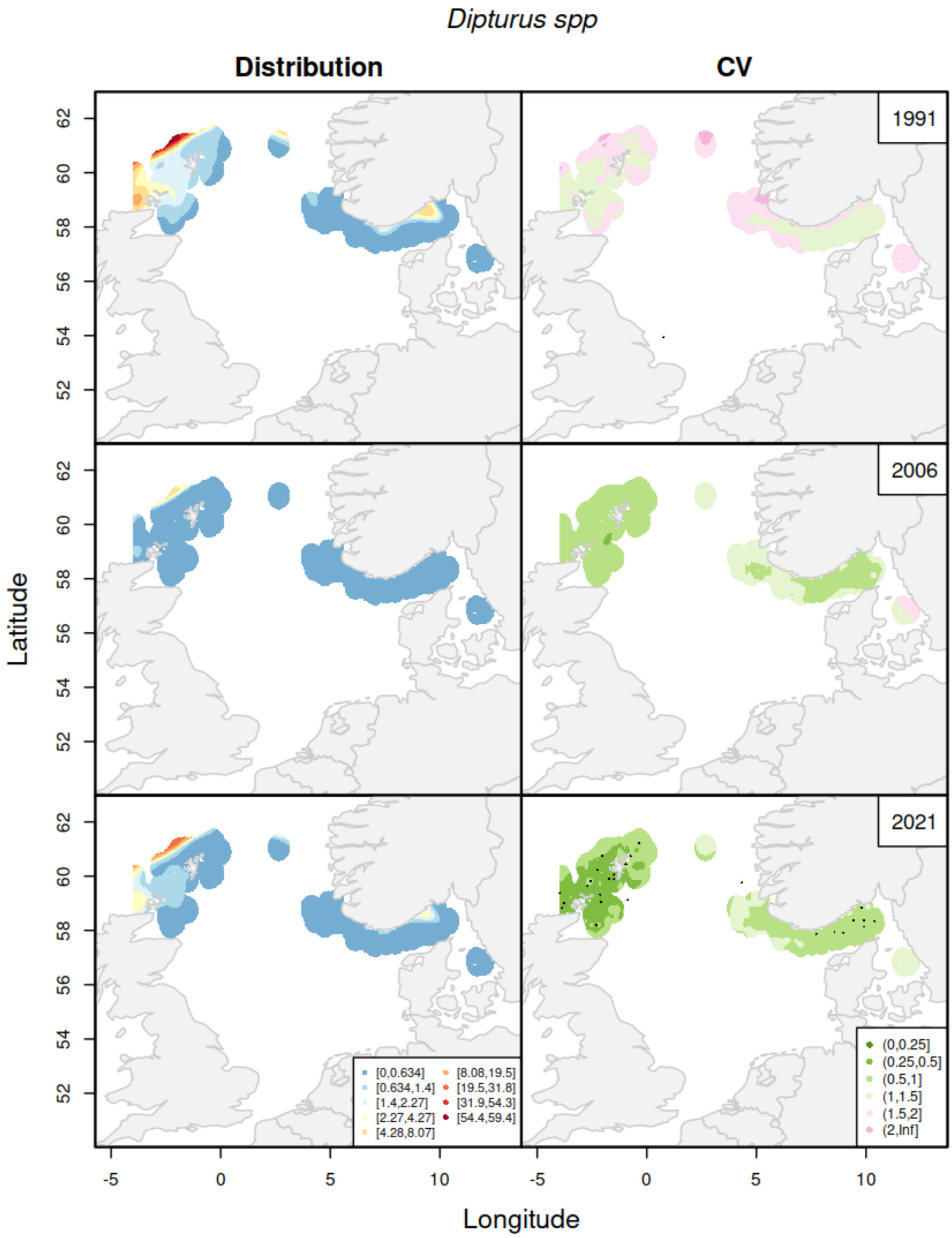

Figure 4.3. Common skate complex. Spatial distribution based on survey catches in numbers.

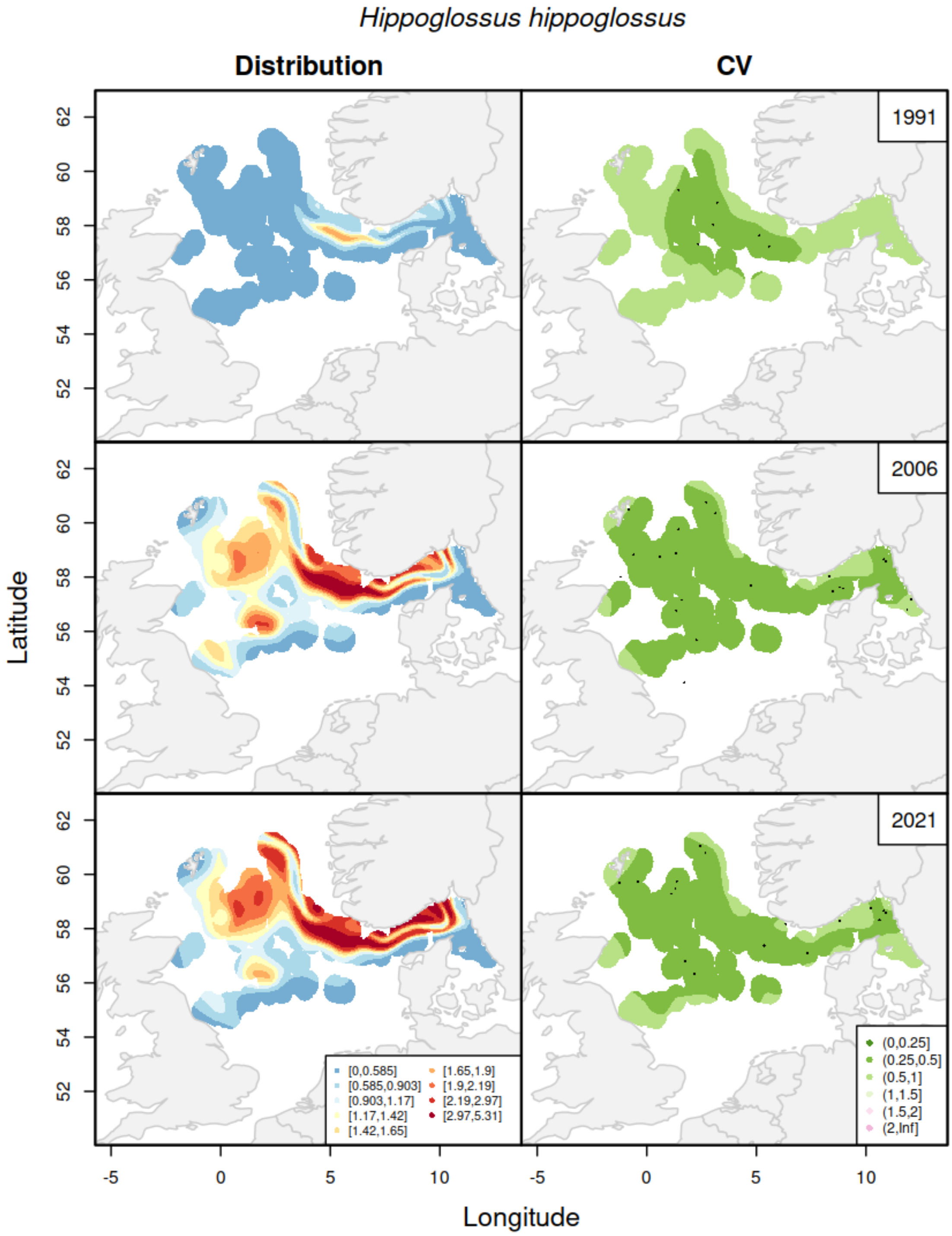

Figure 4.4. Atlantic halibut. Spatial distribution based on survey catches in biomass (kg).

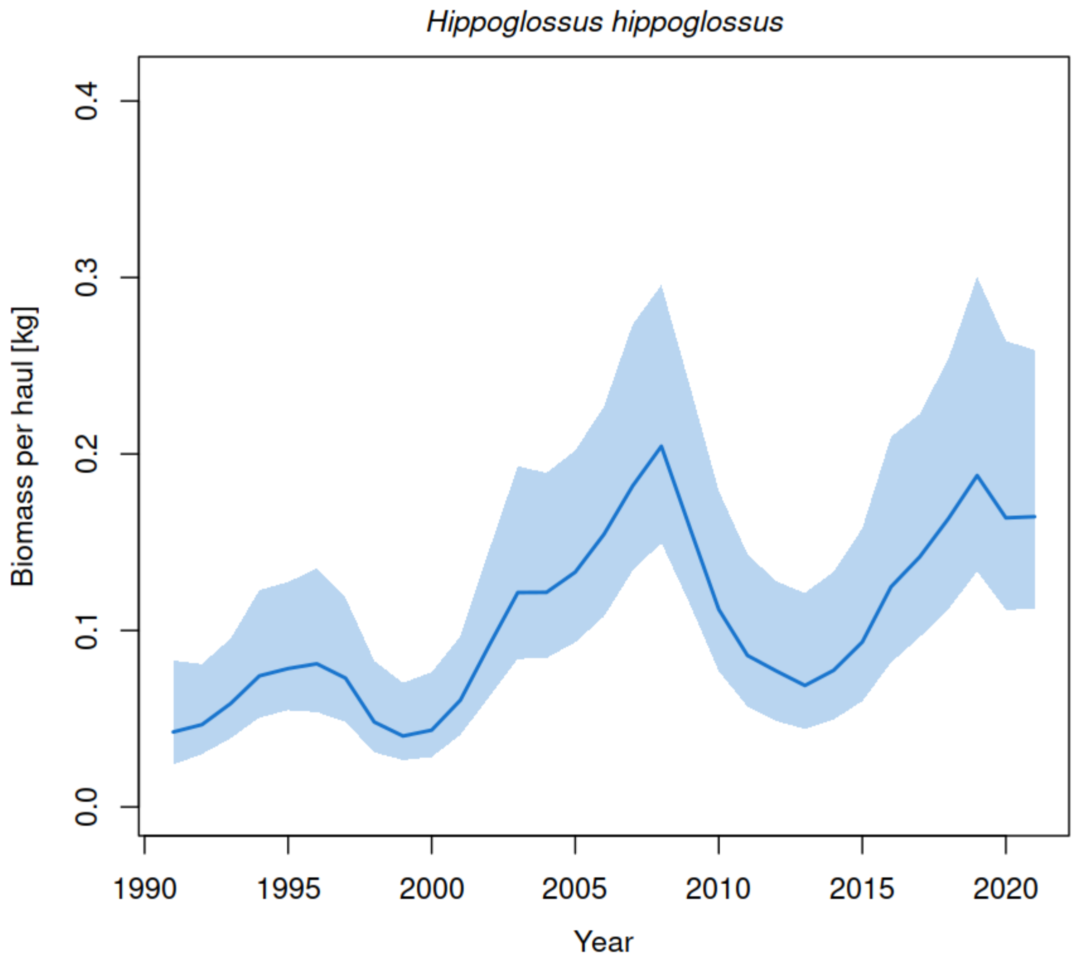

Figure 4.5. Atlantic halibut. Abundance index based on survey catches measured in biomass.

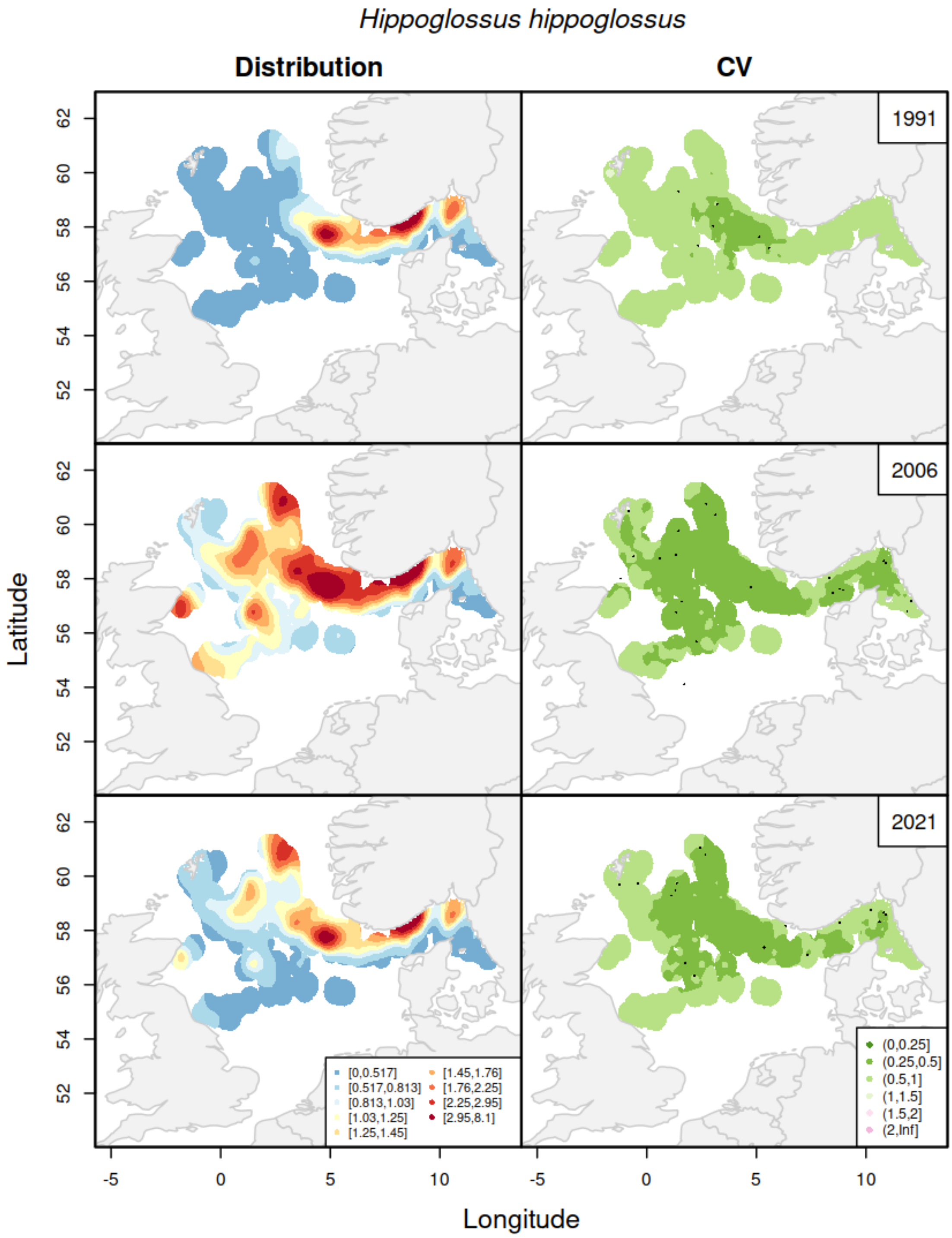

Figure 4.6. Atlantic halibut. Spatial distribution based on survey catches in numbers.

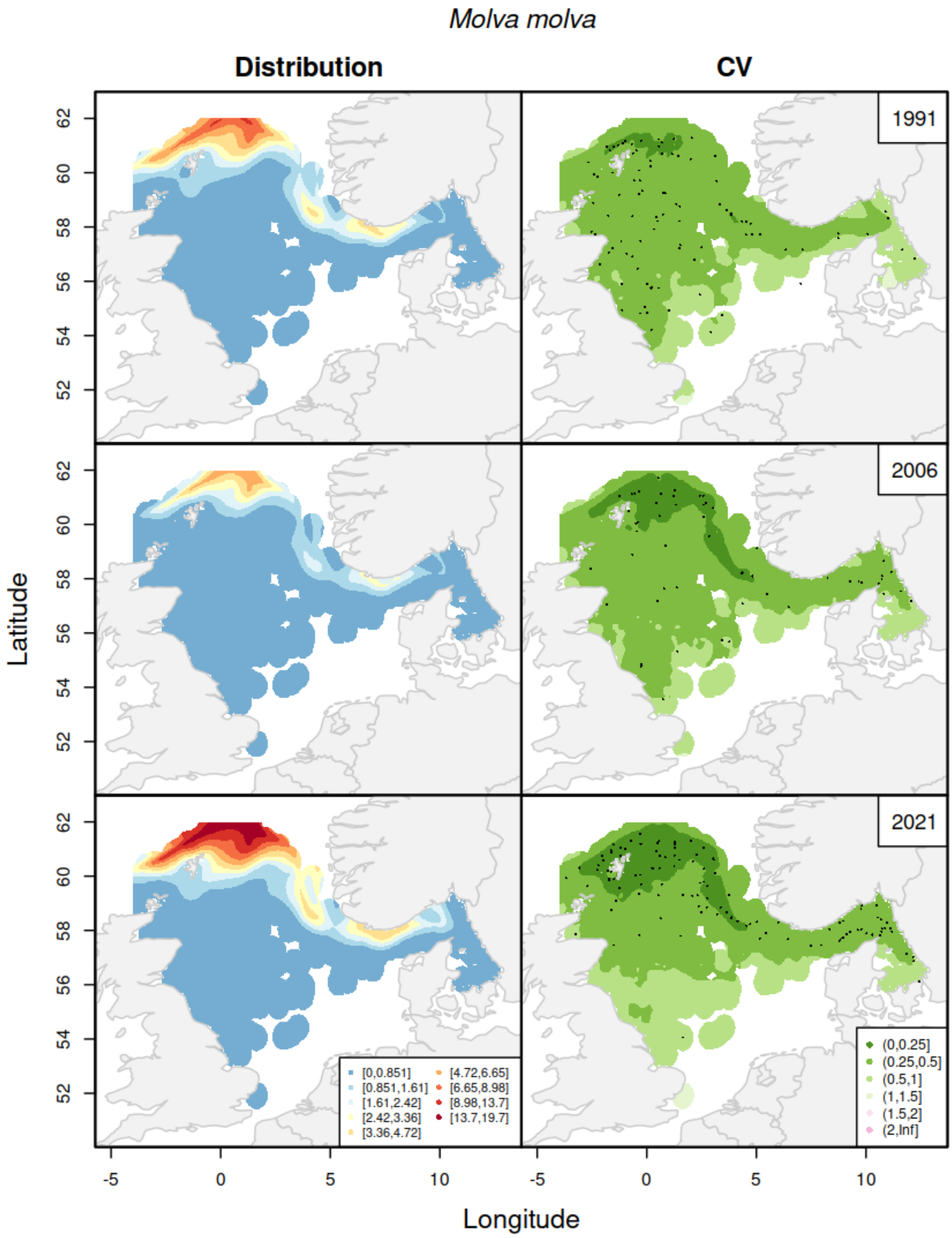

Figure 4.7. Ling. Spatial distribution based on survey catches in biomass (kg).

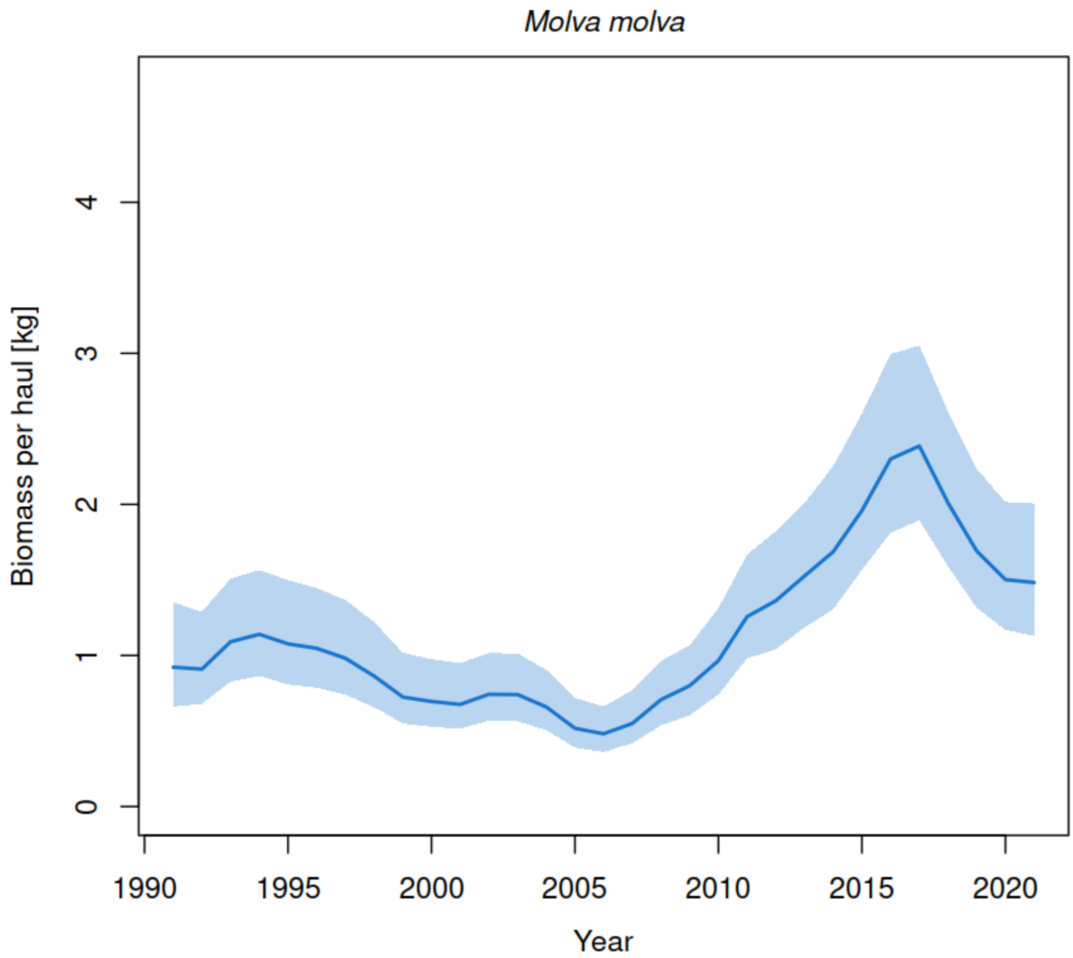

Figure 4.8. Ling. Abundance index based on survey catches measured in biomass.

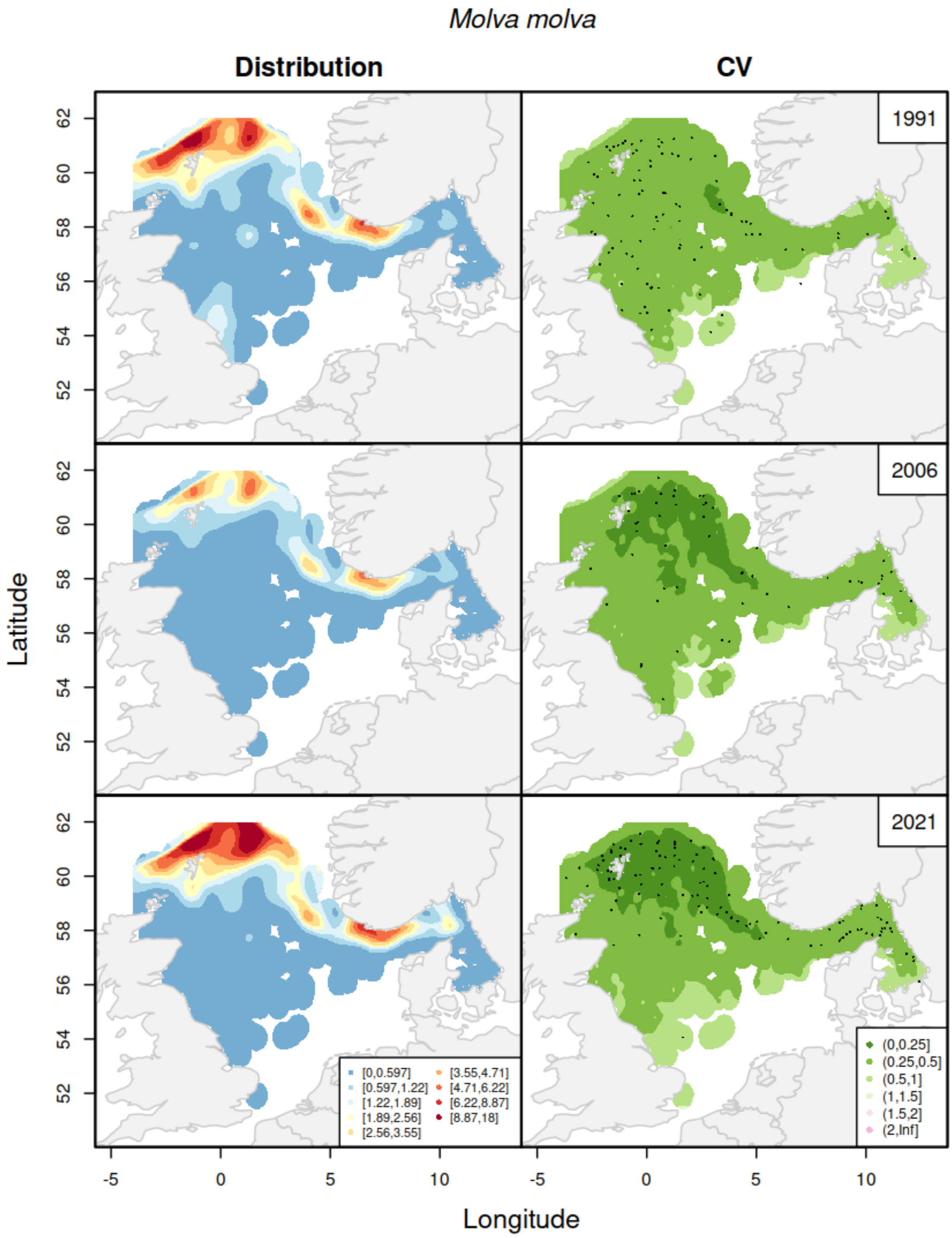

Figure 4.9. Ling. Spatial distribution based on survey catches in numbers.

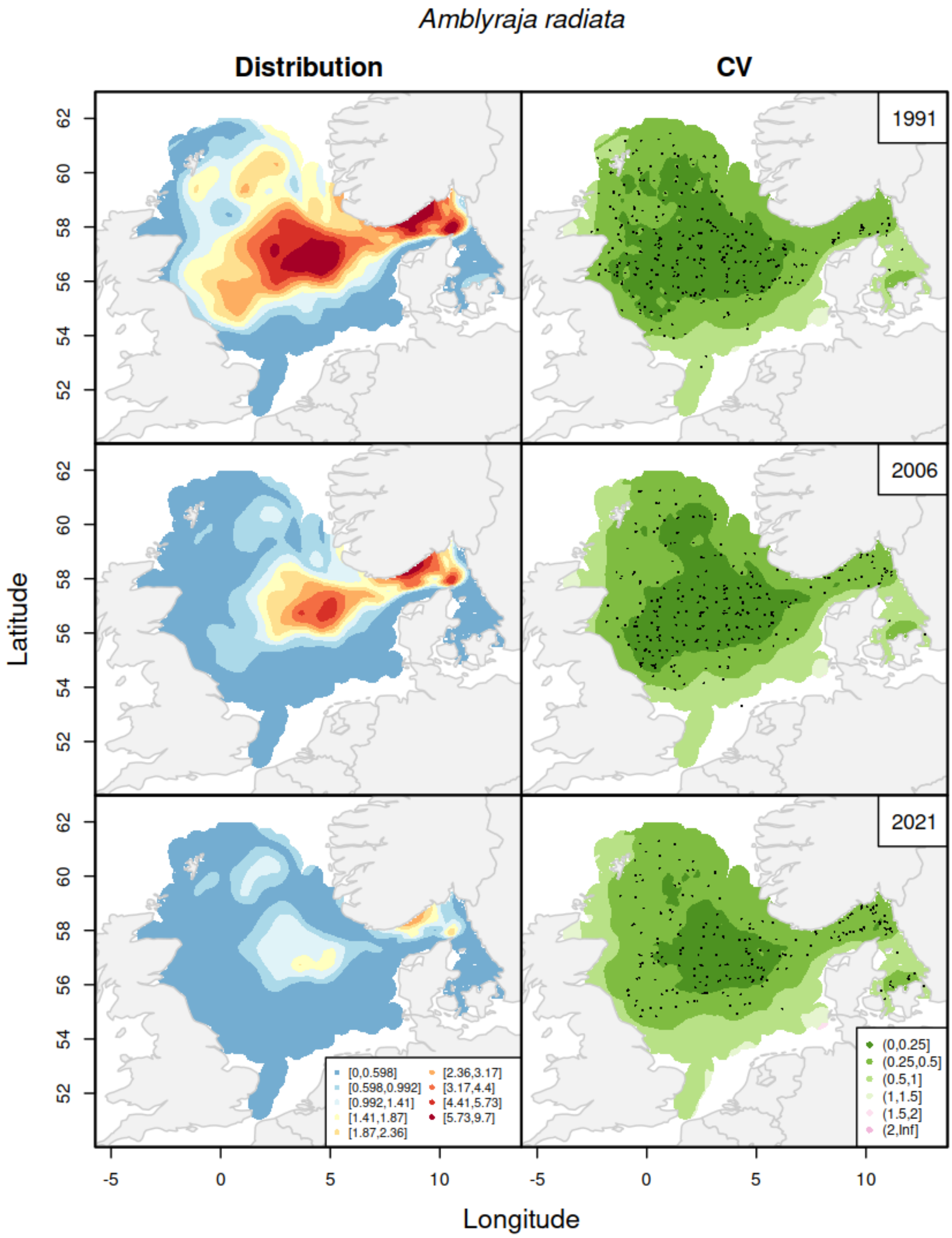

Figure 4.10 Starry ray. Spatial distribution based on survey catches in biomass (kg).

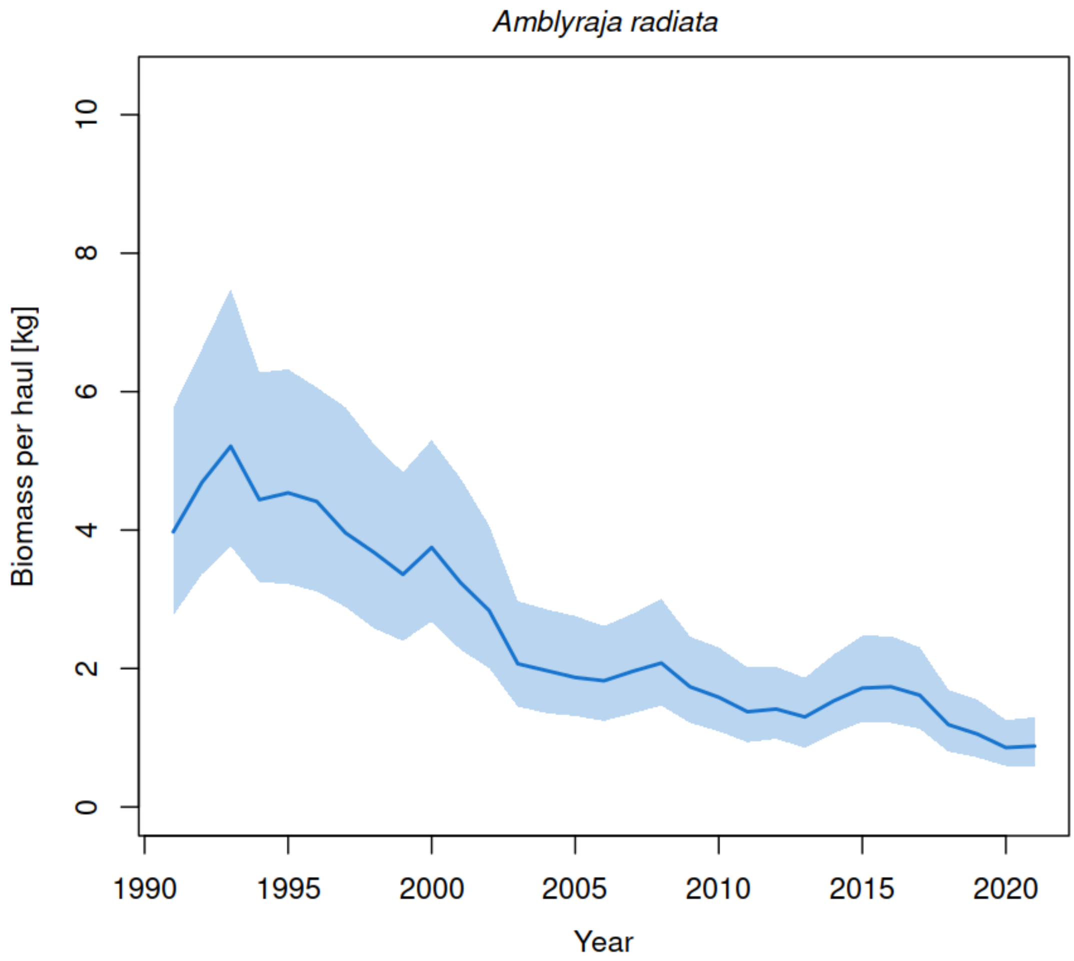

Figure 4.11. Starry ray. Abundance index based on survey catches measured in biomass.

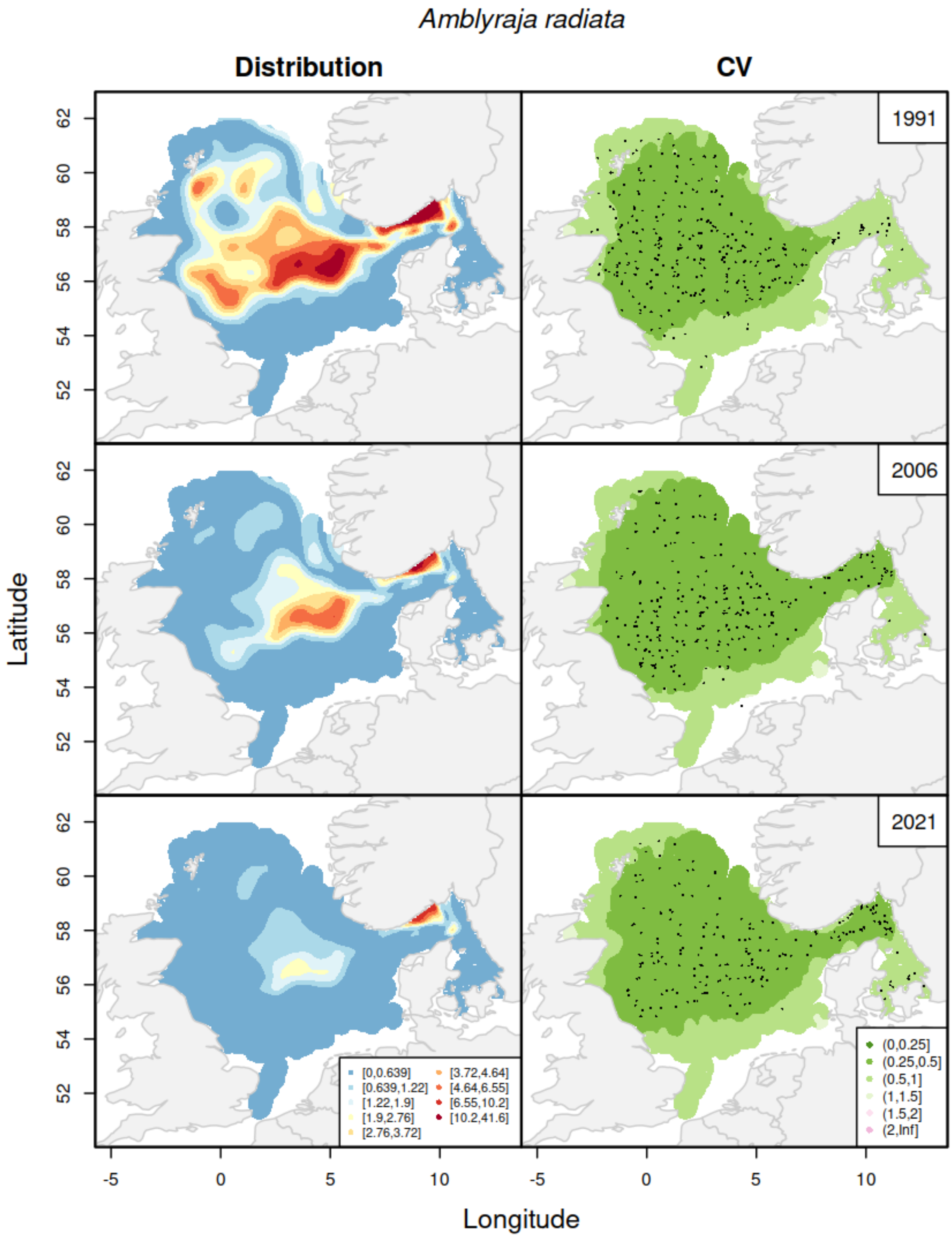

Figure 4.12. Starry ray. Spatial distribution based on survey catches in numbers.

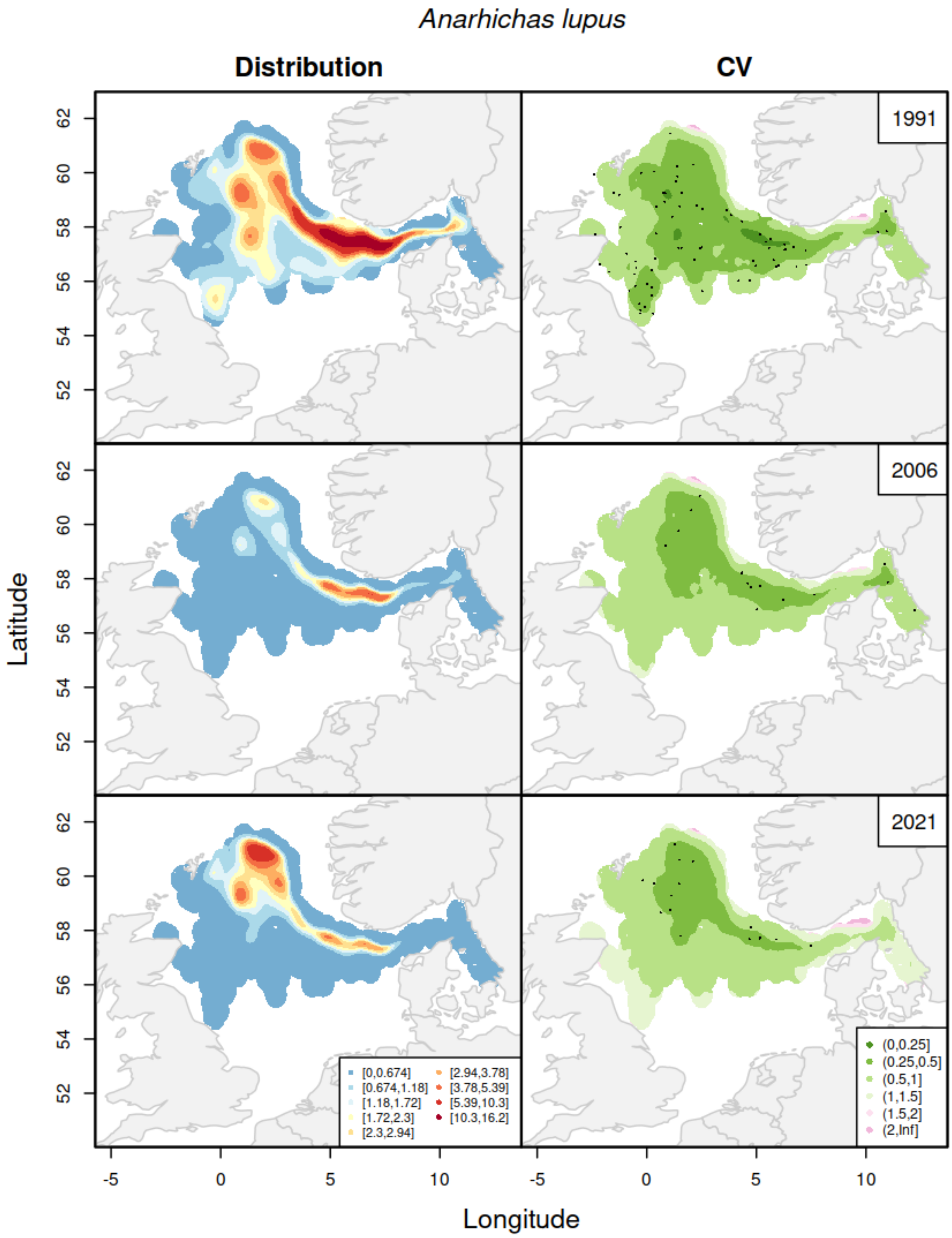

Figure 4.13. Atlantic Wolffish. Spatial distribution based on survey catches in biomass (kg).

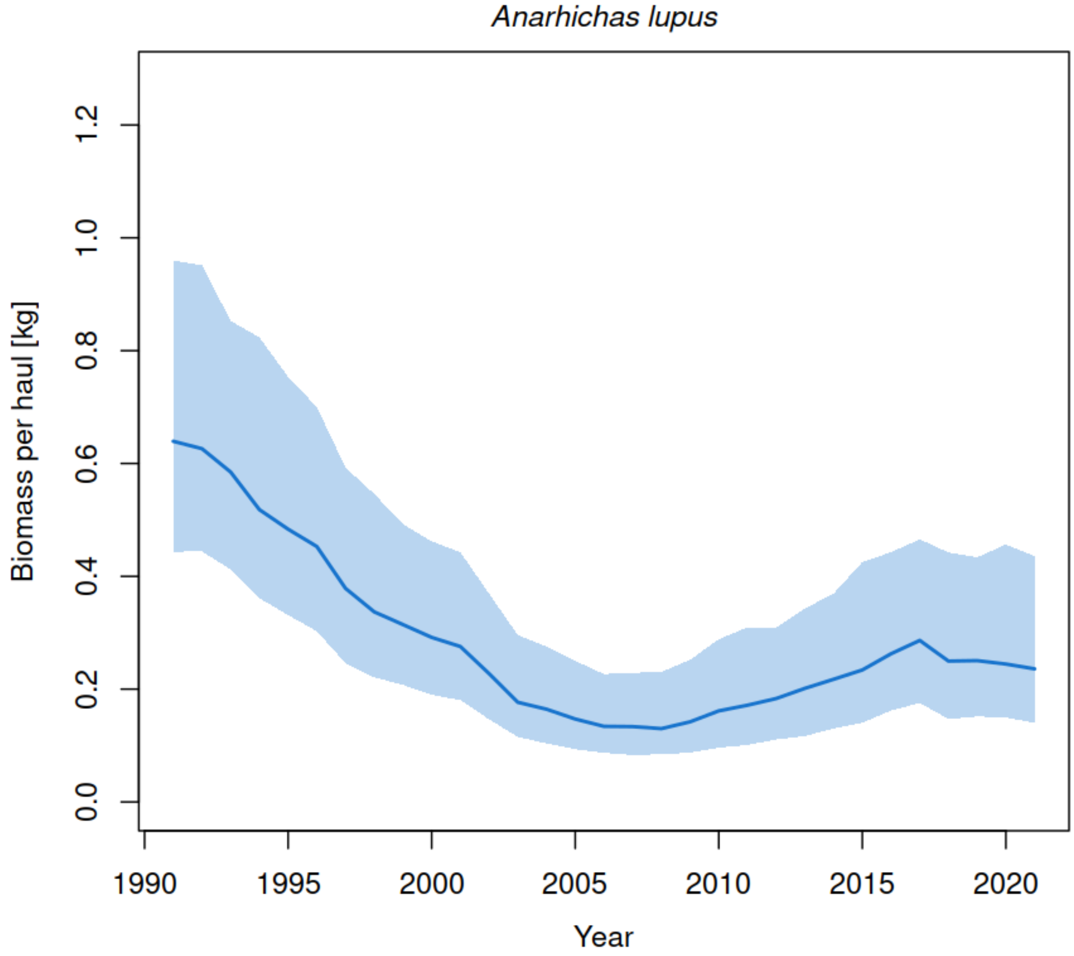

Figure 4.14. Atlantic wolffish. Abundance index based on survey catches measured in biomass.

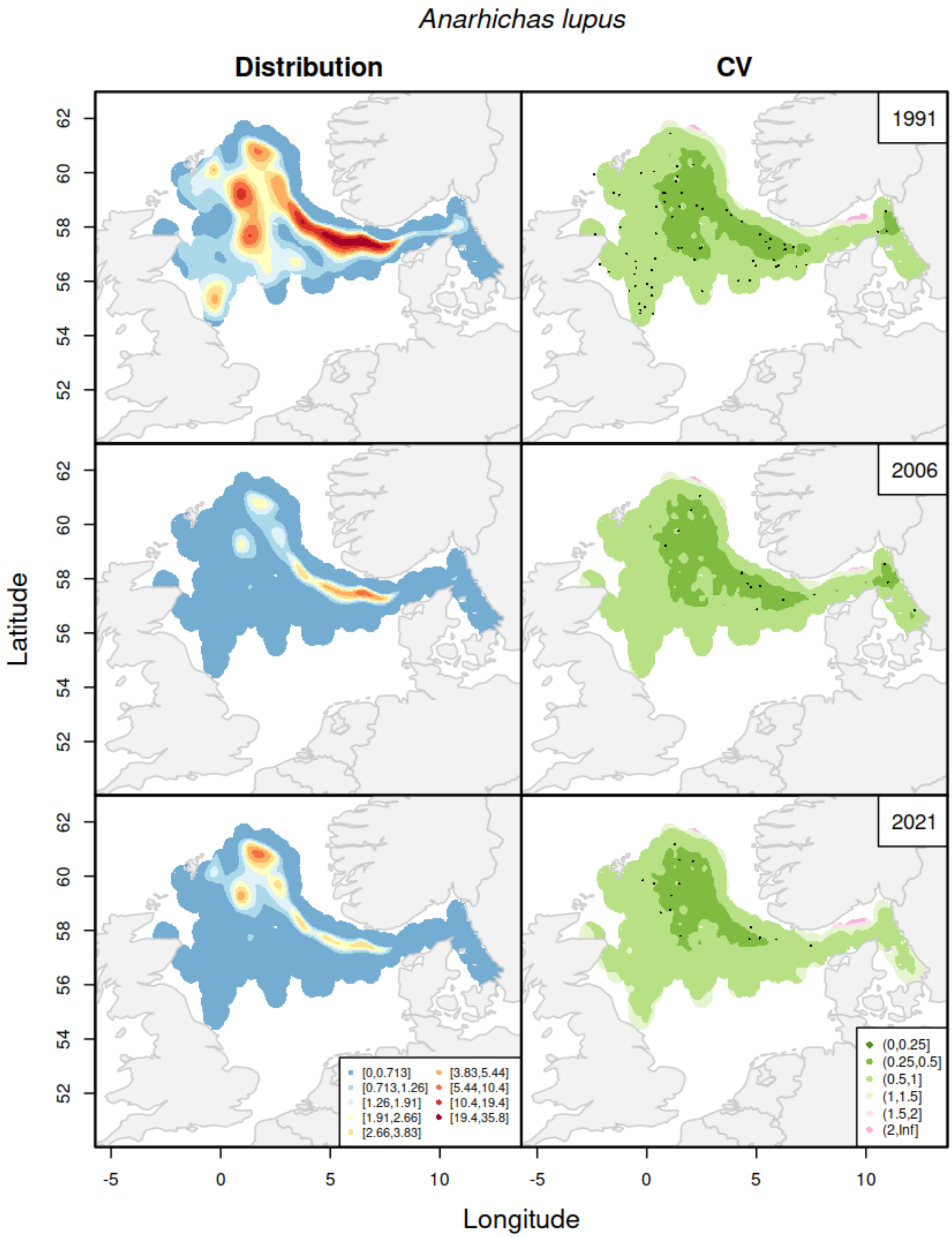

Figure 4.15. Atlantic Wolffish. Spatial distribution based on survey catches in numbers.

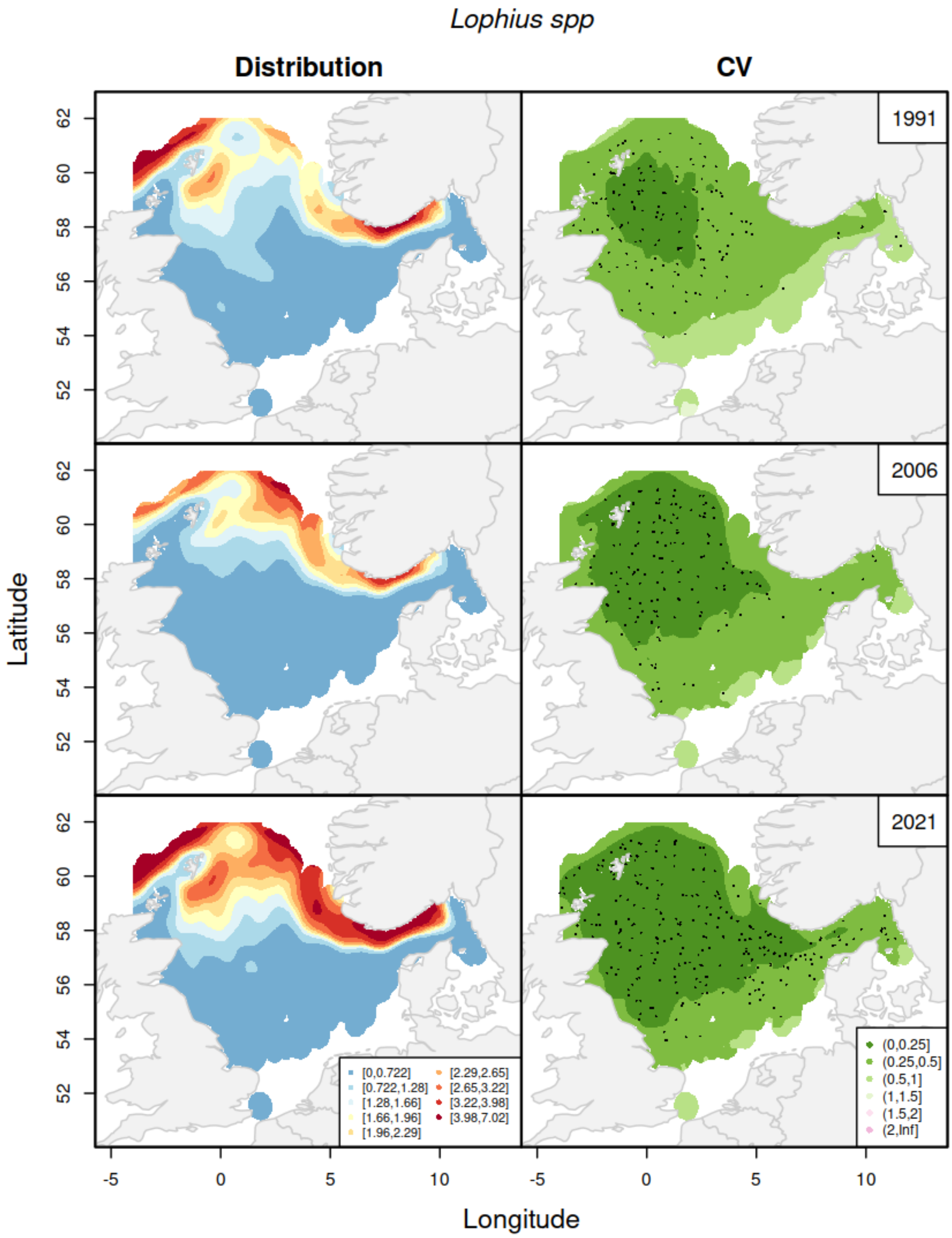

Figure 4.16. Anglerfish. Spatial distribution based on survey catches in biomass (kg).

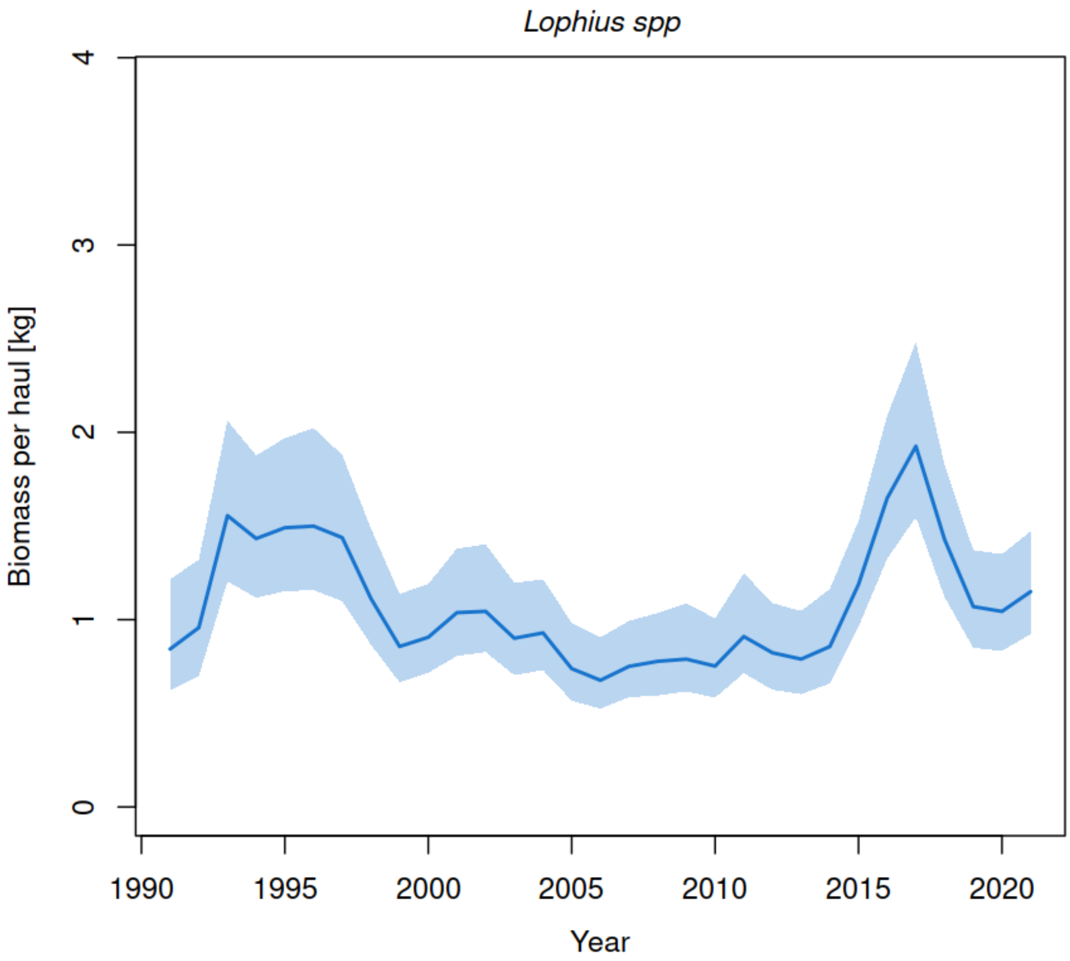

Figure 4.17. Anglerfish. Abundance index based on survey catches measured in biomass.

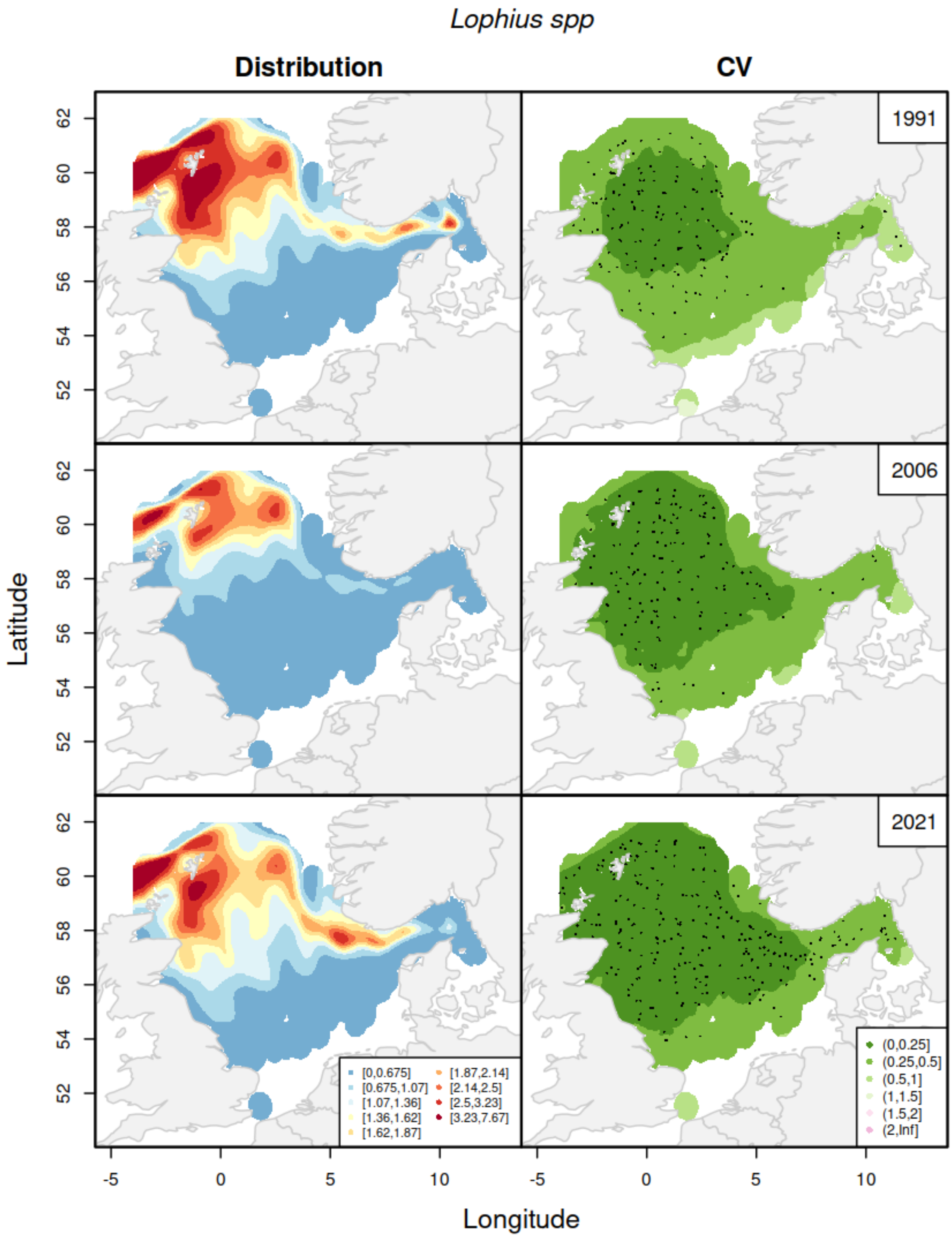

Figure 4.18. Anglerfish. Spatial distribution based on survey catches in numbers.

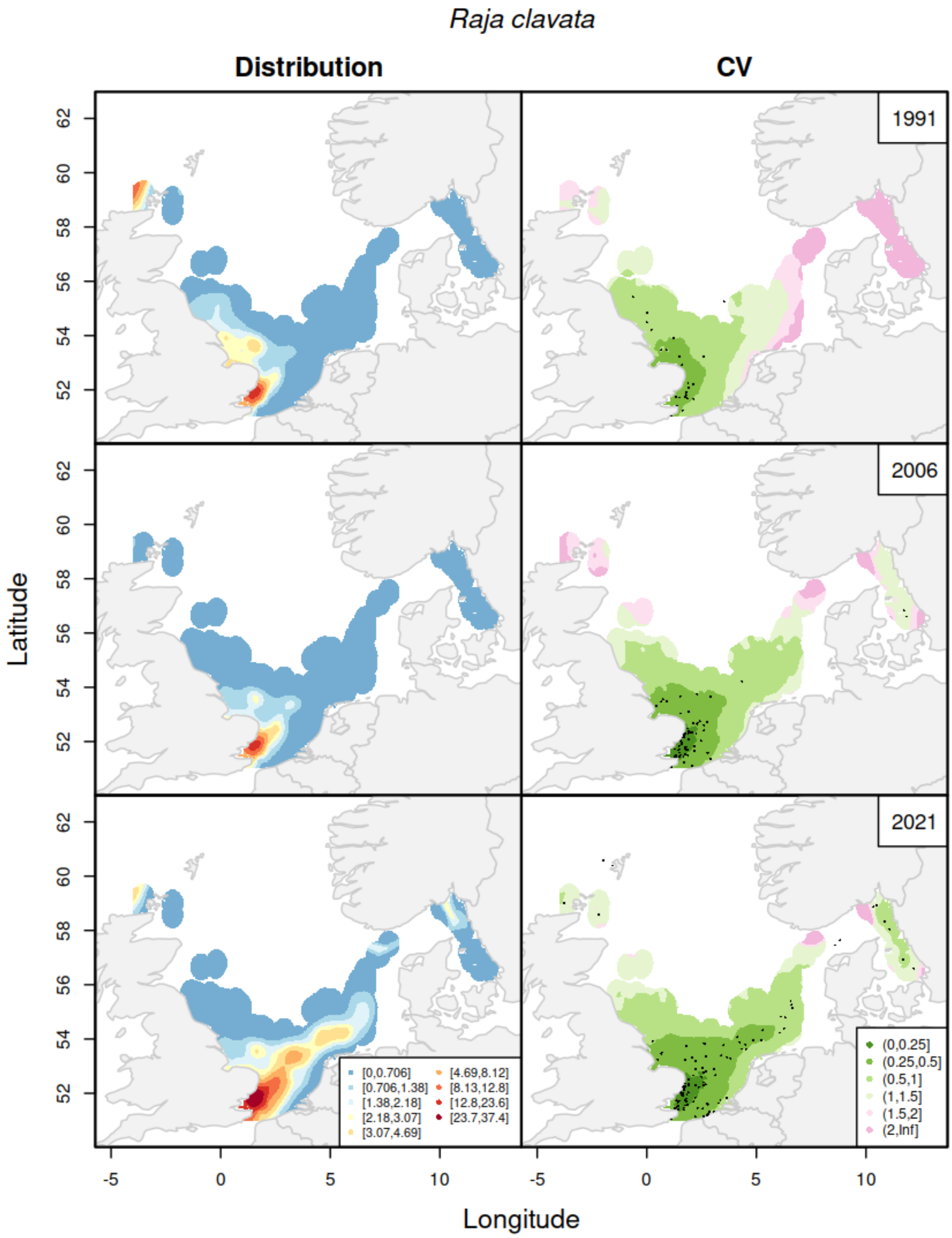

Figure 4.19. Thornback ray. Spatial distribution based on survey catches in biomass (kg).

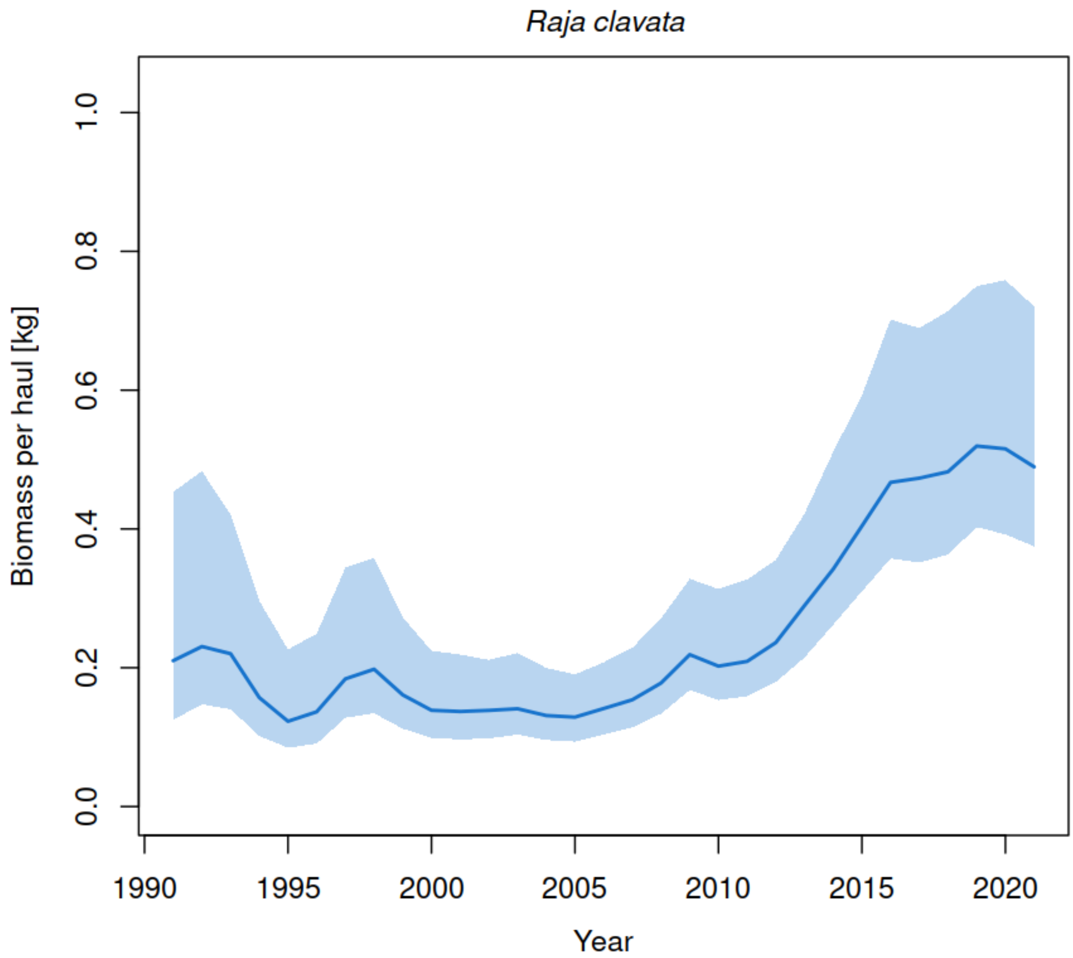

Figure 4.20. Thornback ray. Abundance index based on survey catches measured in biomass.

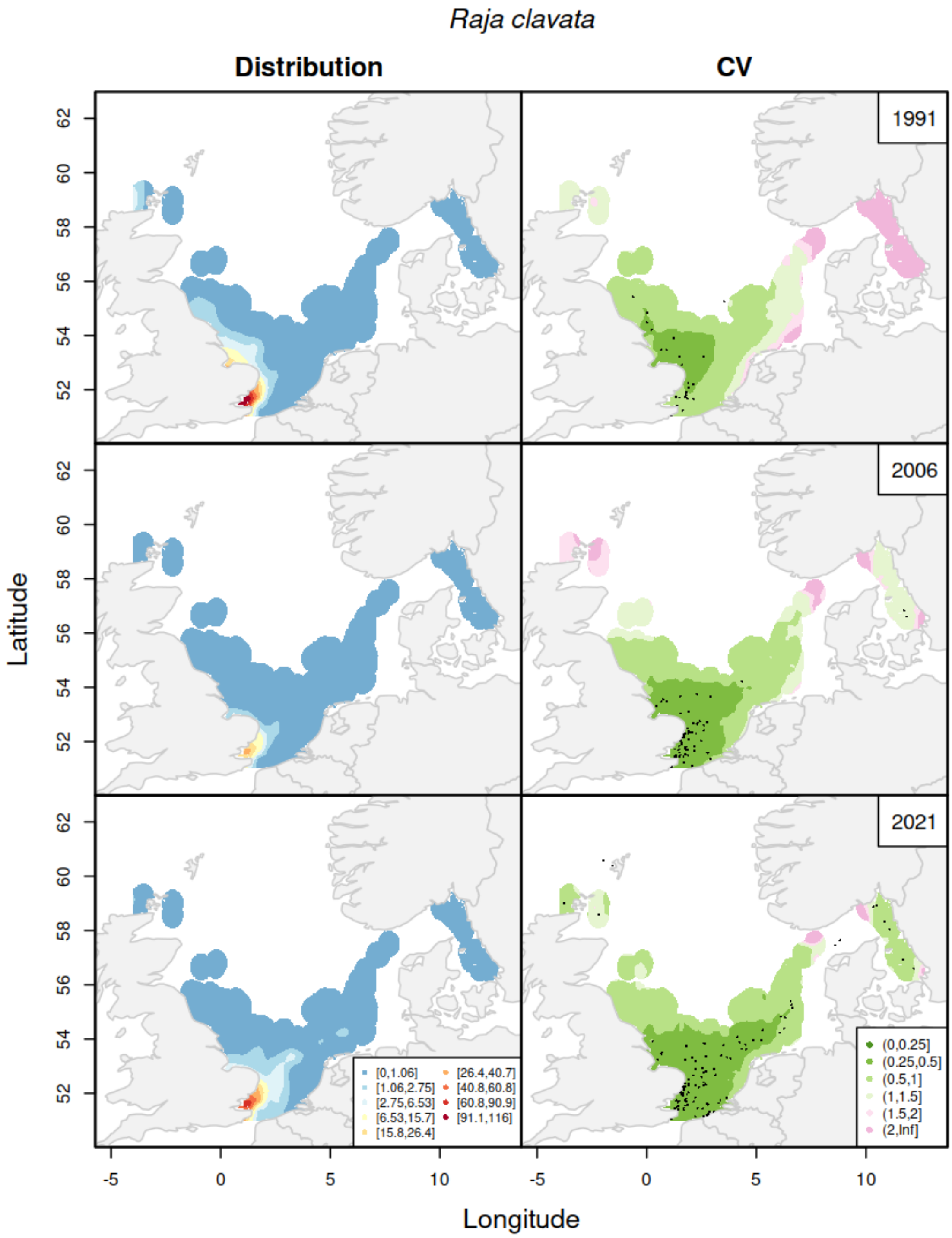

Figure 4.21. Thornback ray. Spatial distribution based on survey catches in numbers.

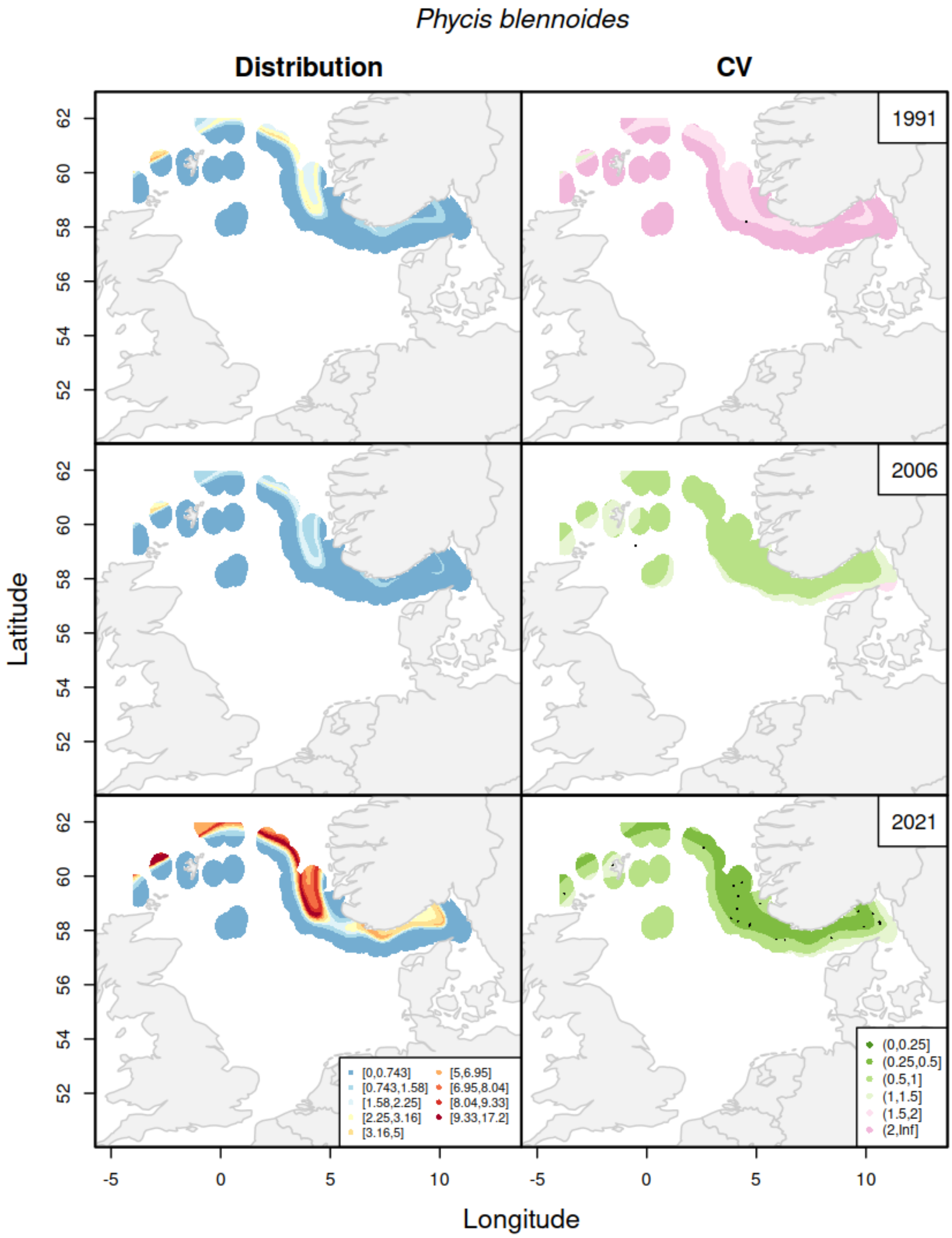

Figure 4.22. Greater forkbeard. Spatial distribution based on survey catches in biomass (kg).

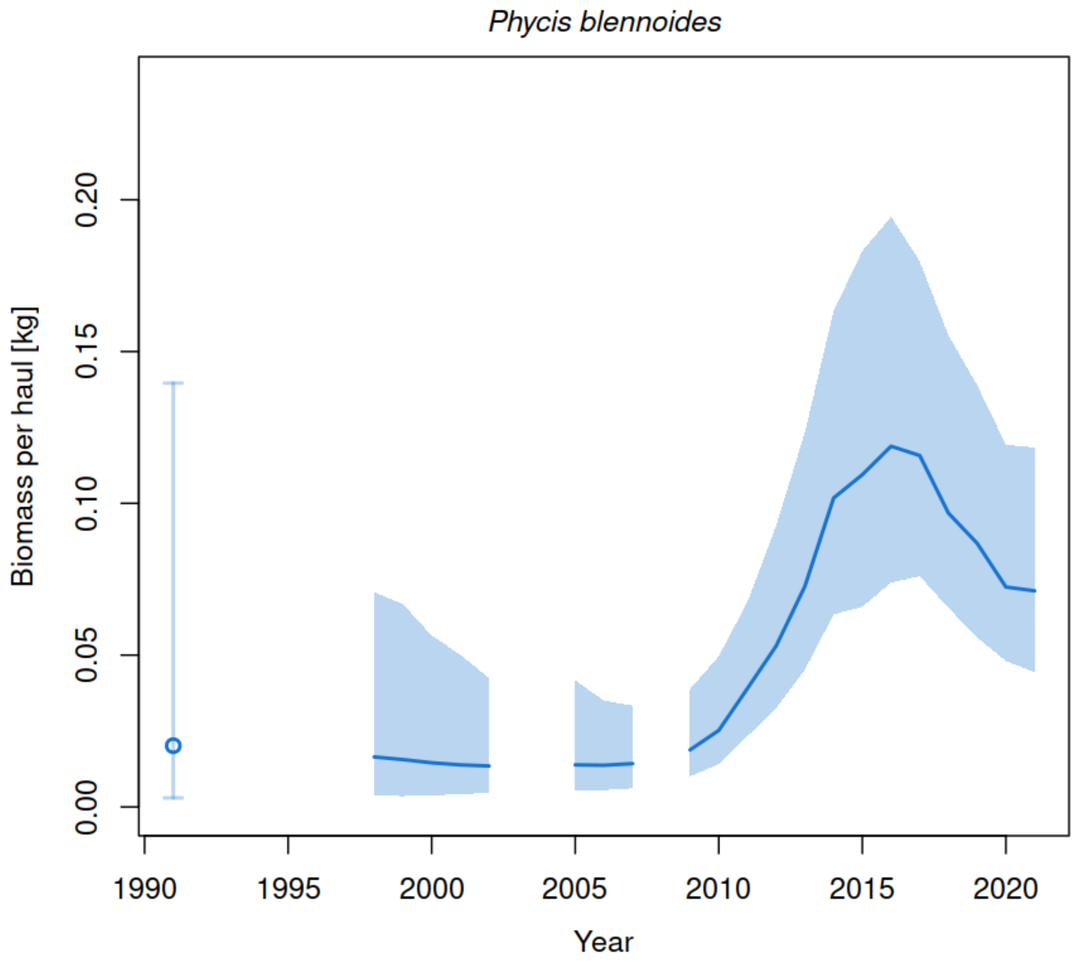

Figure 4.23. Greater forkbeard. Abundance index based on survey catches measured in biomass.

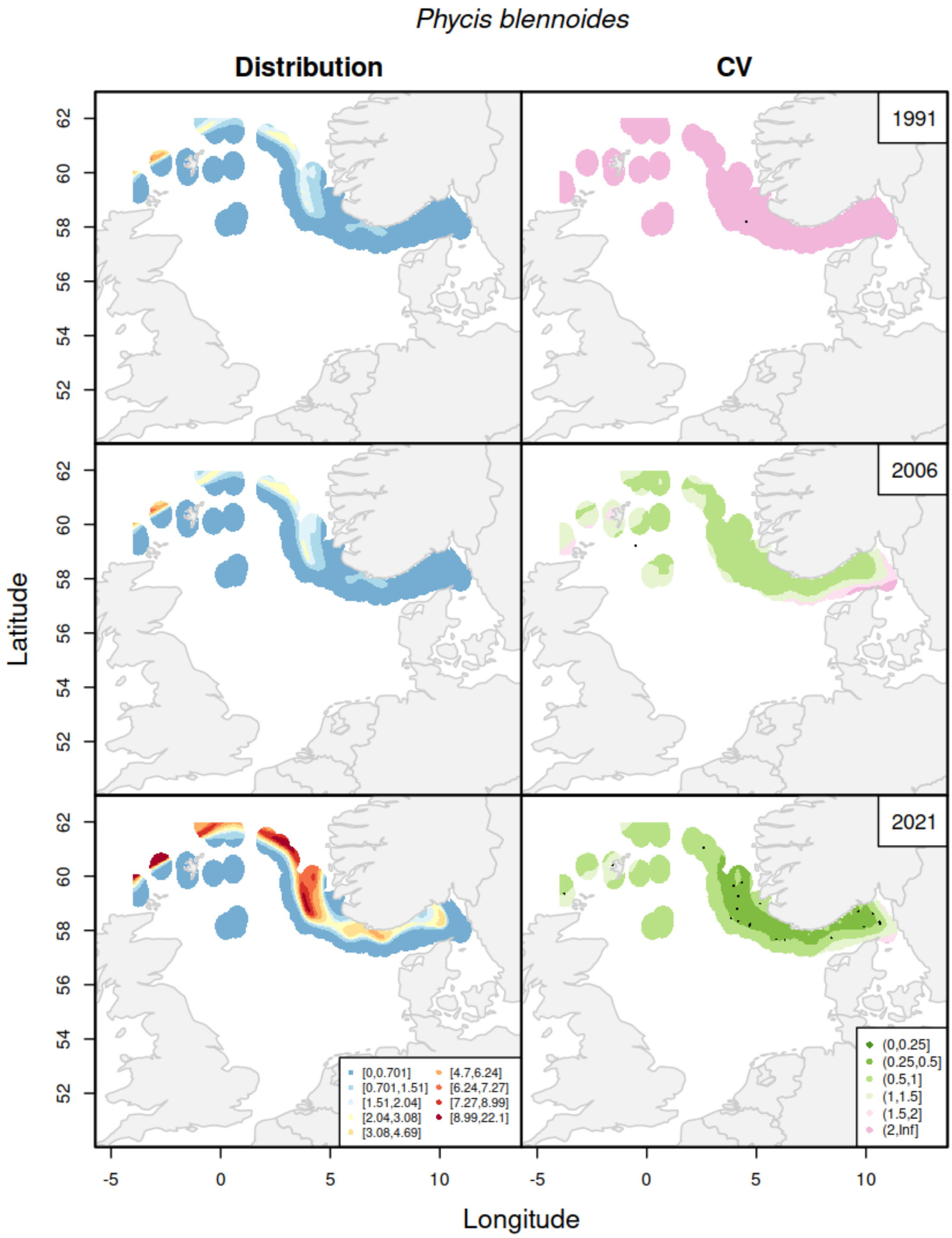

Figure 4.24. Greater forkbeard. Spatial distribution based on survey catches in numbers

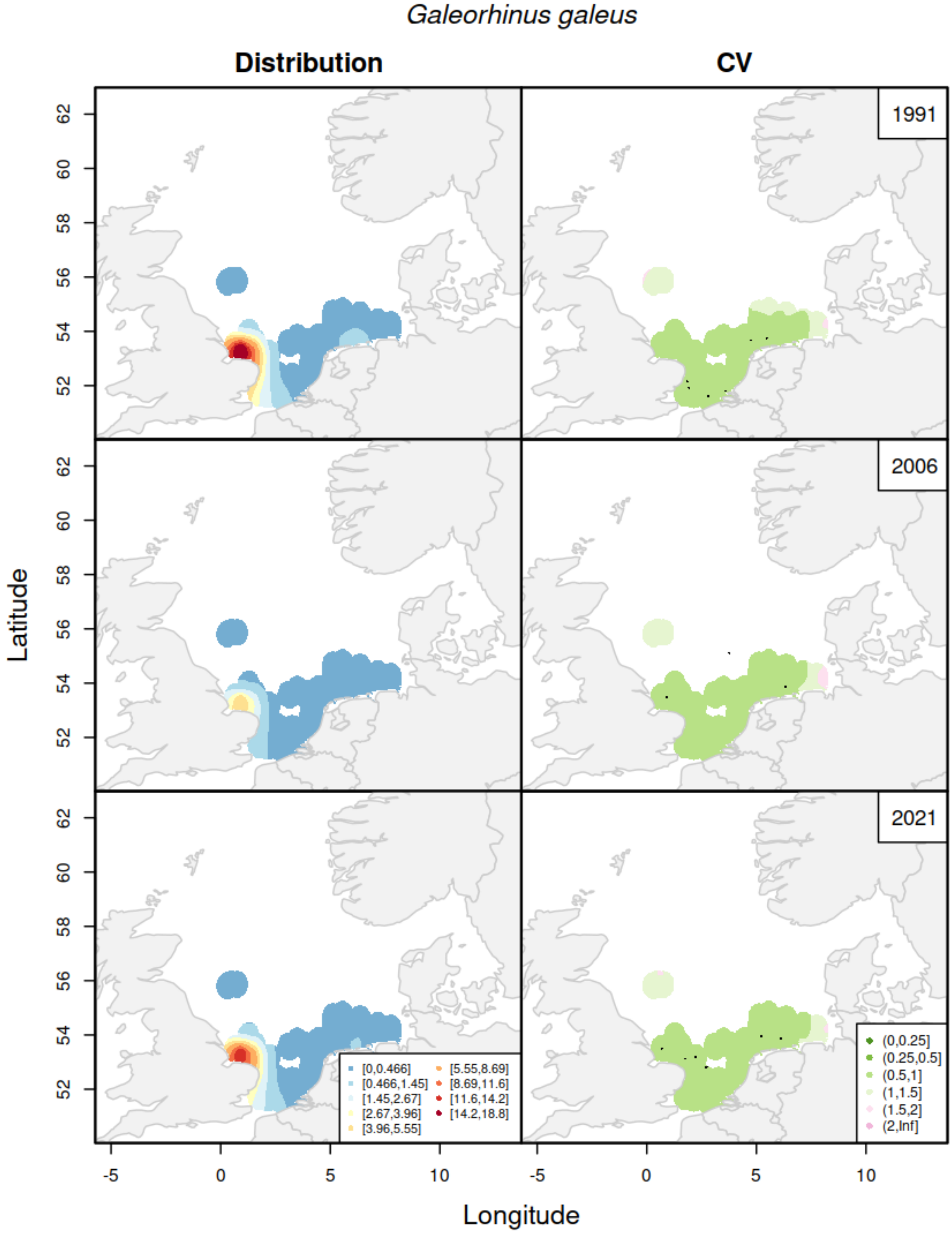

Figure 4.25. Tope. Spatial distribution based on survey catches in biomass (kg).

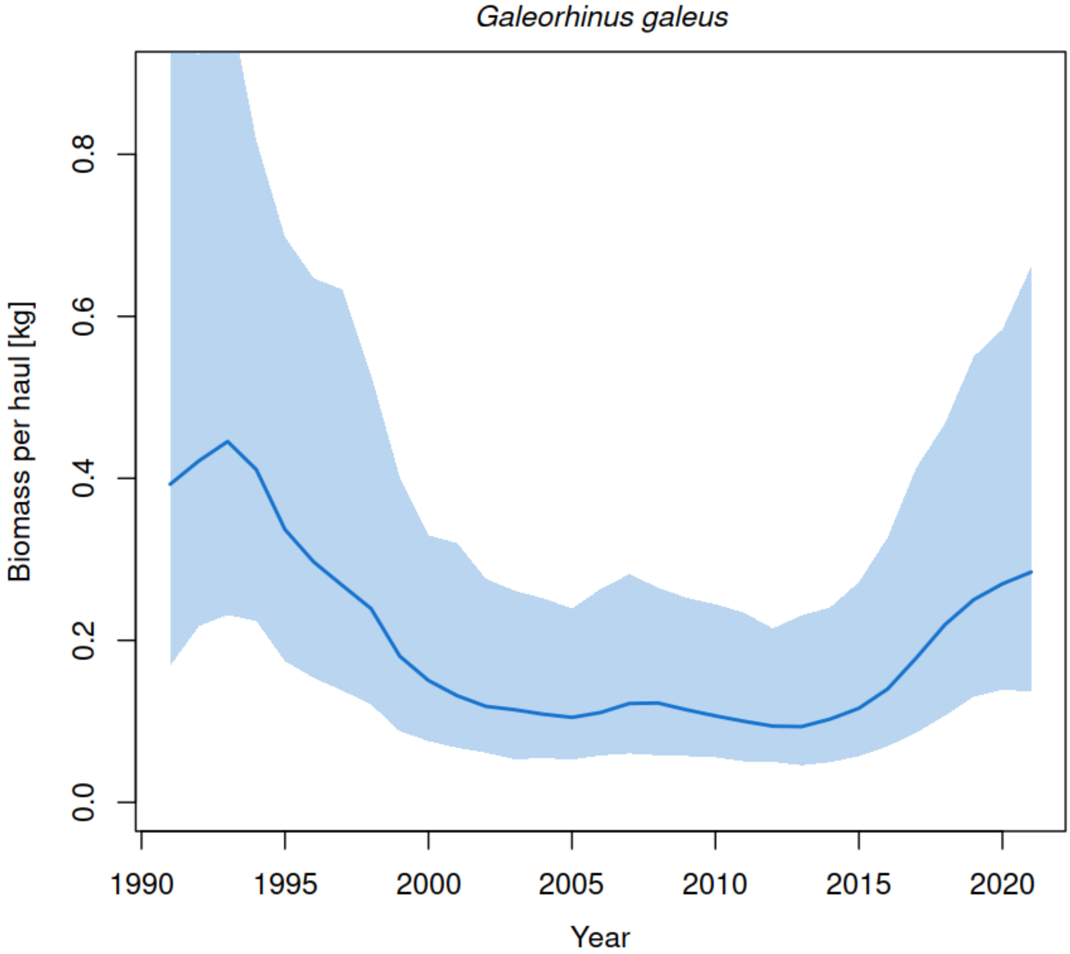

Figure 4.26. Tope. Abundance index based on survey catches measured in biomass.

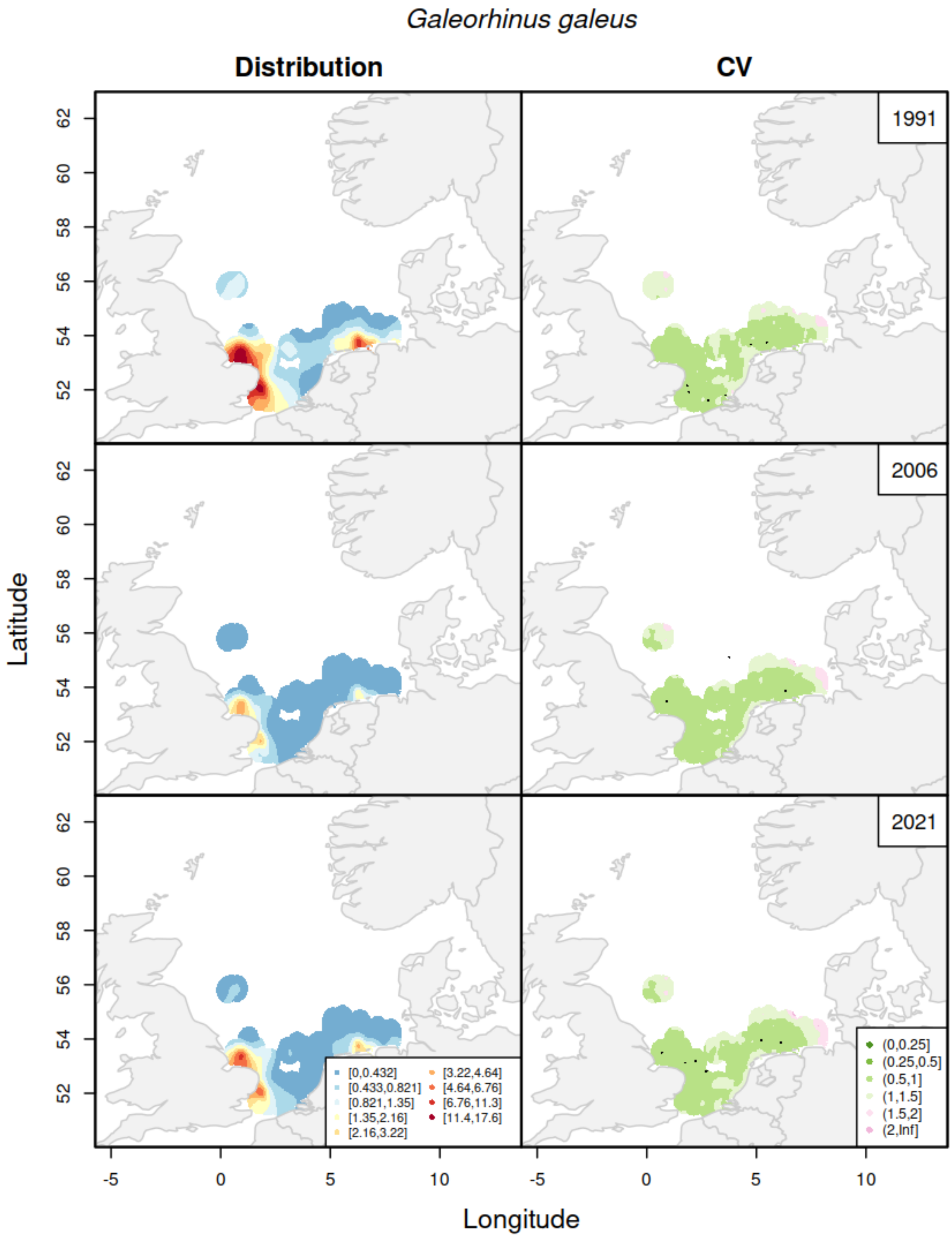

Figure 4.27. Tope. Spatial distribution based on survey catches in numbers.

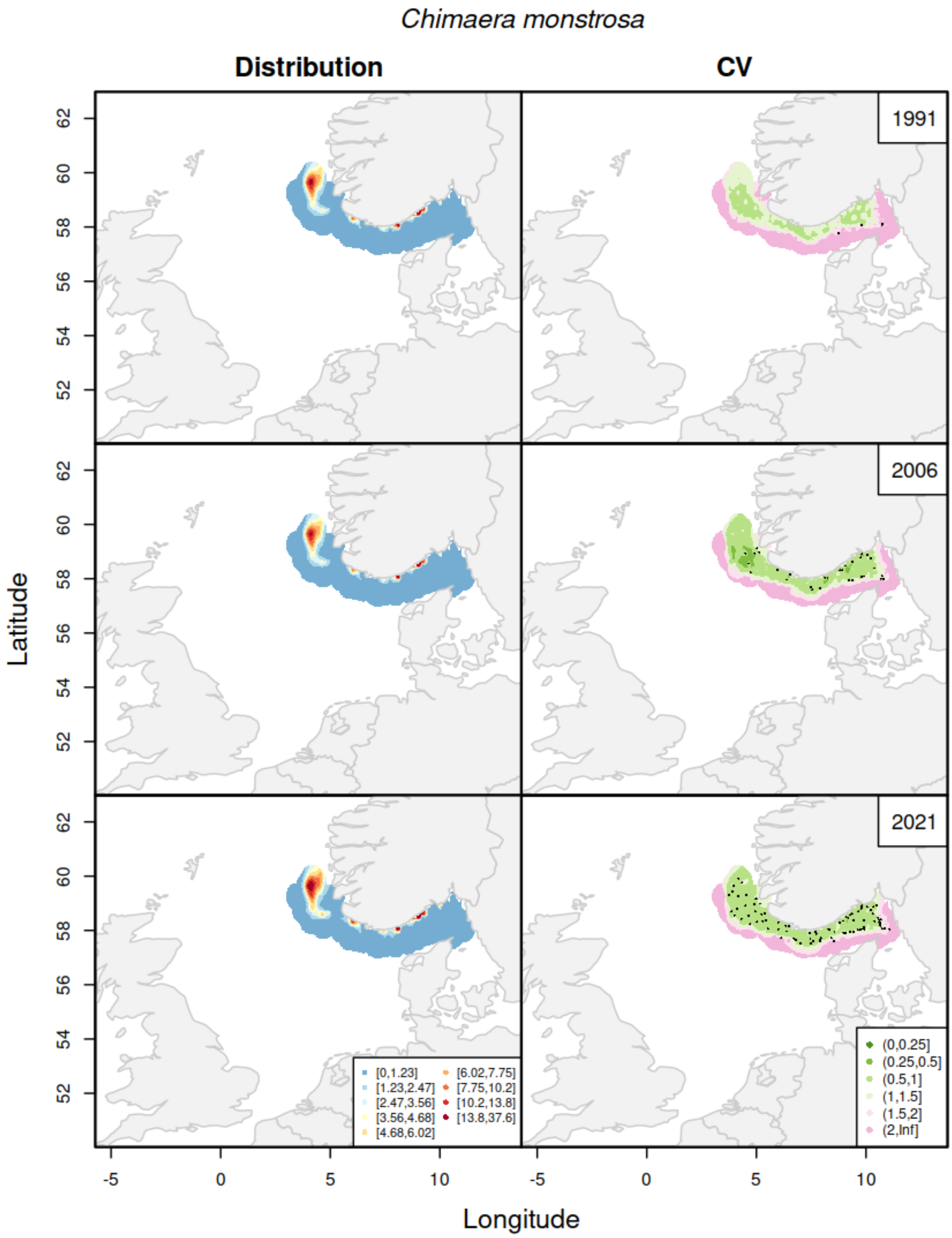

Figure 4.28. Rabbit fish. Spatial distribution based on survey catches in biomass (kg).

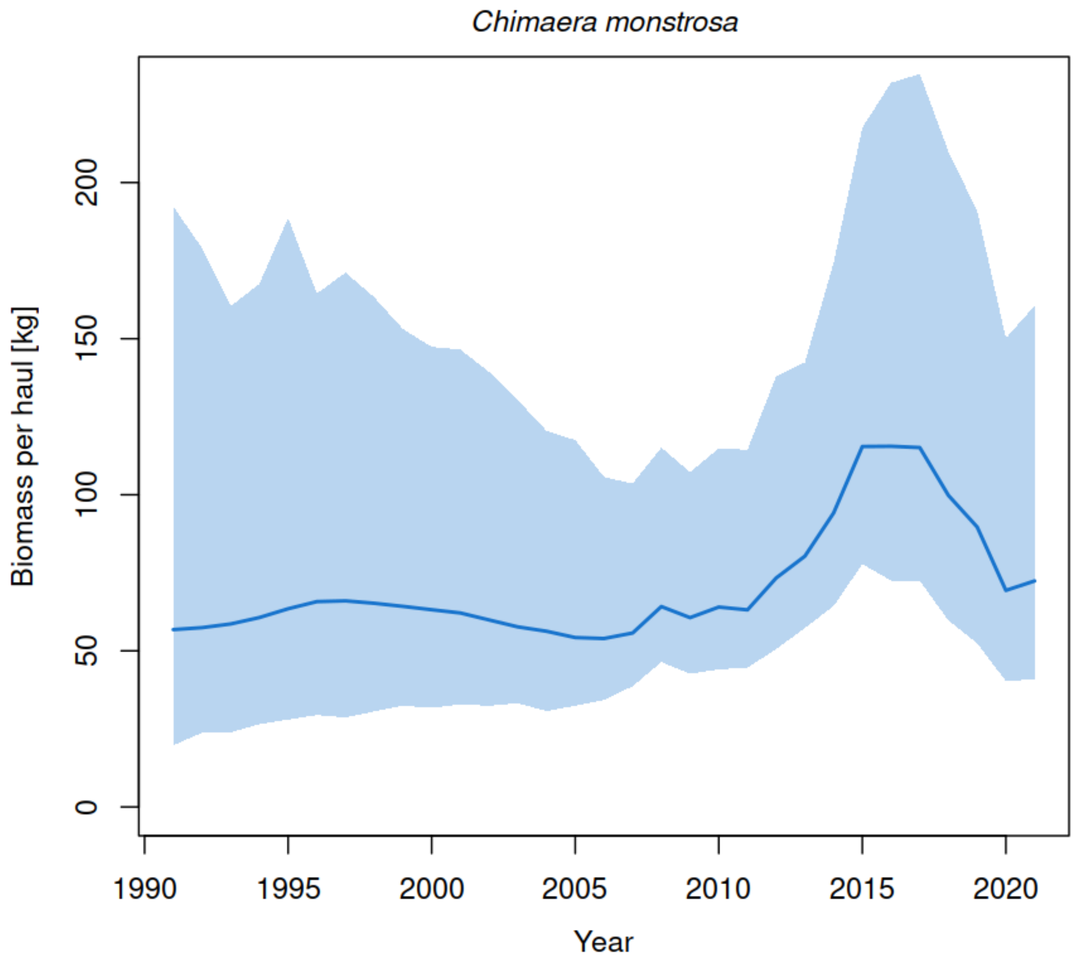

Figure 4.29. Rabbit fish. Abundance index based on survey catches measured in biomass.

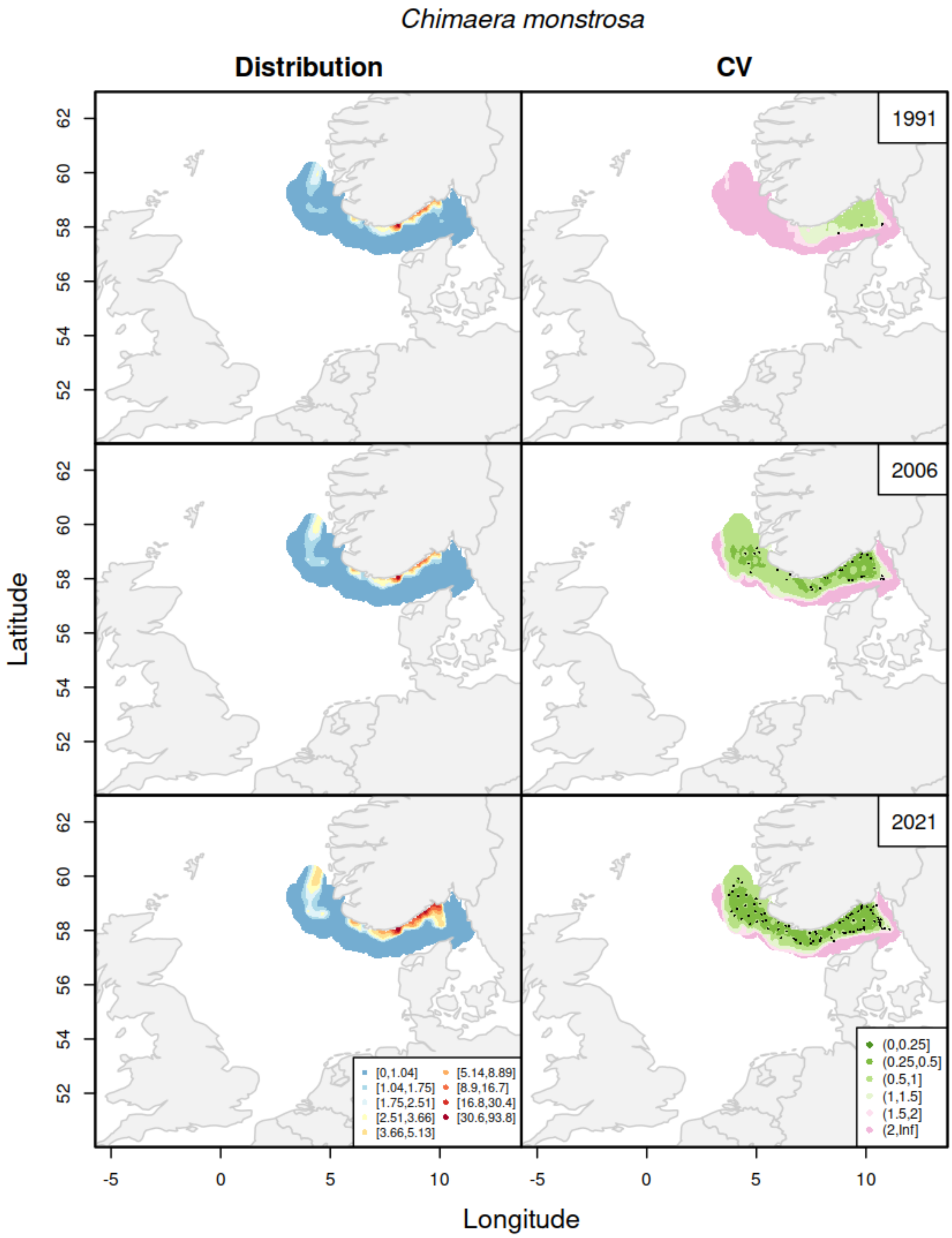

Figure 4.30. Rabbit fish. Spatial distribution based on survey catches in numbers.

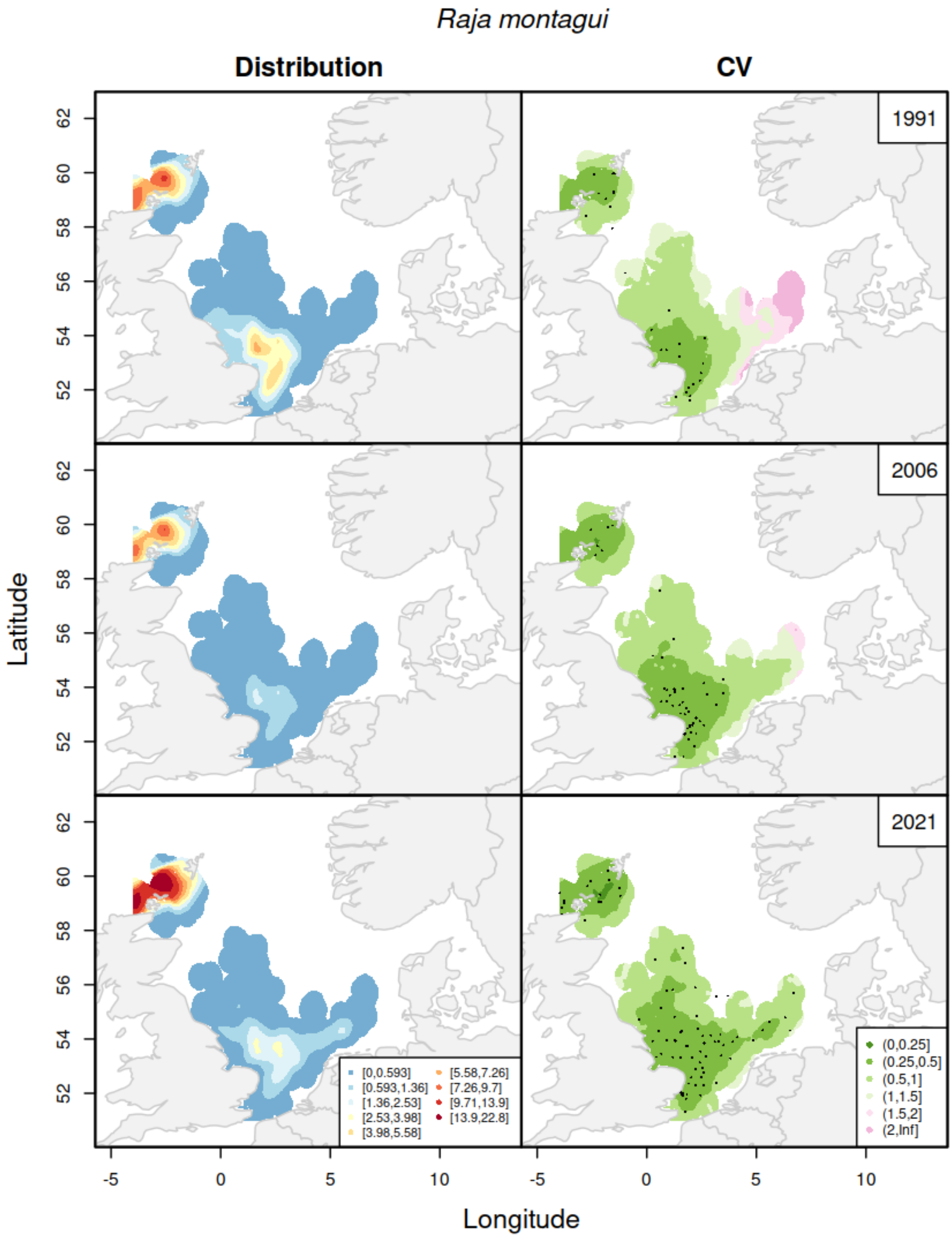

Figure 4.31. Spotted ray. Spatial distribution based on survey catches in biomass (kg).

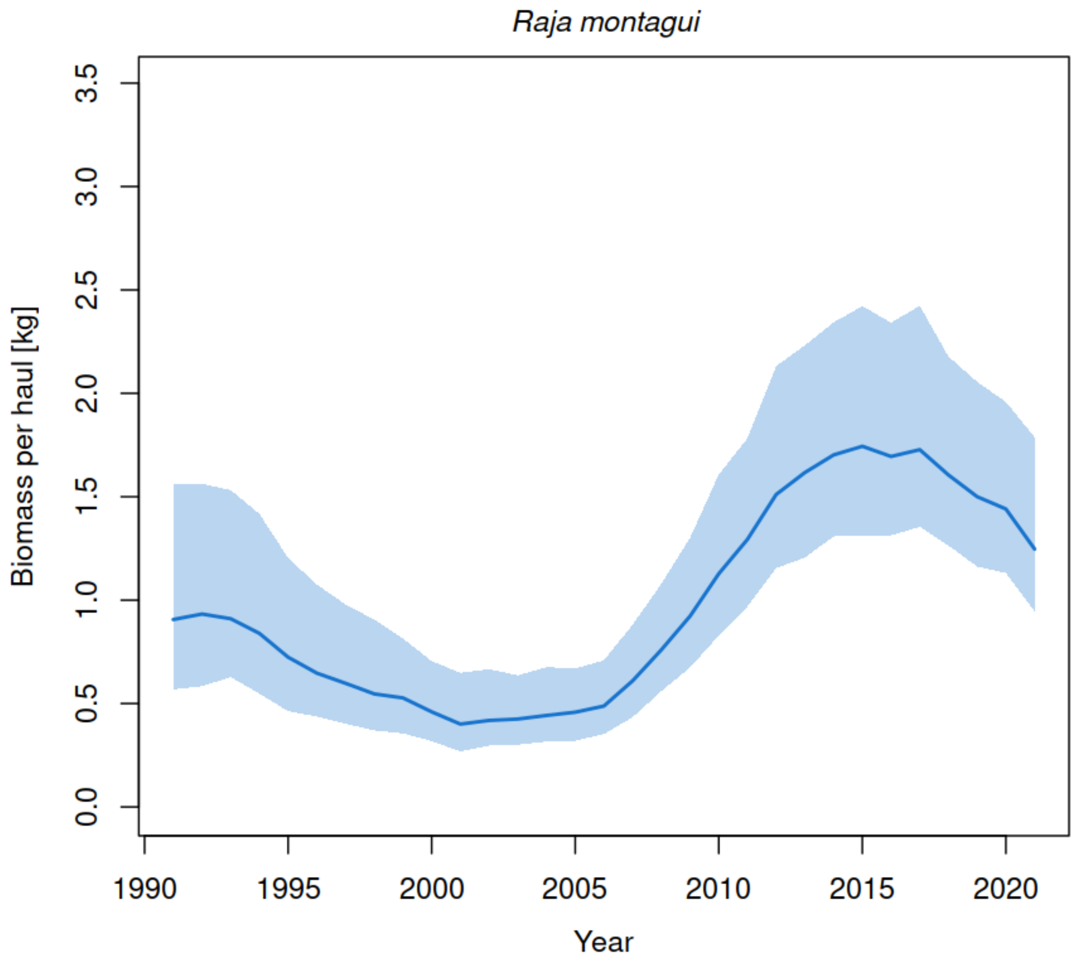

Figure 4.32. Spotted ray. Abundance index based on survey catches measured in biomass.

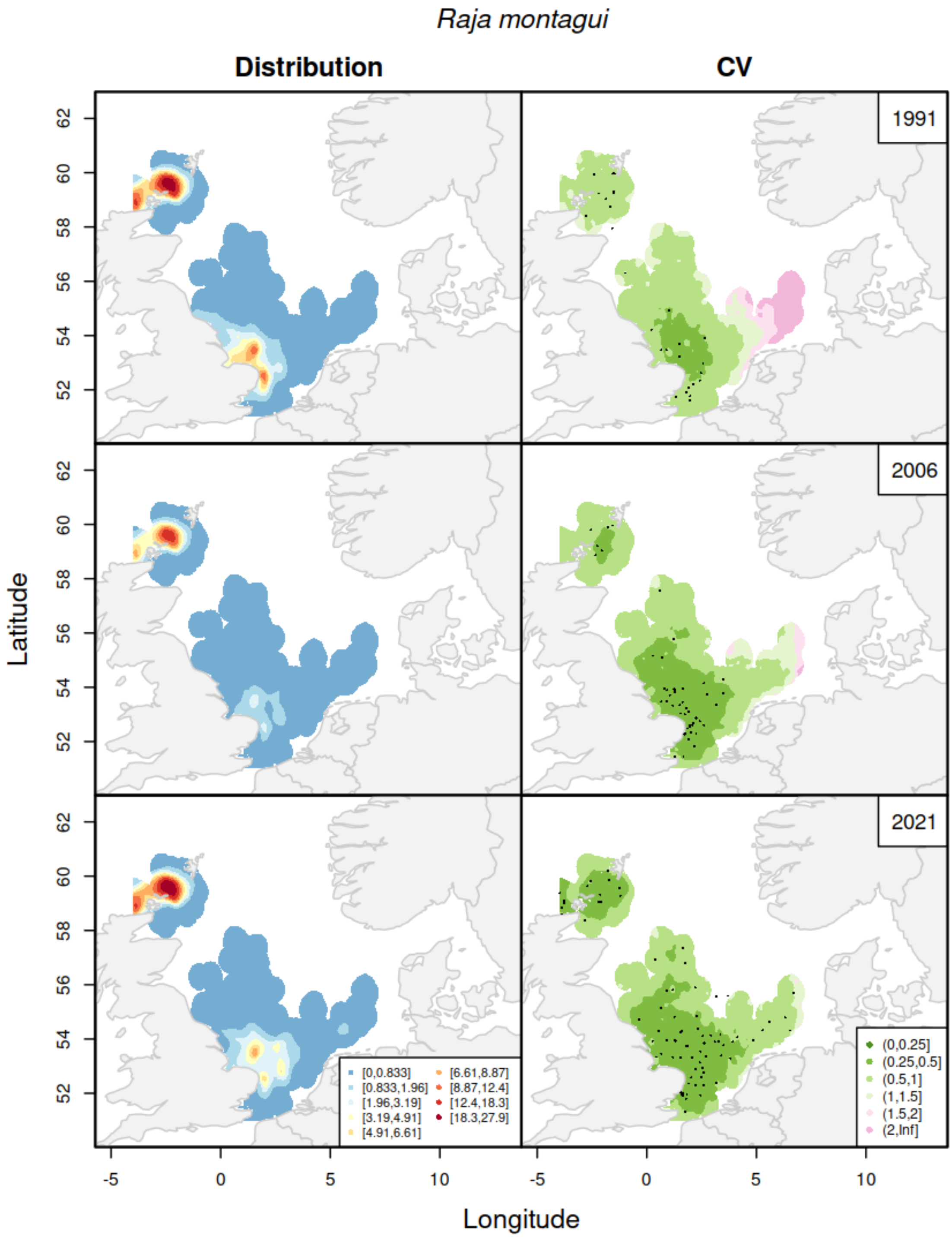

Figure 4.33. Spotted ray. Spatial distribution based on survey catches in numbers.

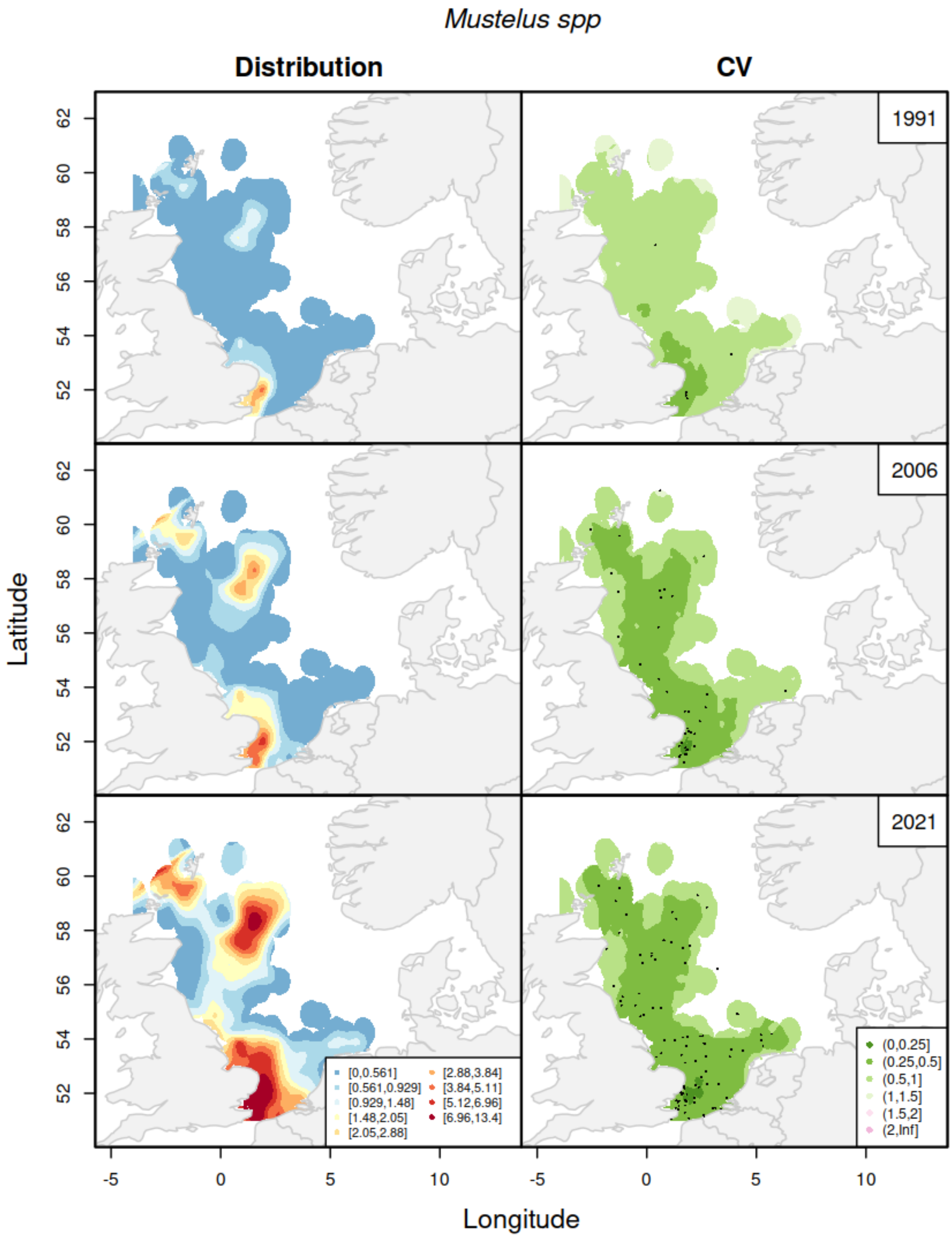

Figure 4.34. Smooth-hounds. Spatial distribution based on survey catches in biomass (kg).

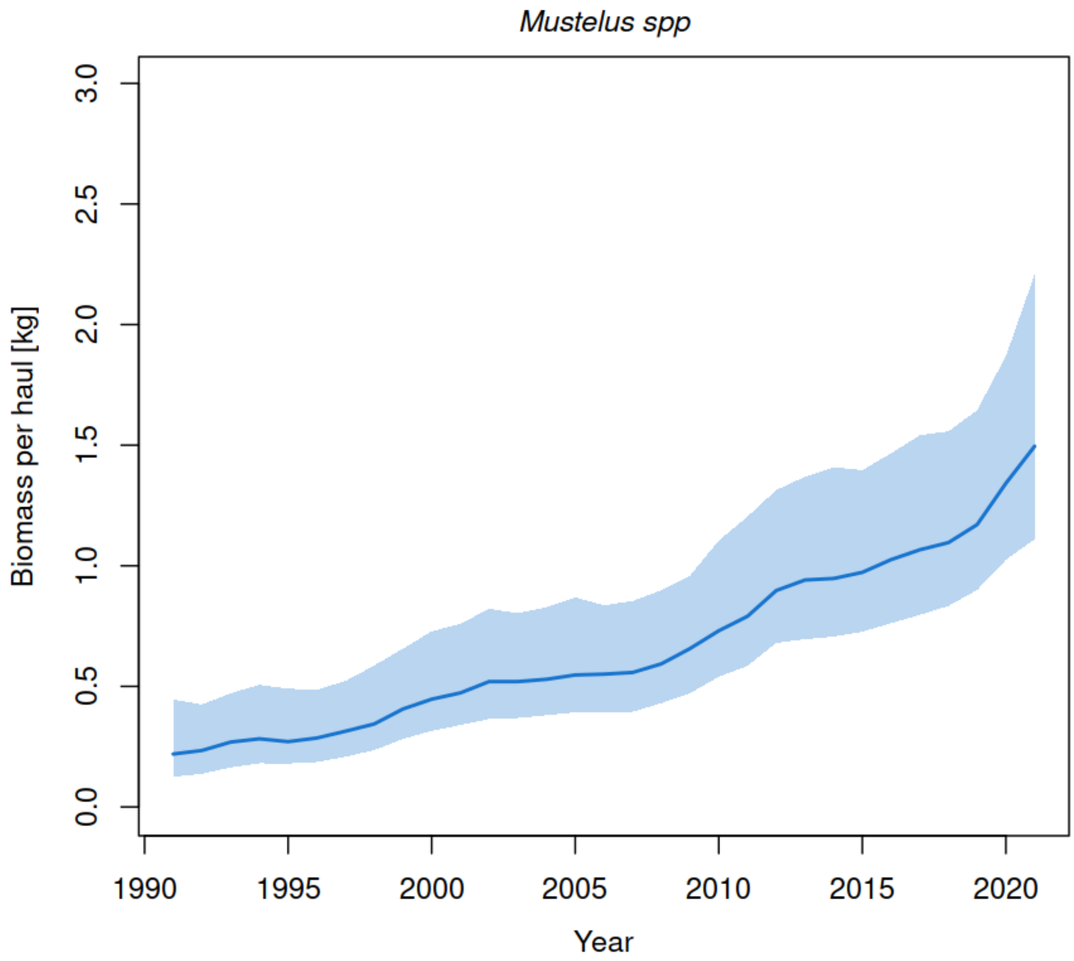

Figure 4.35. Smooth-hounds. Abundance index based on survey catches measured in biomass.

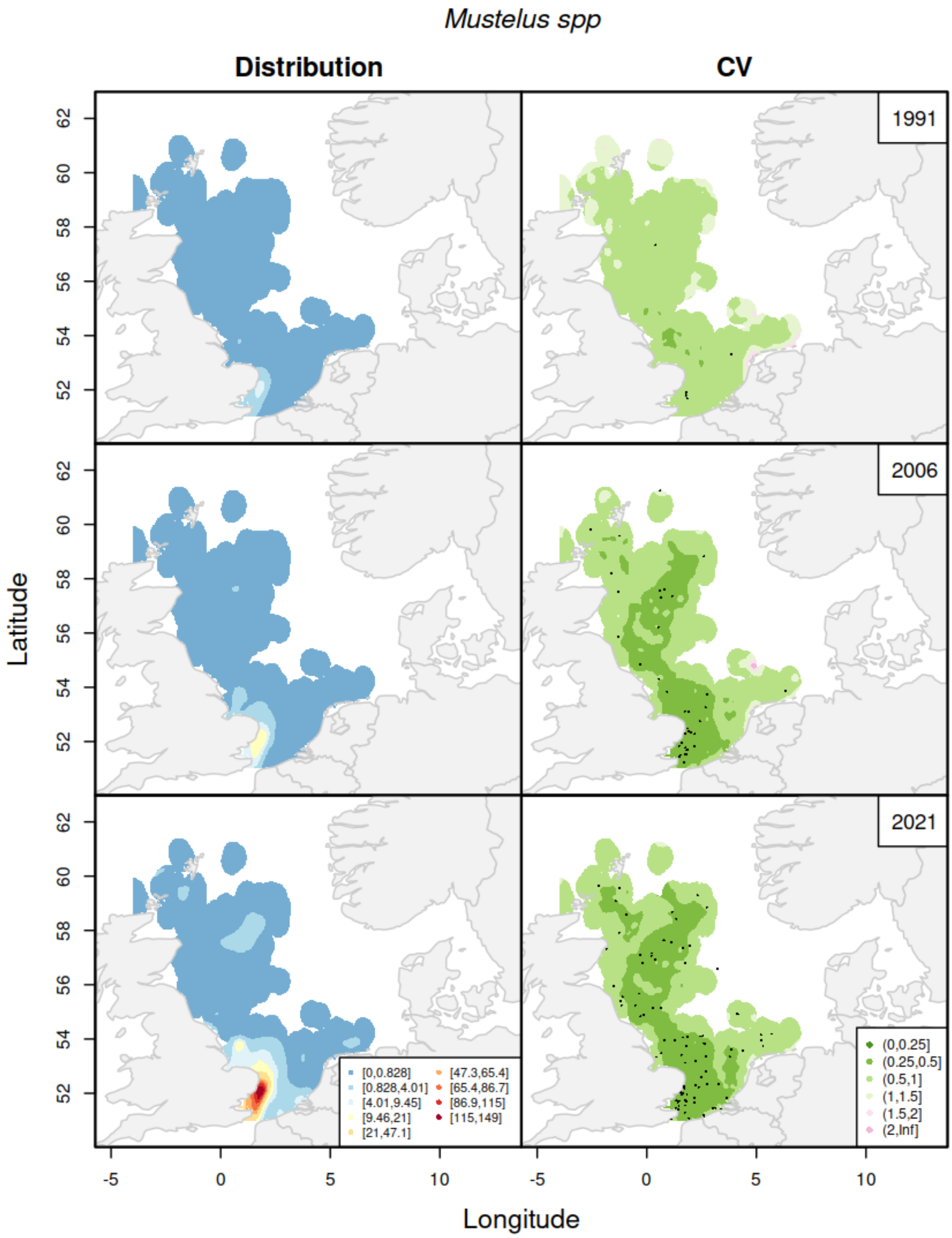

Figure 4.36. Smooth-hounds. Spatial distribution based on survey catches in numbers.

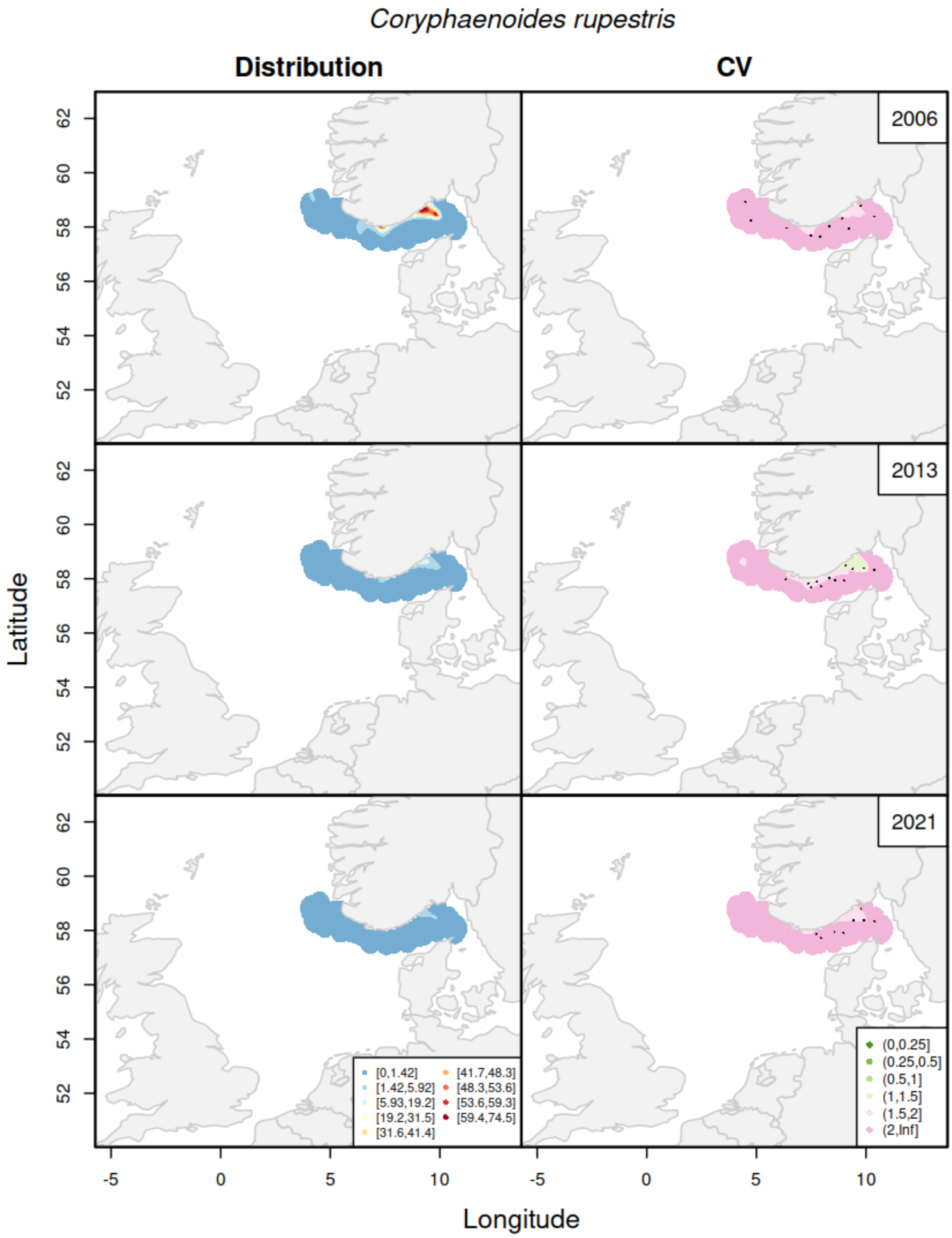

Figure 4.37. Roundnose grenadier. Spatial distribution based on survey catches in biomass (kg).

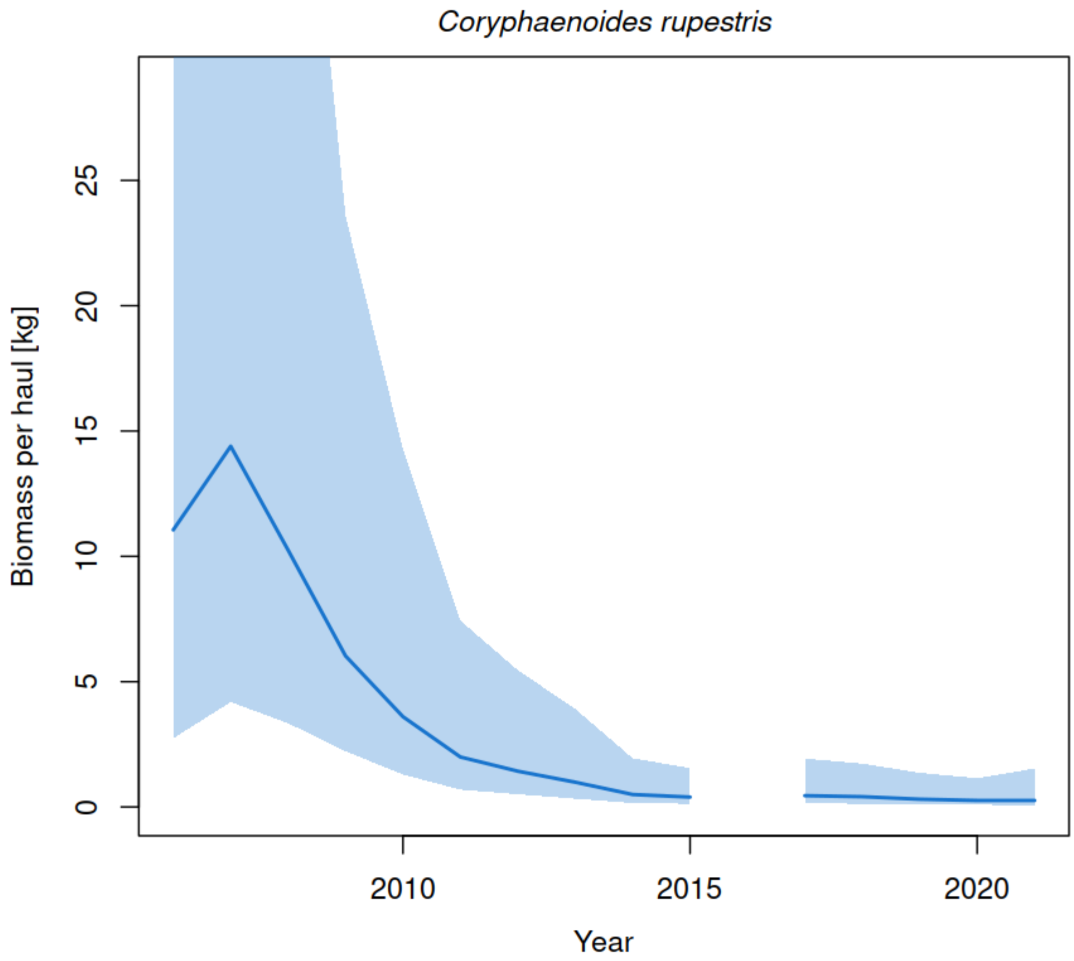

Figure 4.38. Roundnose grenadier. Abundance index based on survey catches measured in biomass.

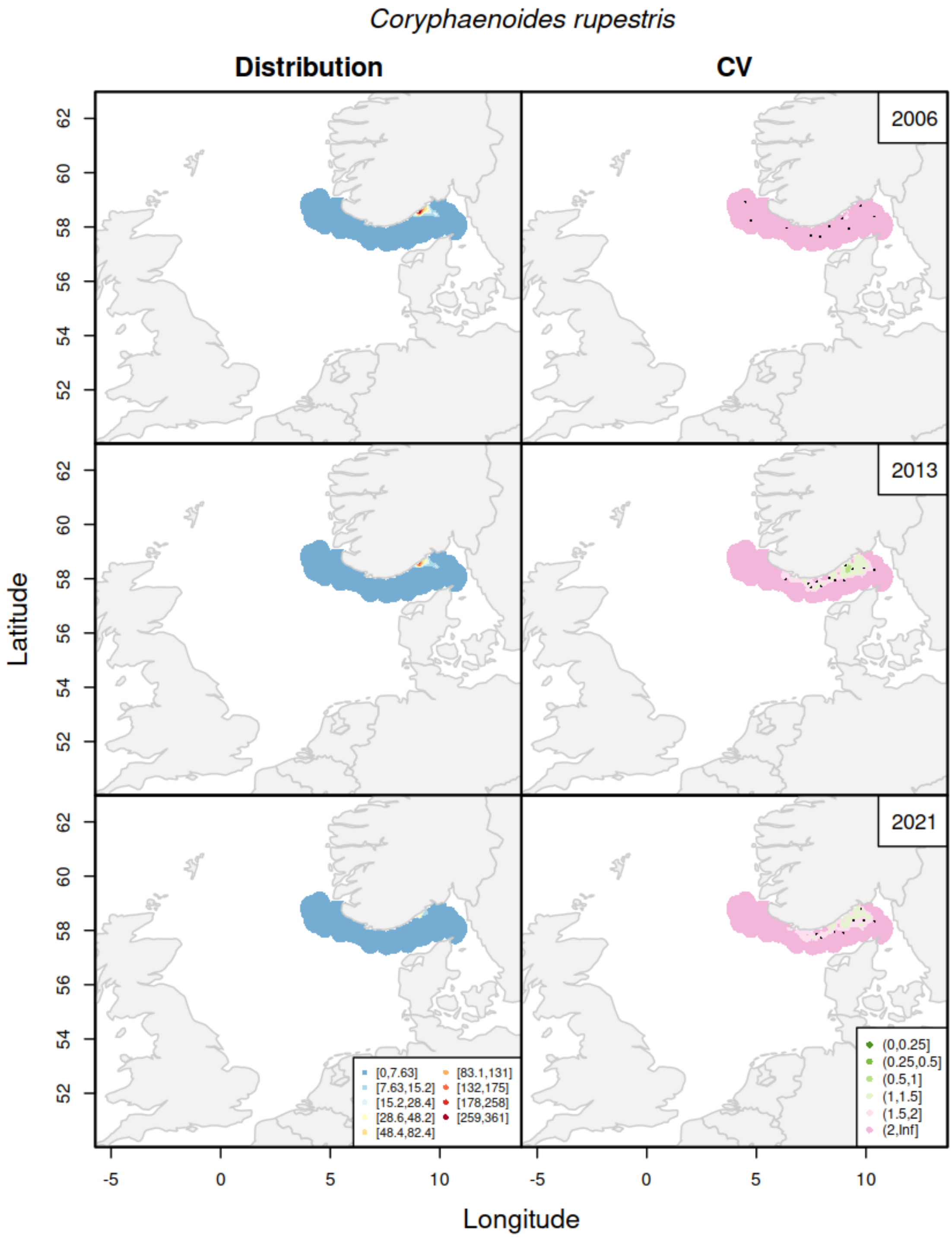

Figure 4.39. Roundnose grenadier. Spatial distribution based on survey catches in numbers.

Appendix 2: Correlation analysis for trend in abundance index

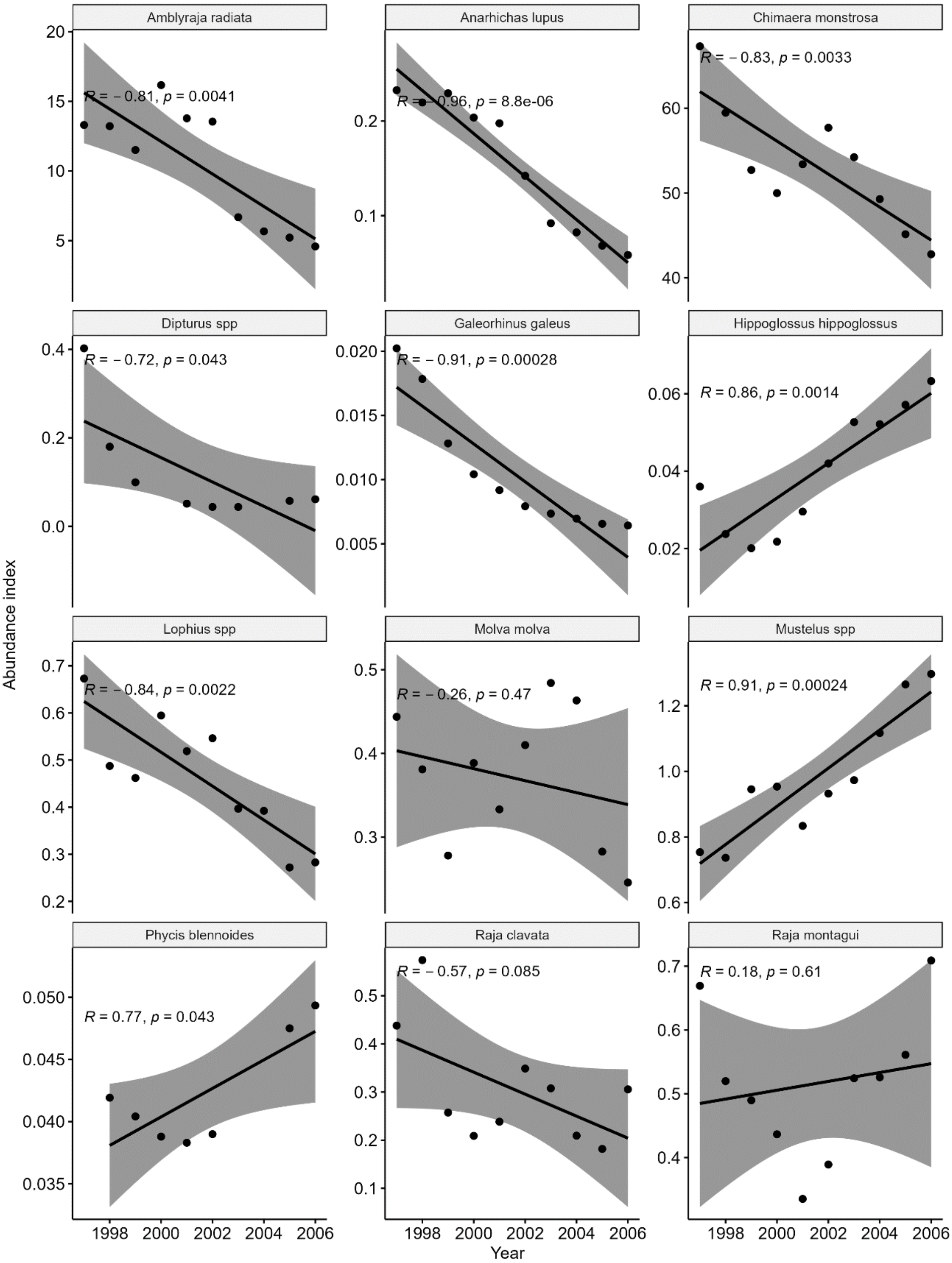

Figure 5.1. Pearson correlation analysis for trend in abundance index 1997-2006.

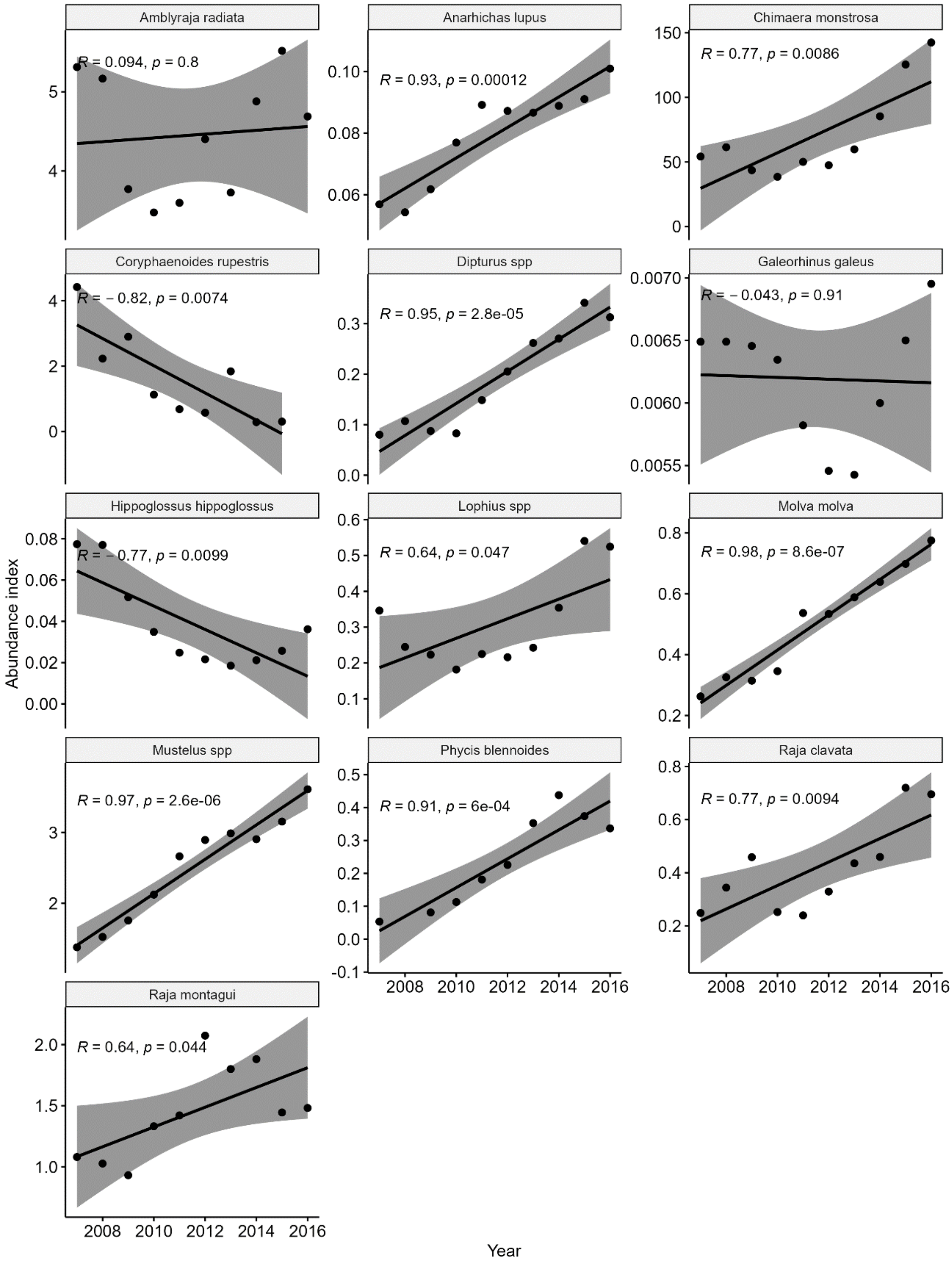

Figure 5.2. Pearson correlation analysis for trend in abundance index 2007-2016.

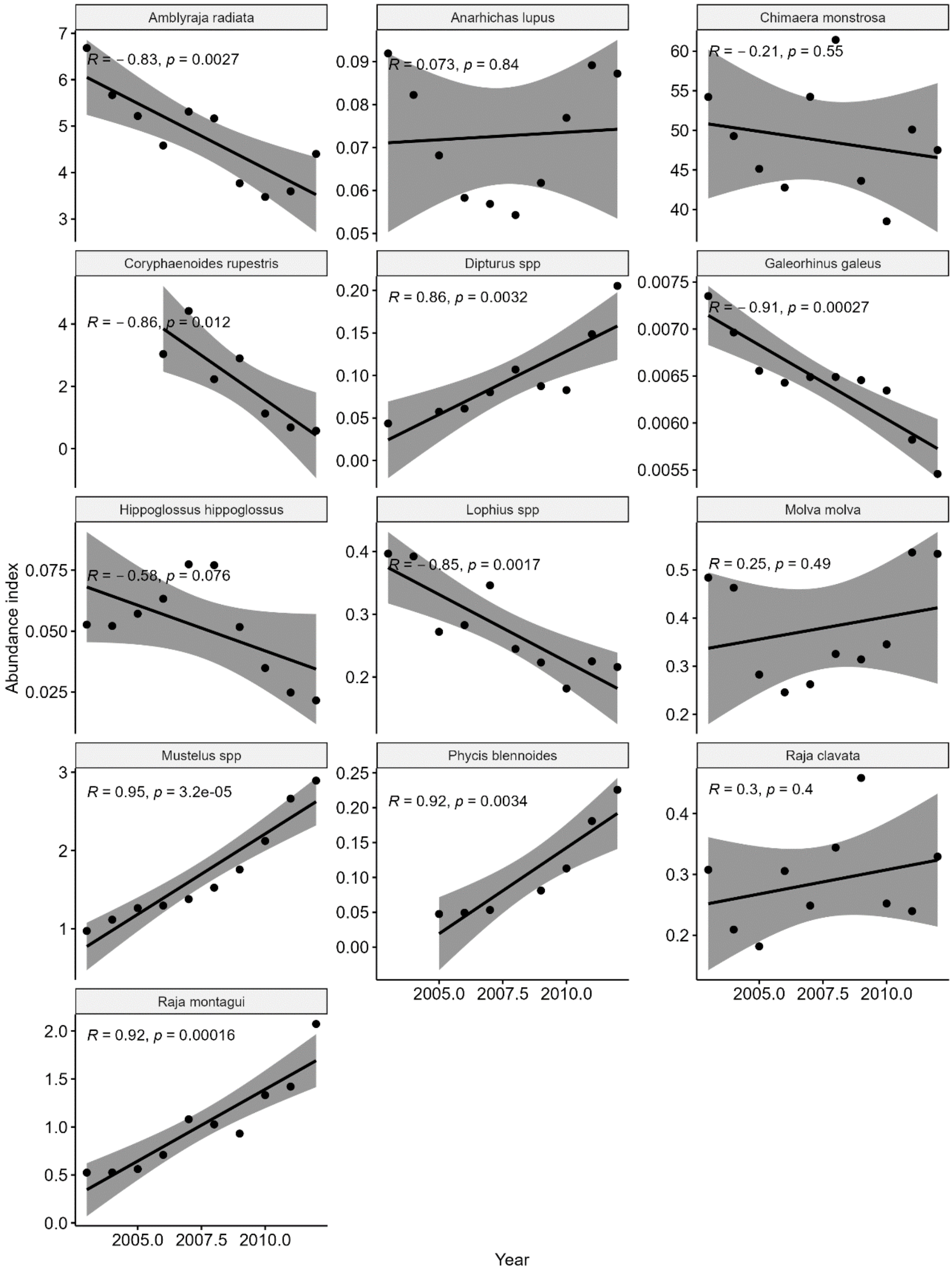

Figure 5.3. Pearson correlation analysis for trend in abundance index 2003-2012.

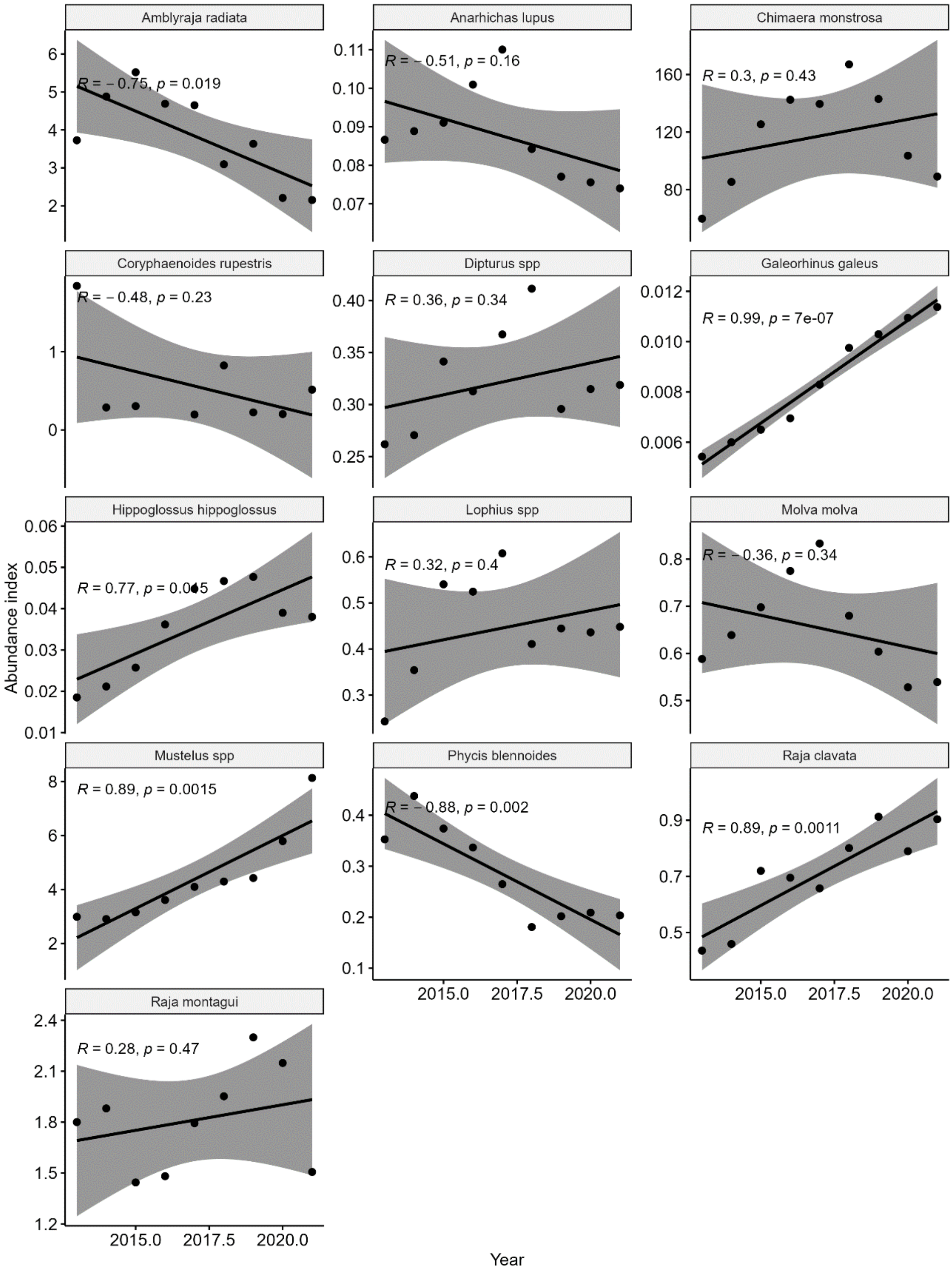

Figure 5.4. Pearson correlation analysis for trend in abundance index 2013-2022.

Technical
University
of Denmark

DTU Aqua
Henrik Dams Allé
DK-2800 Kgs. Lyngby

www.aqua.dtu.dk