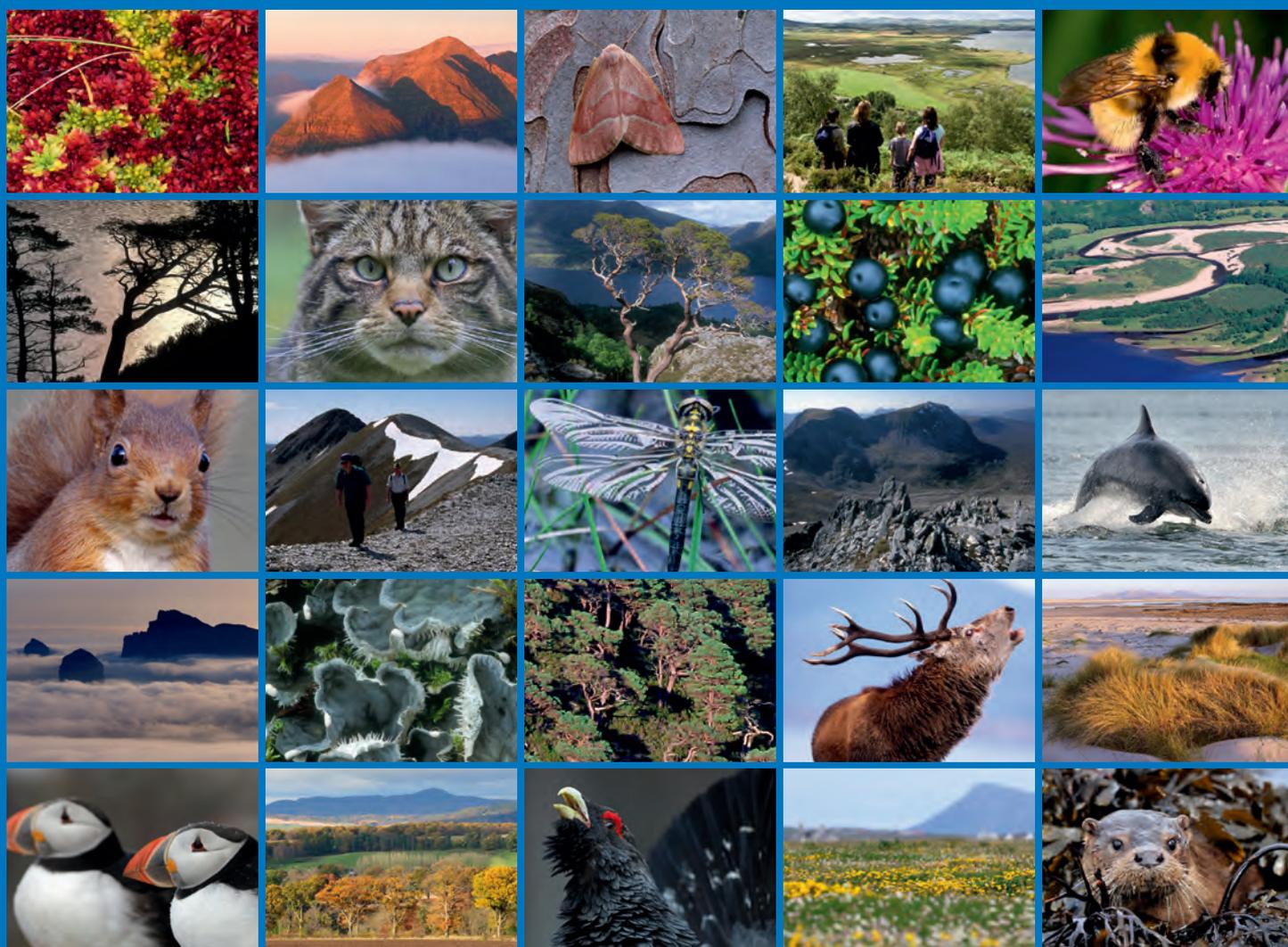


Further advice to Scottish Government on the selection of Nature Conservation Marine Protected Areas for the development of the Scottish MPA network





Scottish Natural Heritage
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ADVICE TO GOVERNMENT

Commissioned Report No. 780

**Further advice to Scottish Government on
the selection of Nature Conservation Marine
Protected Areas for the development of the
Scottish MPA network**

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ADVICE TO GOVERNMENT

Summary

Further advice to Scottish Government on the selection of Nature Conservation Marine Protected Areas for the development of the Scottish MPA network

Commissioned Report No.: 780
Year of publication: 2014

Background

This document sets out our formal advice to Scottish Government on four Nature Conservation Marine Protected Area proposals. These MPA proposals build on the advice provided by SNH and JNCC in our Advice to Scottish Government on the selection of Nature Conservation Marine Protected Areas for the development of the Scottish MPA network published in 2012. In that advice we identified that further survey and research was underway to enable us to provide formal advice on four remaining MPA search locations. The supporting survey and research work is now complete and all four of the MPA search locations have been fully assessed against the Scottish MPA Selection Guidelines.

The four MPA proposals that we are recommending have been developed from the MPA search locations although none are exactly the same i.e. we have made changes to them as the result of our assessment against the Selection Guidelines. We recommend that all four MPA proposals be designated as Nature Conservation MPAs.

We provide detail on the boundaries, features, draft conservation objectives and the potential contribution that these MPA proposals would make to the network of conservation sites under the Marine (Scotland) Act, 2010.

Main findings

- We recommend that all four of the MPA proposals should be designated for the proposed protected features.
- Should these MPA proposals be designated, we consider that all of the MPA search features being proposed as protected features would be assessed as adequate. This includes basking shark, minke whale, Risso's dolphin, burrowed mud, shelf banks and mounds and shelf deeps.
- This updated assessment of adequacy represents a change to our previous advice for one feature only, the basking shark. Although we have only recommended one MPA proposal for basking shark we have concluded that this is adequate. The rationale behind this is similar in some ways to that for fan mussel aggregations i.e. whilst there are some individual records of fan mussels, the only known aggregation lies within the Small Isles MPA. For basking sharks, whilst sightings and habitat modelling work reveal basking sharks in other locations, the only area which we currently understand to be essential is included within the Sea of Hebrides proposal.
- The recommended MPA proposals would also provide protection to circalittoral sand and mixed sediment communities and to northern sea fan and sponge communities. The

former would help to ensure that the MPA network represents the marine environment more broadly. The latter adds to the integrity of the Shiant East Bank MPA proposal.

- The assessment, review and sign-off process are consistent with the evidence principles set out in our 2012 MPA network advice. Publication of all supporting research and survey reports by the end of Summer 2014 ensures that we continue to make our evidence available. In our view, the internal sign-off process we have followed, together with peer review of the more novel work, represents independent expert review of our advice.

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We are grateful to the SNH Scientific Advisory Committee who reviewed the proposed scope and conclusions of the advice as part of the SNH sign-off processes. And to the Protected Areas Committee in their role in ensuring that due process had been followed. We also thank Marine Scotland for their support throughout the project and the peer reviewers for the habitat modelling and basking shark tagging work.

1. PURPOSE OF THIS ADVICE

This document sets out our formal advice to Scottish Government on four Nature Conservation Marine Protected Area proposals (hereinafter referred to as MPA proposals). These MPA proposals build on the advice provided by SNH and JNCC in our Advice to Scottish Government on the selection of Nature Conservation Marine Protected Areas for the development of the Scottish MPA network¹ published in 2012. In that advice we identified that further survey and research was underway to enable us to provide formal advice on four remaining MPA search locations. The supporting survey and research work is now complete and all four of the MPA search locations have been fully assessed against the Scottish MPA Selection Guidelines (hereinafter referred to as the Selection Guidelines²).

The MPA proposals that we are recommending are derived from the four MPA search locations although none are exactly the same i.e. we have made changes to them as the result of our assessment against the Selection Guidelines. Throughout the rest of this document we use the term MPA search location to refer to those sites identified for further assessment in our 2012 advice to Scottish Government. We apply the term MPA proposal to the sites as they are going through the assessment process and also once the assessment is complete.

1.1 Background

1.1.1 *The role of MPAs for cetaceans and basking sharks*

The Scottish MPA Selection Guidelines make reference to highly mobile species in a number of places. Specifically, in the section on *The Role of Nature Conservation Marine Protected Areas*, the Guidelines refer to 'essential areas for key life cycle stages e.g. breeding, feeding, courtship or nursery areas' and to 'significant aggregations of mobile species'. At the 4th national MPA stakeholder workshop in March 2012, we identified the role of MPAs for cetaceans and basking sharks as being to protect the habitats used by these species and to complement existing species protection measures³. Basking sharks are scheduled under the Nature Conservation (Scotland) Act (as amended) and cetaceans as European Protected Species through the Habitats Directive. This means all three species are currently afforded protection wherever they occur in Scotland's seas in relation to licensed activities. Nature Conservation MPAs for these species would not duplicate this existing level of species protection.

We recommend that Nature Conservation MPAs for minke whale, Risso's dolphin and basking shark should be used to provide protection to the habitats within the MPAs that are used by these species, with a particular focus on areas considered to be essential for key life cycle stages. This would reflect their role as set out in the Scottish MPA Selection Guidelines. This should include ensuring these habitats are managed to avoid significant disturbance from unlicensed activities. Note that the phrase 'unlicensed activities' refers to those activities that would not currently fall under consideration of the existing species protection measures e.g. they may be recreational activities and / or activities that, whilst licensed to operate, are not managed spatially at a scale that is relevant to the Nature Conservation MPA.

¹ <http://www.snh.gov.uk/docs/B1187811.pdf>

² <http://www.scotland.gov.uk/Topics/marine/marine-environment/mpanetwork/mpaguidelines>

³ <http://www.scotland.gov.uk/Topics/marine/marine-environment/mpanetwork/engagement/140312>

1.1.2 Recommendations for completing work on the MPA search locations

The two main recommendations made at the March 2012 workshop in relation to basking sharks and cetaceans were that decisions should be made based on effort-corrected sightings data and that habitat modelling work should be completed to support further work on the initial MPA search locations presented for these features. In our 2012 advice to Scottish Government we recommended that this work should be completed and stated our view that the MPA search locations could make a significant contribution to the MPA network in Scotland's seas. The recommendations arising from the workshop and from our 2012 advice provided the basis for our subsequent research and survey work, a summary of which is provided in the section below.

2. UPDATE ON SUPPORTING RESEARCH AND SURVEY WORK

We focussed on completing two key pieces of work to underpin assessment of the MPA search locations for cetaceans and basking sharks. Habitat modelling is an internationally accepted tool used to identify areas of importance for mobile species. The method that we used (see Paxton *et al.*, 2014a; 2014b) relies on combining available survey data to make seasonal and annual predictions about the density of animals in different locations. Our habitat modelling work focussed on minke whale, Risso's dolphin, white-beaked dolphin and basking shark. We have also undertaken two years of basking shark tagging work. Whilst tagging is also an accepted tool for better understanding animals' movements and use of particular areas, the work undertaken represents the first time that some of this technology has been used on basking sharks. Summaries of these projects are provided in Annexes 1 and 2.

For the fourth MPA search location, Shiant East Bank, the focus was on collecting additional data on seabed habitats (circalittoral sand and mixed sediment communities; northern sea fan and sponge communities) and on discussions with the British Geological Survey (BGS) over their recent analysis of the shelf bank and mound feature. In summary, we commissioned an additional seabed habitat survey in 2013 (reported in Allen, 2014⁴; Moore, 2014⁵) and a review of the extent to which the MPA network proposed in 2012 represented geodiversity features (Gordon *et al.*, 2013⁶). Further work has been completed by the BGS which provides a more detailed assessment of the existing multibeam data collected in 2011 and allows for better definition of the Quaternary of Scotland geodiversity feature. The latter is expected to be published later in 2014.

All SNH commissioned reports will be published by the end of Summer 2014. The information most directly relevant to the recommended MPA proposals is summarised in the *Data Confidence Assessments* (DCAs) for each of the MPA proposals (see also Section 3).

2.1 Approach to reviewing the MPA search locations

2.1.1 Cetaceans and basking sharks

There is a large amount of information available which is of relevance to further consideration of the MPA search locations for basking sharks and cetaceans. This comprises existing survey and research work carried out by others and the more recent habitat modelling and tagging work carried out as part of the Scottish MPA Project. To ensure consistency between the assessments of the different MPA search locations and different species, we adopted the following step-wise approach:

⁴ http://www.snh.org.uk/pdfs/publications/commissioned_reports/781.pdf

⁵ http://www.snh.org.uk/pdfs/publications/commissioned_reports/746.pdf

⁶ http://www.snh.org.uk/pdfs/publications/commissioned_reports/633.pdf

1. Consider areas identified as supporting persistently above average densities of relevant species through the habitat modelling work.
2. Refine these areas through the use of available effort-corrected sightings data.
3. Consider other data / information relating to the behaviour / use of these areas by these species.

The areas identified through the habitat modelling work were considered the best starting point. This is because the habitat modelling is based on a wide range of survey data from different sources. A number of assumptions had to be made in combining the different datasets for each species, but doing this allowed the widest possible dataset to be fed into the review of the search locations. The areas of persistently above average density identified through the habitat modelling were then refined using effort-corrected data because we felt that this provided a robust evidence-base i.e. using the model predictions backed up by sightings of the animals. Note that the information used was the adjusted densities from the habitat modelling work and not the effort-corrected sightings data used in the original position papers. The adjusted densities incorporate a wider dataset and are therefore effectively an update of the data used to define the MPA search location boundaries in 2012. Information on the behaviour/use of the area by these species then helped us to focus on areas that could be considered as essential (see *Glossary*), which was a key focus of the position papers from 2012 and is highlighted in the Scottish MPA Selection Guidelines.

2.1.2 *All other features*

For all the other proposed protected features for which either additional data were collected and/or more detailed interpretation has been completed, the approach has not changed to that used for the seabed habitats and geodiversity features associated with the MPA proposals recommended in our 2012 advice. The new information was used to complement existing data by, for example, helping us to understand better the fine-scale distribution of the features and species diversity of habitats. The Shiant East Bank MPA proposal was the only proposal for which boundary changes were driven by the review of information on these other features, rather than by the review of information on the mobile species.

3. CONSIDERATION OF RESULTS AND RECOMMENDATIONS ON NATURE CONSERVATION MPA PROPOSALS

In this section we consider the results of the recent research and survey work in light of the adoption of the assessment approach described above. As a result of the new information available to us and the assessment against the Scottish MPA Selection Guidelines, there are some differences between the MPA proposals that we are recommending and the original MPA search locations identified in 2012. These include changes to the boundaries recommended for all four MPA proposals, removal of one of the features from one of the MPA proposals and changes to the names of two. The recommended MPA proposals are shown in Figure 1 overleaf and summary details are provided in Table 1.

In the following sub-sections, covering each of the MPA proposals, figures are provided to support description of the main changes. These illustrate how the results of research and survey work have been used to complete our assessment.

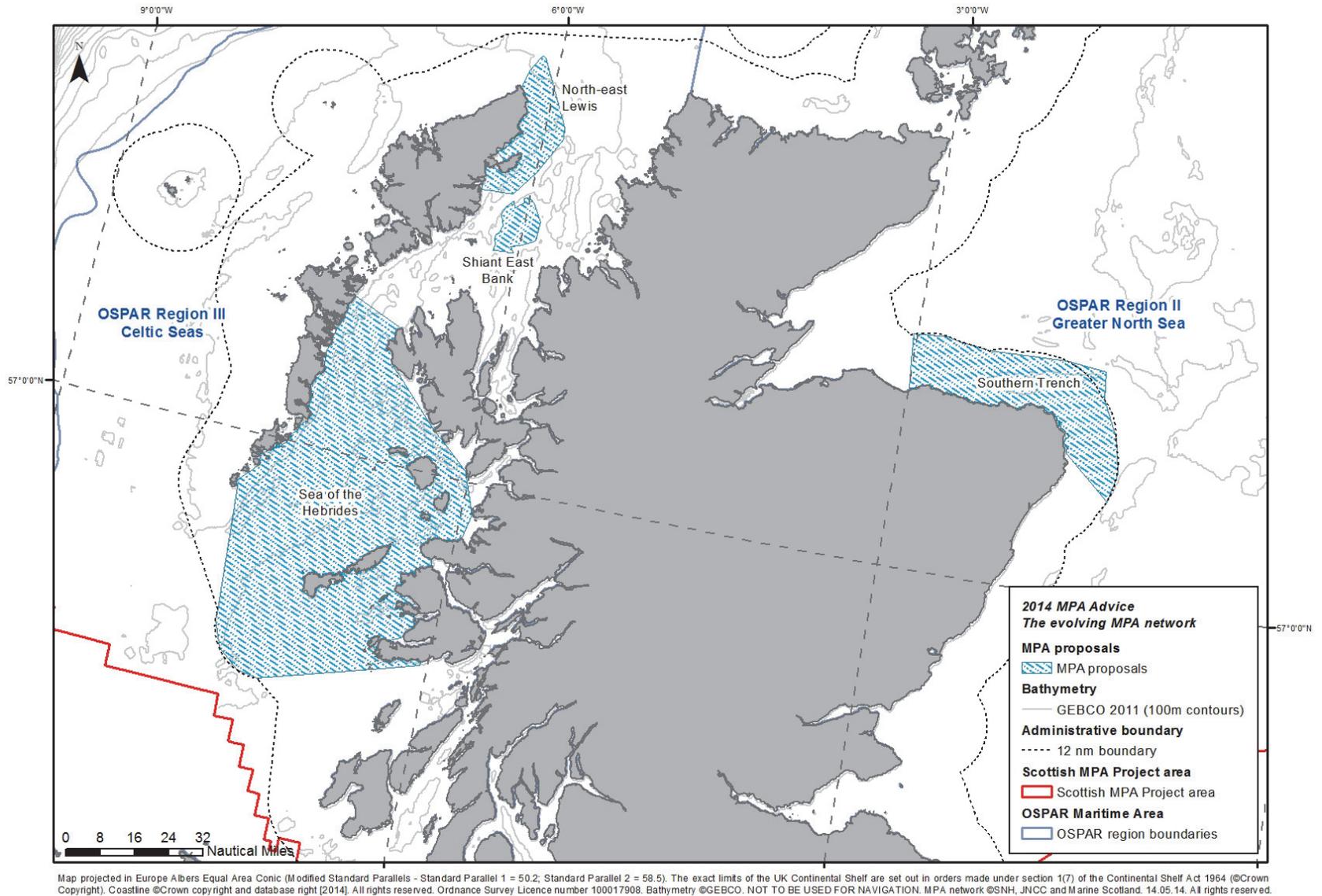


Figure 1. Boundaries of the recommended MPA proposals resulting from assessment of the remaining four MPA search locations.

Table 1. Summary details of the recommended MPA proposals.

MPA proposal	Proposed protected feature	Draft conservation objectives
Sea of the Hebrides [formerly Skye to Mull]	Biodiversity: Basking shark; fronts; minke whale.	Conserve (all features)
	Geodiversity: Marine geomorphology of the Scottish shelf seabed.	
Shiant East Bank	Biodiversity: Circalittoral sand and mixed sediment communities; northern sea fan and sponge communities; shelf banks and mounds.	Conserve (all features)
	Geodiversity: Quaternary of Scotland - glacial lineations; soft and rock drumlins; iceberg scours.	
North-east Lewis [formerly Eye Peninsula to the Butt of Lewis]	Biodiversity: Risso's dolphin; sandeels.	Conserve (all features)
	Geodiversity: Marine geomorphology of the Scottish shelf seabed - longitudinal bedform field; Quaternary of Scotland - glaciated channels / troughs; landscape of areal scour; megascale lineation.	
Southern Trench	Biodiversity: Burrowed mud; fronts; minke whale; shelf deeps.	Conserve (all features)
	Geodiversity: Submarine mass movement - slide scars; Quaternary of Scotland - sub-glacial tunnel valleys and moraines.	

Changes to the boundaries of the MPA proposals for basking shark and cetaceans were influenced by the habitat modelling and tagging work, but not by the other behavioural information on these species. Therefore the sections below do not discuss the latter but this information will be presented in the *Detailed assessments against the Scottish MPA Selection Guidelines* (DAAGs). Should the Minister decide to go out to consultation on these MPA proposals, the DAAGs will be published at the start of the consultation. Details of the evidence to assess each of the MPA search locations are provided in the accompanying *Data Confidence Assessments*⁷. The DCAs include evidence used to assess all of the features (both biodiversity and geodiversity) proposed for each site. Only those features for which there has been a significant change in our assessment since 2012 are described further within this advice.

3.1 Sea of the Hebrides MPA proposal

The results of the habitat modelling work have led us to recommend significant changes to the proposed boundary. The results confirmed the importance of the MPA search location for basking shark and highlighted the importance of the waters to the west of the original Skye to Mull search location boundary for minke whales (see Figure 2). We recommend that the boundary of the MPA proposal extend across to the east coast of the Uists. Sea lochs

⁷ [http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/marine-protected-areas-\(mpa\)/scottish-mpa-project/](http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/marine-protected-areas-(mpa)/scottish-mpa-project/)

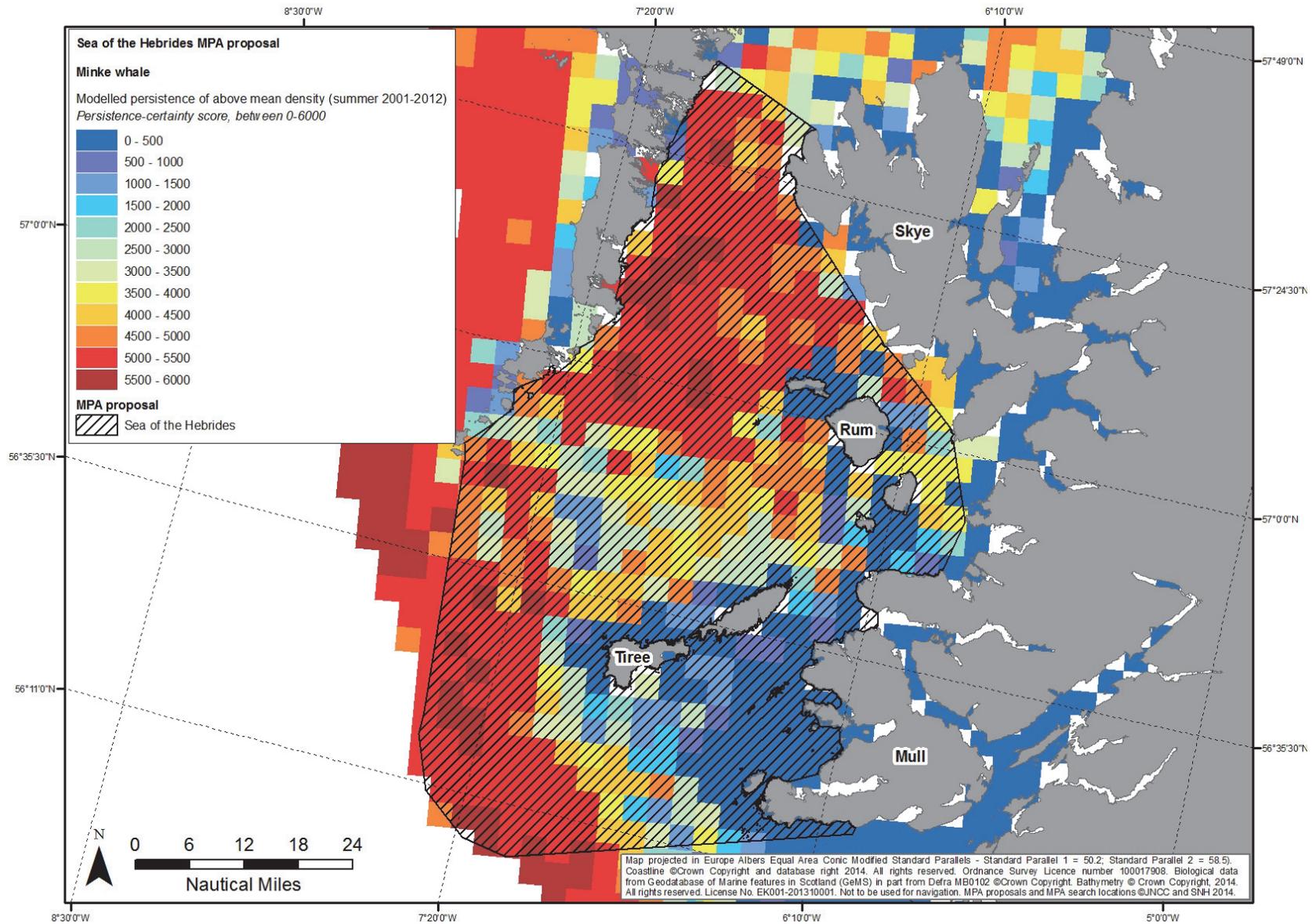


Figure 2. Results of habitat modelling showing areas that are persistently above average density for minke whale and the revised boundary for the Sea of the Hebrides MPA proposal.

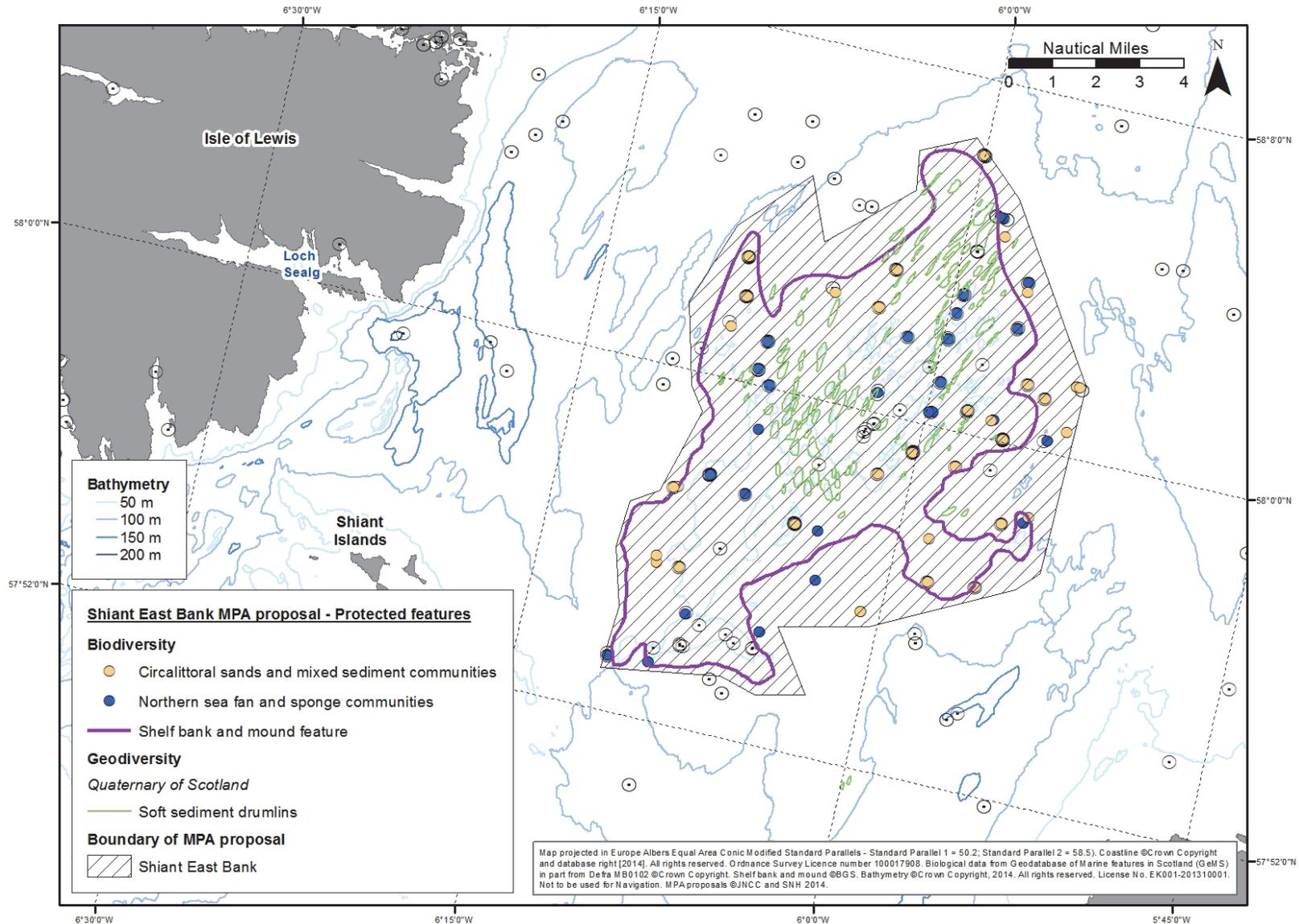


Figure 3. The Shiant East Bank MPA proposal showing the distribution of proposed biodiversity protected features and 'null' records used to delineate the new boundary.

and other inlets have largely been excluded, as have some areas along the eastern margins of the boundary (e.g. Sound of Sleat). Note that, as previously, the fronts feature has been used to define the south-western tip of the proposed MPA.

3.2 Shiant East Bank MPA proposal

The additional survey data and the detailed analysis of recent multibeam bathymetry data by BGS provide up-to-date information on the Shiant East Bank MPA proposal. The presence of all proposed protected features and their broad distribution and extent have been confirmed. A significantly greater level of detail is now available in relation to the geodiversity interests. Using this information, SNH has revised the site boundary to ensure that all records of the proposed protected features have been retained. Null records (i.e. survey/sample locations where proposed protected features were not recorded) were used to exclude areas from the boundary (see Figure 3).

3.3 North-east Lewis MPA proposal

Figure 4 shows the revised boundary of the MPA proposal with the effort-corrected sightings of Risso's dolphin (shown as adjusted densities) and the areas that are persistently above average density. The northernmost limit of the boundary is still being driven by the sandeel data, however, we recommend that the eastern boundary be enlarged to reflect recently updated Risso's dolphin data.

3.4 Southern Trench MPA proposal

Figure 5 shows the MPA proposal with the effort-corrected sightings of minke whale (shown as adjusted densities) and the relationship between the areas identified through the habitat modelling as being persistently of above average density for minke whale. The boundary of the recommended MPA proposal has been broadened to include an additional area to the west of the original MPA search location. The south-eastern edge of the boundary has been defined with reference to the front feature.

Note that the previous boundary in places tracked the 12 nm limit. We have redrawn that part of the boundary using a minimum number of straight lines. This has taken account of the underlying species data and is consistent with the boundary setting principles for Nature Conservation MPAs (as set out in the Selection Guidelines).

3.5 Recommendation on removal of white-beaked dolphin

The results of the habitat modelling work (see Figure A1.5; Annex 1) identified white-beaked dolphins as being present at above average densities across a large proportion of Scottish territorial waters. Whilst there are effort-corrected data for this species, it was not possible to identify areas that could be considered essential. Therefore we recommend that white-beaked dolphin should be removed from the Southern Trench search location and no further work should be carried out on this species as part of the Scottish MPA Project. It would still be appropriate to consider conservation policies and measures for white-beaked dolphin under either the species or wider seas pillars within Marine Scotland's Marine Nature Conservation Strategy (Marine Scotland, 2011).

4. CONTRIBUTION TO THE SCOTTISH MPA NETWORK

Our approach to assessing adequacy and the results of our previous assessment are set out in our 2012 MPA network advice. This section updates that assessment, based on the recommended MPA proposals (i.e. focussed on the MPA search features that we are recommending as proposed protected features of these four sites). This assessment

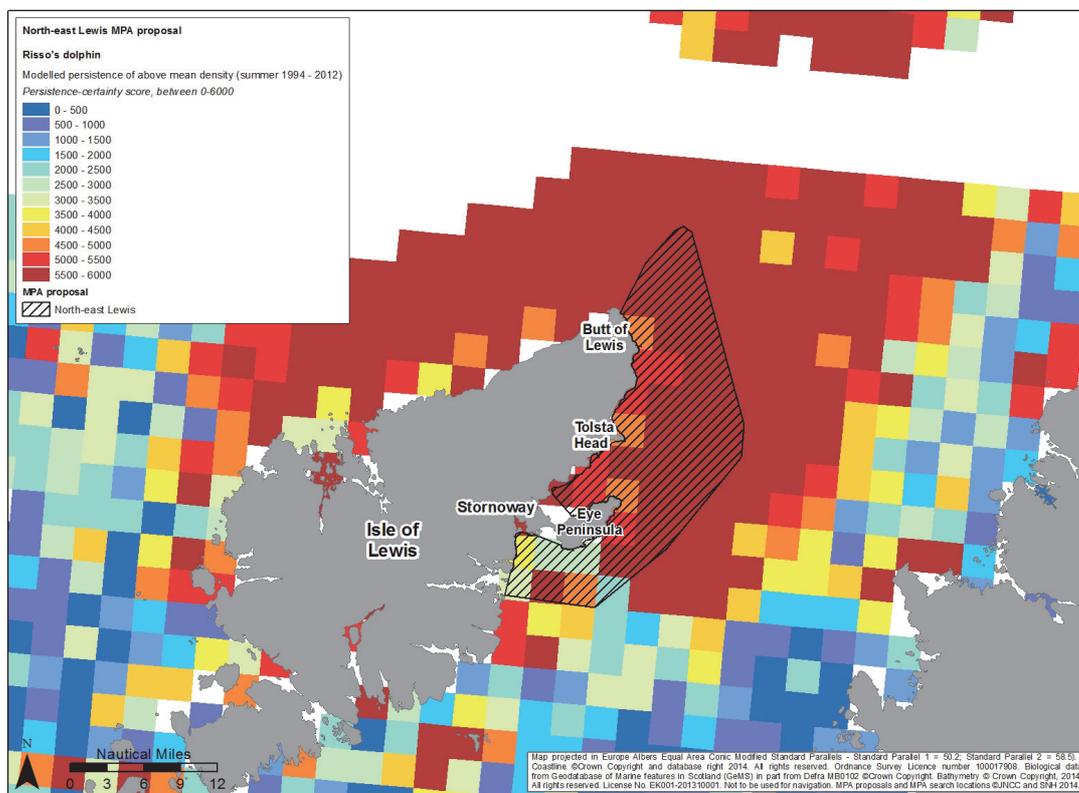
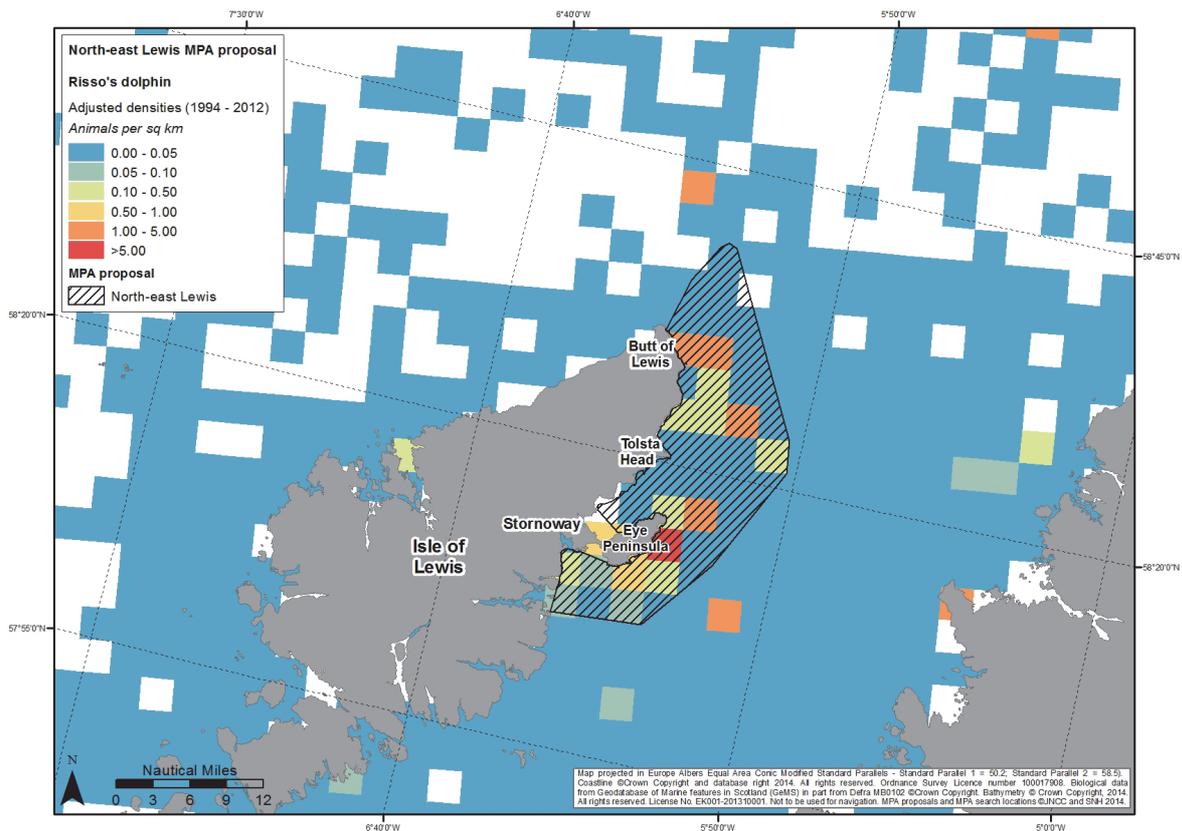


Figure 4. Effort-correct sightings (adjusted densities) and areas of persistently above average density for Risso's dolphin in relation to the North-east Lewis proposal.

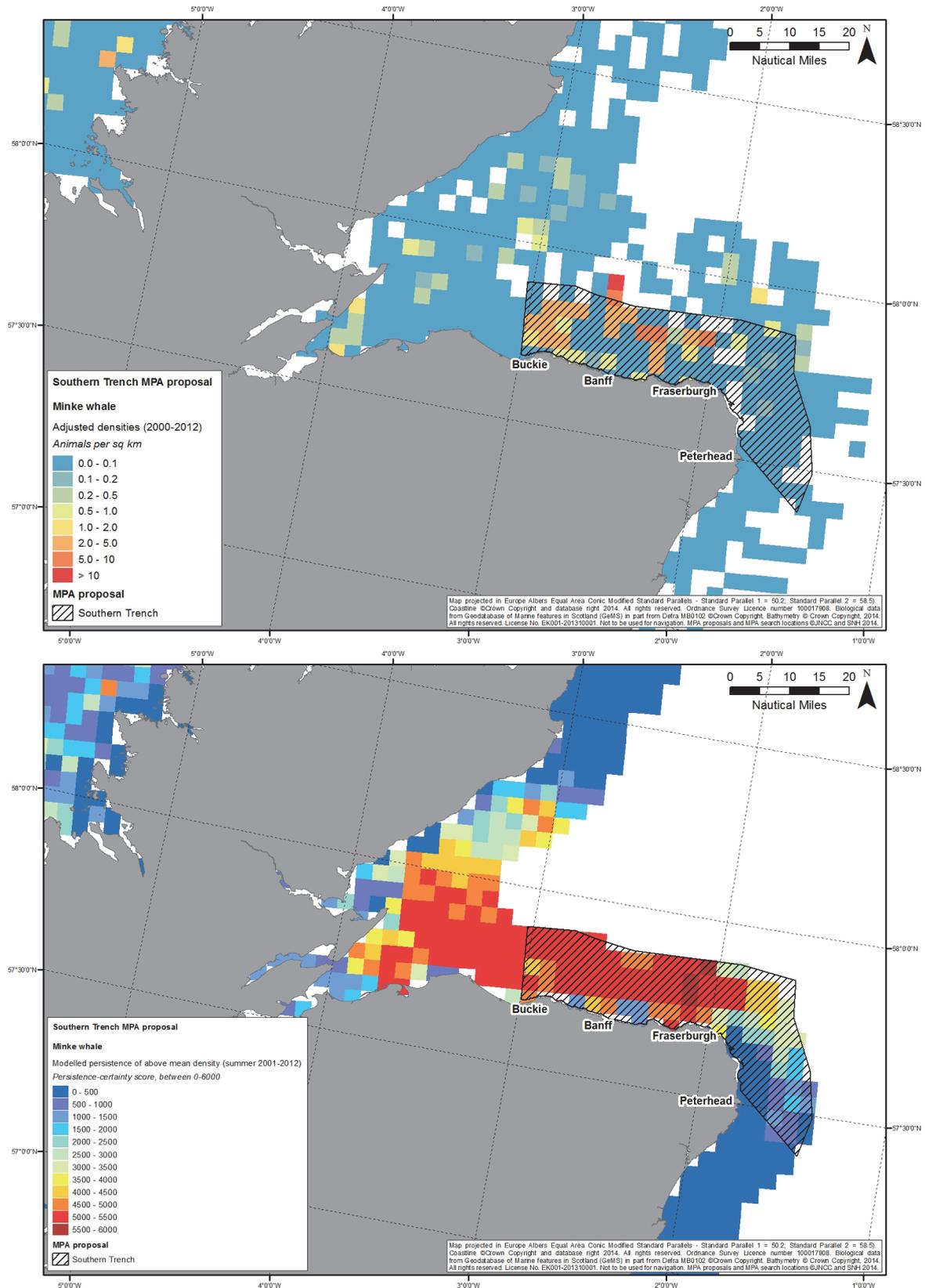


Figure 5. Effort-correct sightings (adjusted densities) and areas of persistently above average density for minke whale in relation to the Southern Trench proposal.

therefore covers minke whale, Risso's dolphin, basking shark, burrowed mud, shelf deeps and shelf banks and mounds. Note that although northern sea fan and sponge communities is an MPA search feature, it is not discussed here because it has not been recommended to help achieve adequacy for this feature within the network. The feature is recommended within the Shiant East Bank MPA proposal to add to the integrity of the site (akin to our 2012 recommendation to add seagrass beds to the South Arran MPA in the Clyde).

In summary, these MPA proposals would make the following contribution to the network:

- Representation - These proposals provide representation of three of the highly mobile MPA search features that would not otherwise be included within the network: minke whale, Risso's dolphin and basking shark. As discussed, it is recommended that white-beaked dolphin be dropped from further consideration (and is therefore not discussed in the remainder of this section). In terms of the other features, these MPA proposals would ensure representation of the shelf banks and mounds in OSPAR Region III and representation of shelf deeps in OSPAR Region II.
- Replication - These proposals would enable replication of minke whale within the Scottish MPA network. As highlighted in our 2012 MPA network advice, although Risso's dolphin would only be included once (within the North-east Lewis MPA proposal), we do not believe that there are any other locations that could constitute essential areas for this species in Scottish waters. Therefore we consider Risso's dolphin would be adequately protected even though replication of this feature has not been achieved within the Scottish MPA network. Basking shark would only be included once within the MPA network, within the Sea of the Hebrides, however, there are currently insufficient data to consider any other locations for this species (see also comments under linkages below). Therefore, we recommend that this species is considered adequate, despite lack of replication. If further data become available then this species could be reconsidered as part of future reviews of the network. The Shiant East Bank MPA proposal would ensure replication of the shelf banks and mounds feature (with Firth of Forth Banks Complex MPA within OSPAR Region II) and the Southern Trench MPA proposal would ensure replication of shelf deeps (with Small Isles MPA in OSPAR Region III). Burrowed mud within the Southern Trench MPA proposal would be the only example of this feature in the Scottish network within OSPAR Region II outside the Fladen Grounds (Central Fladen MPA), with which recent research has shown no connectivity (Gallego *et al.*, 2013). See comments under resilience which is the principle part of the stage five guideline that has driven us to recommend the number of different examples of burrowed mud included within Nature Conservation MPAs.
- Geographic range and variation - For these three highly mobile species, the focus of this part of the assessment was on their geographic range, because there is no known ecological variation across Scotland's seas. The only species whose geographic range would not be reflected in the network would be basking shark.
- Linkages - the assessments for all of the highly mobile species highlight linkages with the wider population, rather than between different MPAs. MPA proposals were developed on the basis of essential areas for key life cycle stages e.g. for minke whale, the inclusion of habitats of key prey species and for Risso's dolphin, the inclusion of areas with relatively high numbers of calves. The results of the tagging work for basking shark have given us greater insight into the movements of this species, showing direct links with areas considered to be 'hotspots' for basking sharks off the coast of Northern Ireland and the Isle of Man. We consider it appropriate to think about the assessment of linkages at this wider scale because of the large distances over which these animals have been shown to travel and

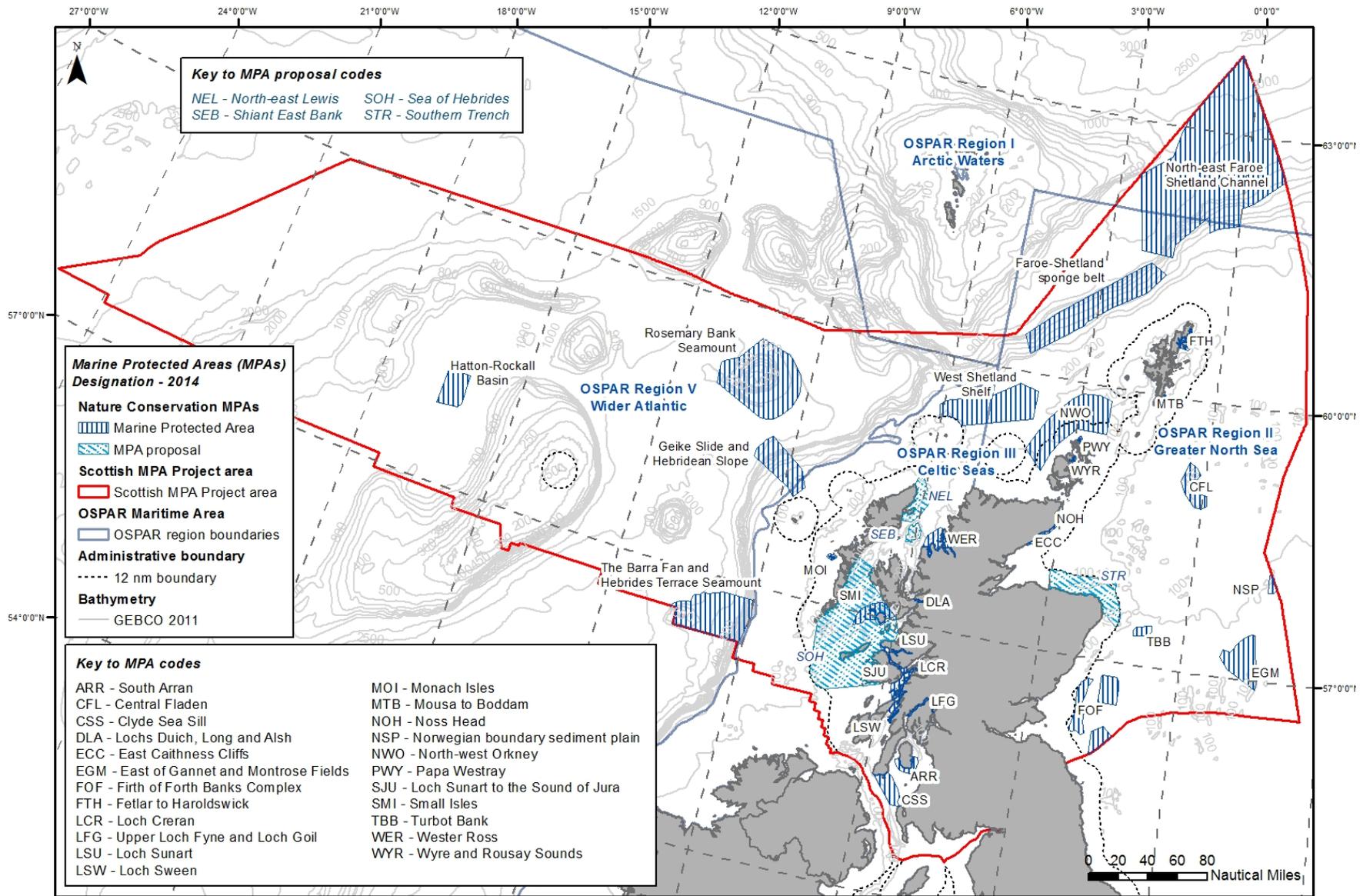


Figure 6. The four MPA proposals shown in context with the Nature Conservation MPAs designated in July, 2014.

- therefore consider this part of the adequacy assessment for basking shark to have been met. This is a change to our previous advice on basking shark.
- **Resilience** - the focus of this part of the assessment was on features that were considered to be threatened and / or declining and / or restricted in their distribution. This part of the assessment did not lead to any changes to the number of examples of MPAs recommended for the three mobile species. In our 2012 MPA network advice we highlighted the inclusion of burrowed mud within the Southern Trench

MPA proposal as one of the examples needed to achieve resilience within the MPA network, given that this feature is on the OSPAR Threatened and/or Declining list and the proportional importance of Scotland's seas for this feature.

In summary, should these MPA proposals be designated for the proposed protected features, together with the possible MPAs designated in 2014 (see Figure 6), all of the features to which the MPA proposals relate would be considered adequate. As discussed above, we have only recommended one site for basking shark although we have concluded that inclusion of basking shark within the MPA network would be adequate if this MPA proposal were to be designated. The rationale behind this is similar in some ways to that for fan mussel aggregations i.e. whilst there are some individual records of fan mussels, the only known aggregation lies within the Small Isles MPA. For basking sharks, whilst sightings and habitat modelling work reveal basking sharks in other locations, the only area which we currently understand to be essential is included within the Sea of Hebrides proposal.

5. USE OF EVIDENCE

In our 2012 MPA network advice SNH and JNCC set out a series of principles that we identified for our use of evidence as part of the Scottish MPA Project (see Section 5.4 *Collecting and applying evidence* in our 2012 MPA network advice). These principles were designed to align with the conclusions of a Defra-commissioned independent review on the use of scientific evidence in the selection of marine Special Areas of Conservation (Graham-Bryce, 2011⁸). We continued to follow these principles when completing our assessment of the MPA proposals. Specifically:

- The results of the habitat modelling and basking shark tagging work have already been published and are available on the SNH website. The remaining SNH reports will be published by the end of Summer 2014.
- Our advice has been reviewed by SNH's Scientific Advisory Committee, Management Team and Protected Areas Committee. Details of the membership of each of these group are also available on the SNH website.
- Given the novel nature of the habitat modelling and basking shark tagging, we also sought peer review of the project reports from relevant academics.

Our view is that the process we have followed has used the best available evidence. The data confidence assessments that accompany this advice provide more detail and include a description and evaluation of the type, age, source and extent of the evidence used to support each of the MPA proposals. The review processes that we have followed included an additional step of peer review of the habitat modelling and basking shark tagging work. We are confident that together, the different steps in reviewing our advice represent an independent expert review.

⁸ <https://www.gov.uk/government/publications/independent-review-of-the-evidence-process-for-selecting-marine-special-areas-of-conservation-proposals>

6. NEXT STEPS

We expect the advice contained in this document to inform Marine Scotland's advice to Scottish Ministers later in 2014. We then expect Scottish Ministers to provide a steer on the next steps including on whether and when they would like formal consultation to be undertaken.

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8. GLOSSARY

Adjusted densities - The observed densities of animals, based on all available effort-corrected survey data. The densities are adjusted in order to correct for imperfect detection (i.e. where not all animals are seen by the observer) and for availability (i.e. where not all animals are at the sea surface to be seen).

Bootstrap - A statistical technique used to estimate uncertainty in modelled predictions. A large number of pseudo-data sets are generated randomly based on the parameters of the fitted models and their associated uncertainty. The model is fitted to each bootstrap data set to provide a series of estimates of the mean (density), which can be used to estimate variance in the predictions.

Confidence limit - An indication of the lower and upper bounds of the range in which the estimate is thought to lie. A measure of uncertainty in the estimate.

Effort-corrected data - Animal sightings data that have been standardised based on the survey effort (e.g. amount of time spent searching/ distance covered) undertaken to produce the sighting.

Essential areas - In the context of the MPA Selection Guidelines these are areas of particular importance for key life cycle stages of mobile species, such as areas used for breeding, feeding, courtship and as nursery areas, or areas supporting significant aggregations of mobile species.

Habitat modelling - A statistical technique whereby animal sightings data are modelled with relevant habitat variables e.g. water depth, seabed sediment type, sea surface temperature, chlorophyll concentration etc. Models can help to describe the observed distribution of animals; to predict the distribution of animals (e.g. into regions of low effort); or to explain the observed distribution of animals.

ANNEX 1: HABITAT MODELLING (MINKE WHALE, RISSO'S DOLPHIN, WHITE-BEAKED DOLPHIN AND BASKING SHARK)

Habitat modelling was carried out for each of minke whale, Risso's dolphin, white-beaked dolphin and basking shark. The project was undertaken by the Centre for Research into Ecological and Environmental Modelling (CREEM) at St Andrews University (Paxton *et al.*, 2014 a & b).

The aims of the work were to predict the relative densities for each of the above species, to identify regions of persistent (relative) high densities of each species and if possible to explain the distributions in relation to relevant environmental variables. To achieve these aims, survey data (1994 - 2012) were combined from a variety of sources into a single spatially indexed density data set. Spatial models were then fitted to these data for each species, and used to make seasonal and annual predictions of relative density over the entire Scottish territorial waters. Uncertainty in the predictions was generated by means of a bootstrap. In addition, persistent areas of above average density were identified by considering the summer prediction surface for each year of the data, with certainty incorporated in the persistence surface using a bootstrap. These methods are described in detail within the full report (Paxton *et al.*, 2014b).

For each species, the project generated observed densities over the time series of data, along with seasonal predictions and a range of annual predictions, all with related confidence surfaces. Examples of these outputs are shown for minke whale in Figures A1.1 and 1.2. The full range of predictions for minke whale, along with the predictions for Risso's dolphin, white-beaked dolphin and basking shark are given in the report (Paxton *et al.*, 2014b).

Persistence-certainty plots were also produced for each species (see Figures A1.3 - A1.6) to provide information on areas predicted to be persistently above average density. These plots reflect both persistence in time and the certainty in the predictions and hence provide a summary of all the available information. They identify areas in which the animals are predicted to be persistently at higher than average density rather than high density areas *per se*. The reason for taking this approach was to avoid setting numerical thresholds for which our understanding of the ecological significance of these thresholds was either limited or did not exist.

On comparing across all these outputs for each species, the areas of interest identified for minke whale included the areas south and west of the Hebrides, the Sea of the Hebrides and the Moray Firth, while the single identified contiguous higher than average density area for Risso's dolphin was the region to the north of Lewis / Harris. White-beaked dolphins were widely dispersed in slightly offshore waters. The northern part of the Minch and off Angus and eastern Aberdeenshire are large contiguous areas of persistent higher than average density. Identified areas for basking shark included the waters of the eastern Sea of the Hebrides and to the west of the Hebrides.

Within the areas identified as a result of the habitat modelling work, several data poor regions were identified. These were west of the Hebrides, around the Isle of Arran, the coast of Sutherland and Caithness, Orkney and Shetland.

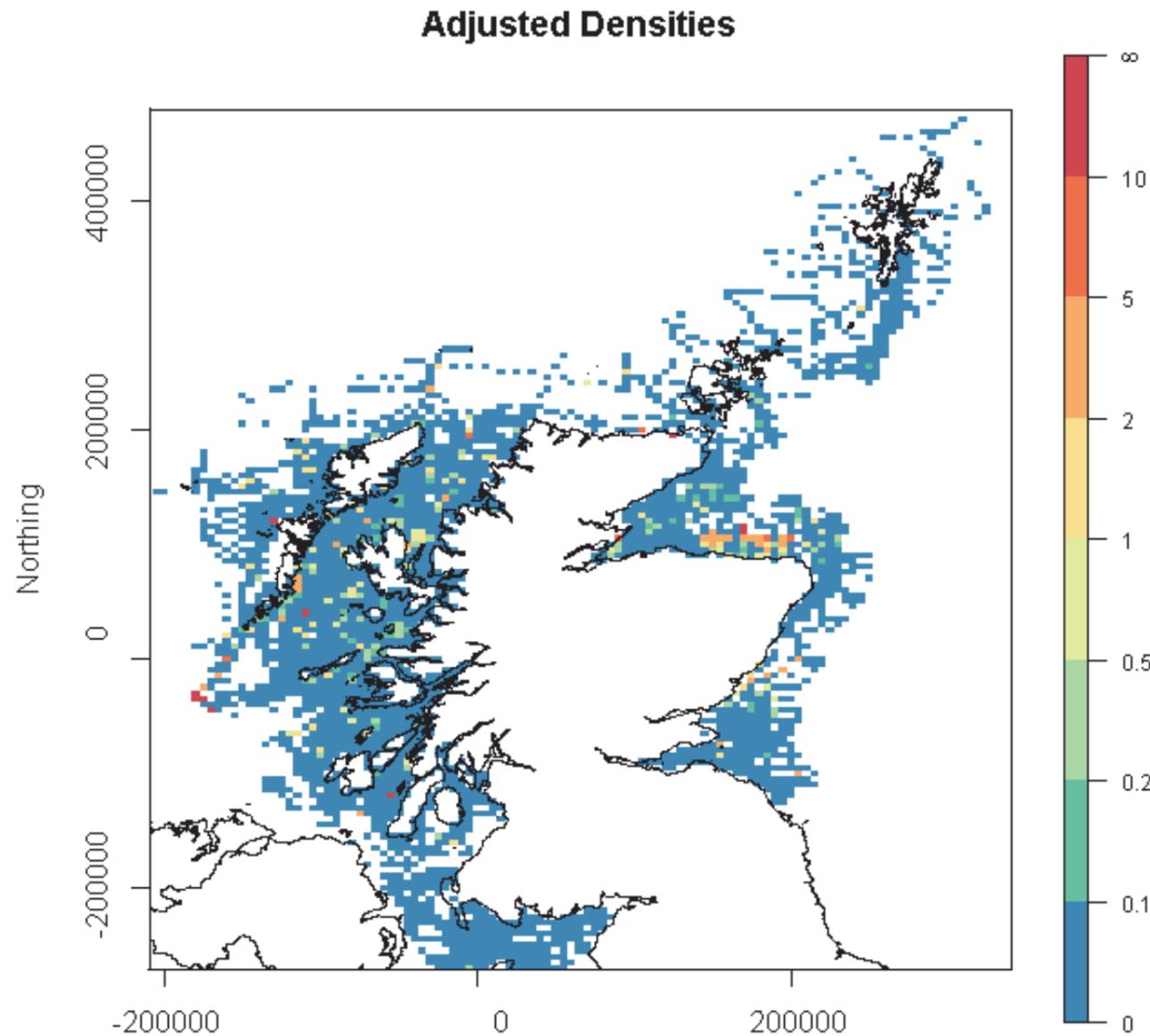


Figure A1.1 (reproduced from Paxton et al., 2014b) Observed adjusted relative densities (\bar{D}) of minke whale 2000 - 2012 - all seasons. Colours indicate animals per km². Each cell is 5 by 5 km. The \bar{D} surface provides a summary of the relevant input data for minke whale both in terms of showing adjusted observed densities and also where there was actually effort across the entire time series of data. Predictions in regions of low effort should be treated with caution.

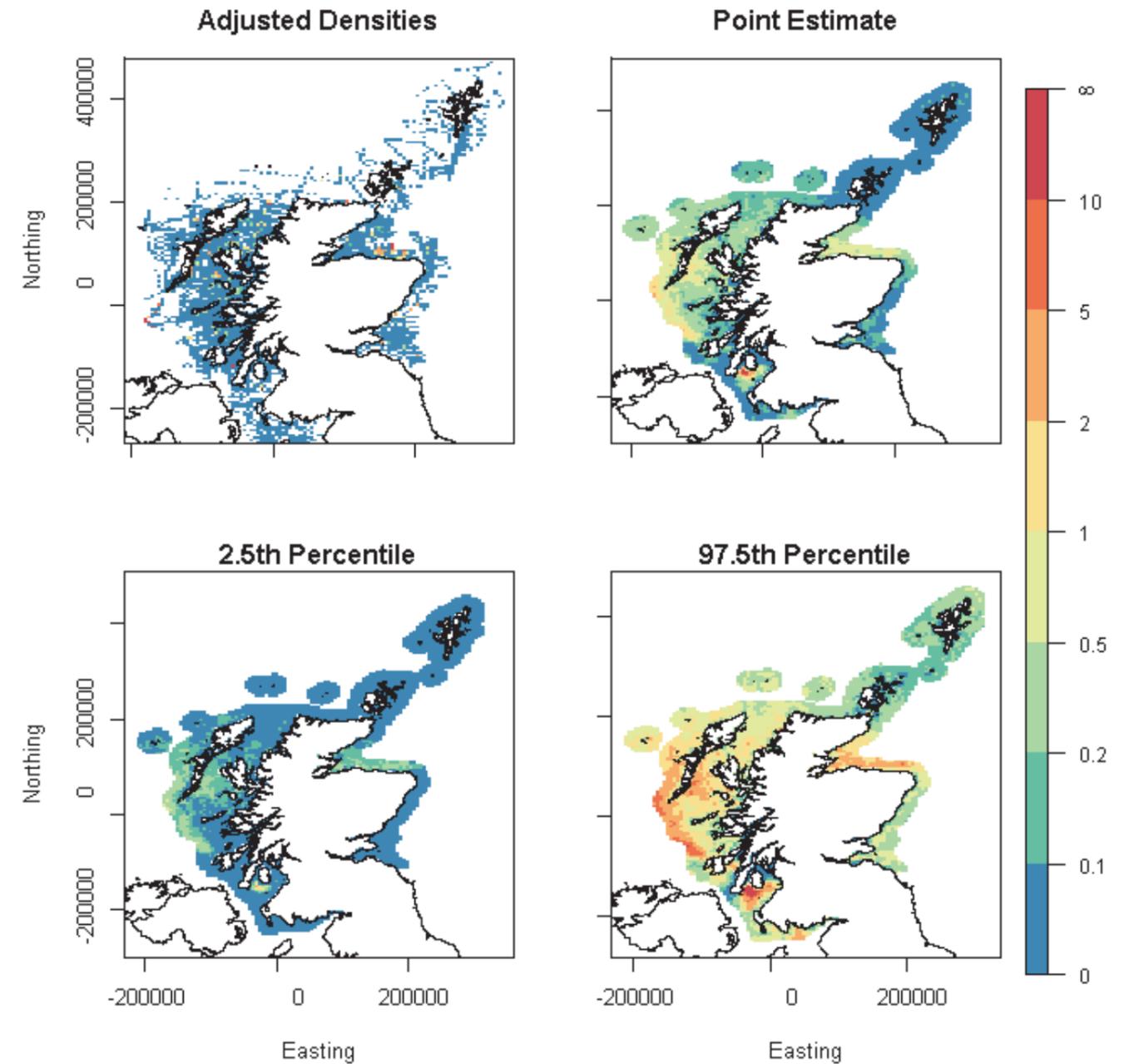


Figure A1.2. (reproduced from Paxton et al., 2014b) Observed adjusted summer (2000 - 2012) densities (\bar{D}) of minke whale. Estimated density surfaces for minke whale on August 15th 2012. Colours indicate animals per km². Each cell is 5 by 5 km. In interpreting these maps, the following points should be considered:

- The \bar{D} surface (top left hand side) provides a summary of the relevant input data for the prediction both in terms of adjusted observed densities but also shows where there was actually effort (albeit not necessarily from the year in question) in that season. Predictions in regions of low effort should be treated with caution.
- The point estimate surfaces (top right hand side) should be considered along with the estimated uncertainty surfaces (bottom row). Of particular interest is the lower bound confidence limit (2.5th Percentile) and whether that is substantially more than zero in the region of interest, as this is robust evidence of high relative density in the region.
- Single predictions over very small areas are generally more likely to be biased than predictions over larger areas. So isolated small regions should be treated with caution.
- Summer is the most effort rich season so it is perhaps conservative to base conclusions primarily on this season.

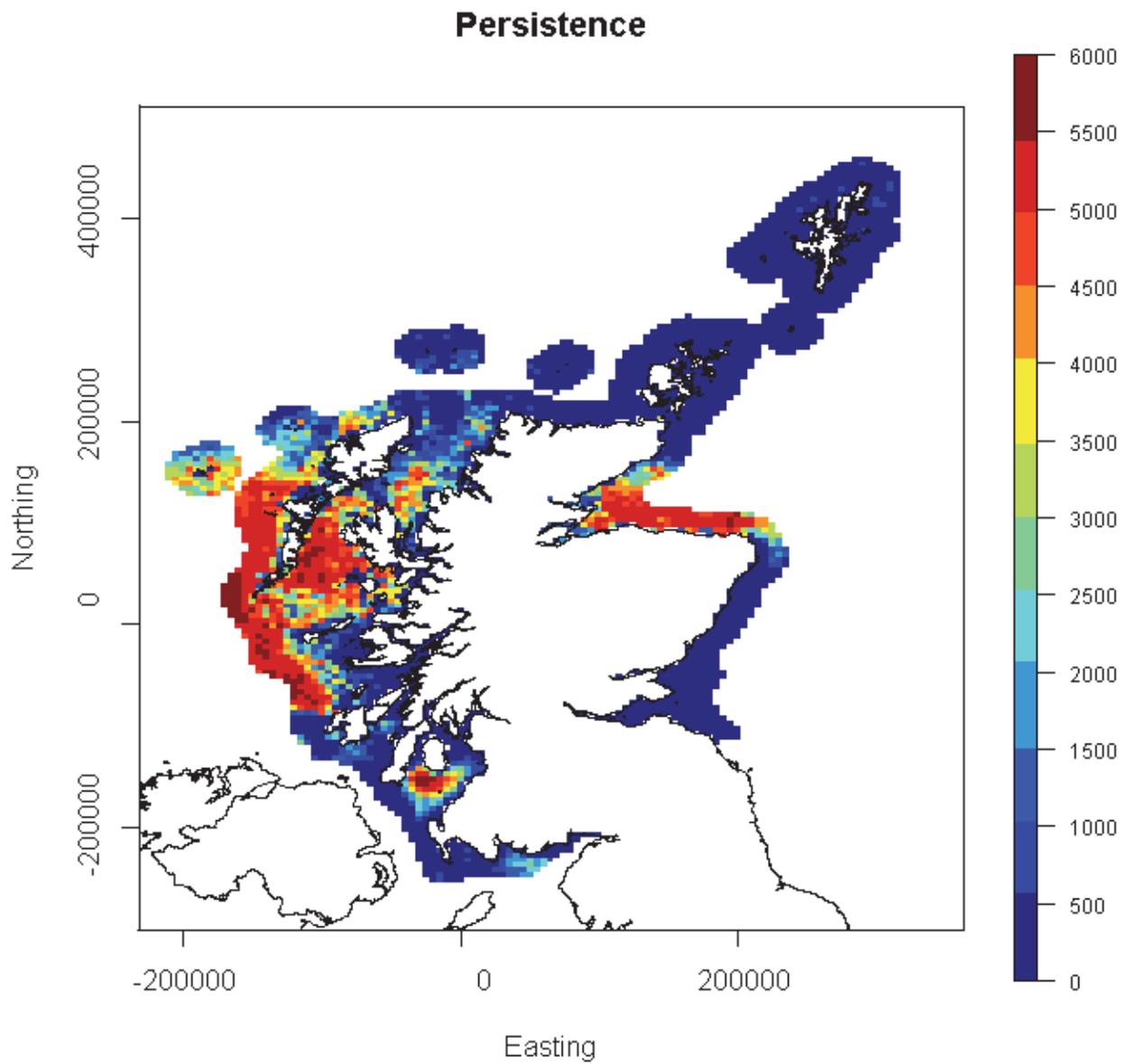


Figure A1.3. (reproduced from Paxton et al., 2014b) Index of predicted minke whale persistence-certainty, summers 2001 - 2012. Colours indicate persistence of above mean density on a score 0 to 6000. Each cell is 5 by 5 km.

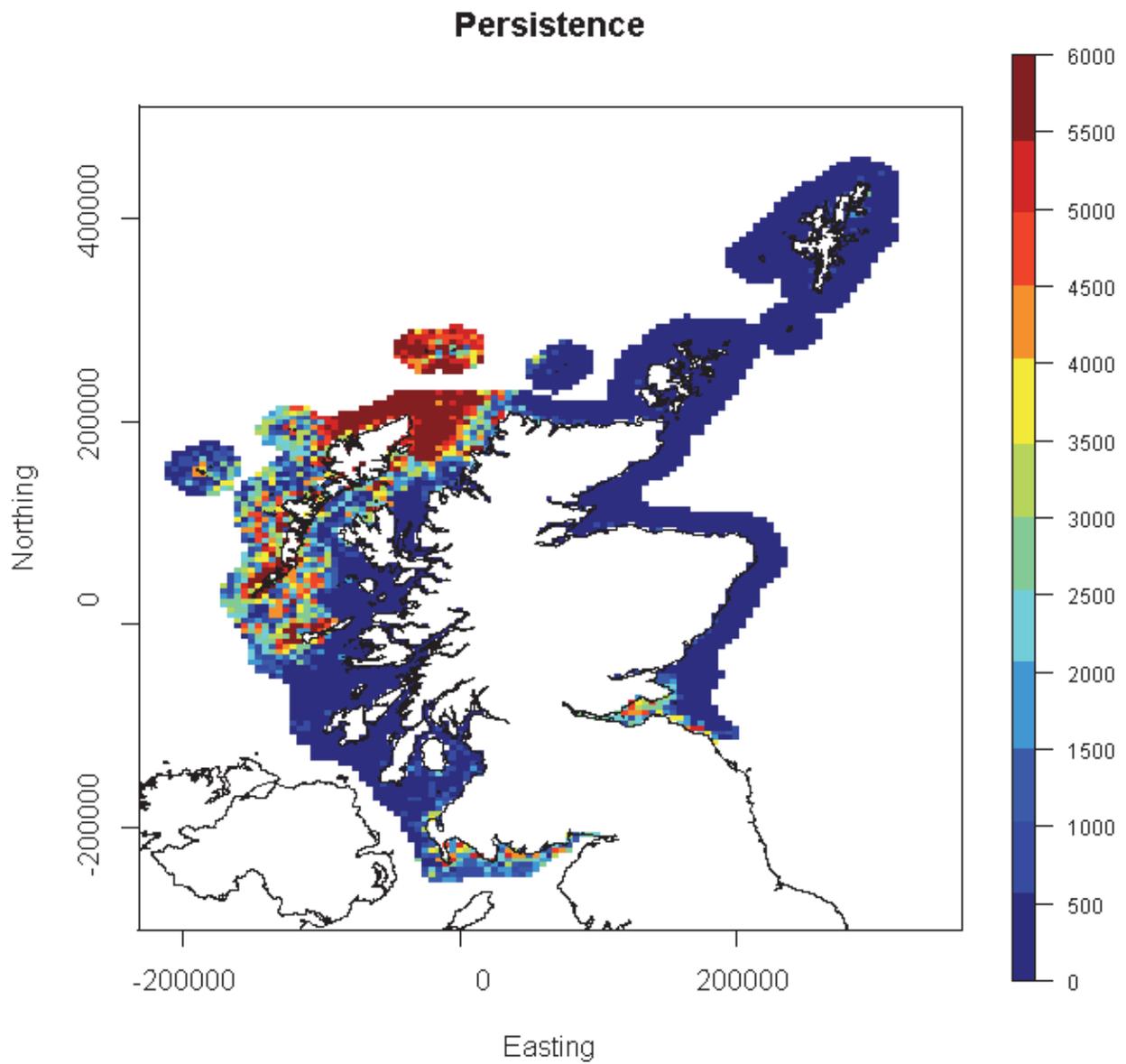


Figure A1.4. (reproduced from Paxton et al., 2014b) Index of predicted Risso's dolphin persistence-certainty, summers 1994 - 2012. Colours indicate persistence of above mean density on a score 0 to 6000. Each cell is 5 by 5 km.

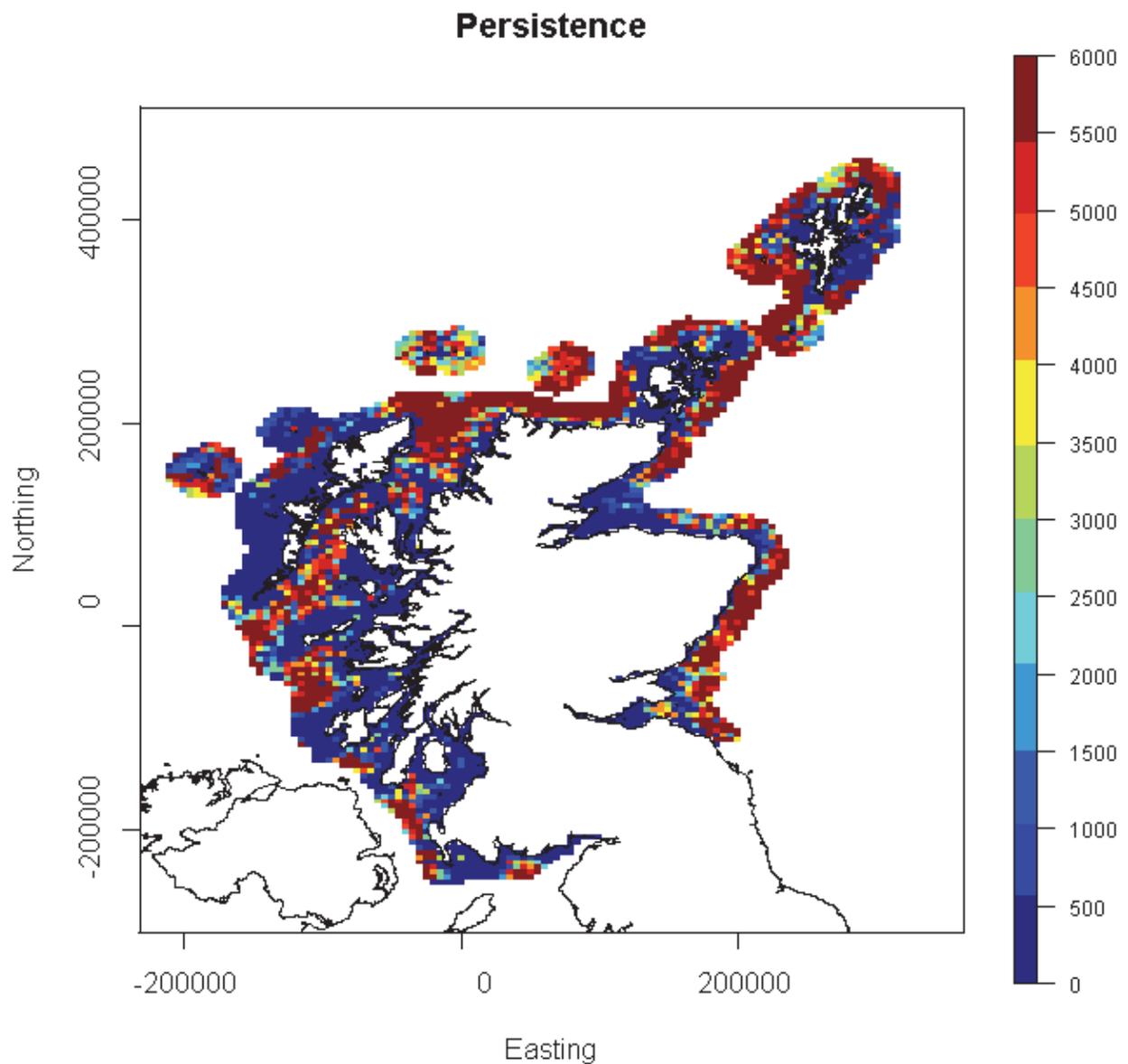


Figure A1.5. (reproduced from Paxton et al., 2014b) Index of predicted white-beaked dolphin persistence-certainty, summers 1994 - 2012. Colours indicate persistence of above mean density on a score 0 to 6000. Each cell is 5 by 5 km.

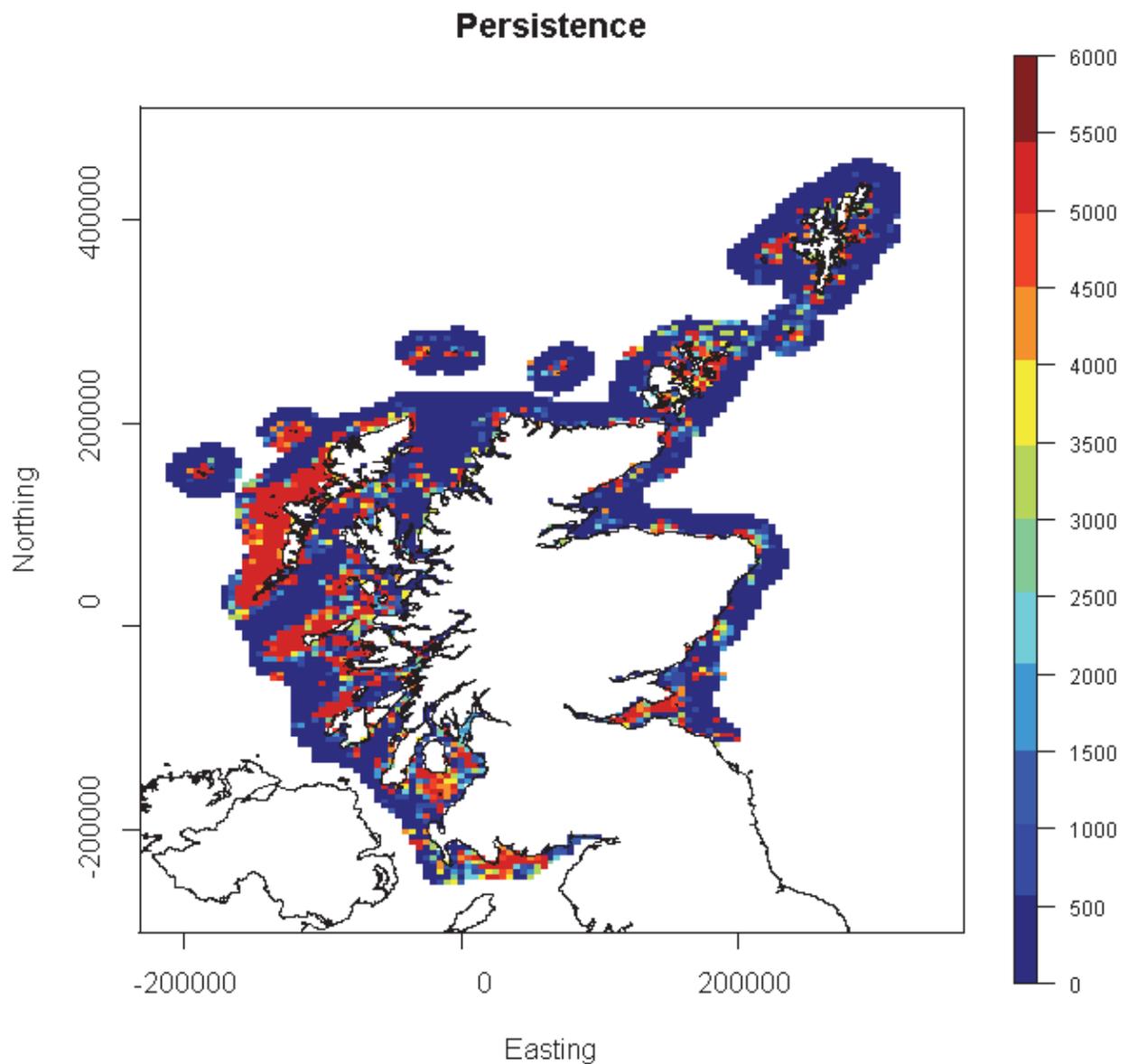


Figure A1.6. (reproduced from Paxton et al., 2014b) Index of predicted basking shark surface persistence-certainty, summers 2001 - 2012. Colours indicate persistence of above mean density on a score 0 to 6000. Each cell is 5 by 5 km.

ANNEX 2: BASKING SHARK TAGGING WORK

A satellite tagging project was set-up in 2012 in collaboration with the University of Exeter, with the aim to understand more about basking shark distribution, habitat-use, movement and behaviour within the Inner Hebrides. A total of 51 sharks were tagged during 2012 and 2013 using a range of the latest tagging technology (Wildlife Computers) giving data on location, depth and temperature. A Phase I report has been published (Witt *et al.*, 2014) and a Phase II report will include further analysis and capture data from planned tagging in summer 2014.

Results indicate that all 23 basking sharks (8 sharks in 2012 and 15 sharks in 2013) tagged with SPOTs showed a degree of site fidelity within the areas they were tagged, particularly around the south-west of Tiree, Gunna Sound and Hyskeir during the months of July, August and September. Figure A2.1 shows the tracks of 8 sharks during July to September in 2012. Figure A2.2 shows the corresponding figures from the 2013 survey work (Witt *et al.*, 2014).

Several areas supporting a high relative density of sharks were identified. Three different techniques were used (see Figure A2.3) comprising i) Minimum Convex Polygon ii) Grid; Point density enumeration and iii) Kernel; Quartic density estimation. These techniques were performed over two time periods: 28 days using data from all sharks tagged with SPOTs and a longer time period (July - September) with data from the sharks that had retained their tags. The latter is shown in Figure A2.3.

Figure A2.4 is a composite figure showing the tracks of all sharks tagged with SPOT tags in 2012 and 2013. Please note that the shading showing the search location relates to the previous boundary of the Skye to Mull MPA search location, not the proposed new boundary of the Sea of the Hebrides MPA proposal.

The results of satellite tracking have progressed our understanding of basking shark movement and distribution in the Sea of the Hebrides and some broad patterns of behaviour have emerged, including evidence of spatial residency in both 2012 and 2013.

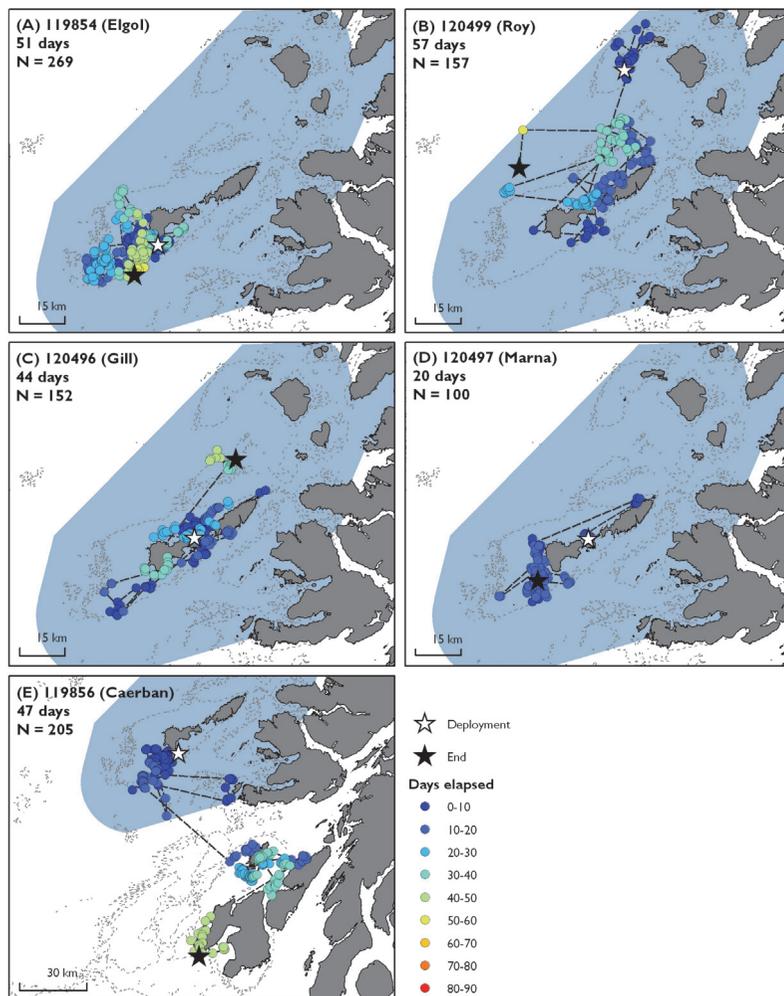


Figure A2.1. (reproduced from Witt et al. 2014) Summertime movements of basking sharks tracked with SPOT tags in 2012. Satellite tracking data from basking sharks satellite tracked between July and September. Shark tag ID, name (if applicable), tracking duration and total number of filtered locations indicated for each figure part. Note figure parts to differing scales. Dashed lines join consecutive locations but do not infer straight line movement. Skye to Mull MPA search location (blue polygon), 50m depth contour (grey broken line; © SeaZone Solutions, 2013, Licence O1035263). Contains Ordnance Survey data © Crown copyright and database right 2013.

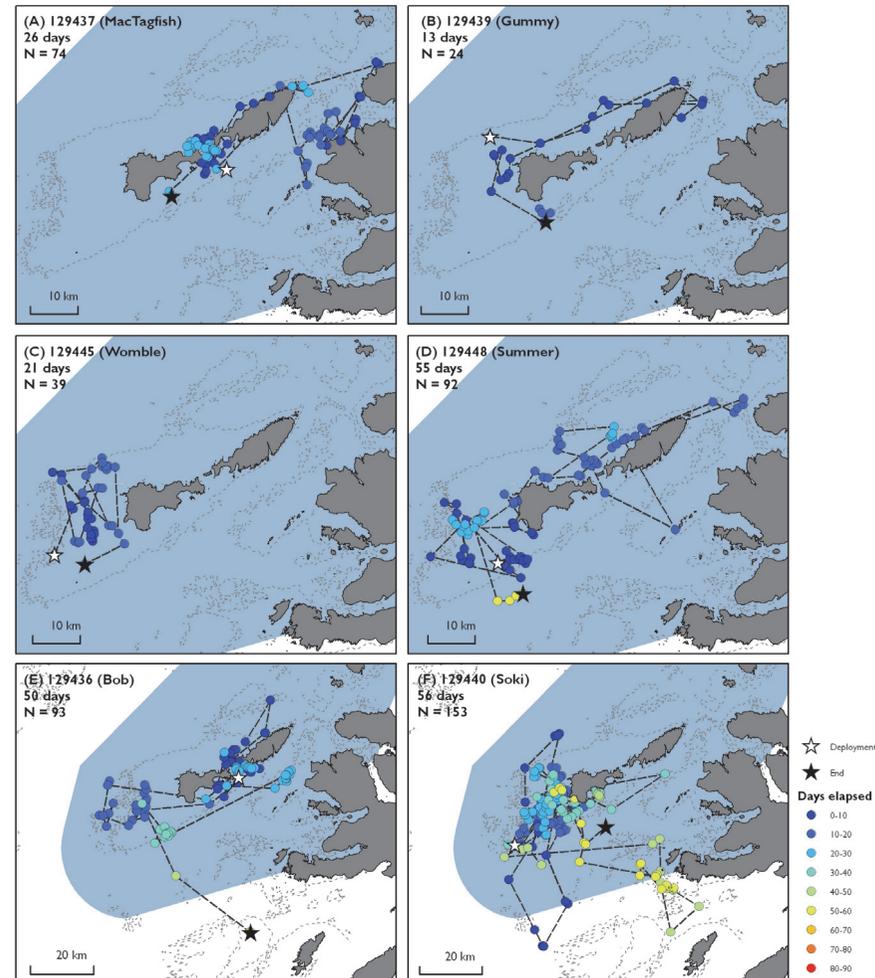


Figure A2.2. (reproduced from Witt et al. 2014) Summertime movements of basking sharks tracked with SPOT tags in 2013. Satellite tracking data from basking sharks satellite tracked between July and September. Shark tag ID, name (if applicable), tracking duration and total number of filtered locations indicated for each figure part. Note figure parts to differing scales. Dashed lines join consecutive locations but do not infer straight line movement. Skye to Mull MPA search location (blue polygon), 50m depth contour (grey broken line; © SeaZone Solutions, 2013, Licence O1035263). Contains Ordnance Survey data © Crown copyright and database right 2013.

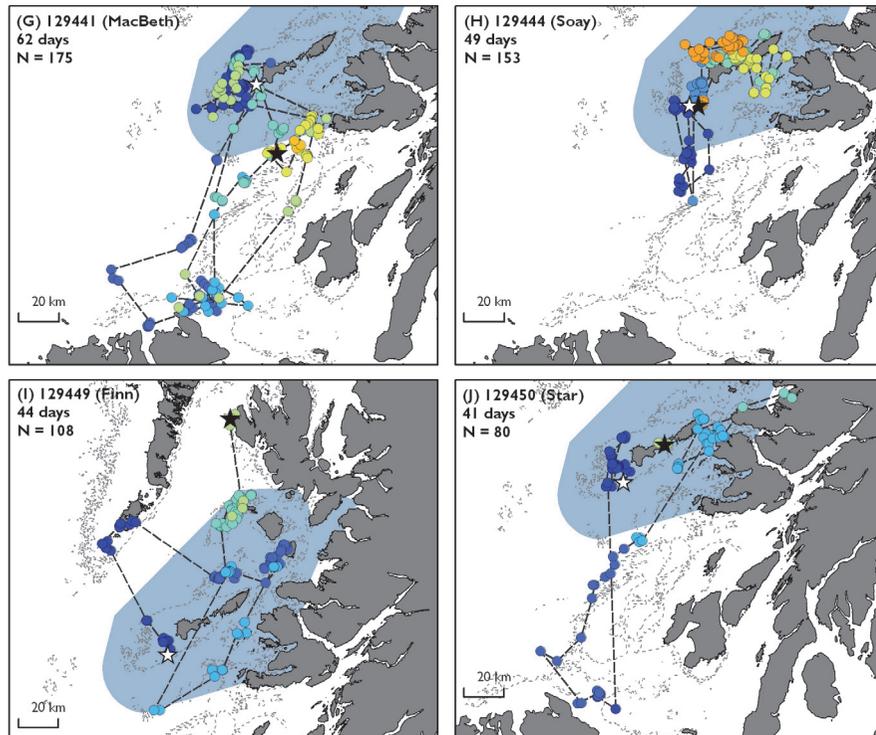


Figure A2.2. continued. Movements of basking sharks tracked with SPOT in 2013.

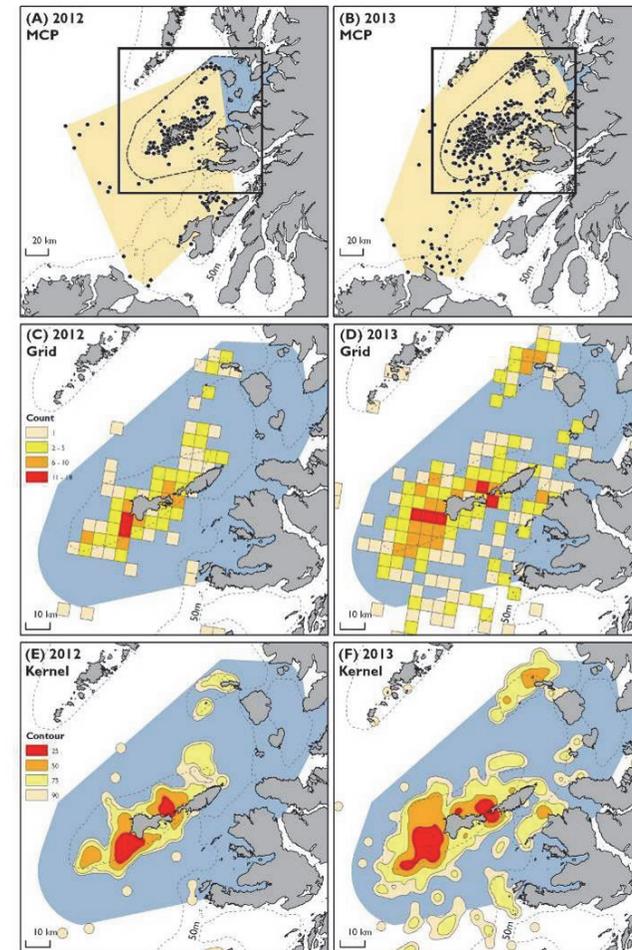


Figure A2.3. (reproduced from Witt et al. 2014) Identifying areas of high relative importance in summer months (July to September). Home-range estimation using: i) Minimum Convex Polygon (MCP; A,B), ii) Grid; Point density enumeration (C,D), and iii) Kernel; Quartic density estimation (E,F) for SPOT-tagged basking sharks in 2012 (A, C and E) and 2013 (B, D and F) using daily highest quality location from individual basking sharks. Skye to Mull MPA search location (blue polygon). 50 m depth contour (labelled grey broken line; GEBCO). Ordnance Survey data © Crown copyright and database right 2013.

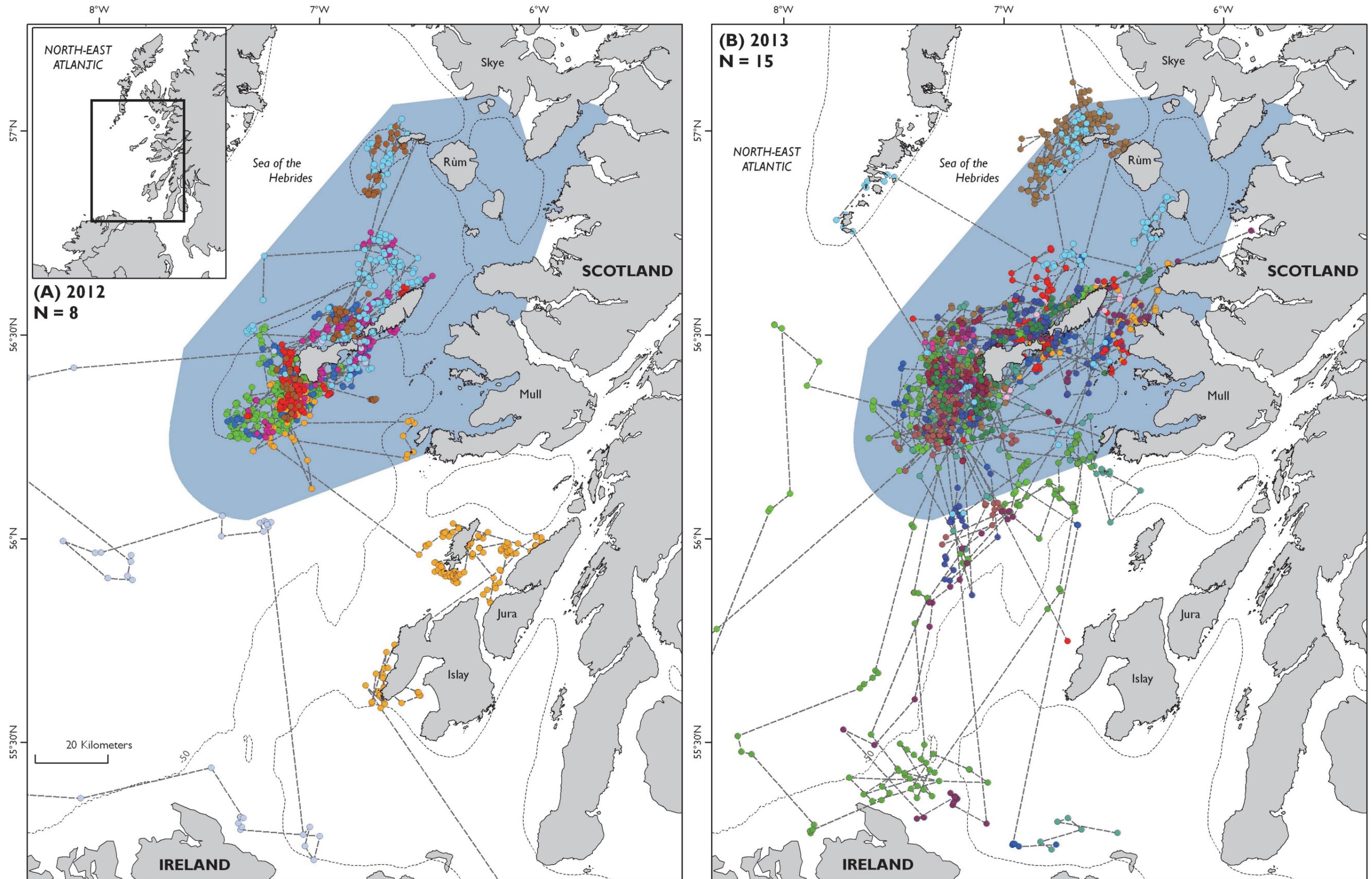


Figure A2.4. (reproduced from Witt et al 2014). Satellite tracking locations of basking sharks gathered in the Sea of the Inner Hebrides from SPOT tags during (A) 2012 and (B) 2013. Individual shark locations represented by single colour points, dashed line joins consecutive locations. Skye to Mull MPA search location (blue polygon). Contains Ordnance Survey data © Crown copyright and database right 2013.

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