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The numbers and distribution of inshore waterbirds along the south Cornwall coast during winter

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The Joint Nature Conservation Committee (JNCC) is the statutory adviser to the UK Government and devolved administrations on UK and international nature conservation. Its work contributes to maintaining and enriching biological diversity, conserving geological features and sustaining natural systems. JNCC delivers the UK and international responsibilities of the Council for Nature Conservation and the Countryside (CNCC), Natural Resources Wales (NRW), Natural England (NE), and Scottish Natural Heritage (SNH).

Summary

The EC Birds Directive requires that EU Member States identify Special Protection Areas (SPAs) on both land and sea. The Joint Nature Conservation Committee (JNCC), on behalf of Natural England and the other Statutory Nature Conservation Bodies (SNCBs), identified 45 Areas of Search (AoS) around the UK that were suspected to support important aggregations of wintering divers, seaduck and grebes that might warrant protection in SPAs. One of these AoSs was the sea area adjacent to the coast of south Cornwall, which was known to support important numbers of wintering divers and grebes. The area is an Important Bird Area (IBA) and also has many existing designations including a Special Area of Conservation (SAC) and five Sites of Special Scientific Interest (SSSI). However, wintering waterbirds in the area currently have no site-based protection.

To determine the numbers of wintering waterbirds regularly using the South Cornwall Coast AoS, three aerial surveys were carried out in the South Cornwall Coast AoS, in January 2007, March 2007 and February 2009. Additionally, four systematic shore-based counts of the AoS were conducted in 2009-2011. Distance sampling methods and the mean of peak counts (the mean of the highest counts from each winter) were used to estimate the numbers of each waterbird species within the AoS. Aerial surveys recorded fewer birds than shore-based counts, probably due to most waterbirds being close inshore and consequently overlooked by observers on the aircraft as it turned or climbed on approach to the coast. However, due to the relatively restricted number of aerial surveys undertaken, significant use of areas further offshore at other times cannot be ruled out. Indeed, it may be expected that divers make some use of deeper waters offshore.

- An estimated **115 black-throated divers** were present in the AoS. This population **exceeded the Stage 1.1** UK SPA Selection Guidelines threshold of 6 individuals and exceeded the 50 individuals usually considered the minimum for site selection, in both winters for which data were available. This is the largest population of black-throated divers in the UK, making the South Cornwall Coast AoS the most important area in the UK for this species.

- An estimated **74 great northern divers** were present in the AoS. This population **exceeded the Stage 1.1** UK SPA Selection Guidelines threshold of 25 individuals and exceeded the 50 individuals usually considered the minimum for site selection, in both winters for which data were available. Many more great northern divers winter around Scottish coasts but the South Cornwall Coast AoS supports the largest population in England. It is the most southerly area in the UK to regularly hold great northern divers and so it potentially contributes to the range requirements of this species.

- An estimated **39 black-necked grebes** were present in the AoS. This population **did not exceed the Stage 1.2** UK SPA Selection Guidelines threshold of 2,200 individuals, nor did it exceed the minimum of 50 individuals usually considered the minimum for site selection in either winter for which data were available. However, this is the largest marine population, making the South Cornwall Coast AoS the most important area in the UK for this species, so the species could be considered for inclusion under stage 1.4 of the Guidelines.

- An estimated **6 red-necked grebes** were present in the AoS. This population **did not exceed the Stage 1.2** UK SPA Selection Guidelines threshold of 510 individuals, in either winter for which data were available, nor did it exceed the minimum of 50 individuals usually considered the minimum for site selection. However, this is the largest population in England and the most southerly population in the UK, so this area

potentially contributes to the range requirements of this species and could be considered for inclusion under stage 1.4 of the Guidelines.

- An estimated **333 European shags** were present in the AoS. This population **did not exceed the Stage 1.2** UK SPA Selection Guidelines threshold of 2,000 individuals, in the single winter for which data were available. However, a preliminary analysis suggests this is one of the largest population in England and one of the most southerly population in the UK, so this area potentially contributes to the range requirements of this species and could be considered for inclusion under stage 1.4 of the Guidelines.

- An estimated **8.5-14 Slavonian grebes** were present in the AoS (8.5 from JNCC-commissioned counts during 2009/10 & 2010/11;WeBS counts recorded a mean-of-peaks count of 10.6 between 2004/5-2008/9 and 14 between 2005/6-2009/10. These population estimates **were close to the Stage 1.1** UK SPA Selection Guidelines threshold of 11 individuals, but did not exceed the minimum of 50 individuals usually considered the minimum for site selection. The AoS holds low numbers of Slavonian grebe compared with other areas around the UK, especially Scotland.

- An estimated 57 **red-breasted mergansers** were present in the AoS. This population **did not exceed the Stage 1.2** UK SPA Selection Guidelines threshold of 1,700 individuals, in either winter for which data were available.

- All other species of diver, grebe and seaduck, were recorded in low numbers and did not exceed the Stage 1.1, Stage 1.2 or Stage 1.3 thresholds. These species regularly occur elsewhere in England, such that the South Cornwall Coast AoS is of low importance for these species.

Two surveys of the South Cornwall Coast AoS in the mid and late 1990s found broadly similar numbers to these more recent surveys. Black-throated and great northern divers were present in numbers in excess of the Stage 1.1 thresholds, while all other species did not meet the UK SPA Selection Guidelines thresholds at Stage 1.1, Stage 1.2 or Stage 1.3.

Options are presented for possible approaches to identifying a boundary for an area that might warrant classification as an SPA.

Contents

1 Introduction

In 1979, the European Commission adopted the European Council (EC) Directive on the conservation of wild birds, commonly known as the Birds Directive. The Birds Directive addresses, “the conservation of all species of naturally occurring birds in the wild state in the European territory of the Member States to which the treaty applies” (EC 2009). It requires Member States to identify and classify, in particular, the “most suitable territories” in number and size as Special Protection Areas (SPAs) for the conservation of rare and vulnerable species, both listed on Annex I of the Directive and regularly occurring migratory species.

The UK SPA Selection Guidelines advise that SPA identification should be determined in two stages (Stroud *et al* 2001; Webb & Reid, 2004; http://jncc.defra.gov.uk/page-1405). Stage 1 is intended to identify areas that are likely to qualify for SPA status and Stage 2 further considers these areas to select the most suitable areas in number and size for SPA classification (Stroud *et al* 2001).

Stage 1 has four selection criteria:

1. Stage 1.1, an area is used regularly by 1% or more of the Great Britain (GB) population of a species listed in Annex I of the EC Birds Directive;

2. Stage 1.2, an area is used regularly by 1% or more of the biogeographic population of a regularly occurring migratory species, other than those listed in Annex I of the EC Birds Directive;

3. Stage 1.3, an area is used regularly by an assemblage of more than 20,000 waterbirds comprising at least two species;

4. Stage 1.4, where the application of stages 1.1-1.3 does not identify an adequate suite of areas, sites may be selected if they meet one or more of the Stage 2 guidelines.

Stage 2 has seven selection criteria:

1. Areas holding more birds and/or higher concentrations are favoured for selection;

2. Areas providing as wide a geographic coverage across the species’ range as possible are favoured for selection;

3. Areas of higher breeding success than others are favoured for selection;

4. Areas known to have a longer history of occupation or use by the relevant species are favoured for selection;

5. Areas holding the larger number of qualifying species under Article 4 of the Birds Directive are favoured for selection;

6. Areas comprising natural or semi-natural habitats are favoured for selection;

7. Areas used at least once a decade by significant proportions of the biogeographic population of a species in periods of severe weather in any season, and which are vital to the survival of a viable population, are favoured for selection.

The GB population estimates and 1% thresholds for species listed on Annex I, which are assessed at Stage 1.1, are published in Baker *et al* (2006), with the exception of the red-throated diver population estimate which is published in O’Brien *et al* (2008). For Annex I species for which 1% of their GB population is <50 birds, a threshold of 50 birds is used. This is because, in an international context, these very small numbers are not of major significance for sustaining viable biogeographic populations (Stroud *et al*, 2001). For regularly occurring migratory species, which are assessed at Stage 1.2, the biogeographic population estimate is published in *Waterbird Population Estimates* (Wetlands International, 2006). For an area to be considered to be 'used regularly', the area must be shown to support more than 1% of the GB (Stage 1.1) or biogeographic (Stage 1.2) population in two-thirds of seasons for which adequate data are available or the mean of the maximum annual population estimates, obtained over at least a five year period, needs to exceed the 1% population thresholds (Webb & Reid, 2004).

Although the Birds Directive states that conservation measures should be taken both in, "the geographical sea and land area", most SPAs in the United Kingdom (UK) do not extend further than the mean low water mark (or mean low water springs in Scotland). Work to provide information to facilitate Government in consideration of important areas on a wider basis in the marine environment is currently being undertaken by the Joint Nature Conservation Committee (JNCC) in collaboration with Natural England and the other country statutory nature conservation bodies (SNCBs)**.**

To date, JNCC has provided advice on extensions to breeding seabird colony SPAs into the sea adjacent to colonies; 31 seabird colony SPAs have been extended into the marine environment in Scotland. Three entirely marine SPAs have been classified for wintering aggregations of red-throated diver *Gavia stellata* and/or common scoter *Melanitta nigra*: Bae Caerfyrddin/Carmarthen Bay SPA, Outer Thames Estuary SPA and Liverpool Bay/Bae Lerpwl SPA. JNCC is leading and coordinating work on behalf of the SNCBs to identify important areas for seabirds in the marine environment. This includes work to identify concentrations of birds within and beyond 12nm offshore using the European Seabirds at Sea database (Kober *et al* 2010). JNCC are also carrying out species-specific work to identify marine areas regularly used by European shag *Phalacrocorax aristotelis* both during the breeding and non-breeding season, breeding tern and breeding red-throated diver foraging areas and marine areas used by post-breeding aggregations of Balearic shearwater *Puffinus mauretanicus*. Additionally, aggregations of wintering divers, seaduck and grebes in inshore areas around the UK have been identified by JNCC. In 2000, 45 initial Areas of Search (AoS) around the UK were selected for further investigation as evidence suggested these marine areas had the potential to hold important numbers of divers, seaduck and grebes outwith the breeding season (Reid 2004). JNCC, on behalf of Natural England, has collected new data and collated existing data on the numbers and distribution of divers, seaduck and grebes in the 15 AoS that are within English waters. One of these AoS covers the sea area to the south of Cornwall.

The target species were those inshore waterbirds that spend the winter period within coastal areas of the UK and are listed in Table 1 of the African-Eurasian Waterbird Agreement Action Plan (Convention of Migratory Species 1999): http://www.cms.int/species/aewa/aew_ap.htm or in Annex I of the EC Birds Directive (EC 2009), or are migratory species that occur regularly in the UK.

These species are Annex I species (assessed against the Stage 1.1 thresholds): red-throated diver, black-throated diver, great northern diver and Slavonian grebe; and regularly occurring migratory species (assessed against the Stage 1.2 thresholds): greater scaup *Aythya marila*, common eider *Somateria mollissima*, long-tailed duck *Clangula hyemalis*, common scoter, velvet scoter *Melanitta fusca*, common goldeneye *Bucephala clangula*, red-breasted merganser, goosander *Mergus merganser*, little grebe *Tachybaptus ruficollis,* great crested grebe *Podiceps cristatus*, red-necked grebe, and black-necked grebe (Webb & Reid, 2004). Additionally, information on numbers and distribution of wintering European shag *Phalacrocorax aristotelis* in the South Cornwall Coast AoS are considered in this report as this is another species for which JNCC aims to identify areas which could be considered for classification as SPAs.

The aim of this report is to quantify the numbers and distribution of divers, seaduck and grebes regularly using the inshore marine area along the coast of south Cornwall. It considers whether the area meets the UK SPA Selection Guidelines in respect of the numbers of inshore waterbirds that use the area outwith the breeding season. Options for a possible SPA boundary around bird aggregations are presented for consideration should the area be deemed suitable for classification as an SPA. It is the role of Natural England to determine, and to advise Government of, the most suitable areas for classification as SPAs in English inshore waters (within 12nm). JNCC co-ordinates, and applies common standards to, the identification of SPAs and the SPA network across the UK as a whole. JNCC undertakes the research, survey and analytical work that underpins marine SPA identification on behalf of Natural England (and the other UK statutory nature conservation organisations). Thus the identification of marine SPAs is founded upon an as sound and defensible evidence base as possible.

2 Methods

2.1 South Cornwall Coast Area of Search

The county of Cornwall, bordered to the north and the south by sea, has 326 miles of coastline. The north coast, exposed to the Atlantic, is less sheltered than the south coast, which has a rocky coastline interspersed with sandy bays and estuaries. The South Cornwall Coast Area of Search (AoS) is mid way along the south coast of Cornwall (Figure 2.1). Wetland Bird Survey (WeBS) data recognised the national importance of the South Cornwall Coast (Holt *et al* 2011). Gerrans Bay and the Fal Complex, two WeBS count areas that lie within the AoS, are regularly mentioned in the WeBS *Waterbirds in the UK* reports for black-throated divers and both red-necked and black-necked grebes (Holt *et al* 2011). The sea area adjacent to the south coast of Cornwall was also identified as holding many more wintering divers and grebes than the rest of the sea around south west England, by surveys in the 1990s (Geary & Lock, 2001; Lock & Robbins, 1994; Slade, 1996). Using information from these surveys, an AoS was defined, within which the numbers and distribution of wintering waterbirds was assessed. The South Cornwall Coast AoS extends from St Austell Bay in the east to the tip of The Lizard peninsula in the west and extends up to 23 km out to sea (Figure 2.2). Most of the AoS faces south-east and is sheltered from the prevailing south-westerly winds. The AoS includes a ria (drowned river valley) system, which has steep sides and slow tidal currents. It has low freshwater input and a diversity of fully marine habitats. Much of the ria has subtidal rocky shores with intertidal flats along tributaries.

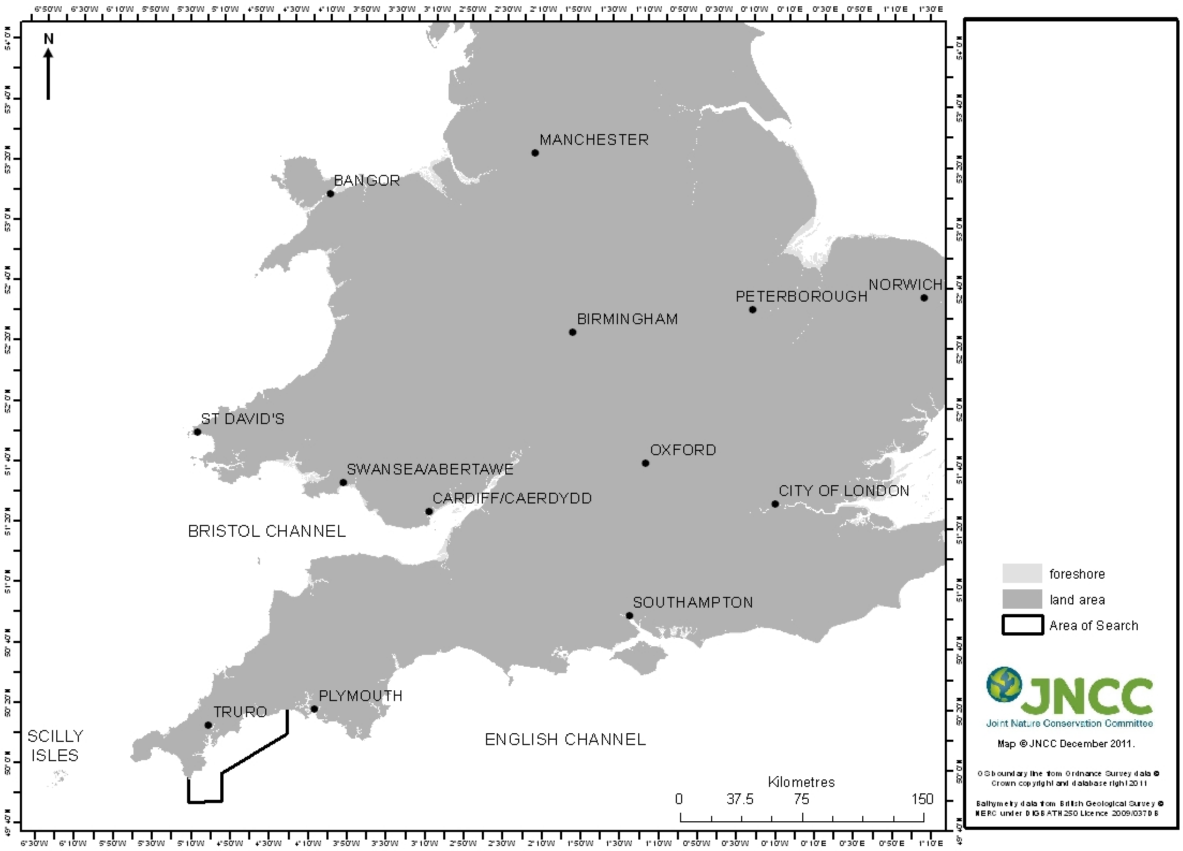

Figure 2.1. Map of England and Wales indicating the location of the South Cornwall Coast Area of Search, in south west England.

During the 16th and 17th centuries, the pilchard fishery contributed considerably to the economy of Cornwall but by the 20th century, the fishing industry targeted a greater diversity of species, particularly crab species and lobster *Homarus gammarus*. Small boats work lines of pots close inshore around the coast of Cornwall, catching crab and lobster. A fleet of 150 small boats, most <10m in length, catch primarily mackerel *Scomber scombrus* but also bass *Dicentrarchus labrax*, pollock *Theragra chalcogramma* and squid. Most fish are caught within six miles of land by handline, a low intensity fishing method that appears sustainable and results in little bycatch (Marine Stewardship Council, 2009). During winter, the fleet works along the more sheltered south Cornwall coast, within the South Cornwall AoS. Crab and lobster boats will also work the inshore areas of the South Cornwall AoS in winter.

Tourism makes a considerable contribution to the economy of Cornwall, providing an estimated 25% of all employment in Cornwall (SWT, 2010), but marine recreation during winter months, when waterbirds are using the waters off the south Cornwall coast, is negligible. Some yachts will still use the South Cornwall AoS during winter but fewer than during summer.

The South Cornwall AoS has predominantly sandy shallow bays, separated by more steeply shelving rocky outcrops (Figure 2.2; Figure 2.3). Within the South Cornwall AoS, there are many small fishing ports but also a large harbour at Falmouth. Falmouth Port offers facilities for leisure boats, commercial shipping and cruise ships, including almost 600 moorings and deep water anchorages. Additionally, fish are landed in Falmouth, the deep water channel enabling large fishing vessels to land fish.

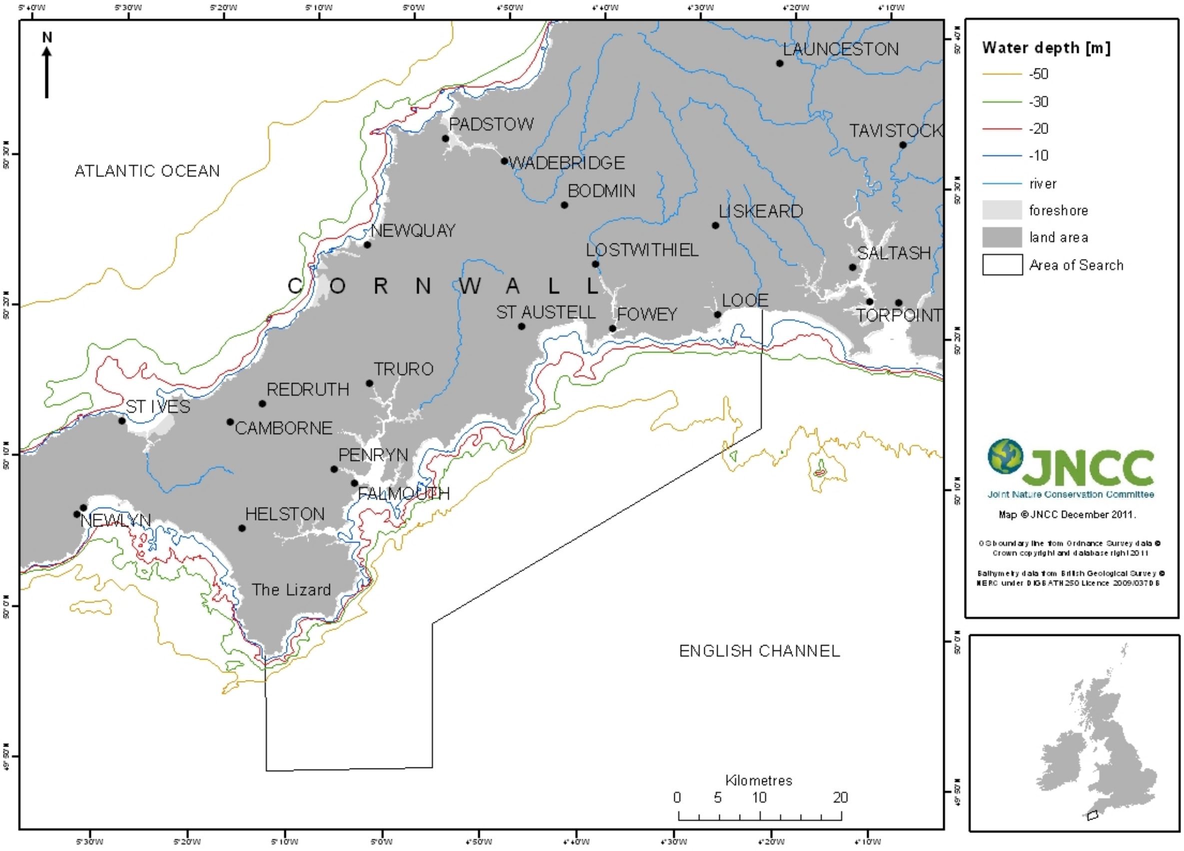

Figure 2.2. Map of Cornwall showing the bathymetry around the coast (up to a depth of 50m) and the South Cornwall Coast Area of Search.

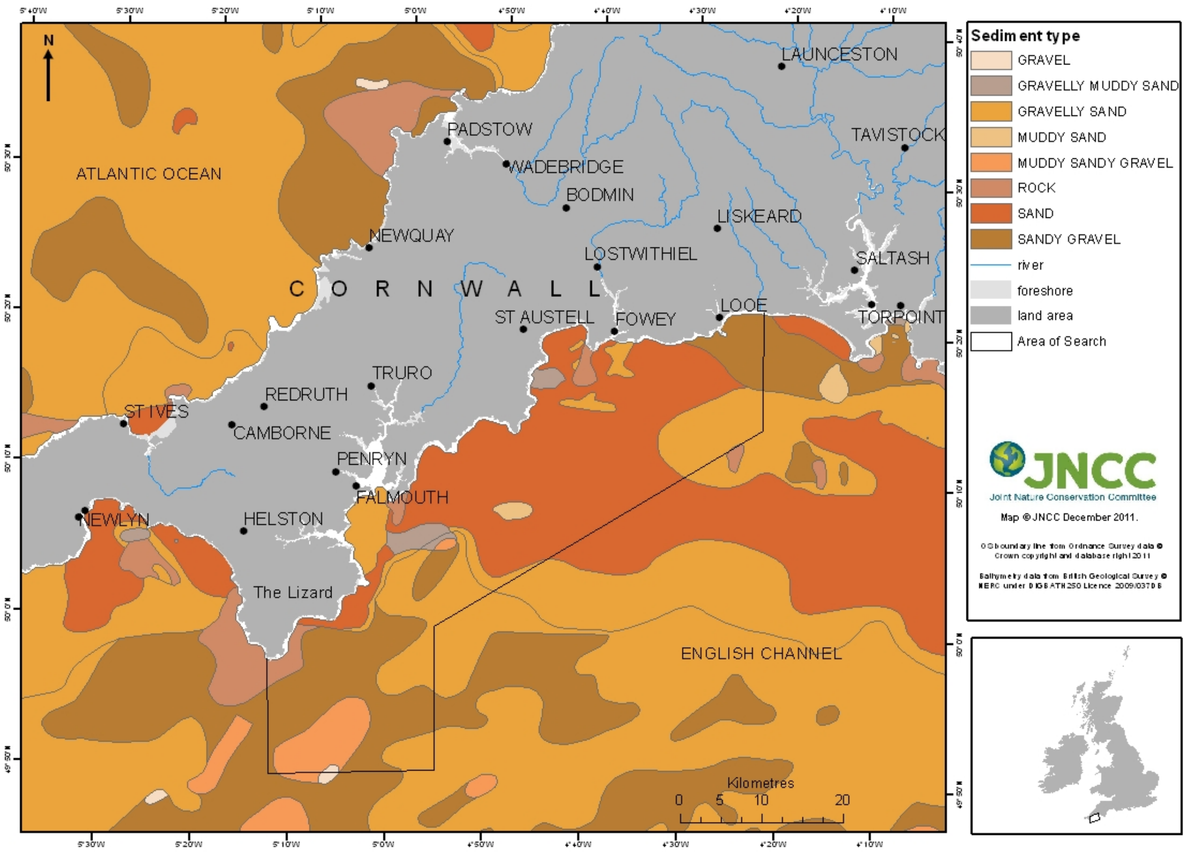

Figure 2.3. Map of Cornwall showing the different sediment types around the coast and the South Cornwall Coast Area of Search.

2.1.1 Existing Protected Areas within the South Cornwall Area of Search

There are no existing SPAs within the South Cornwall AoS but further east, in Devon, the interest features of the Exe Estuary SPA include wintering Slavonian grebe, red-breasted merganser and cormorant (Stroud *et al* 2001). The Fal and Helford Special Area of Conservation (SAC), in the west of the South Cornwall AoS, was classified for its biologically rich sandbanks, sheltered intertidal mudflats and sandflats, marine inlets and shallow bays and Atlantic salt meadows. The Lizard Point marine candidate SAC was selected for its Annex 1 reef feature and the Polruan to Polperro SAC protects a range of cliff habitats, some of which support the Annex II species, shore dock *Rumex rupestris.*

The South Cornwall Coast Important Bird Area (IBA), which extends 6km out to sea, was selected by BirdLife International for its numbers of black-throated divers, great northern divers and Slavonian grebe, of which there were estimated to be 135, 84 and 50 individuals, respectively, within the South Cornwall Coast IBA (BirdLife International, 2011; Geary & Lock, 2001). However, in the UK, IBAs do not offer any legal protection to birds.

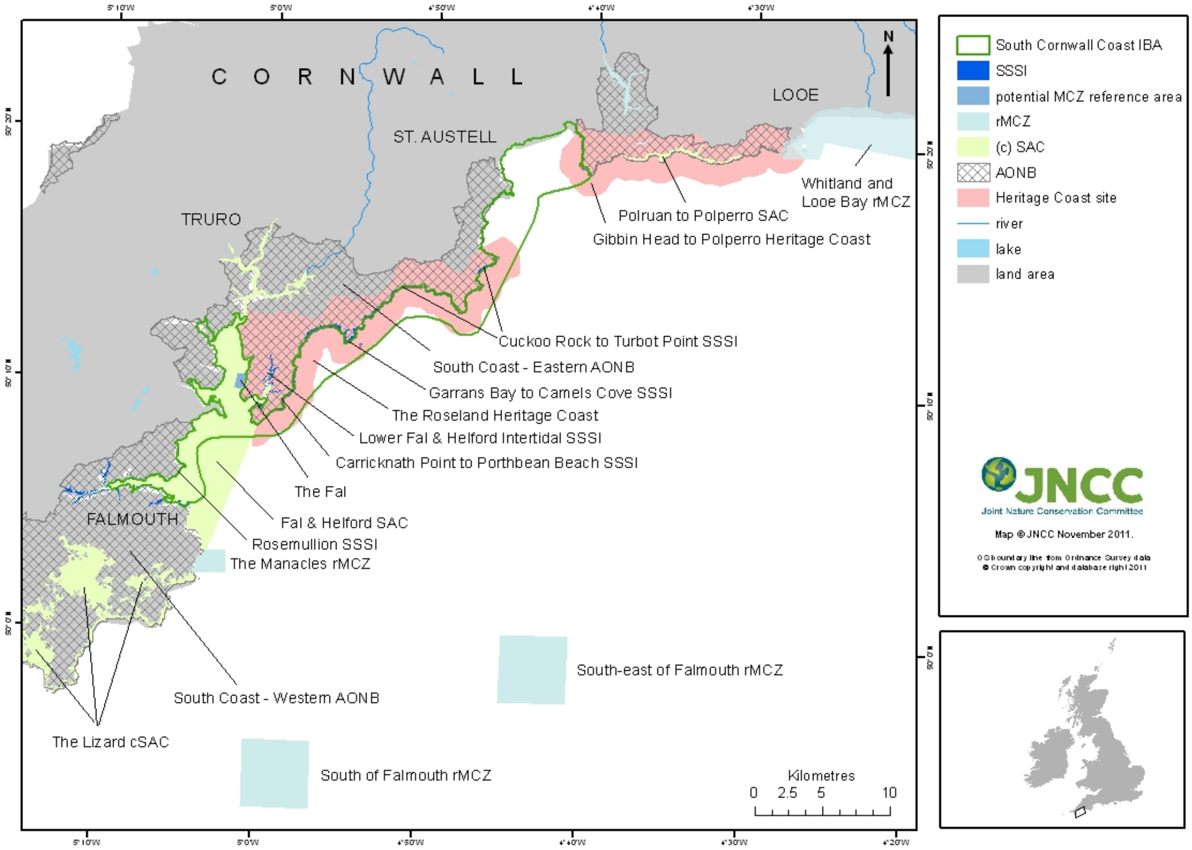

Figure 2.4. Map of existing protected areas within and adjacent to the South Cornwall Area of Search. (c)SAC = (candidate) Special Area of Conservation, IBA = Important Bird Area, rMCZ = recommended Marine Conservation Zone, SSSI = Site of Special Scientific Interest, AONB = Area of Outstanding Natural Beauty.

Within the South Cornwall AoS and Fal and Helford SAC, there is one potential reference area associated with Marine Conservation Zones, The Fal, selected for the high quality of subtidal and intertidal habitats, maerl and seagrass beds and associated species in the area. Additionally there are four more recommended Marine Conservation Zones (rMCZs) close to the South Cornwall AoS, South-east of Falmouth rMCZ, South Falmouth rMCZ, the Manacles rMCZ and Whitland and Looe Bay rMCZ. These aim to protect broad scale habitats and associated species on the seafloor (Lieberknecht *et al* 2011).

Much of the coastline around the South Cornwall AoS is designated as a Site of Special Scientific Interest (SSSI). Many of the SSSIs feature complex geological terrain (e.g. Cuckoo Rock to Turbot Point SSSI) which supports nationally rare and scarce plants on land (e.g. Carricknath Point to Porthbean Beach SSSI) and unusual algae, seaweeds and marine invertebrates in the sea (e.g. Rosemullion SSSI). The Lower Fal and Helford Intertidal SSSI has a ria system that supports a great diversity of habitats and species, including entirely marine communities. The Gerrans Bay to Camels Cove SSSI includes a seabird colony on Gull Rock, as well as complex geology and coastal vegetation. In 2007, the Gull Rock colony was found to have 143 guillemots *Uria aalge*, 12 razorbills *Alca torda*, 36 great black-backed gull *Larus marinus* apparently occupied nests (AON), 25 cormorant AON and 34 herring gull *Larus argentatus* AON (Seabird Monitoring Programme database http://jncc.defra.gov.uk/page-4460).

In the west of the AoS, the Helford Voluntary Marine Conservation Area, designated in 1987, is run by an Advisory Group of a wide range of stakeholders, with the aim of protecting and enhancing the biodiversity of the Helford Estuary (Helford Voluntary Marine Conservation

Group, 2010). The southwestern section of the South Cornwall AoS is part of the South Coast - Western (Lizard to Marazion and the Helford River) Area of Outstanding Natural Beauty (AONB) and most of the rest of the coastline within the South Cornwall AoS is part of the South Coast - Eastern (Mylor & The Roseland to Porthpean) AONB. The South Cornwall AoS also overlaps the Roseland Heritage Coast and the Gibbin Head to Polperro Heritage Coast.

2.2 Data Collection

2.2.1 Types of data on waterbird numbers and distribution

A variety of different types of data, collected for different reasons, have been used to assess the numbers and distribution of waterbirds in the South Cornwall AoS, summarised in Table 2.1. Broadly, data were either collected during aerial survey or from shore-based counts. JNCC carried out a visual aerial survey in 2009, funded by Natural England (NE). On this survey only 3 divers and no seaduck or grebes were recorded. Consequently, systematic shore-based counts over two winters were carried out, also funded by NE. Additionally, WWT Consulting carried out two aerial surveys of the AoS as part of a Strategic Environmental Assessment for renewable energy developments and parts of the AoS are regularly counted from land for the British Trust for Ornithology (BTO), Wetland Bird Surveys (WeBS).

Table 2.1. Summary of data on divers, seaduck and grebes along the south Cornwall coast.

Method of data collection	Date(s) of survey	Who collected the data	Quality of data obtained	Reference
Visual aerial survey	January and March 2007	WWT Consulting	Likely to have missed certain species of waterbird	WWT Consulting (2008)
Visual aerial survey	21 February 2009	JNCC, funded by NE	Likely to have missed certain species of waterbird	JNCC unpublished data
Systematic shore-based counts	Five times during Nov 1994-March 1995	RSPB	Systematic survey along coast counting target species so best estimate of bird numbers and distribution, although will have missed birds further offshore.	Slade (1996)
Systematic shore-based counts	Five times during Dec 1999-March 2000	RSPB	Systematic survey along coast counting target species so best estimate of bird numbers and distribution, although will have missed birds further offshore.	Geary & Lock (2001)
Systematic shore-based counts	Dec 2009, Feb 2010, Dec 2010, Feb 2011	Contractor, funded by NE, via JNCC	Systematic survey along coast counting target species so best estimate of bird numbers and distribution, although will have missed birds further offshore.	JNCC unpublished data

Method of data collection	Date(s) of survey	Who collected the data	Quality of data obtained	Reference
Wetland Bird Survey (WeBS)	Monthly, during winters of 2004/05 to 2008/09	Volunteers, survey coordinated by British Trust for Ornithology	Might have missed divers and grebes as mostly focussing on shorebirds; surveys synchronised nationwide once a month regardless of weather conditions	Holt *et al* (2011)
County records	Dec 2010	Volunteers, county bird recorder	Opportunistic records with inconsistent and unquantified effort so difficult to assess bird numbers	Cornwall Monthly Bird Reviews (www.cornwall-birding.co.uk)

2.2.2 Methods of data collection

Advantages and disadvantages of different methods of data collection

Estimating numbers and distribution of waterbirds in marine areas can be challenging. Traditionally, data on the number and distribution of seabirds at sea has been collected by observers on board ships, e.g. the European Seabirds at Sea (ESAS) database (Reid & Camphuysen, 1998). However, some species, such as divers and seaduck, are sensitive to disturbance caused by ships and either dive or fly, thereby evading detection by the observer (Schwemmer *et al* 2011). This leads to a considerable underestimate in the numbers of divers and seaduck in an area if the estimate is based on data collected from a ship.

Aerial surveys generally provide less biased estimates of the numbers of wintering divers and seaduck than boat-based surveys, as the aircraft usually reaches birds before they can fly off or dive. However, species that aggregate very close inshore are often missed by visual aerial surveys as the aircraft has to climb or turn as it approaches land. Recent developments in aerial survey methods that use digital video or photography from an aircraft flying at higher altitudes than traditional visual surveys do not disturb the birds and so are preferable for estimating numbers of these species. Additionally, digital aerial surveys provide more reliable information on the numbers and distribution of birds immediately adjacent to the coast, as digital aerial surveys do not have to climb or bank on approach to the coast. However, both visual and digital aerial surveys struggle to identify some species beyond genus, e.g. separating observations of red- and black-throated divers beyond *Gavia* spp. Also, some species are easily missed by both visual and digital aerial surveys due to their cryptic plumage, e.g. grebe species.

Counting birds on the sea from land (shore-based counts) allows an observer sufficient time to fully identify birds to species and is a better method for recording species that occur very close inshore or have cryptic plumage. However, shore-based counts may underestimate numbers of birds further offshore. A limit of 2km is assumed to be the maximum distance an observer on land could identify a bird at sea, under optimum conditions (*pers. comm.* Andy Webb), though greater distances are possible, depending upon conditions and species (Banks *et al*, 2007). However, we consider 2km to be a maximum distance to detect divers and identify them with confidence. WeBS counts are not ideal for species such as divers and grebes and these species are frequently under recorded by WeBS (Holt *et al* 2011). Systematic shore-based counts which allow observers to select optimal locations and weather conditions for counting divers, grebes and seaduck provide better quality estimates of the numbers of these species and should be favoured over WeBS estimates.

Ideally, more than one method should be used in an area, depending on the species to be surveyed. For example, visual aerial surveys and shore-based counts are complementary methods that together, count birds both close inshore and further offshore.

Aerial Survey

A brief description of the standard visual aerial survey methods that were used is given here but see Kahlert *et al* (2000), Dean *et al* (2003) and Dean *et al* (2004) for more details. Aerial surveys were carried out by Wildfowl and Wetlands Trust (WWT) Consulting in January 2007 and March 2007 and by JNCC in February 2009. Line transects were flown in a Partenavia (PN-68) aircraft at 76m (250ft) above the sea, at a speed of 185km.h^{-1} (100 knots). Transects were spaced 2km apart to maximise the detection of birds located between transects while minimising the risk of double counting birds (Kahlert *et al* 2000). Transects ran perpendicular to the south coast of Cornwall, crossing environmental gradients such as sea depth, in an attempt to minimise variation in bird numbers across transects caused by environmental variation and to minimise glare (Buckland *et al* 2001). Observers recorded numbers of birds and time of observation, to the nearest second, from both sides of the aircraft. A Global Positioning System (GPS) recorded the location of the aircraft. All bird observations were allocated to one of four distance bands (A = 44-162m, B = 163-282m, C = 283-426m and D = 427-1000m) based on the perpendicular distance of the birds from the aircraft. These distance bands were easily identified by the observer during surveys using a clinometer. Birds immediately below the aircraft could not be seen by the observers, so Band A began at 44m from the aircraft.

The track of the JNCC aerial survey can be seen in Figure 3.5 and the tracks of the two WWT Consulting surveys can be seen in Figure 3.1 (January 2007) and in Figure 3.2. (March 2007). The WWT Consulting survey area was divided into three survey blocks, SW12 in the west, SW13 that covers the South Cornwall AoS, and SW14 to the east of the South Cornwall AoS (Figure 3.1). Each survey block is equivalent to one day of aerial survey and extends up to approximately 23km offshore. WWT Consulting also carried out aerial surveys around much of the coast of England but those data were not considered here.

Shore-based counts

Systematic shore-based counts were carried out twice each winter, over two winters (2009/10 and 2010/11). Counts were made from 35 count points along the south Cornwall coast within the South Cornwall Coast AoS. Count points were selected to be regularly spaced and to provide a good vantage point from which to estimate numbers of birds on the sea. Counts were carried out during calm conditions (Beaufort scale < 4). All divers, seaduck and grebes that could be seen from the count point with binoculars and/or a telescope were recorded. Both flying birds and birds on the water were recorded but data on flying birds were not presented in this report as it would have increased the risk of double counting individual birds. These 35 count points and shore-based count methods were almost exactly the same as those used on the surveys carried out in the mid and late 1990s by the RSPB (Geary & Lock, 2001; Slade, 1996) so data from the 1990s surveys are comparable with the more recent surveys. However, during the RSPB surveys, counts were made for up to 30 minutes duration from each count point and surveys were conducted five times during the winter period (see Geary & Lock, 2001, and Slade, 1996 for more details on methods). Consequently, there was greater likelihood of an individual bird being counted during the RSPB surveys, than the more recent surveys.

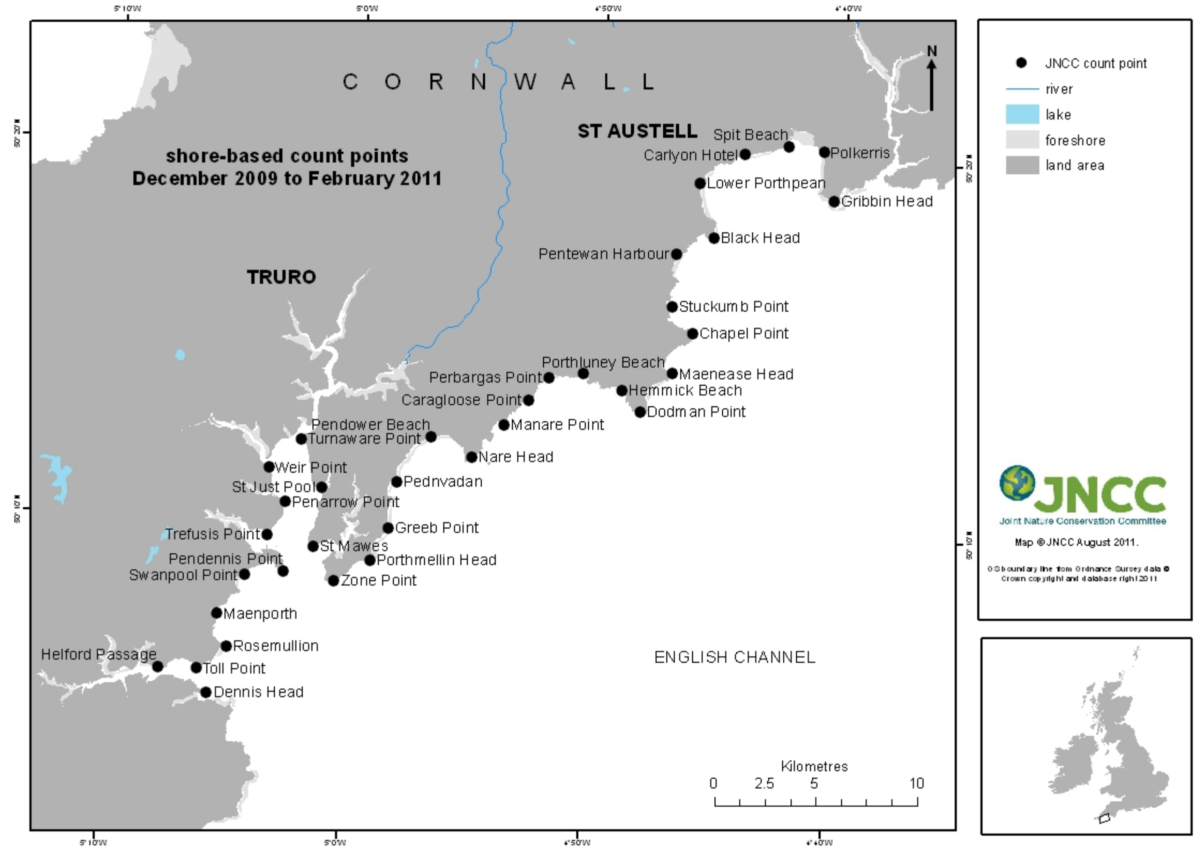

Figure 2.5. Names and location of the 35 count points from which the numbers of divers, seaduck and grebes were counted during four shore-based count surveys.

2.3 Estimating numbers of birds

An estimate of the number of individuals within the South Cornwall AoS, for each species, was obtained and was compared with the UK SPA Selection Guidelines thresholds (Stroud *et al* 2001).

2.3.1 Aerial survey data

During aerial surveys, birds more distant from the aircraft were less likely to be seen than birds close to the aircraft. By modelling the decreasing probability of an observer detecting a bird with increasing distance from the aircraft, it is possible to compensate for the birds that were missed due to being far from the aircraft and to better estimate the numbers of birds in the survey area. This model is known as a detection function. The model assumes that all birds were seen in Band A and calculates the proportion of birds that were overlooked in Bands B, C and D to estimate the total number of birds within the AoS during that survey. The process of generating a detection function and estimating the total number of birds in an area is known as distance sampling. These methods are widely used in ecology to estimate the numbers of animals in an area when it is not feasible to make a complete count (Buckland *et al* 2001). Distance sampling is most easily conducted using the software *Distance* 6.0 (Thomas *et al* 2010). *Distance* fits different types of models to the data and the model that best fits the data is used to estimate how many birds were overlooked. See Thomas *et al* (2010) for more information on distance sampling methods.

When numbers of bird observations from an aerial survey are low (<15), there is insufficient information on how the probability of detecting birds declines with increasing distance from the aircraft to enable a detection function to be built. When this happens, the aerial survey data are instead treated as strip transects. This assumes that all birds within a certain distance from the aircraft were seen (normally birds within Band A and Band B, i.e. within 282m). The mean bird density within the surveyed area (transect length x 0.282km) was calculated and extrapolated across the area of the AoS to give an estimated number of birds within the AoS. The software *Distance* 6.0 allows this to be calculated, with confidence intervals around the population estimate, using a uniform model, trunctated to 282m, with zero adjustment terms (a uniform model assumes there is no decline in detection probability with increasing distance from the aircraft).

2.3.2 Shore-based count data

Systematic shore-based counts, that were carried out under contract to JNCC, in which numbers of divers, grebes and seaduck were recorded at 35 count points within the AoS, were carried out four times, twice each winter. A population estimate for the whole AoS for each species was found, firstly, by summing the number of individuals of that species recorded at each count point on each survey. Secondly, a mean of peak (MoP) estimate for each species was calculated by taking the sum of individuals from either the first or second survey each winter, whichever was highest, from each of the two winters and taking the mean of these. The peak count is taken from each winter, rather than a mean from each winter, to compensate for the likely underestimate in numbers of birds recorded, e.g. because birds were too far offshore to be counted. WeBS counts and county records were used to verify and supplement the systematic shore-based counts. Where counts could not be completed in one day, they spanned two, but potential biases resulting from this were considered not to be systematic. For example, double counting would be no more likely to occur than under-counting, so long as bird movement between and within count sectors was random.

3 Results

3.1 Numbers of birds in the South Cornwall AoS

3.1.1 Aerial Surveys

The South Cornwall Coast AoS was surveyed from aircraft a total of three times, twice in 2007 (January and March) by WWT Consulting and once in February 2009 by JNCC. All three surveys recorded low numbers of divers, seaduck and grebes.

WWT Consulting Aerial Surveys

The WWT Consulting aerial surveys recorded no grebes or seaduck within the survey blocks of SW12, SW13 or SW14 (Figure 3.1, Figure 3.2). Most of the divers recorded on the two WWT Consulting surveys were not allocated to species, only to genus as unidentified diver 'species' (Table 3.1.). A total of 10 divers were recorded in the survey block SW13 (which encompasses the South Cornwall AoS) in January 2007 and 11 divers in March 2007 (Table 3.1). When using distance sampling methods, this number of observations is insufficient to build a detection function, so transects were treated as strip transects using only observations recorded in Bands A and B. Extrapolation gave an estimated number of birds within the AoS of 28 divers (95% CI: 10-75) for January 2007 and 51 divers (95% CI: 28-93) for March 2007[1]. However, since red-throated, great northern and black-throated diver were all recorded within SW13 and most of the observations were not recorded to species, but only to genus, it is not possible to estimate the numbers of each species of diver present within the survey block.

Table 3.1. Raw counts of divers recorded during WWT Consulting aerial surveys along the south Cornwall coast. The South Cornwall AoS lies within the survey block SW13, SW12 covers the sea area adjacent to southwest Cornwall and SW14 covers the sea area adjacent to southeast Cornwall and south-west Devon (WWT Consulting, 2008).

	January 2007			**March 2007**		
Species	**SW12**	**SW13**	**SW14**	**SW12**	**SW13**	**SW14**
Red-throated diver	0	0	0	2	1	0
Black-throated diver	1	2	0	0	2	0
Great northern diver	0	1	0	0	0	0
Unidentified diver species	2	7	9	3	8	1
Total numbers of divers	**3**	**10**	**9**	**5**	**11**	**1**

On the January 2007 survey, European shags were recorded in high numbers (raw counts: 104 shag, 5 cormorant, 127 cormorant/shag in SW13) (WWT Consulting, 2008). Cormorant/shag records were observations that were not identified to species and could have been either cormorant or shag. By the March 2007 survey the number of shags had decreased considerably (raw counts: 24 shag, 17 cormorant, 1 cormorant/shag SW13) (WWT Consulting, 2008). Using distance sampling methods to compensate for shags that were not counted as they were too far from the aircraft gave an estimated peak number of

[1] Estimates were obtained using a uniform model and extrapolating estimated density across the aerial survey block.

shag of 333 individuals (Table 3.2). This estimate includes observations of cormorant/shag, which may have been cormorants. However, given that only 5 cormorants were recorded on that survey, it is much more likely that they were shags. A more precautionary estimate of the numbers of shag in January 2007 is 186 individuals but this is probably an underestimate. By March 2007, the estimated number of shags had dropped to 113 individuals, or 120 individuals if the single cormorant/shag record is included in the population estimate.

Table 3.2. Estimated numbers of shag only and shag + cormorant/shag (observations that were not identified to species but were recorded as cormorant or shag) on the two WWT Consulting aerial surveys in 2007. Confidence intervals around the mean estimate are given in brackets.[2]

Date of survey	Shag only	Shag + cormorant/shag
January 2007	186 (132-295)	333 (259-434)
March 2007	113 (36-221)	120 (46-239)

JNCC Aerial Survey

On the JNCC aerial survey of 21 February 2009, the only birds to be recorded were three divers, one great northern, one red-throated and one unidentified diver.

3.1.2 Shore-based counts

Recent Systematic Shore-based Counts

Four systematic shore-based counts were carried out over two consecutive winters (2009/10 and of 2010/11). The contractor (Derek Julian) was specifically searching for divers, seaduck and grebes (also cormorant and shag) along the coast of the South Cornwall Coast AoS and recorded high numbers of divers, grebes and shag. The sum of observations from all count points is presented here; the counts from each individual count point are presented in Appendix A.

Only birds recorded sitting on the sea were used in these analyses. Of the total of 1166 records, only 1.7% were flying. Scoter were most frequently recorded flying (common scoter: n=8; velvet scoter n=1), divers were the second most frequently recorded flying (great northern diver: n=6; black-throated diver, n=1) and Slavonian grebe were the third most common species to be recorded flying (n=4). The exclusion of records of flying birds will make negligible difference to the population estimates and reduces the probability of double counting.

The most frequently recorded species was shag, followed by black-throated diver and great northern diver (Table 3.3). During both winters, both the diver species were present in numbers in excess of the respective UK SPA Selection Guidelines Stage 1.1 thresholds and in excess of the minimum of 50 birds usually accepted as the minimum for site selection (Stroud *et al* 2001).

All five grebe species were recorded, with black-necked grebe being the most common species, but only Slavonian grebe was present in numbers approaching the relevant (in this case, Stage 1.1) threshold (Table 3.3). (Thresholds are: Slavonian grebe: 11 birds (though

[2] Estimate obtained using a half-normal model and bootstrapped confidence intervals (see Methods for more information).

the minimum usually considered for site selection is 50 after Stroud *et al* 2001); little grebe: 4,000 birds; great crested grebe: 3,600 birds; red-necked grebe: 510 birds; black-necked grebe 2,200 birds.) However, under Stage 1.4 of the guidelines, where the application of the numerical thresholds under Stage 1.1-1.3 does not identify an adequate suite of areas, sites may be selected if they meet one of more of the Stage 2 guidelines (see section 2 of this report). No other species were recorded in high numbers or came close to exceeding the Stage 1.1 or Stage 1.2 thresholds. Carrick Roads, in the South Cornwall AoS, is the most important area in Cornwall for wintering red-breasted merganser (pers. comm. Derek Julian) but, with a MoP of 57 birds, there was less than 1% of the GB population of 8,400 birds and the MoP was far from the Stage 1.2 threshold of 1,700 birds.

Table 3.3. Numbers of waterbirds recorded during four shore-based counts carried out over two winters. The numbers are the sum of all individuals of that species recorded from the 35 count points along the coast of the South Cornwall AoS (see Figure 3.5) on that survey date. The mean of peaks (MoP) was the mean of the highest counts from each winter, indicated in bold.

	Winter 2009/10		**Winter 2010/11**		
	Dec 2009	**Feb 2010**	**Dec 2010**	**Feb 2011**	**MoP**
Greater scaup	**0**	0	0	**2**	1
Common Eider	0	**1**	6	**12**	6.5
Common Scoter	**66**	28	**40**	29	53
Velvet Scoter	**2**	0	**0**	0	1
Goldeneye	1	1	**6**	1	3.5
Red-breasted Merganser	10	**65**	34	**49**	57
Goosander	**0**	0	**10**	0	5
Red-throated Diver	0	**4**	**0**	0	2
Black-throated Diver	16	**127**	53	**102**	115
Great Northern Diver	45	**72**	27	**75**	74
Little Grebe	0	**9**	**10**	8	9.5
Great Crested Grebe	7	**9**	9	**17**	13
Red-necked Grebe	0	**6**	4	**6**	6
Slavonian Grebe	1	**7**	3	**10**	8.5
Black-necked Grebe	5	**11**	**67**	53	39
European shag	**330**	173	317	**472**	401

Previous Systematic Shore-based Counts

Systematic shore-based counts of the South Cornwall Coast AoS were also carried out in the winters of 1994/95 and 1999/2000 by the RSPB (Geary & Lock, 2001; Slade, 1996). The same 35 count points were used for both the more recent surveys, in 2009-2011, and the earlier surveys in the 1990s. Methods were the same, except that the counts in the 1990s spent longer (30 minutes) at each count point than the more recent surveys (10-15 minutes) and that a total of five visits each winter were done in the 1990 surveys, rather than two visits in 2009-11. See Geary & Lock (2001) and Slade (1996) for more information. Appendix A gives a detailed breakdown of shore-based counts by count section for the winters 2009/10 and 2010/11. Table 2.1, compares the peak counts from the 1994/1995 survey, the 1999/2000 survey and the 2009-2011 survey. With the exception of black-necked grebe, numbers of waterbirds wintering in the South Cornwall Coast AoS appeared to be similar but slightly higher in the 1990s. However, this may be due to the increased survey effort in the 1990 surveys, which might lead to slightly higher estimates when compared to the more recent surveys. European shag numbers appeared to decline substantially from the mid to the late 1990s and stabilise thereafter. The previous surveys demonstrate the historical occupancy of the South Cornwall Coast AoS by wintering divers, grebes and shag over a 16 year period and show that the numbers and distribution within the AoS were broadly similar over this period (Geary & Lock, 2001; Slade, 1996).

Table 3.4. Peak estimates of numbers of waterbirds wintering in the South Cornwall Coast AoS, from systematic shore-based counts carried out in 1994/1995 (Slade, 1996), 1999/2000 (Geary & Lock, 2001) and mean of peak estimates from the 2009-2011 surveys.

	1994/1995	1999/2000	2009-2011
Black-throated Diver	135	160	115
Great Northern Diver	88	109	74
Red-necked Grebe	26	35	6
Slavonian Grebe	36	57	8.5
Black-necked Grebe	14	18	39
Red-breasted Merganser	155	123	57
European Shag	1127	443	401

WeBS counts from within the South Cornwall AoS

The WeBS counts are more likely to be under estimates of the numbers of divers and grebes present in the area, than are systematic shore-based counts, and so the WeBS counts should be accorded lower importance than the systematic shore-based counts.

There are three WeBS count areas within the South Cornwall AoS: the Fal Complex, Gerrans Bay and the Helford Estuary (http://blx1.bto.org/websonline). The Helford Estuary supported only very low numbers of divers (one or two records each winter) and out of five species of grebes only little grebes occurred more regularly but also in very low numbers (MoP = 4). Therefore, the data are not presented here. The Fal Complex comprises seven individual count areas but only two areas regularly supported divers and grebes: Carrick Roads and the Percuil River.

Gerrans Bay supported the greatest number of divers and grebes, with black-throated and great northern divers present, the former in numbers in excess of the Stage 1.1 UK SPA Selection Guidelines threshold of 6 birds and in excess of the 50 birds usually considered the minimum for site selection (Table 3.5). In comparison with black-throated divers, great northern divers appear to be under recorded by WeBS counts, probably due to most of them occurring outside the WeBS counts areas. Black-necked grebes were most common in Carrick Roads, although low numbers were consistently recorded in Gerrans Bay. Within the Fal Complex, only Carrick Roads supported high numbers of grebes, although WeBS counts were lower than the systematic shore-based counts for both red- and black-necked grebes.

Table 3.5. Mean of peak counts over five winters (2004/05 to 2008/09) for three WeBS count areas. Peak counts for each winter are presented in Appendix A.

	WeBS Count Area Name		
Species	**Gerrans Bay**	**Carrick Roads**	**Percuil River**
Goldeneye		8.7	
Red-breasted merganser		47.0	15.3
Black-throated diver	51.2		
Great northern diver	14.2	2.8	
Little grebe		9.75	7.2
Red-necked grebe	1.6		
Slavonian grebe	10.6*		
Black-necked grebe	3.4	23.2	
Great cormorant	31.8	13.4	4.4
European shag	47.4	29.8	

*WeBS counts 2005/6-2009/10 gave a MoP of 14 for Slavonian grebe.

Shags were recorded in low numbers in Gerrans Bay and Carrick Roads, with a peak count of 128 birds in Gerrans Bay in January 2009 (Appendix A). Counts in January and March 2007 were not unusually high, suggesting that the WWT Consulting aerial survey population estimates for shag were representative of the numbers present in other years. The systematic shore-based counts broadly agree with the WeBS counts, both in terms of species present and the numbers of birds, although the systematic counts recorded many more shags, black-throated and great northern divers than the WeBS counts, presumably due to counting over a larger area.

British Trust for Ornithology Atlas data

Winter counts contributing to the forthcoming BTO Atlas reinforced the importance of Carrick Roads for black-necked grebes in recent years. Peak counts from non-timed (casual) visits in the winters 2007/8 to 2011/12 for Carrick Roads gave the following numbers, respectively: 9, 35, 26, 78, 81. Note that these peaks are sector-specific and not necessarily (or likely) relating to the spatial extent of the AoS.

Cornish Bird Reports

The Cornwall Monthly Birding Reviews did not generally report numbers of divers and grebes, although 52 black-necked grebes were reported off Loe Beach in Carrick Roads in December 2010 (www.cornwall-birding.co.uk); 81 were reported from the same site in February 2012 (www.cbwps.org.uk/bird_news1%202012%20Feb.htm).

3.2 Distribution of Birds

3.2.1 Aerial survey data

WWT Consulting aerial survey data

The WWT Consulting aerial survey data show that divers do occur further offshore than can be recorded from land, (Figure 3.2). All the observations of divers that were recorded to species were very close inshore and all those recorded further offshore were only identified to genus, so it is not possible to detect any species-specific pattern to the distribution of divers along the South Cornwall coast. The distribution of divers changed between the two surveys, with more divers recorded further offshore in the March 2007 survey, compared with the January 2007 survey.

Similarly, shags were recorded further offshore on the March 2007 WWT Consulting aerial survey, compared to the January 2007 survey, although the large flocks of 20, 60 and 120 birds were not seen on the later survey (Figure 3.3, Figure 3.4). More cormorants were recorded on the March 2007 survey, than the January 2007 survey, although this could be due to some cormorants being identified as ‘cormorant/shag’ on the first survey.

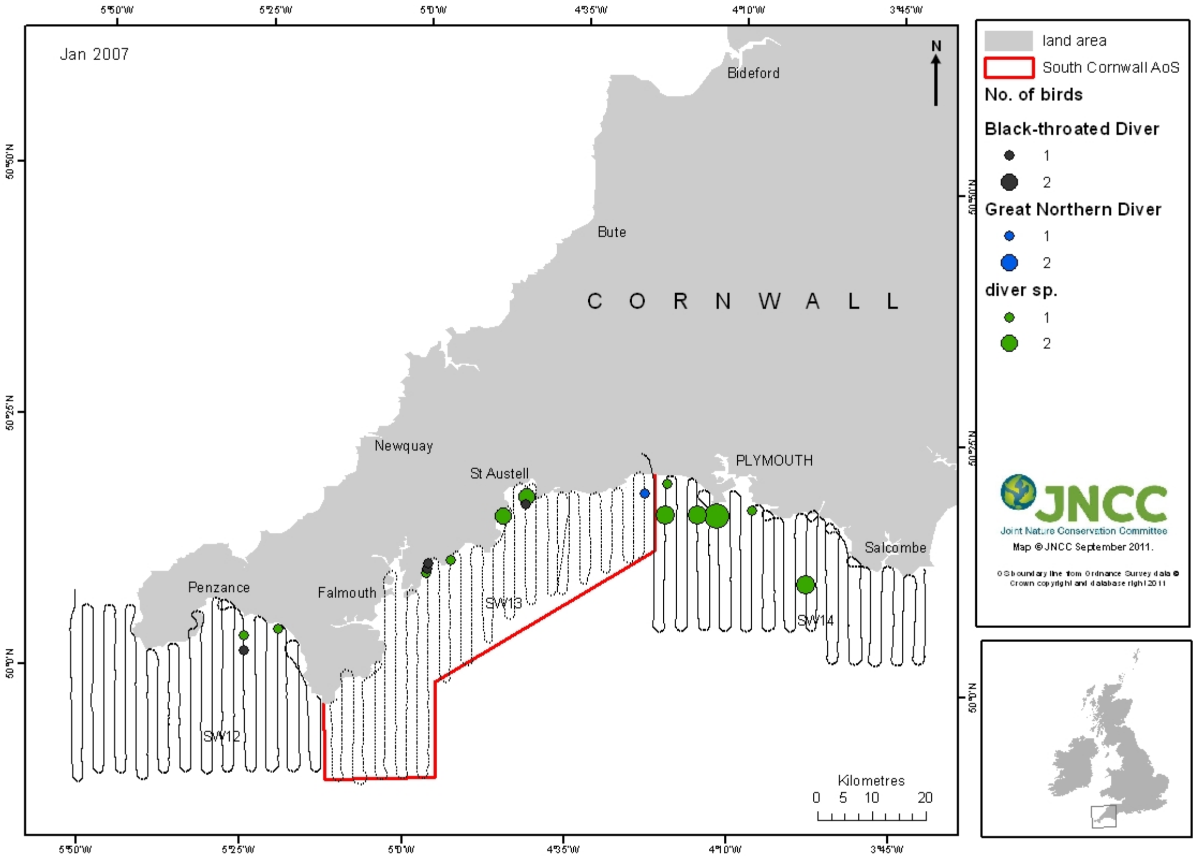

Figure 3.1. Divers recorded on WWT Consulting aerial surveys in January 2007 and the South Cornwall Coast AoS (area of search).

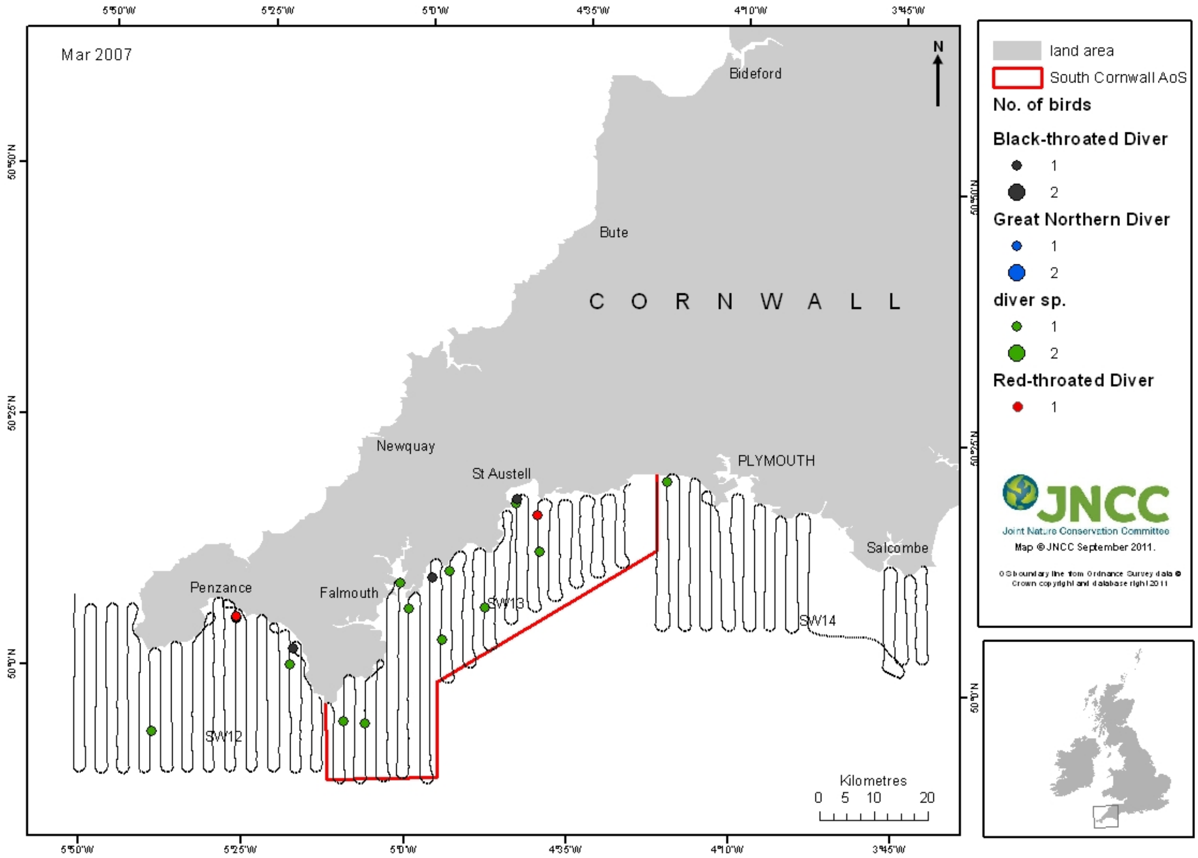

Figure 3.2. Divers recorded on WWT Consulting aerial surveys in March 2007 and the South Cornwall Coast AoS (area of search).

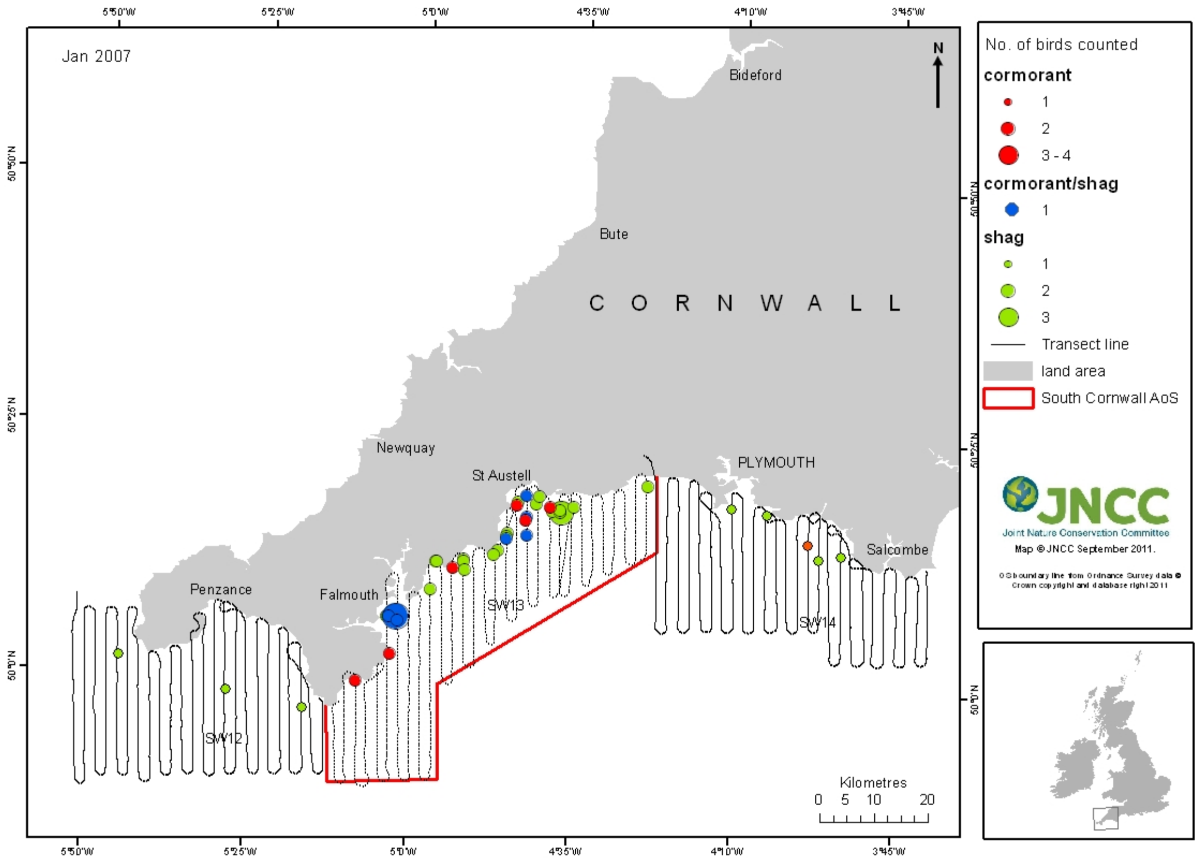

Figure 3.3. Shags and cormorants recorded on WWT Consulting aerial surveys in January 2007 and the South Cornwall Coast AoS (area of search).

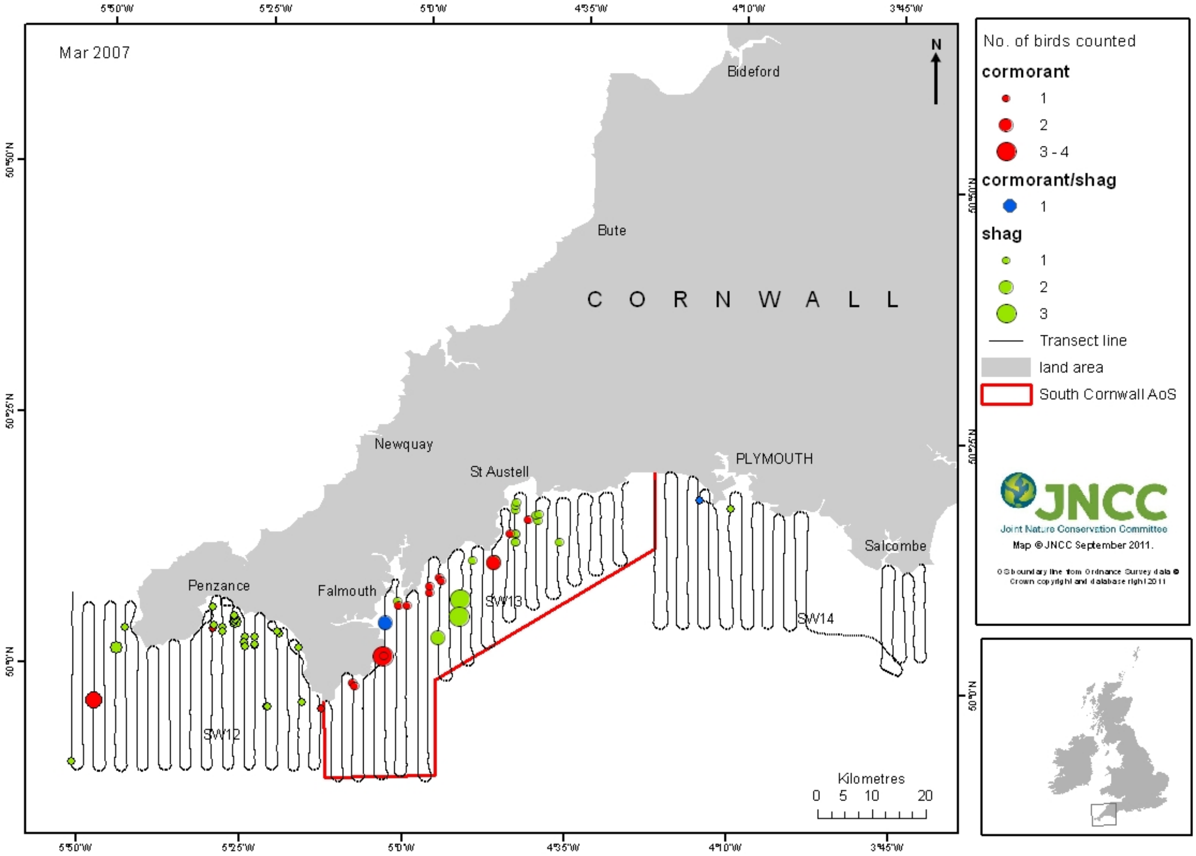

Figure 3.4. Shags and cormorants recorded on WWT Consulting aerial surveys in March 2007 and the South Cornwall Coast AoS (area of search).

<u>Aerial surveys by JNCC</u>

The single JNCC aerial survey recorded only three divers. All three observations were to the south and east of Greeb Point (Figure 3.4). No grebes or seaduck were recorded. Observers were not instructed to look for shags or cormorants.

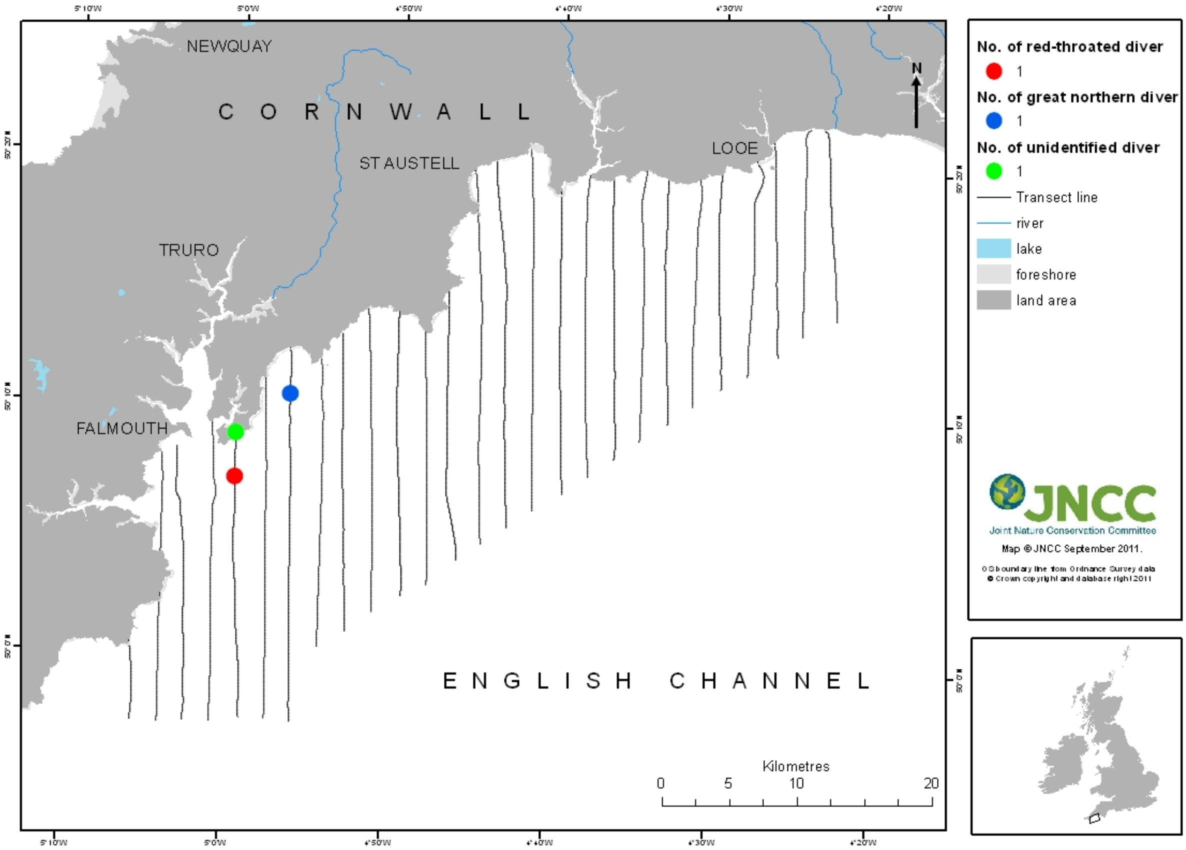

Figure 3.5. Numbers and distribution of divers recorded during an aerial survey carried out by JNCC during February 2009.

3.2.2 Shore-based counts

Systematic shore-based counts

Black-throated divers were most frequently recorded in the central part of the South Cornwall AoS, in Veryan Bay, with lower numbers in Gerrans Bay and St Austell Bay, in the east of the AoS. None were recorded in the west of the AoS, in Falmouth Bay, on any of the four surveys (Figure 3.6, Figure 3.7, Figure 3.9). Black-throated divers were seen to move between bays, depending on state of tide and wind direction (*pers. comm.* Derek Julian). Great northern divers were recorded throughout the AoS, from almost every count point. Generally, they tended to be recorded less frequently and in lower numbers in the west of the AoS, in Falmouth Bay, and more commonly in the central part and east of the AoS, in Gerrans Bay, Veryan Bay, Mevagissey Bay and St Austell Bay (Figure 3.10., Figure 3.11., Figure 3.12., Figure 3.13.).

Black-necked grebes were only ever recorded in Carrick Roads, mostly at the northern end of the ria (Figure 3.14., Figure 3.15., Figure 3.16., Figure 3.17.). Red-necked grebes were not recorded on the first survey, in December 2009, but on subsequent surveys were widespread throughout the AoS, being recorded around the Helford Estuary, Carrick Roads, Veryan Bay, Gerrans Bay and Mevagissey Bay, often being seen in waves breaking on the beach (*pers. comm.* Derek Julian) (Figure 3.18., Figure 3.19., Figure 3.20.). Slavonian grebes were recorded regularly in Gerrans Bay, and at times in most other areas of the AoS (Figure 3.21-3.24), always in small numbers. For counts of all species in each count section on each shore-based survey during 2009/10 and 2010/11, see Appendix A.

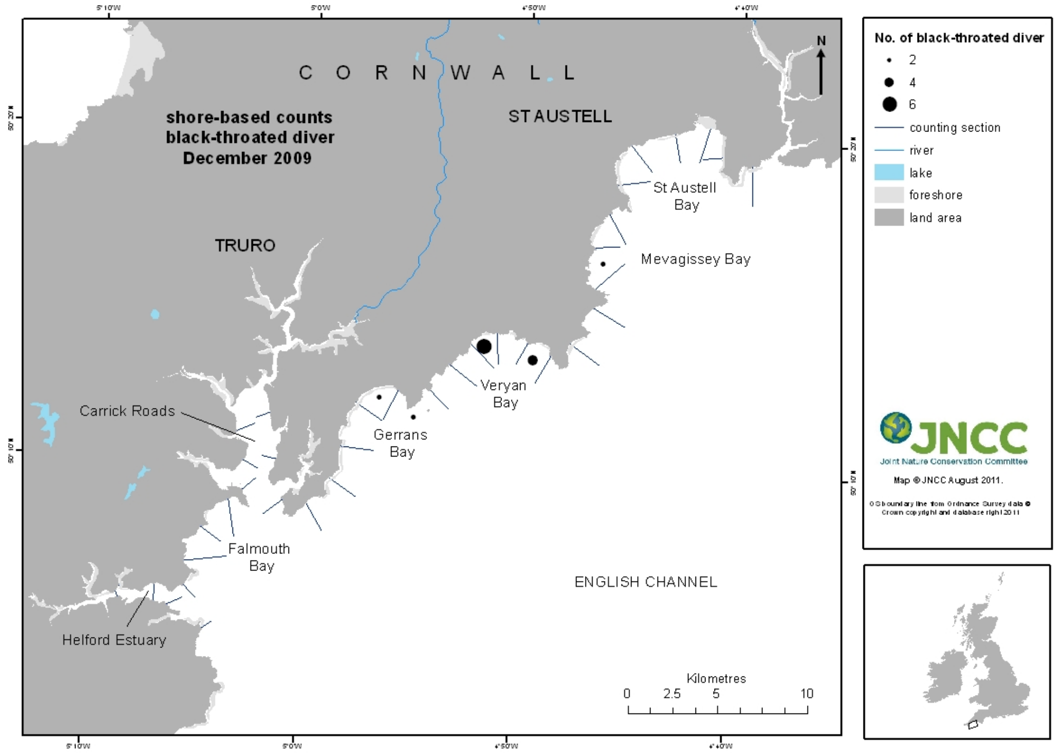

Figure 3.6. Distribution of black-throated divers in December 2009 during shore-based counts.

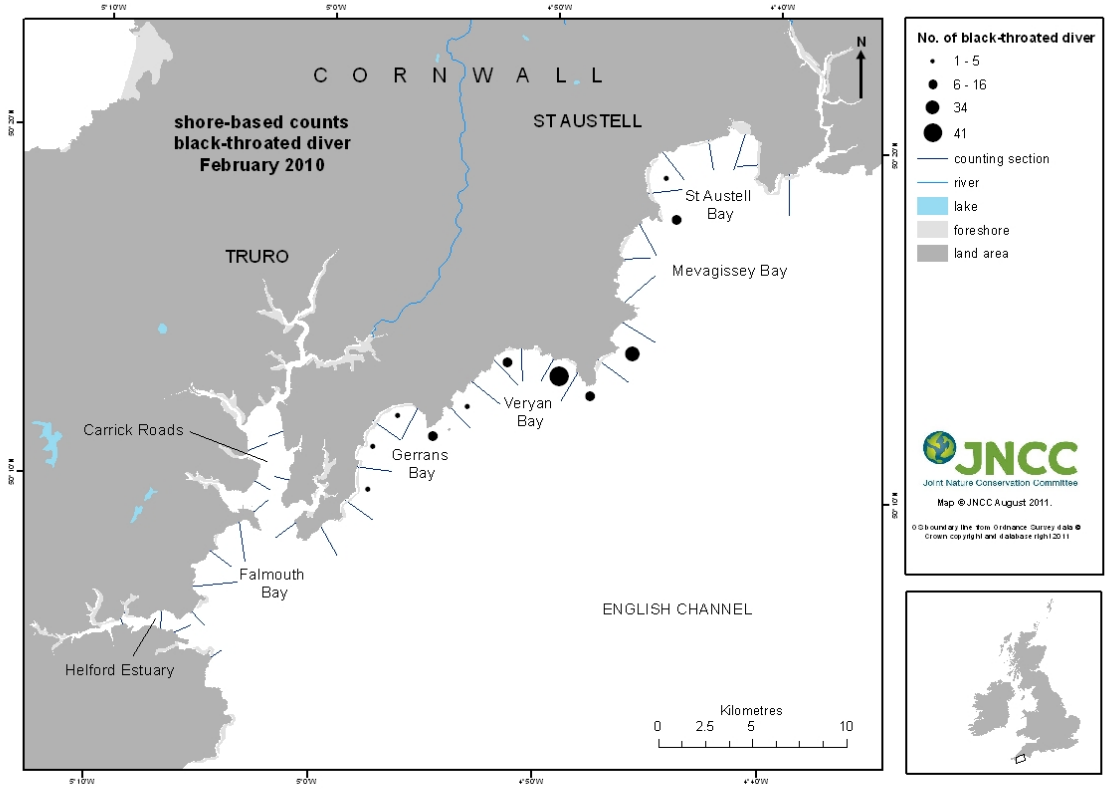

Figure 3.7. Distribution of black-throated divers in February 2010 during shore-based counts.

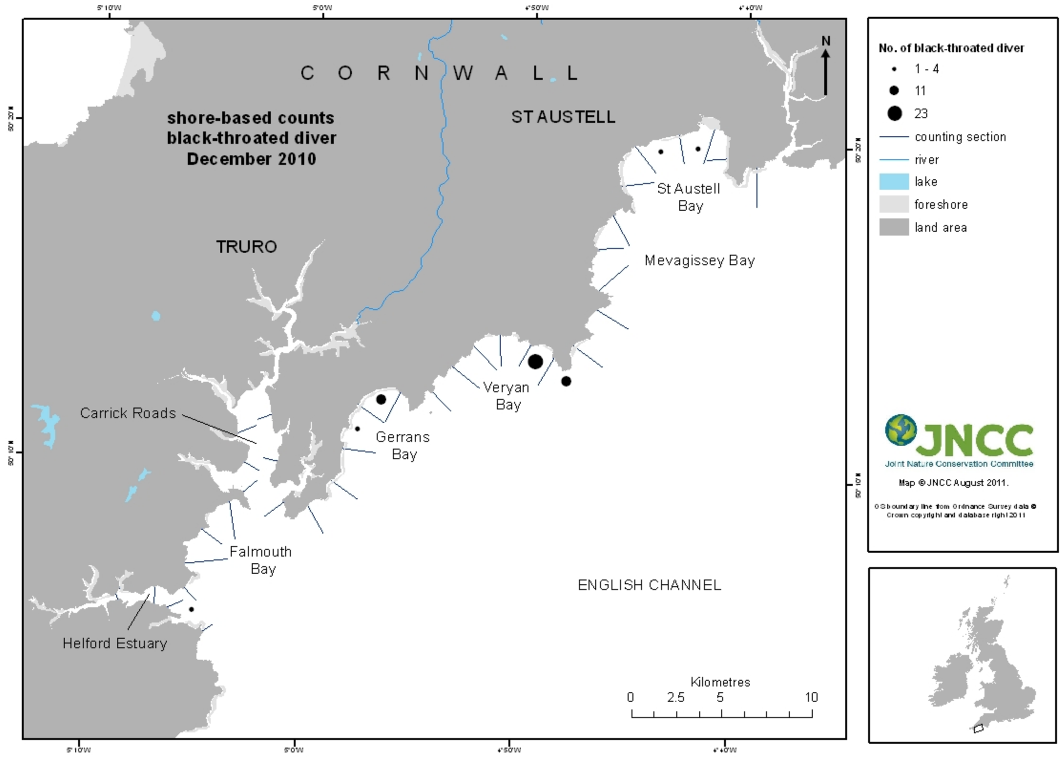

Figure 3.8. Distribution of black-throated divers in December 2010 during shore-based counts.

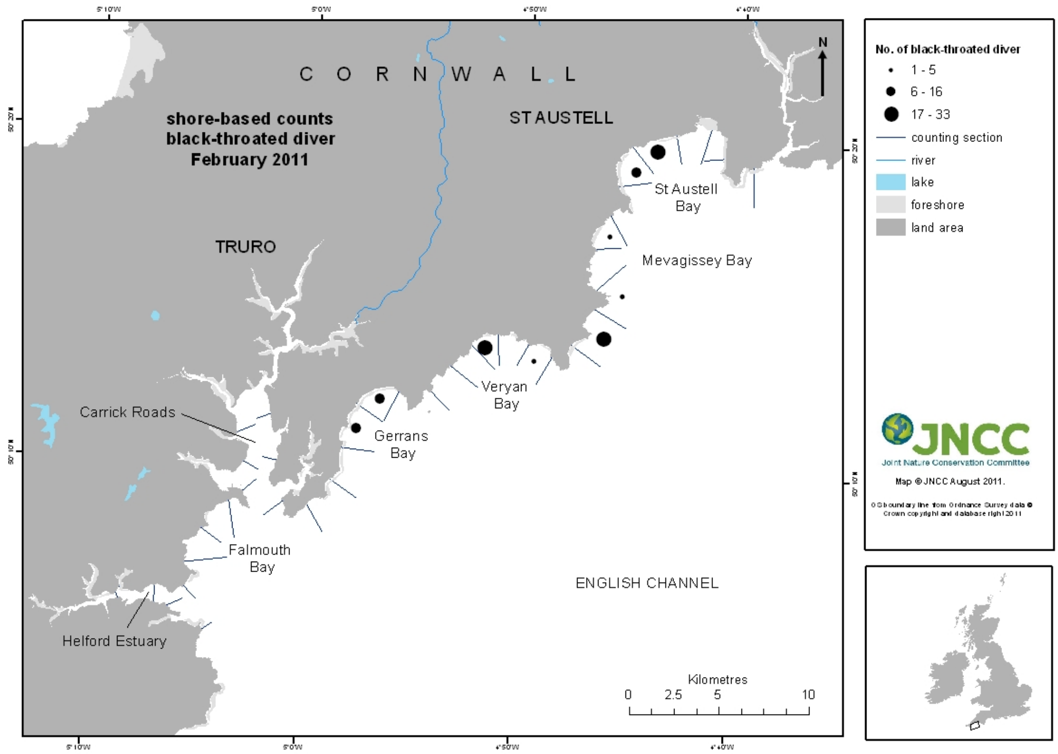

Figure 3.9. Distribution of black-throated divers in February 2011 during shore-based counts.

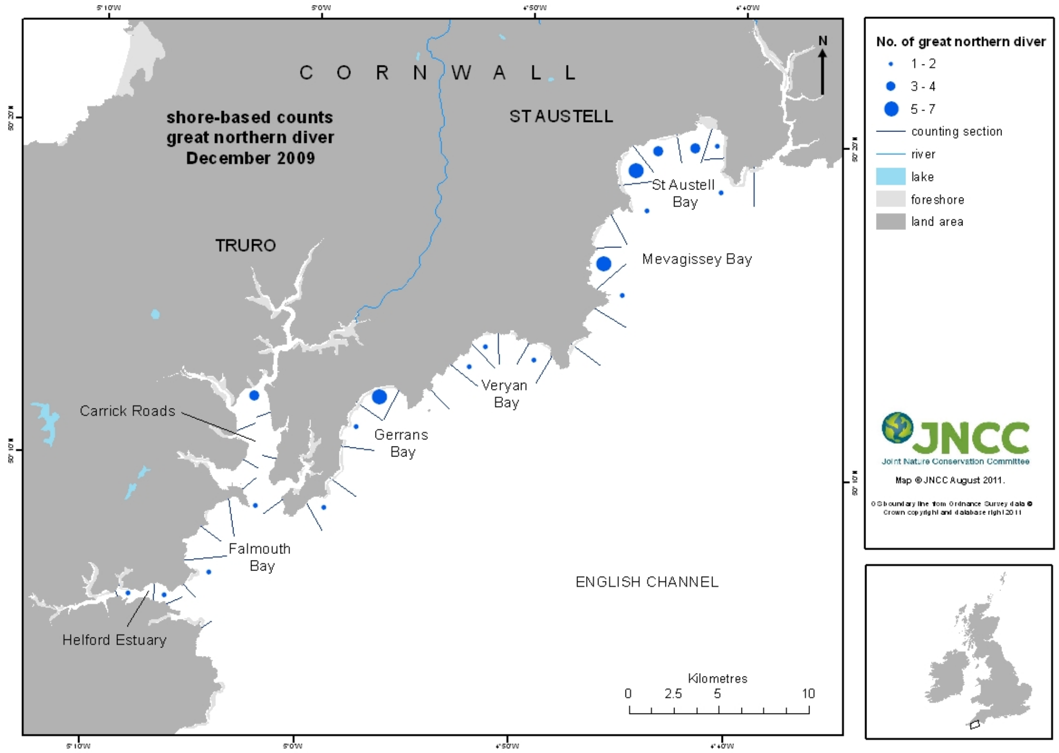

Figure 3.10. Distribution of great northern divers in December 2009 during shore-based counts.

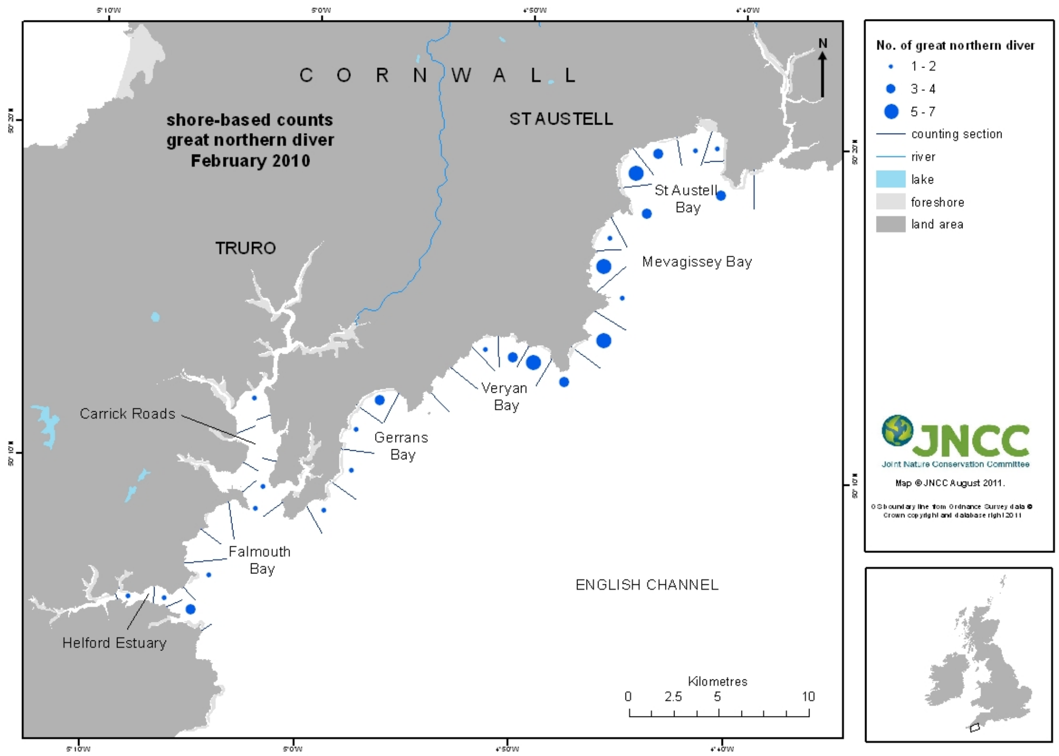

Figure 3.11. Distribution of great northern divers in February 2010 during shore-based counts.

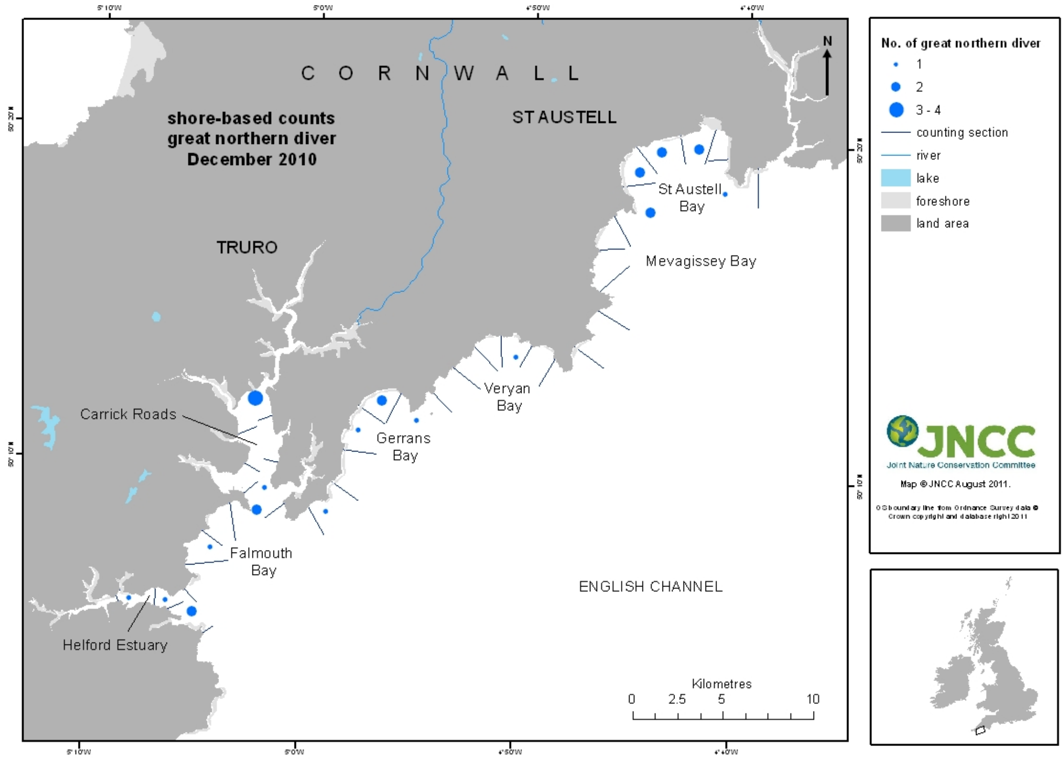

Figure 3.12. Distribution of great northern divers in December 2010 during shore-based counts.

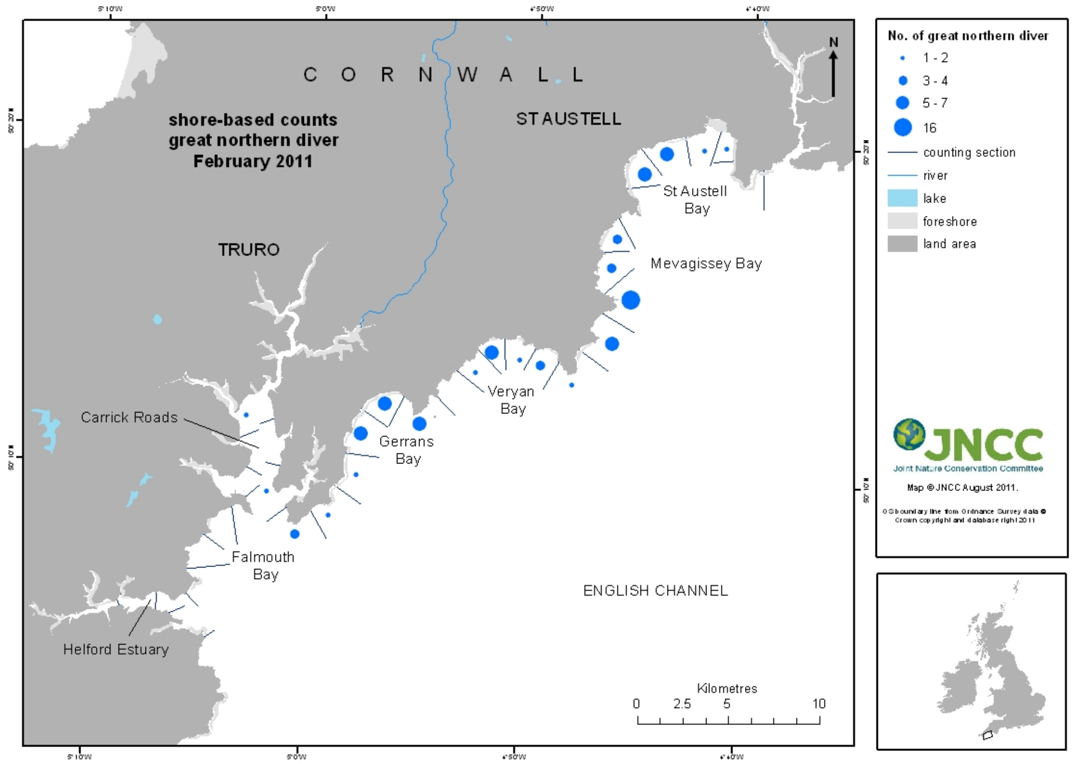

Figure 3.13. Distribution of great northern divers in February 2011 during shore-based counts.

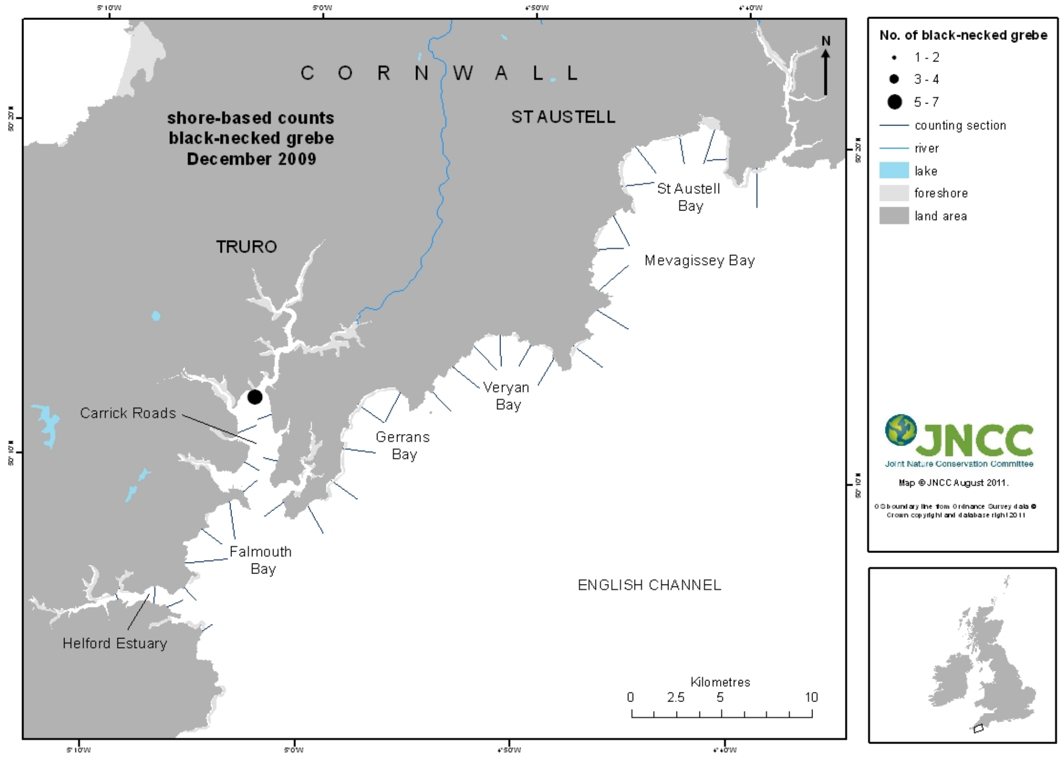

Figure 3.14. Distribution of black-necked grebes in December 2009 during shore-based counts.

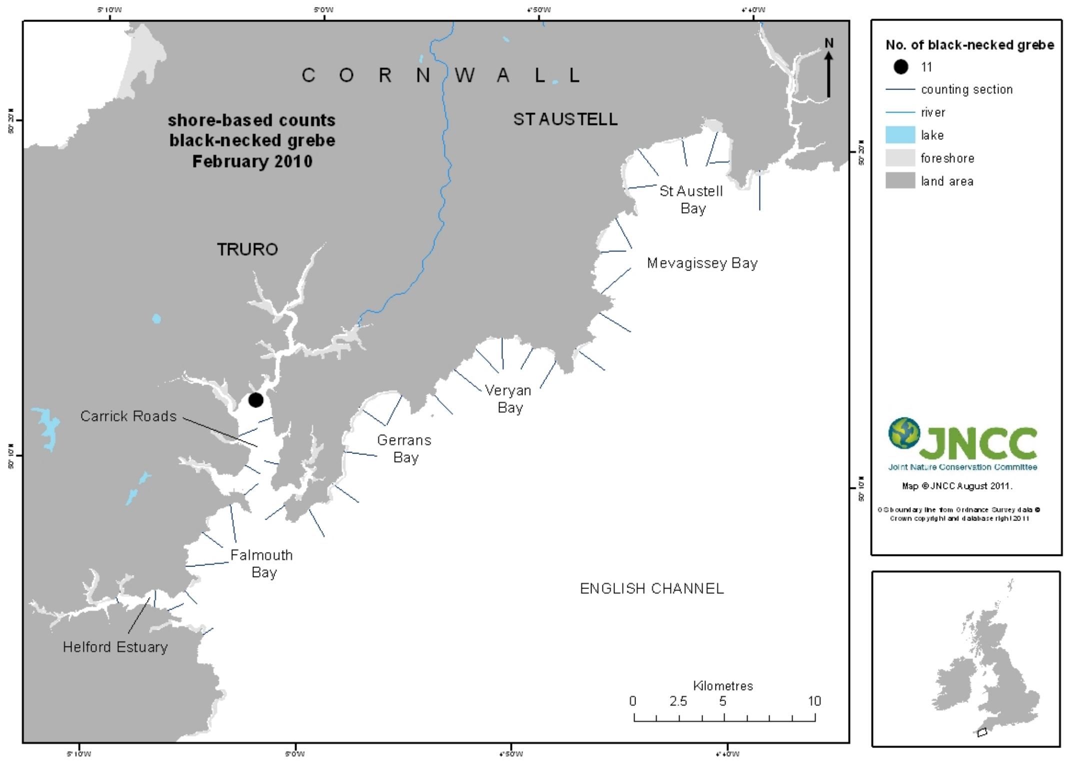

Figure 3.15. Distribution of black-necked grebes in February 2010 during shore-based counts.

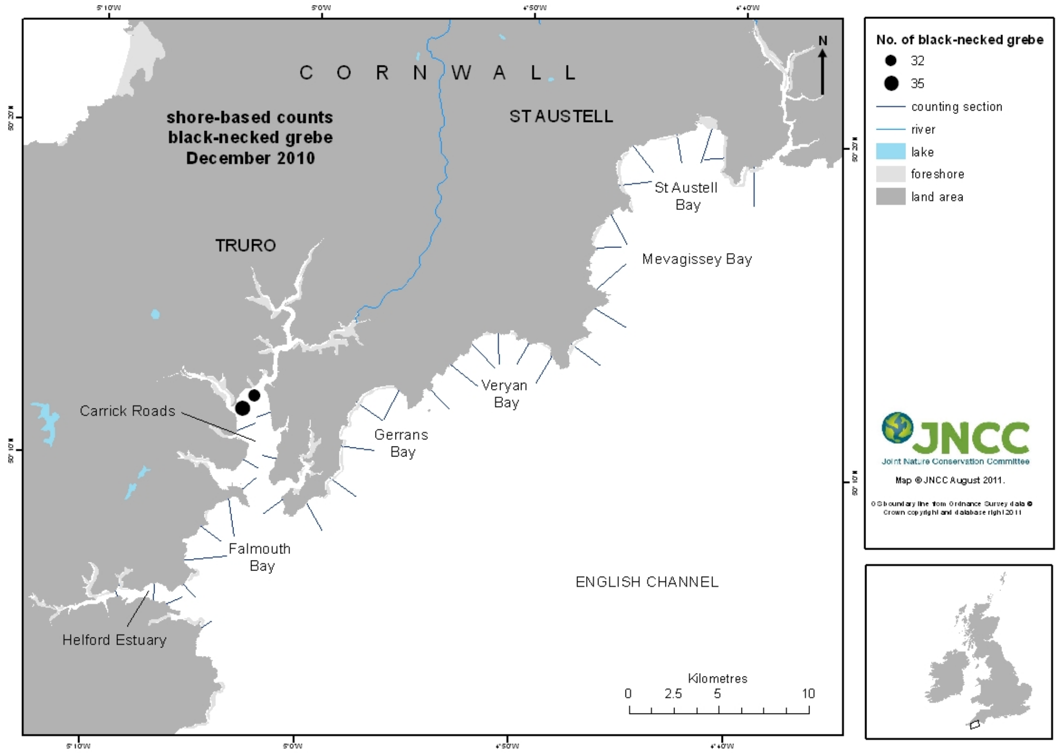

Figure 3.16. Distribution of black-necked grebes in December 2010 during shore-based counts.

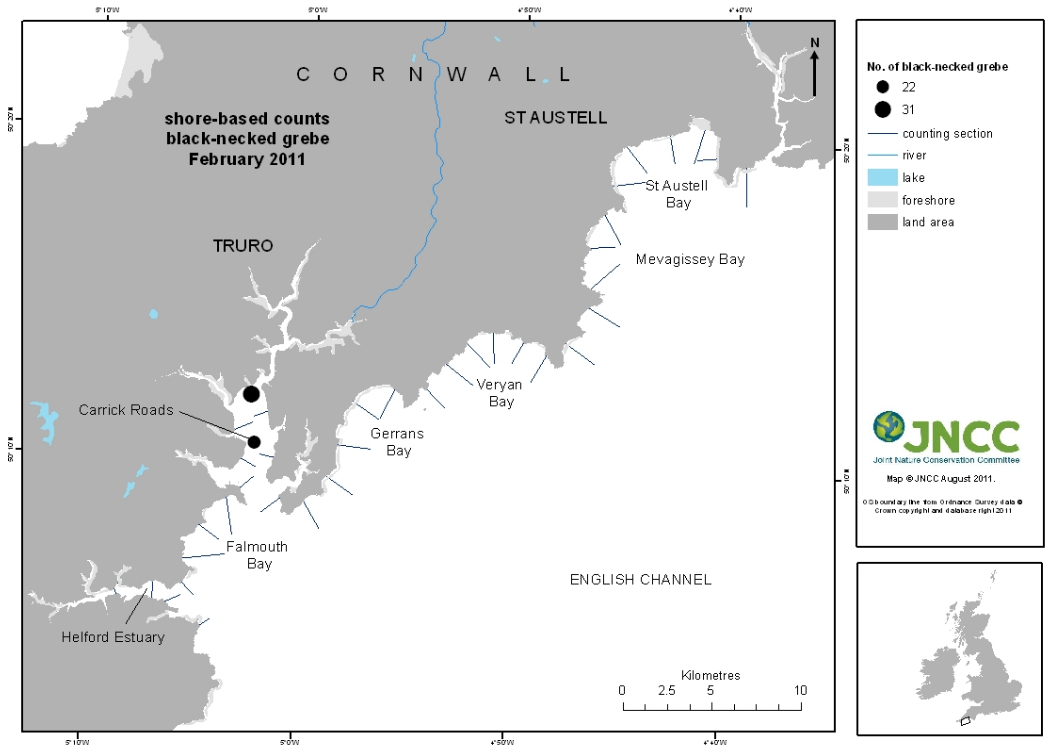

Figure 3.17. Distribution of black-necked grebes in February 2011 during shore-based counts.

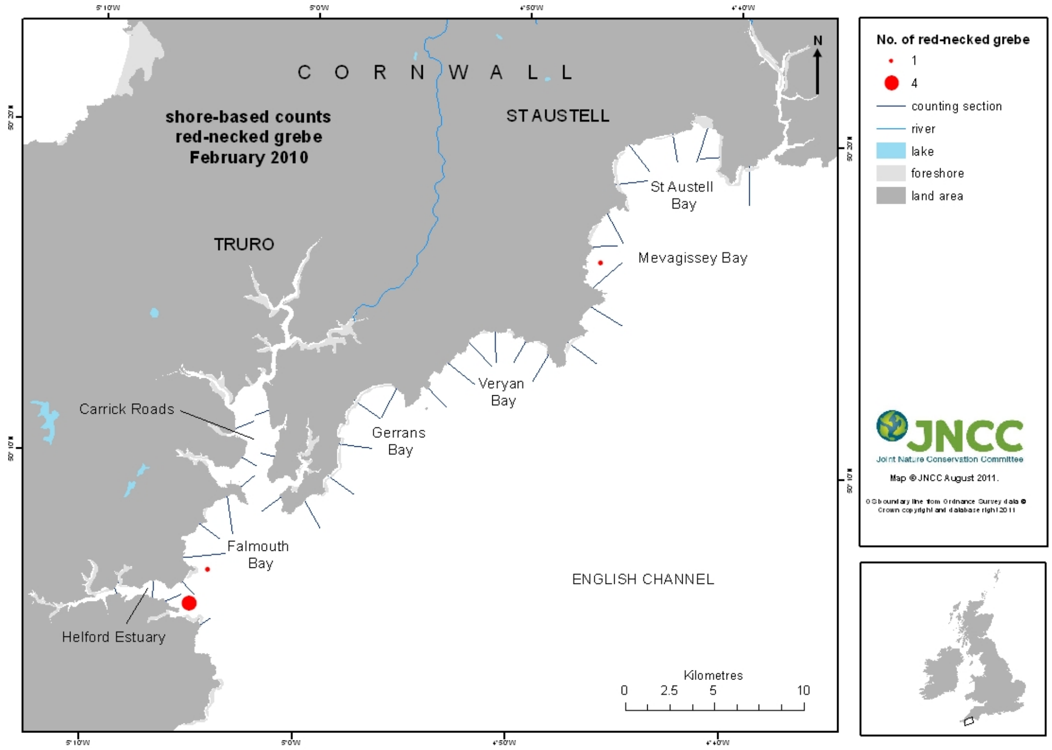

Figure 3.18. Distribution of red-necked grebes in February 2010 during shore-based counts. (No red-necked grebes were recorded in December 2009.)

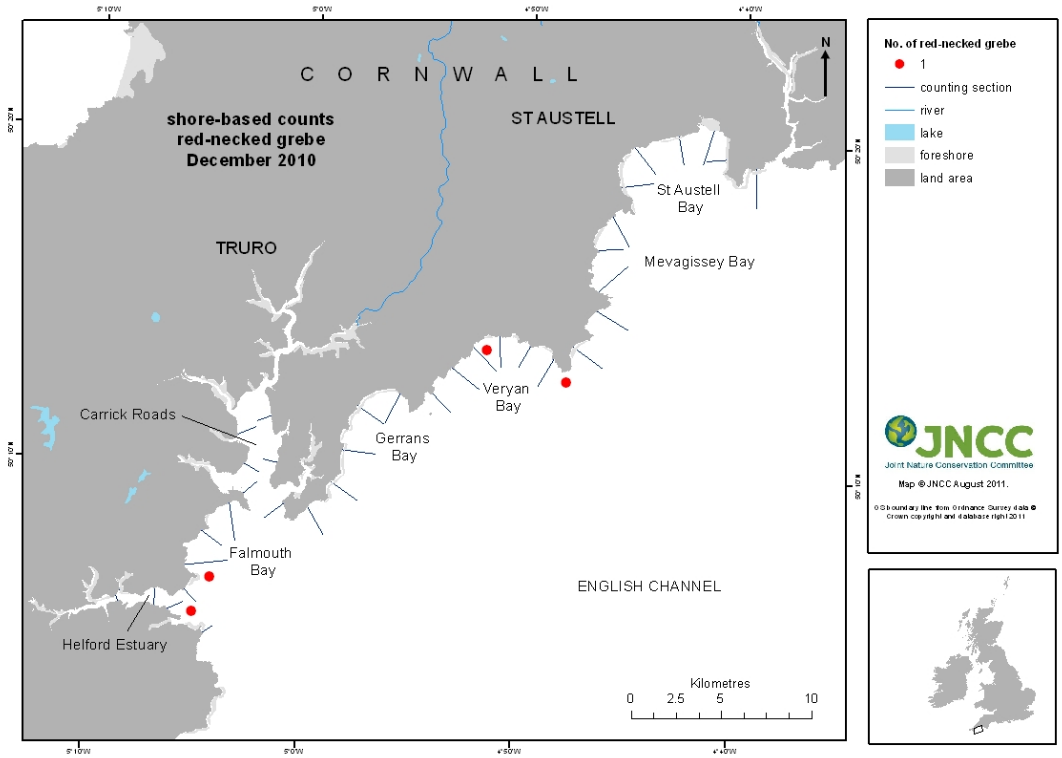

Figure 3.19. Distribution of red-necked grebes in December 2010 during shore-based counts.

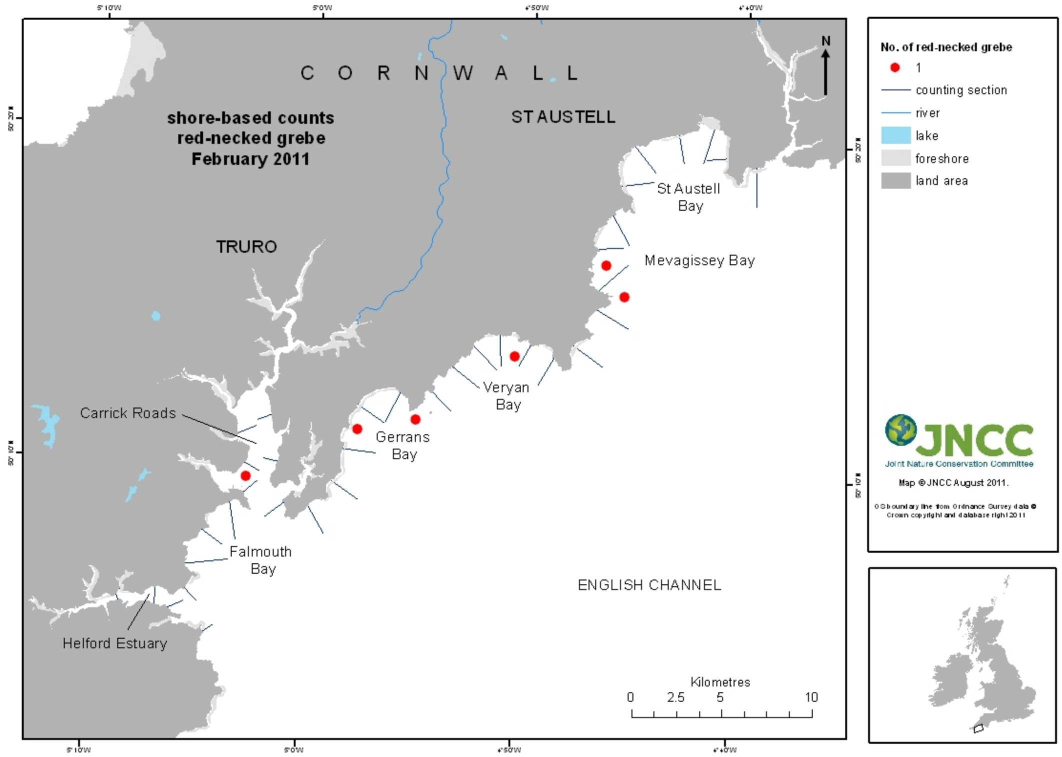

Figure 3.20. Distribution of red-necked grebes in February 2011 during shore-based counts.

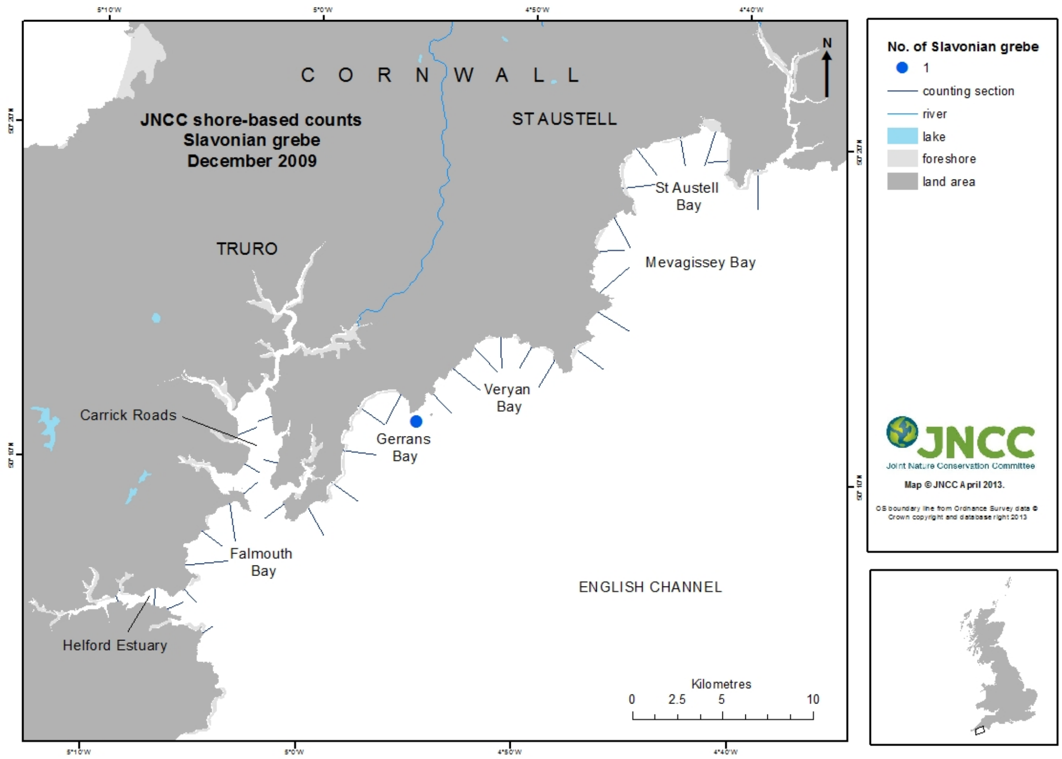

Figure 3.21. Distribution of Slavonian grebes in December 2009 during shore-based counts.

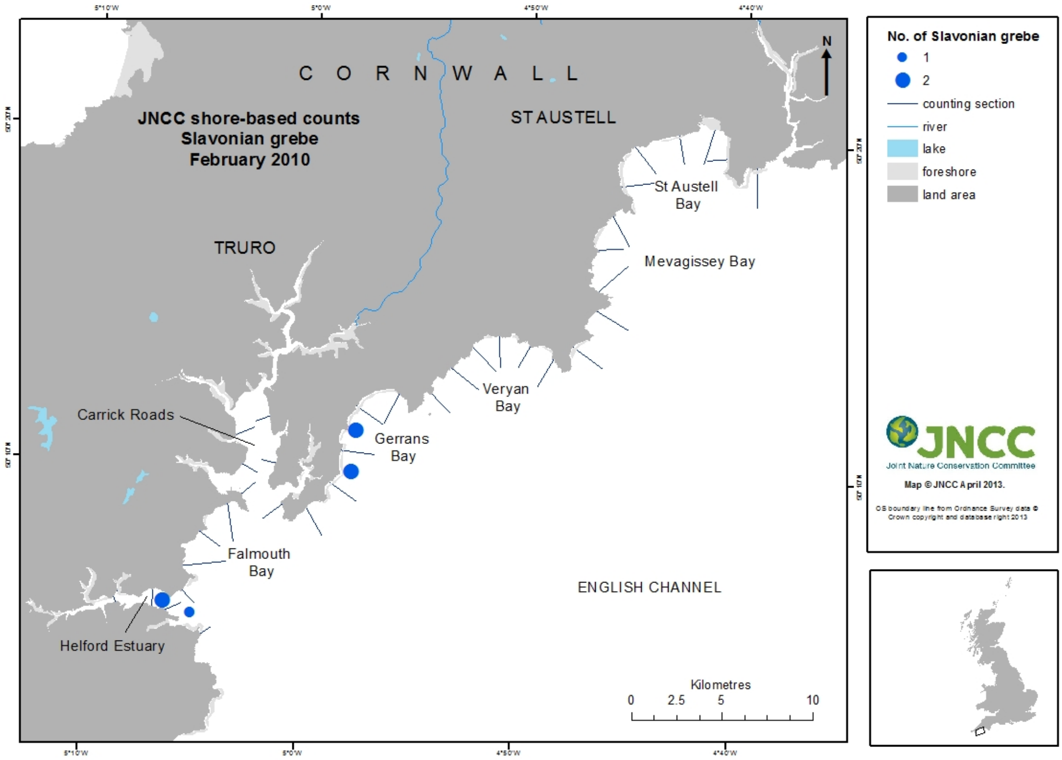

Figure 3.22. Distribution of Slavonian grebes in February 2010 during shore-based counts.

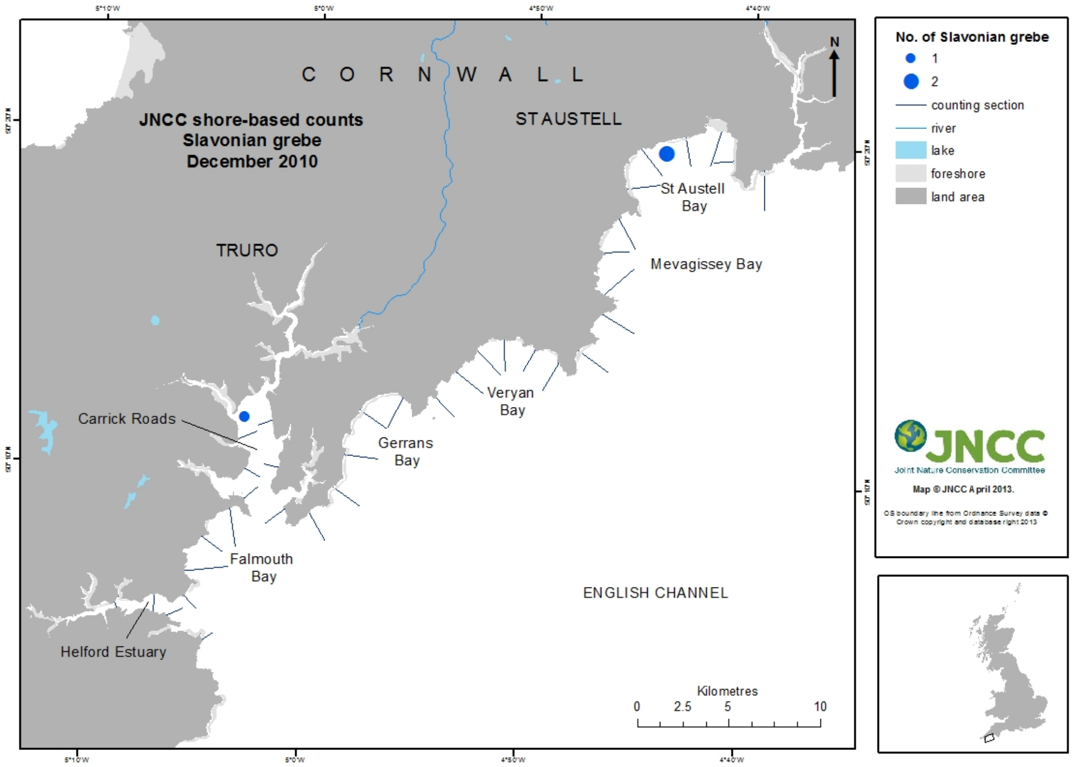

Figure 3.23. Distribution of Slavonian grebes in December 2010 during shore-based counts.

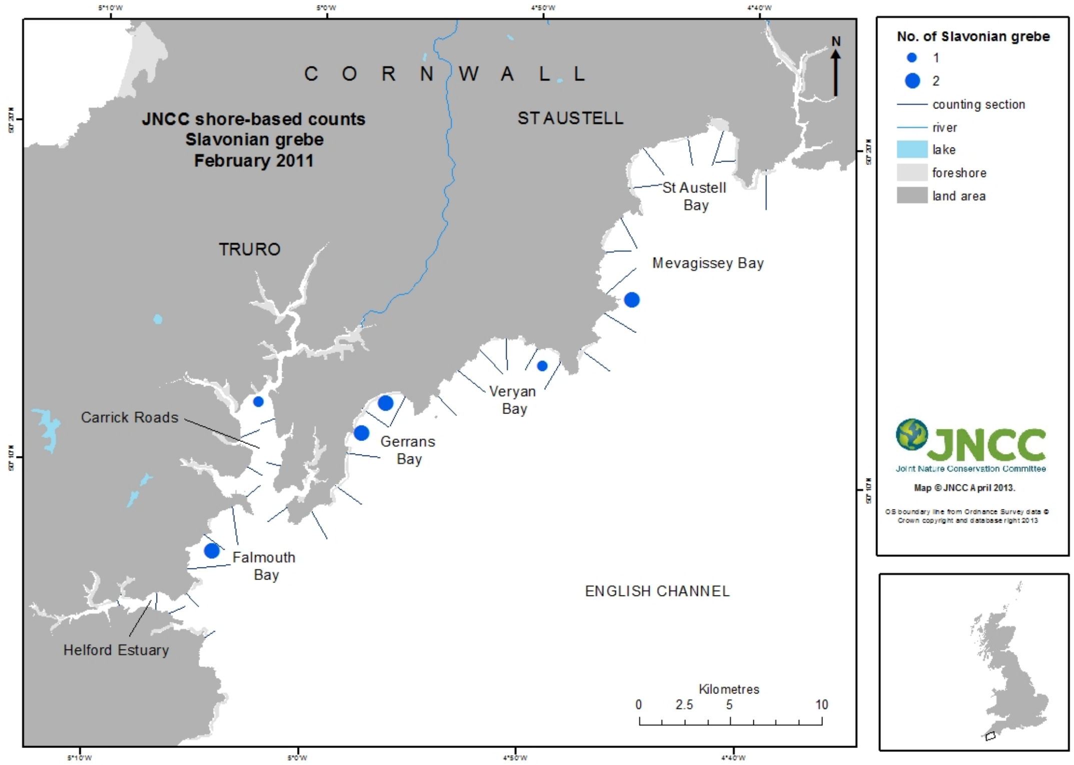

Figure 3.24. Distribution of Slavonian grebes in February 2011 during shore-based counts.

3.3 Importance of the South Cornwall AoS in a regional and national context

3.3.1 Regional Importance of the South Cornwall AoS

There is a lack of good quality data to assist with understanding the relative importance of the South Cornwall AoS for divers and grebes, compared with the rest of the Cornish coast. For example, systematic shore-based counts that focussed on divers, grebes and seaduck, are restricted to the AoS. However, WeBS counts, opportunistic shore-based counts and aerial survey data provide some information on the numbers of divers and grebes outside the AoS.

The WWT Consulting aerial survey data suggest there may be more divers to the east and west of the AoS but since most of the observations were not identified to species it is not possible to know which species they might be (Figure 3.1, Figure 3.2). Additional data collected by the systematic shore-based count surveyor, Derek Julian, showed that numbers of black-throated divers in Mounts Bay, to the west of the South Cornwall AoS, have been increasing in recent years. An estimated 30 black-throated divers and 35 great northern divers regularly use Mounts Bay (D. Julian, unpublished data) but these are not systematic counts, only opportunistic sightings and, while they exceed the respective 1% national population threshold under Stage 1.1 of the SPA Selection guidelines, neither meets the 50 birds usually considered a minimum for site selection. Mounts Bay is not contiguous with the South Cornwall Coast AoS; the two areas are separated by the Lizard Peninsula. The same opportunistic counts suggest numbers of divers to the east of the AoS, as far as the county border, were low and numbers of grebes to the east and west of the AoS were low.

WeBS counts from other parts of the Cornish coast are sparse but, where counts have been made, the data show there are no consistent aggregations of divers, seaduck or grebe elsewhere along the coast. For example, WeBS counts of the Tamar Complex, collected during the last eight years (2001/02 to 2008/09), of divers, seaduck and the three rarer grebe species never exceeded six birds. The WWT Consulting aerial survey recorded some shag to the east and especially to the west of the AoS, in Mounts Bay, but the majority of shag and cormorant/shag records were within and further offshore from the South Cornwall AoS. The numbers of shags recorded during WeBS counts from the Tamar Complex were very low (only one or two birds each year).

The RSPB survey of 1994/1995 (Slade, 1996) carried out shore-based counts in several inshore areas around the coast of Devon and Cornwall, but not Mounts Bay. They recorded low numbers of all species of diver, seaduck and grebe and identified the South Cornwall Coast as the most important area in the southwest region for divers, grebes and shag. Those data were used to inform the location and size of the South Cornwall Coast Important Bird Area.

3.3.2 National Importance of the South Cornwall AoS

Black-throated diver

No other area in the UK is known to support as many black-throated divers as the South Cornwall AoS. The JNCC systematic shore-based counts, covering the whole of the AoS including Gerrans Bay, estimated a MoP of 115 birds, which is almost 21% of the GB wintering population estimate (Musgrove *et al* 2011). Three AoS in Scotland were also found to have high numbers of black-throated diver (MoP: Wester Ross = 65; Scapa Flow = 57; Outer Hebrides = 41; O'Brien *et al*, 2010; O'Brien *et al*, 2011) but the South Cornwall AoS had almost twice as many black-throated diver as the next most important area.

WeBS data recognise the national importance of Gerrans Bay, with a MoP from five years of counts of 72 birds (Holt *et al* 2011). (The MoP presented in the WeBS report differs to the MoP calculated in this report as the WeBS report used data from throughout the year, whereas this report only considered WeBS counts conducted during October to March, inclusive.) The systematic shore-based counts are a more reliable estimate of the numbers of divers in the South Cornwall Coast AoS than the WeBS data and so should be accorded higher priority. This is because the observers collecting the shore-based count data, unlike the WeBS volunteers, have the opportunity to select good vantage points and fair weather conditions for counting divers and grebes. Both WeBS data and other shore-based count data around the UK found black-throated divers to have a northerly distribution. All other important wintering black-throated diver areas in the UK are in Scotland, so any SPA off the coast of south Cornwall would offer protection, not only to the largest aggregation of wintering black-throated divers in the UK, but would also protect this species at the southern edge of their UK range.

Figure 3.25. Gerrans Bay in south Cornwall, which supports the highest numbers of wintering black-throated divers in the UK.

Great northern diver

Great northern divers are found in high numbers in many areas of north and west Scotland, e.g. an estimated 1400 individuals off the west coast of the Outer Hebrides (O'Brien *et al* 2011). However, the South Cornwall AoS is the most important area for this species within the UK, outside Scotland, with a MoP of 74 individuals. This represents 3% of the GB wintering population (Musgrove *et al* 2011), although the current wintering population estimate of 2,500 birds is likely to be an underestimate (O'Brien *et al* 2011). This area is several hundred miles south of the main UK wintering population, suggesting any SPA off south Cornwall would contribute to the protection of this species at the southern edge of its UK range.

Black-necked grebe

Black-necked grebes are recorded in low numbers inland in England but Carrick Roads, within the South Cornwall AoS, is probably the most important marine area in the UK for this species, with a MoP of 39 birds, based on JNCC systematic shore-based counts. WeBS counts (Holt *et al* 2011) suggested Studland Bay (MoP of 28 birds) was more important than Carrick Roads (MoP of 23 birds) but this is still less than the MoP for the South Cornwall AoS of 39 birds obtained by JNCC counts. The systematic shore-based counts are a more reliable estimate of the numbers of grebes in the South Cornwall Coast AoS than the WeBS data and so should be accorded higher priority. This is because the observers collecting the shore-based count data, unlike the WeBS volunteers, have the opportunity to select good vantage points and fair weather conditions for counting divers and grebes. The South Cornwall AoS holds an estimated 30% of the GB wintering population of black-necked grebes (Musgrove *et al* 2011).

Figure 3.26. Carrick Roads, with Falmouth Harbour visible in the distance, is the most important marine area in the UK for black-necked grebes.

Red-necked grebe

Red-necked grebes are recorded only in low numbers at a few areas in the UK. The Firth of Forth consistently holds more red-necked grebes than any other area. The South Cornwall AoS is the third most important area within the UK for this species, after the Firth of Forth and Scapa Flow (O'Brien *et al* 2011), with a MoP of 6 birds. This represents approximately 11% of the GB wintering population of red-necked grebes (Musgrove *et al* 2011). As with black-necked grebes, this species appears to be under recorded by WeBS. The systematic shore-based counts are a more reliable estimate of the numbers of grebes in the South Cornwall Coast AoS than the WeBS data and so should be accorded higher priority. This is because the observers collecting the shore-based count data, unlike the WeBS volunteers, have the opportunity to select good vantage points and fair weather conditions for counting divers and grebes.

Slavonian grebe

Slavonian grebes occur in many Scottish areas in numbers greater than those estimated in Gerrans Bay, as indicated by comparison of WeBS counts (Holt *et al* 2011). Unlike red- and black-necked grebes, WeBS counts (MoP 2004/5-2008/9=10.6; 2005/6-2009/10=14) exceeded the JNCC-commissioned systematic shore-based count estimates for Slavonian grebe, where the MoP over two years was 8.5. Outside Scotland, Gerrans Bay is the most important area for Slavonian grebe (Holt *et al* 2011). Slavonian grebe is known to occur elsewhere along the south coast of England, e.g. it is a feature of the Exe Estuary SPA, with an estimated 20 birds wintering at the site (Stroud *et al* 2001). The South Cornwall AoS is estimated to support 0.77-1.3% of the GB Slavonian grebe wintering population (Musgrove *et al* 2011), based on the JNCC-commissioned systematic shore-based counts for 2009/10 & 2010/11 and a higher estimate from 2005/6-2009/10 WeBS counts.

European shag

The European shag has a northerly distribution during winter, with many coastal areas of Scotland supporting high numbers (O'Brien *et al* 2010; O'Brien *et al* 2011). For example, Scapa Flow regularly supports an estimated 2,900 shags (O'Brien *et al* 2010). Outside Scotland, WeBS data suggest Gerrans Bay, with a MoP of 134 birds, is the most important area for wintering shag in the UK, with the exception of Strangford Lough and Outer Ards Shoreline in Northern Ireland (Holt *et al* 2011). However, shag is likely to be under recorded by WeBS counts as high numbers in Scapa Flow and North Orkney were not recorded by WeBS counts (O'Brien *et al* 2010). The WWT Consulting aerial survey data and the JNCC shore-based counts suggested the south coast of Cornwall, including the AoS, is important for shag, with a peak estimate of 333 individuals in 2007 from the aerial survey block SW13 and a mean of peaks of 401 individuals from the shore-based counts. This is approximately 0.3% and 0.4%, respectively, of the GB wintering shag population (Musgrove *et al* 2011).

A map of the UK wintering shag distribution, based on the European Seabirds at Sea database (Kober *et al*, 2010) found numbers of wintering shag were very low throughout England and Wales, with most shag wintering around Scotland (Figure 3.27). It is surprising that numbers of shag around the South Cornwall Coast were so low, given the relatively high numbers found on aerial survey and shore-based counts, but this may reflect poor survey coverage in the ESAS database in the inshore area around the coast of Cornwall (Kober *et al*, 2010). There could be other inshore areas around the coast of England and Wales supporting high numbers of shag, which have been overlooked, to date, and were not detected by the ESAS database. However, WeBS has not identified any other area within England or Wales supporting large numbers of wintering shag (Holt *et al* 2011).

An initial exploration of aerial survey data from around the coast of England and Wales found the highest raw counts to be in south Cornwall (SW13). However, a comparison of raw counts alone is misleading as the data have not been processed through distance sampling methods which compensate for birds missed due to being more distant from the aircraft. The aerial survey data needs to be processed through *Distance* to generate reliable population estimates for each survey block, before it is certain that south Cornwall holds the highest numbers of shag in England and Wales.

There is a large (more than 1000 pairs) breeding population of shag in the Isles of Scilly, which is identified as an assemblage for shag among other seabirds. If it proves that the waters around the Isles of Scilly also hold important aggregations of shag in winter, then the numbers in South Cornwall need to be assessed in relation to this.

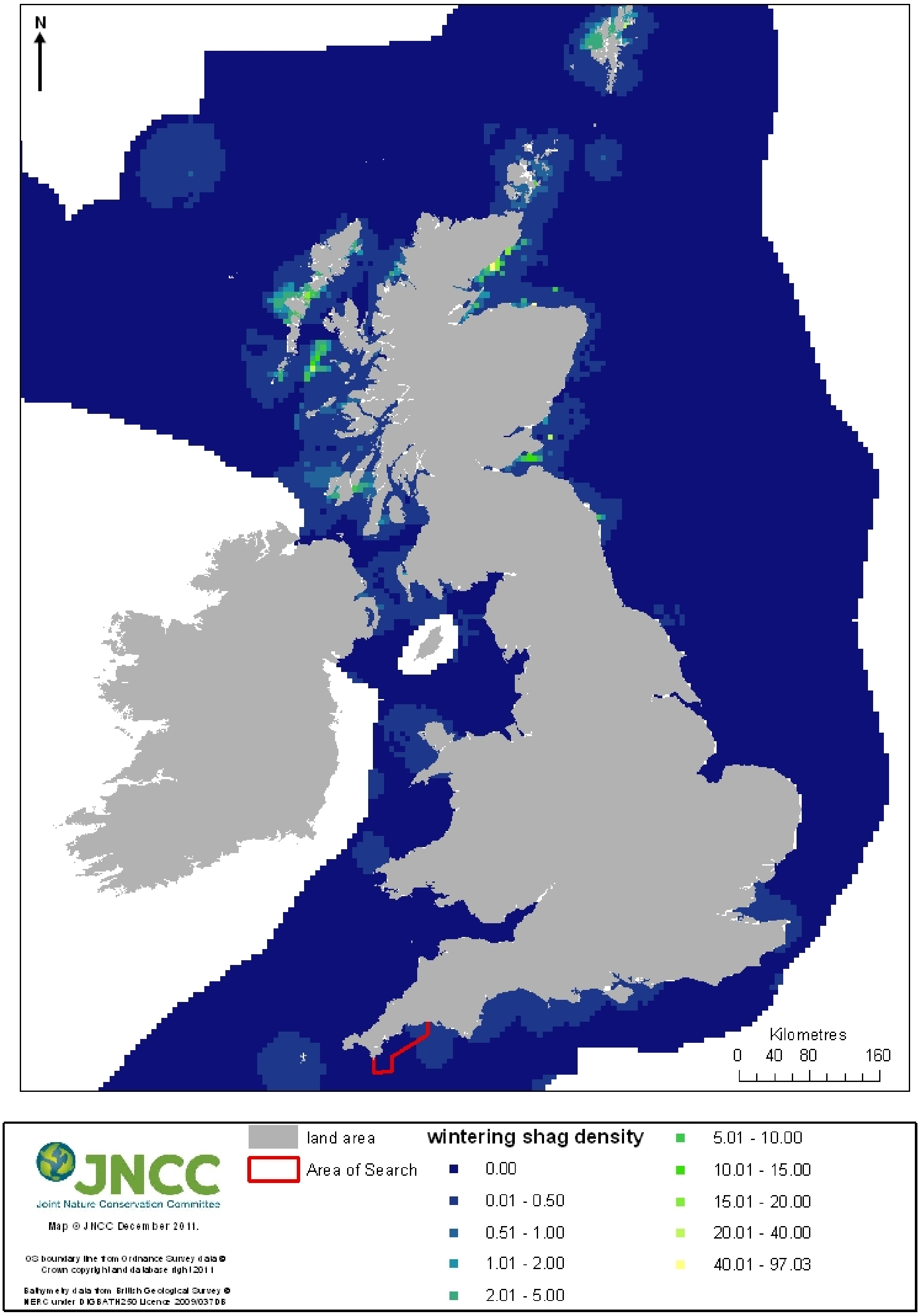

Figure 3.27. Estimated density of wintering shag in UK waters, redrawn from Kober *et al* (2010). Estimated density was informed by the European Seabirds at Sea database.

Red-breasted merganser

Carrick Roads, within the South Cornwall AoS, is the most important area in Cornwall for wintering red-breasted mergansers (*pers. comm.* Derek Julian) but the area is not of national importance for this species. There are many other WeBS count sites that regularly supported more red-breasted mergansers than the MoP of 57 found by the systematic shore-based counts of the South Cornwall AoS, including sites along the south coast of England, such as the Exe Estuary SPA, which has red-breasted merganser listed as a component of an assemblage feature. The South Cornwall AoS supported an estimated 0.7% of the GB red-breasted merganser wintering population (Musgrove *et al* 2011).

4 Discussion

Black-throated divers and great northern divers were regularly present in the South Cornwall Coast AoS in numbers in excess of the UK SPA Selection Guidelines threshold at Stage 1.1. No other species was regularly present in numbers in excess of the Stage 1.1, Stage 1.2 or Stage 1.3 guidelines (Appendix B).

The South Cornwall Coast AoS is the most important marine area in the UK for black-necked grebes and is the third most important area in the UK for red-necked grebes. South Cornwall Coast AoS is thought to be one of the most important areas in England for wintering European shag. Natural England may wish to consider including these three species within any SPA on the south Cornwall coast, through the application of Stage 2 judgments from the UK SPA Selection Guidelines (Stroud *et al* 2001).

Aerial surveys underestimated the numbers of divers and grebes in the South Cornwall AoS. During the single JNCC aerial survey only three divers were recorded. During the WWT Consulting surveys, a maximum of 11 divers were recorded, but almost all of them only as 'unidentified diver sp'. Extrapolation of aerial survey observations indicated a peak estimate of 51 divers of all species combined but this is an underestimate of the true numbers present in the AoS. The shore-based counts found an estimated 115 black-throated divers and 74 great northern divers using the South Cornwall AoS. The large discrepancy between aerial survey and shore-based counts is most likely to be due to visual aerial surveys overlooking large aggregations of divers very close inshore. As the aircraft approaches land, it must either climb or bank, meaning that observers have to break off survey before reaching the coast. Aerial surveys have successfully estimated the numbers of red-throated divers and great northern divers throughout the rest of the inshore marine area of the UK (e.g. O'Brien *et al* 2010, O'Brien *et al* 2011), although black-throated divers have been under recorded by aerial surveys in other areas. Great northern divers, in particular, are relatively large and distinctive birds and it is very unlikely that observers were missing this species during aerial surveys.

Thus the combined results of the aerial survey and shore-based counts suggest that great northern divers, and quite probably black-throated divers, were aggregating close inshore along the coast of South Cornwall, when compared with many other inshore areas around the UK. The bathymetry of south Cornwall is different to some other areas of search; e.g. the Outer Thames Estuary SPA and Liverpool Bay SPA have many shallow sandbanks far offshore, whereas the sea floor along the coast of south Cornwall shelves relatively steeply. The results of the aerial survey show that a few divers do occur further offshore than could be recorded from land but the low numbers recorded further offshore indicate that the shore-based counts are unlikely to be a large under estimate of the true numbers of divers in the South Cornwall Coast AoS. However, due to the relatively restricted number of aerial surveys undertaken in the South Cornwall Coast AoS, significant use of areas further offshore at other times cannot be ruled out. Indeed, it may be expected that divers make some use of deeper waters offshore; for example Haney (1990) found that 87% of GND in waters off the SE United states were in water of up to 40m, and an analysis of Scottish GND distribution in areas of search under consideration as possible SPA (See Appendix C) found 95% of individuals to be present in waters up to 44m depth. Appendix B presents options for a possible seaward boundary; Appendix C presents an analysis of one of these options, using the water depth distribution of great northern divers in Scottish AoS. Appendix D presents an analysis of the relative importance of sectors of the AoS for two diver species and Slavonian grebe, which was requested by NE following analysis of more recent WeBS data.

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Appendix A

Raw counts from 2009/10 and 2010/11 shore-based counts and WeBS counts 2004/5 to 2008/9

Table A 1. Numbers of birds for each species recorded on systematic shore-based counts during December 2009 along the South Cornwall coast. Species codes: E = common eider, CS = common scoter, GN = common goldeneye, RBM = red-breasted merganser, RTD = red-throated diver, BTD = black-throated diver, GND = great northern diver, LG = Little grebe, GCG = great crested grebe, RNG = red-necked grebe, SG = Slavonian grebe, BNG = back-necked grebe.

Count point	Date	CS	VS	GN	RBM	BTD	GND	GCG	SG	BNG	SHAG
Gribbin Head	04/12/2009						1				11
Polkerris	04/12/2009						1	7			3
Spit Beach	04/12/2009						4				3
Carlyon Hotel	04/12/2009	12					4				4
Lower Porthpean	04/12/2009	47					6				
Black Head	04/12/2009						1				5
Pentewan Harbour	05/12/2009	2									8
Stuckumb Point	05/12/2009	2				2	7				10
Chapel Point	05/12/2009						1				6
Maenease Head	05/12/2009										10
Dodman Point	05/12/2009										
Hemmick Beach	05/12/2009					4	2				
Porthluney Beach	05/12/2009										5
Perbargas Point	05/12/2009					6	1				10
Caragloose Point	05/12/2009						1				8
Manare Point	05/12/2009										11
Nare Head	05/12/2009					2					27
Pendower Beach	06/12/2009	3				2	6		1		8
Pednvadan	06/12/2009						1				7
Greeb Point	06/12/2009										8
Porthmellin Head	06/12/2009						1				8
Zone Point	06/12/2009										16
St Mawes	06/12/2009										14
St Just Pool	06/12/2009										3
Turnaware Point	06/12/2009		2	1	6		3			5	5
Weir Point	11/12/2009				4						8
Penarrow Point	11/12/2009										8
Trefusis Point	11/12/2009										16
Pendennis Point	11/12/2009						1				58
Swanpool Point	11/12/2009										9
Maenporth	11/12/2009										25
Rosemullion	11/12/2009						1				8
Toll Point	11/12/2009						1				2
Helford Passage	11/12/2009						2				6
Dennis Head	11/12/2009										
Total		**66**	**2**	**1**	**10**	**16**	**45**	**7**	**1**	**5**	**330**

Table A.1. Numbers of birds for each species recorded on systematic shore-based counts during February 2010 along the South Cornwall coast. Species codes: E = common eider, CS = common scoter, GN = common goldeneye, RBM = red-breasted merganser, RTD = red-throated diver, BTD = black-throated diver, GND = great northern diver, LG = little grebe, GCG = great crested grebe, RNG = red-necked grebe, SG = Slavonian grebe, BNG = back-necked grebe.

Count point	Date	E	CS	GN	RBM	RTD	BTD	GND
Gribbin Head	05/02/2010							3
Polkerris	05/02/2010							2
Spit Beach	05/02/2010							1
Carlyon Hotel	05/02/2010							3
Lower Porthpean	05/02/2010		3			3	1	6
Black Head	05/02/2010		6				6	4
Pentewan Harbour	06/02/2010		16					2
Stuckumb Point	06/02/2010					1		7
Chapel Point	06/02/2010	1						2
Maenease Head	06/02/2010						34	6
Dodman Point	06/02/2010						12	4
Hemmick Beach	06/02/2010						41	6
Porthluney Beach	06/02/2010							3
Perbargas Point	06/02/2010		1				6	1
Caragloose Point	06/02/2010							
Manare Point	06/02/2010						3	
Nare Head	06/02/2010						16	
Pendower Beach	07/02/2010		2				5	4
Pednvadan	07/02/2010			1			2	2
Greeb Point	07/02/2010						1	2
Porthmellin Head	07/02/2010							1
Zone Point	07/02/2010							
St Mawes	07/02/2010				2			2
St Just Pool	07/02/2010				19			
Turnaware Point	07/02/2010				22			2
Weir Point	08/02/2010				4			
Penarrow Point	08/02/2010				8			
Trefusis Point	08/02/2010				6			
Pendennis Point	08/02/2010							2
Swanpool Point	08/02/2010							
Maenporth	08/02/2010							
Rosemullion	08/02/2010							2
Toll Point	08/02/2010				4			1
Helford Passage	08/02/2010							1
Dennis Head	08/02/2010							3
Total		**1**	**28**	**1**	**65**	**4**	**127**	**72**

Count point	Date	LG	GCG	RNG	SG	BNG	SHAG
Gribbin Head	05/02/2010						6
Polkerris	05/02/2010		8				
Spit Beach	05/02/2010						
Carlyon Hotel	05/02/2010						4
Lower Porthpean	05/02/2010		1				5
Black Head	05/02/2010						
Pentewan Harbour	06/02/2010						3
Stuckumb Point	06/02/2010			1			
Chapel Point	06/02/2010						
Maenease Head	06/02/2010						34
Dodman Point	06/02/2010						
Hemmick Beach	06/02/2010						
Porthluney Beach	06/02/2010						3
Perbargas Point	06/02/2010						4
Caragloose Point	06/02/2010						
Manare Point	06/02/2010						
Nare Head	06/02/2010						
Pendower Beach	07/02/2010						3
Pednvadan	07/02/2010				2		5
Greeb Point	07/02/2010				2		
Porthmellin Head	07/02/2010						
Zone Point	07/02/2010						19
St Mawes	07/02/2010	4					14
St Just Pool	07/02/2010	2					
Turnaware Point	07/02/2010					11	
Weir Point	08/02/2010						6
Penarrow Point	08/02/2010	3					7
Trefusis Point	08/02/2010						14
Pendennis Point	08/02/2010						13
Swanpool Point	08/02/2010						4
Maenporth	08/02/2010						5
Rosemullion	08/02/2010			1			7
Toll Point	08/02/2010				2		3
Helford Passage	08/02/2010						
Dennis Head	08/02/2010			4	1		14
Total		**9**	**9**	**6**	**7**	**11**	**173**

Table A.2. Numbers of birds for each species recorded on systematic shore-based counts during December 2010 along the South Cornwall coast. Species codes: E = common eider, CS = common scoter, GN = common goldeneye, RBM = red-breasted merganser, RTD = red-throated diver, BTD = black-throated diver, GND = great northern diver, LG = Little grebe, GCG = great crested grebe, RNG = red-necked grebe, SG = Slavonian grebe, BNG = back-necked grebe.

Count point	Date	E	CS	GN	RBM	GD	BTD	GND
Gribbin Head	06/12/2010							1
Polkerris	06/12/2010							
Spit Beach	06/12/2010	4	21	1			1	2
Carlyon Hotel	06/12/2010						1	2
Lower Porthpean	06/12/2010	1						2
Black Head	06/12/2010							2
Pentewan	07/12/2010	1				10		
Stuckumb Point	07/12/2010							
Chapel Point	07/12/2010							
Maenease Head	07/12/2010							
Dodman Point	07/12/2010						11	
Hemmick Beach	07/12/2010						23	
Porthluney Beach	07/12/2010							1
Perbargas Point	07/12/2010		5					
Caragloose Point	07/12/2010							
Manare Point	07/12/2010							
Nare Head	07/12/2010							1
Pendower Beach	08/12/2010						11	2
Pednvadan	08/12/2010						4	1
Greeb Point	08/12/2010							
Porthmellin Head	08/12/2010							1
Zone Point	08/12/2010							
St Mawes	08/12/2010							1
St Just Pool	08/12/2010							
Turnaware Point	08/12/2010				14			4
Weir Point	09/12/2010			4	12			
Penarrow Point	09/12/2010				8			
Trefusis Point	09/12/2010							
Pendennis Point	09/12/2010							2
Swanpool Point	09/12/2010		1	1				
Maenporth	09/12/2010		1					1
Rosemullion	09/12/2010							
Toll Point	09/12/2010							1
Helford Passage	09/12/2010							1
Dennis Head	09/12/2010		12				2	2
Total		**6**	**40**	**6**	**34**	**10**	**53**	**27**

Count point	Date	LG	GCG	RNG	SG	BNG	SHAG
Gribbin Head	06/12/2010						12
Polkerris	06/12/2010		7				1
Spit Beach	06/12/2010		1				5
Carlyon Hotel	06/12/2010	2	1		2		18
Lower Porthpean	06/12/2010						6
Black Head	06/12/2010						17
Pentewan Harbour	07/12/2010						3
Stuckumb Point	07/12/2010						2
Chapel Point	07/12/2010						9
Maenease Head	07/12/2010						36
Dodman Point	07/12/2010			1			8
Hemmick Beach	07/12/2010						4
Porthluney Beach	07/12/2010						2
Perbargas Point	07/12/2010			1			
Caragloose Point	07/12/2010						
Manare Point	07/12/2010						
Nare Head	07/12/2010						5
Pendower Beach	08/12/2010						
Pednvadan	08/12/2010						2
Greeb Point	08/12/2010						12
Porthmellin Head	08/12/2010						5
Zone Point	08/12/2010						4
St Mawes	08/12/2010						4
St Just Pool	08/12/2010	4					8
Turnaware Point	08/12/2010	3				32	8
Weir Point	09/12/2010				1	35	6
Penarrow Point	09/12/2010	1					14
Trefusis Point	09/12/2010						18
Pendennis Point	09/12/2010						81
Swanpool Point	09/12/2010						19
Maenporth	09/12/2010						8
Rosemullion	09/12/2010			1			
Toll Point	09/12/2010						
Helford Passage	09/12/2010						
Dennis Head	09/12/2010			1			
Total		**10**	**9**	**4**	**3**	**67**	**317**

Table A.3. Numbers of birds for each species recorded on systematic shore-based counts during February 2011 along the South Cornwall coast. Species codes: E = common eider, CS = common scoter, GN = common goldeneye, RBM = red-breasted merganser, RTD = red-throated diver, BTD = black-throated diver, GND = great northern diver, LG = Little grebe, GCG = great crested grebe, RNG = red-necked grebe, SG = Slavonian grebe, BNG = back-necked grebe.

Count point	Date	SP	E	CS	GN	RBM	BTD	GND
Gribbin Head	17/02/2011							
Polkerris	17/02/2011							1
Spit Beach	17/02/2011		5					1
Carlyon Hotel	17/02/2011			1			27	5
Lower Porthpean	17/02/2011			26			6	6
Black Head	17/02/2011							
Pentewan Harbour	18/02/2011						1	4
Stuckumb Point	18/02/2011							4
Chapel Point	18/02/2011	1					1	16
Maenease Head	18/02/2011						17	5
Dodman Point	18/02/2011							2
Hemmick Beach	18/02/2011						1	3
Porthluney Beach	18/02/2011							2
Perbargas Point	18/02/2011						33	5
Caragloose Point	18/02/2011							1
Manare Point	18/02/2011							
Nare Head	18/02/2011							7
Pendower Beach	18/02/2011	1		1			15	5
Pendower Beach	19/02/2011			1			16	6
Pednvadan	19/02/2011				1			1
Greeb Point	19/02/2011							1
Porthmellin Head	19/02/2011							3
Zone Point	19/02/2011							1
St Mawes	19/02/2011		7			1		
St Just Pool	19/02/2011							
Turnaware Point	19/02/2011					18		1
Weir Point	22/02/2011					16		
Penarrow Point	22/02/2011					14		
Trefusis Point	22/02/2011							
Pendennis Point	22/02/2011							
Swanpool Point	22/02/2011							
Maenporth	22/02/2011							
Rosemullion	22/02/2011							
Toll Point	22/02/2011							
Helford Passage	22/02/2011							
Dennis Head	22/02/2011							
Total		**2**	**12**	**29**	**1**	**49**	**102**	**75**

Count point	Date	LG	GCG	RNG	SG	BNG	SHAG
Gribbin Head	17/02/2011						
Polkerris	17/02/2011		15				
Spit Beach	17/02/2011						3
Carlyon Hotel	17/02/2011						2
Lower Porthpean	17/02/2011						5
Black Head	17/02/2011						
Pentewan Harbour	18/02/2011		2				5
Stuckumb Point	18/02/2011			1			4
Chapel Point	18/02/2011			1	2		22
Maenease Head	18/02/2011						42
Dodman Point	18/02/2011						9
Hemmick Beach	18/02/2011				1		
Porthluney Beach	18/02/2011			1			6
Perbargas Point	18/02/2011						6
Caragloose Point	18/02/2011						
Manare Point	18/02/2011						
Nare Head	18/02/2011			1			11
Pendower Beach	18/02/2011						24
Pendower Beach	19/02/2011			1	2		7
Pednvadan	19/02/2011				2		11
Greeb Point	19/02/2011	5					19
Porthmellin Head	19/02/2011						6
Zone Point	19/02/2011						41
St Mawes	19/02/2011						6
St Just Pool	19/02/2011						2
Turnaware Point	19/02/2011				1	31	
Weir Point	22/02/2011	2					
Penarrow Point	22/02/2011	1		1		22	2
Trefusis Point	22/02/2011						19
Pendennis Point	22/02/2011						8
Swanpool Point	22/02/2011						156
Maenporth	22/02/2011				2		62
Rosemullion	22/02/2011						
Toll Point	22/02/2011						
Helford Passage	22/02/2011						1
Dennis Head	22/02/2011						
Total		**8**	**17**	**6**	**10**	**53**	**472**

Table A.4. Peak WeBS counts of seaduck, divers and grebes from areas within the South Cornwall Area of Search, extracted from http://blx1.bto.org/websonline. Species codes: GN = common goldeneye, RBM = red-breasted merganser, RTD = red-throated diver, BTD = black-throated diver, GND = great northern diver, LG = little grebe, RNG = red-necked grebe, SG = Slavonian grebe, BNG = black-necked grebe, COR = cormorant, SHA = European shag.

	GN	RBM	RTD	BTD	GND	LG	RNG	SG	BNG	COR	SHAG
Gerrans Bay											
2004/05			1	47	14		1	5	2	22	25
2005/06			1	70	16		4	26	4	21	16
2006/07			1	60	12		1	5	1	28	40
2007/08			1	24	12		1	4	5	30	28
2008/09			1	55	17		1	13	5	58	128
Mean of peak			**1**	**51.2**	**14.2**		**1.6**	**10.6**	**3.4**	**31.8**	**47.4**
Carrick Roads											
2004/05	16	42			2				19	31	18
2005/06	5	72			2	12			56	8	35
2006/07		32			5	5			4	16	32
2007/08	5	53			2	8			5	7	38
2008/09		36			3	14			32	5	26
Mean of peak	**8.7**	**47**			**2.8**	**9.8**			**23.2**	**13.4**	**29.8**
Percuil River											
2004/05		14				12				1	
2005/06		18				7				2	
2006/07						6				9	
2007/08		12				6				5	
2008/09		17				5				5	
Mean of peak		**15.3**				**7.2**				**4.4**	

Appendix B

South Cornwall Coast Potential Interest Features and Boundary Options

Potential Interest Features

Seven species were recorded in notable numbers during shore-based counts of the South Cornwall Coast (SCC) AoS (see main report): great northern diver, black-throated diver, black-necked grebe, red-necked grebe, Slavonian grebe, European shag and red-breasted merganser. Each of these species is hereby assessed against the UK SPA Selection Guidelines (Stroud *et al* 2001[3]). However, ultimately, it is Natural England's role to decide upon which species to include as potential features of a site.

Black-throated diver:
Stage 1

- Black-throated diver is listed on Annex 1 of the Birds Directive and so this population is compared against the GB population of 560 individuals (Musgrove *et al* 2011[4]) for this species.
- A mean of peak population estimate of 115 birds was derived from two years of shore-based counts carried out in 2009/10 and 2010/11.
- During both years of survey, black-throated diver numbers exceeded the Stage 1.1 1% threshold of 6 birds and exceeded 50 birds usually considered the minimum for site selection.

Stage 2

- Population size: 115 birds, which is 21% of the GB population, the largest population of wintering black-throated diver in the UK.
- History of occupancy: the area held internationally important numbers of birds in the past, with a mean of peak counts of 147 birds from the 1990's (Slade 1996[5]; Geary & Lock 2001[6]).
- Range: the nearest (to Cornwall) large concentration in Britain of wintering black-throated divers is in Scotland, suggesting SCC contributes to the range requirements of this species.

Great northern diver:
Stage 1

- Great northern diver is listed on Annex 1 of the Birds Directive and so this population is compared against the GB population of 2,500 individuals (Musgrove et al 2011) for this species.
- A mean of peak population estimate of 74 birds was derived from two years of shore-based counts carried out in 2009/10 and 2010/11.
- During both years of survey, great northern diver numbers exceeded the Stage 1.1 1% threshold of 25 birds and exceeded the 50 birds usually considered the minimum for site selection.

Stage 2

- Population size: 74 birds, which is 3% of the GB population. Many areas in Scotland hold much larger populations.

[3] Stroud, D.A., Chambers, D., Cook, S., Buxton, N., Fraser, B., Clement, P., Lewis, I., McLean, I., Baker, H. & Whitehead, S. (2001). *The UK SPA Network: its scope and content. Vols 1 – 3*. JNCC, Peterborough.
[4] Musgrove, A.J., Austin, G.E., Hearn, R.D., Holt, C.A., Stroud, D.A. & Wotton, S.A. (2011). Overwinter population estimates of British waterbirds. *British Birds* 104, 364 – 397.
[5] Slade, G. (1996). *Nearshore winter seabird survey of South West England*. RSPB unpublished report, Exeter.
[6] Geary, S. & Lock, L. (2001). *Winter nearshore seabird survey of South Cornwall Coast Important Bird Area (1999/2000)*. RSPB unpublished report, Exeter.

- History of occupancy: the area held internationally important numbers of birds in the past, with a mean of peaks of 98 birds from the 1990's (Slade 1996; Geary & Lock 2001).
- Range: the nearest large concentrations in Britain of wintering great northern divers are in Scotland, although a small population (<50 individuals) regularly occurs in north west Wales; this, suggests SCC contributes to the range requirements of this species.

Black-necked grebe:

Stage 1

- Black-necked grebe is a regularly occurring migratory species and so this population is compared against the biogeographic population of 220,000 individuals (Wetlands International, 2006[7]) for this species.
- A mean of peak population estimate of 39 birds was derived from two years of shore-based counts carried out in 2009/10 and 2010/11.
- Black-necked grebe counts did not exceed the Stage 1.2 1% threshold of 2,200 individuals in either year of survey, nor did it exceed the 50 individuals usually considered the minimum for site selection.

Stage 2

- Population size: 39 birds, which is 30% of the GB population and 0.02% of the biogeographic population. SCC supports the largest population of black-necked grebes in the UK, based on JNCC systematic counts. WeBS counts (Holt *et al* 2011[8]) suggest that Studland Bay also holds important numbers, though systematic survey there required to confirm status.
- History of occupancy: the area has held nationally important numbers of birds in the past, with a mean of peaks of 16 birds from the 1990's (Slade 1996; Geary & Lock 2001).
- Range: SCC supports the largest wintering population of black-necked grebes in the UK. Currently, this species is not a listed feature of any SPA in the UK and no other areas are currently being considered for classification for this species.

Red-necked grebe:

Stage 1

- Red-necked grebe is a regularly occurring migratory species and so this population is compared against the biogeographic population of 51,000 individuals (Wetlands International, 2006) for this species.
- A mean of peak population estimate of six birds was derived from two years of shore-based counts carried out in 2009/10 and 2010/11.
- Red-necked grebe counts did not exceed the Stage 1.2 1% threshold of 510 individuals in either year of survey, nor did it exceed the 50 individuals usually considered the minimum for site selection.

Stage 2

- Population size: 6 birds, which is 11% of the GB population and 0.01% of the biogeographic population. SCC supported the third largest population of red-necked grebes in the UK, after two Scottish areas.
- History of occupancy: the area has held nationally important numbers of birds in the past, with a mean of peaks of 30 birds from the 1990's (Slade 1996; Geary & Lock 2001).
- Range: SCC is the most southerly population of red-necked grebes in the UK, with the nearest large population of wintering red-necked grebes in Scotland, although this

[7] Wetlands International 2006. Waterbird Population Estimates, 4th edn. Wetlands International, Wageningen.
[8] Holt, C., Austin, G., Calbrade, N., Mellan, H., Mitchell, C., Stroud, D., Wotton, S. & Musgrove, A. (2011). *Waterbirds in the UK 2009/10: The Wetland Bird Survey*. BTO/RSPB/JNCC, Thetford.

species is recorded in low numbers elsewhere along the south coast of England. At least one other marine inshore area may be classified as an SPA for red-necked grebe.

European shag:

Stage 1

- European shag is a regularly occurring migratory species and so this population is compared against the biogeographic population of 20,000 individuals (Wetlands International, 2006) for this species.
- A mean of peak population estimate of 333 birds was derived from two aerial surveys carried out in January and March of 2007. This estimate includes observations which were recorded as '*Phalacrocorax* spp' and could have been cormorant or shag. Few cormorants were recorded and, consequently, it is likely these observations were shags. Using only shag observations to estimate population size gave a population estimate of 186 individuals.
- European shag numbers did not exceed the Stage 1.2 1% threshold of 2,000 individuals.

Stage 2

- Population size: 333 birds, which is 0.3% of the GB population and 0.17% of the biogeographic population. This is possibly the largest wintering population of European shag in England, although coverage of wintering shag distribution is incomplete and the Isles of Scilly may hold a larger wintering population.
- History of occupancy: the area has held more shags in the past, with a mean of peaks of 785 birds from the 1990's (Slade 1996; Geary & Lock 2001).
- Range: the nearest large aggregations of wintering European shag are in Scotland, where it is recorded in higher numbers in winter than in England. However, the Isles of Scilly is believed to support wintering shag as shag generally winter close to their breeding colonies and the Isles of Scilly supports a large shag colony of 1,092 apparently occupied nests (Mitchell *et al* 2004[9]; Wernham *et al* 2002[10]).
- At present, there are no existing marine SPAs for this species but there are several marine inshore areas of search in Scotland (O'Brien *et al* 2010[11]; O'Brien *et al* 2011[12]).
- If Natural England is minded to extend the existing Isles of Scilly SPA into the marine environment for European shag, and that there is evidence that shag also winter around the Isles of Scilly in higher numbers than off the SCC, then given the close proximity of the Isles of Scilly to the SCC a case might be made that the Isles of Scilly is a more suitable site for classification. Certainly, breeding numbers on the Isles of Scilly are far in excess of the 333 birds recorded of SCC.

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[9] Mitchell, P.I., Newton, S.F., Ratcliffe, N. & Dunn, T.E. 2004. Seabird populations of Britain and Ireland: Results of the Seabird 2000 Census (1998-2002). T & AD Poyser, London.

[10] Wernham, C.V., Toms, M.P., Marchant, J.H., Clark, J.A., Siriwardena, G.M. & Baillie, S.R. (eds.) 2002. *The Migration Atlas: movements of the birds of Britain and Ireland.* T. & A.D. Poyser, London.

[11] O'Brien, S.H. S. H. O'Brien, I. Win, C. Bingham, L. J. Wilson, A. Webb, J. Black & J. B. Reid 2010. Identifying important wintering aggregations of seaduck, divers and grebes at seven locations around Scotland: an assessment of the numbers and distribution of birds in each area and possible boundary options. JNCC Unpublished report to Scottish Natural Heritage.

[12] S. H. O'Brien, C. Bingham, I. Win, L. J. Wilson, A. Webb, & J. B. Reid. 2011. Identifying important wintering aggregations of seaduck, divers and grebes at fifteen locations in north and west Scotland: an assessment of the numbers and distribution of birds in each area and boundaries around high density aggregations of birds. JNCC Unpublished report to Scottish Natural Heritage.

Slavonian grebe:
Stage 1

- Slavonian grebe is listed on Annex 1 of the Birds Directive and so this population is compared against the GB population of 1,100 individuals (Musgrove *et al* 2011) for this species.
- A mean of peaks population estimate of 8.5 birds was derived from two years of shore-based counts. WeBS counts recorded a MoP of 10.6 between 2004/5-2008/9 and 14 between 2005/6-2009/10.
- Slavonian grebe numbers did not exceed the Stage 1.1 1% threshold of 11 individuals nor did it exceed the minimum of 50 individuals usually considered the minimum for site selection.

Stage 2

- Population size: 8.5 birds (10.6-14 from WeBs over a greater number of years), which is 0.77% (0.96-1.27% from WeBS) of the GB population. SCC holds low numbers of Slavonian grebe compared with other areas around the UK, especially Scotland.
- History of occupancy: the area held a mean of peaks of 46 birds from the 1990's (Slade 1996; Geary & Lock 2001).
- Range: Slavonian grebe is a feature of the relatively close Exe Estuary SPA, although the wintering Slavonian grebe distribution is concentrated in Scotland.

Red-breasted merganser:
Stage 1

- Red-breasted merganser is a regularly occurring migratory species and so this population is compared against the biogeographic population of 170,000 individuals (Wetlands International, 2006) for this species.
- A mean of peak population estimate of 57 birds was derived from two years of shore-based counts.
- Red-breasted merganser numbers did not exceed the Stage 1.2 1% threshold of 1700 individuals.

Stage 2

- Population size: 57 birds, which is 0.7% of the GB population and 0.03% of the biogeographic population. SCC holds low numbers of red-breasted merganser compared with other areas around the UK.
- History of occupancy: the area held a mean of peaks of 139 birds from the 1990's (Slade 1996; Geary & Lock 2001).
- Range: non-breeding red-breasted merganser is a feature of the relatively close Exe Estuary SPA and is also a feature of 14 other SPAs around the UK.

Boundary Options for the South Cornwall Coast

Landward extent of the boundary

Where the distribution of birds at a site is likely to meet land, a boundary should usually be set at the mean high water mark (MHW), or in Scotland at the mean high water springs (MHWS), unless there is evidence that the qualifying species make no use of the intertidal region at high water (Webb & Reid, 2004) There is some evidence that black-necked grebe feed over intertidal seagrass *Zostera* sp. beds (R. Caldow *pers. comm*.) and that black-throated diver and great northern diver feed above the low water mark in this area of search (Derek Julian, *pers. comm*.); therefore Natural England may consider it appropriate in this case to take the landward boundary at Mean High Water. Appendix A presents information on the use of each shore-based count section.

Seaward limit to boundary

Four options for defining a seaward limit to the South Cornwall Coast boundary based on existing data are presented below. While JNCC has supplied options, it is ultimately Natural England's role to decide upon an appropriate one. The established approach of boundary-setting that has been applied to the Outer Thames Estuary SPA and Liverpool Bay SPA and other possible inshore SPA, that of kernel density estimation and maximum curvature using aerial survey information (O'Brien *et al*, 2012), could not be applied to any Annex 1 species in the south Cornwall AoS. This is because the number of divers recorded during aerial surveys were very low when compared with numbers found using shore-based counts (though there are a range of potential explanations for this, and birds may use deeper water areas even if not detected on aerial surveys).
A total of 10 divers were recorded by aerial surveys of South Cornwall AoS in January 2007 and 11 divers in March 2007, while another survey in February 2009 recorded just three divers. The raw counts from these first two surveys resulted in population estimates of 28 and 51 divers respectively, which compares with peak counts of 203 and 177 divers (of all three species) during shore counts in 2009/10 and 2010/11, respectively. Moreover, aerial surveys were not able to assign most diver records to species, which prevented the establishment of population estimates for each diver species from aerial survey information. Together, these circumstances demanded an alternative boundary option to be considered.

Option 1: A boundary 2km offshore, parallel to the coast

Generally, counts from land are thought to record birds up to a maximum distance of 2km from the coast (*pers. comm.* Andy Webb), though greater distances are possible, depending upon conditions and species (Banks *et al*, 2007[13]). However, we consider 2km to be a maximum distance to detect divers and identify them with confidence. A boundary 2km from the coast will include all the sea area that was searched during the systematic shore-based counts. However, Figure 1 shows that a few diver observations and many shag observations from aerial surveys were outside of the 2km band boundary option.

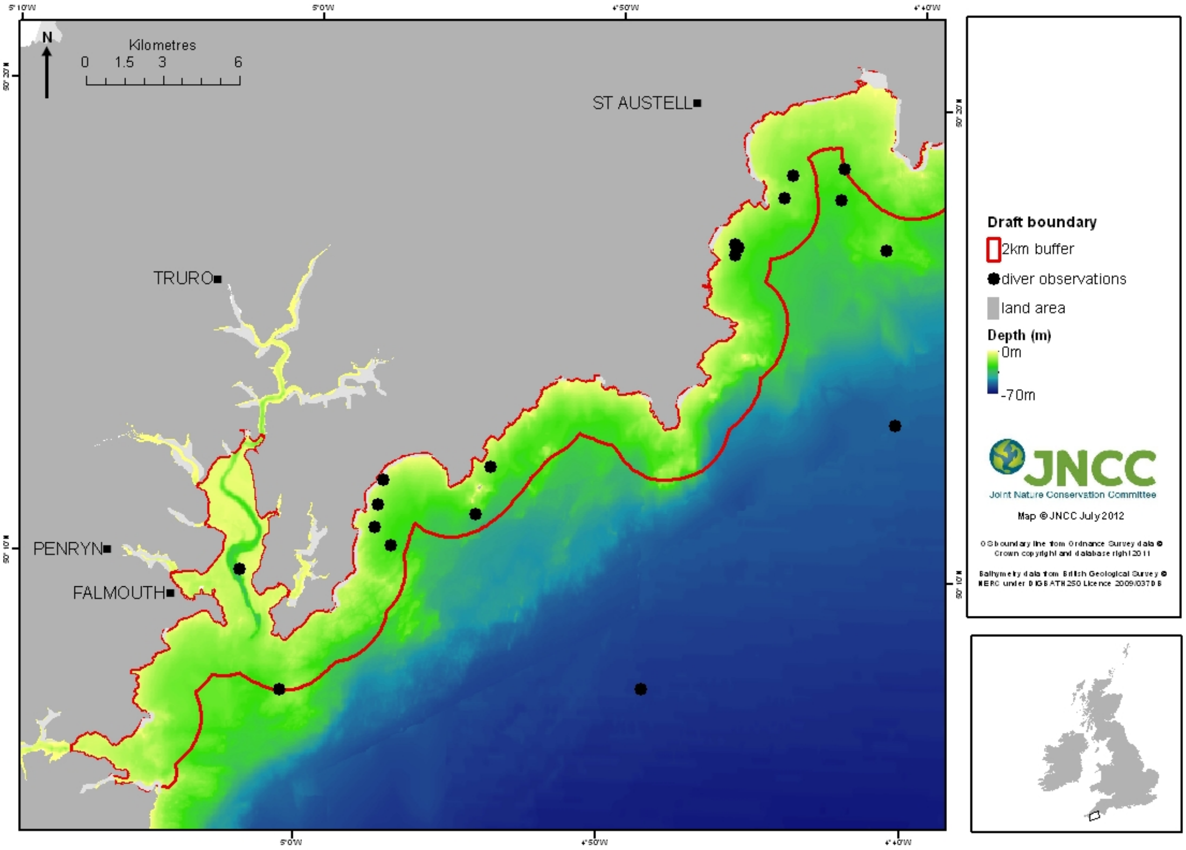

Figure B.1. Boundary Option 1: a 2km boundary running parallel to the coast. All observations from the three aerial surveys of divers (all three species of diver, plus those unidentified to species) are shown. The highest counts of divers and grebes came from shore-based counts, which are not shown on this map. This boundary is only indicative and would need to be redrawn if this boundary is selected to define the extent of an SPA.

[13] Banks, A., Bolt, D., Bullock, I., Collier, M., Fairney, N., Hasler, C., Haycock, B., Maclean, I., Roberts, P., Sanderson, B., Schofield, R., Smith, L., Swan, J., Taylor, R. & Whitehead, S. 2007. Ground and aerial monitoring for Carmarthen Bay SPA 2004-07. CCW Marine Monitoring Report No: 48, 80pp.

Option 2: A boundary that follows a bathymetry contour

A boundary could be informed by the divers' habitats, e.g. drawn following a sea depth contour. Unfortunately, other habitat variables such as sediment type, do not vary sufficiently across the AoS to be useful in boundary setting and the relationship between the birds' distribution and other environmental variables is not well understood. JNCC holds a large amount of aerial survey data on diver distribution around the UK. 95% of great northern diver records were recorded in water shallower than 44m depth. Since 95% of GNDs is a somewhat arbitrary cut-off, the statistical procedure of maximum curvature (O'Brien *et al* 2012[12]) was applied to the relationship between diver depth and proportion of study population, to identify the point (at 49m) where there was a change in the relationship between the rate of increase in GND numbers and depth. Figure B.2 shows draft boundaries based upon the 44 m depth contour and the 49m contour identified from maximum curvature. See Appendix C for details of the analyses used to identify these depth contours.

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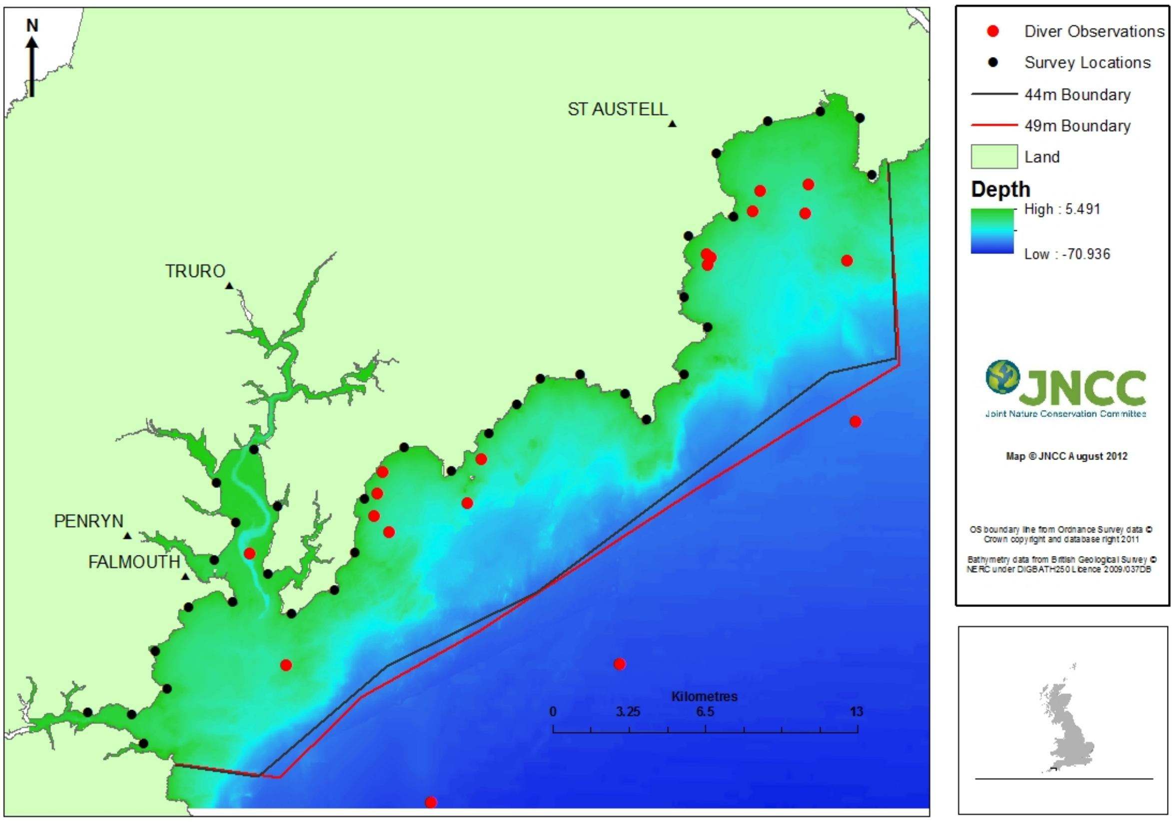

Figure B.2. Boundary Option 2: a boundary based on the 44m or 49m sea depth contour. All observations from the three aerial surveys of divers (all three species of diver, plus those unidentified to species) are shown, with the exception of four observations at the extreme east and west of the AoS. The highest counts of divers and grebes come from shore-based counts, which are not shown on this map. Note: The seaward extent of the boundary options is only indicative and would need to be redrawn if this boundary is selected to define the extent of an SPA. This map is not intended to represent the landward extent of possible boundaries; land-based survey locations have simply been circumscribed.

Option 3: A minimum convex polygon drawn around diver observations

A multinucleate minimum convex polygon (MCP) was drawn around all diver observations made from aerial surveys. This defines the smallest area that includes all diver observations from aerial survey while allowing multiple components to the boundary. Figure B.3 shows the MCPs drawn around all diver observations recorded in the aerial survey block SW13. The MCP boundary does not encompass Veryan Bay, which was shown to be important for black-throated divers and great northern divers during shore-based counts. This boundary option also does not encompass Carrick Roads, the only area supporting black-necked grebes in the South Cornwall Coast AoS. (See main report for maps and tables of grebe and diver distributions from shore-based counts.)

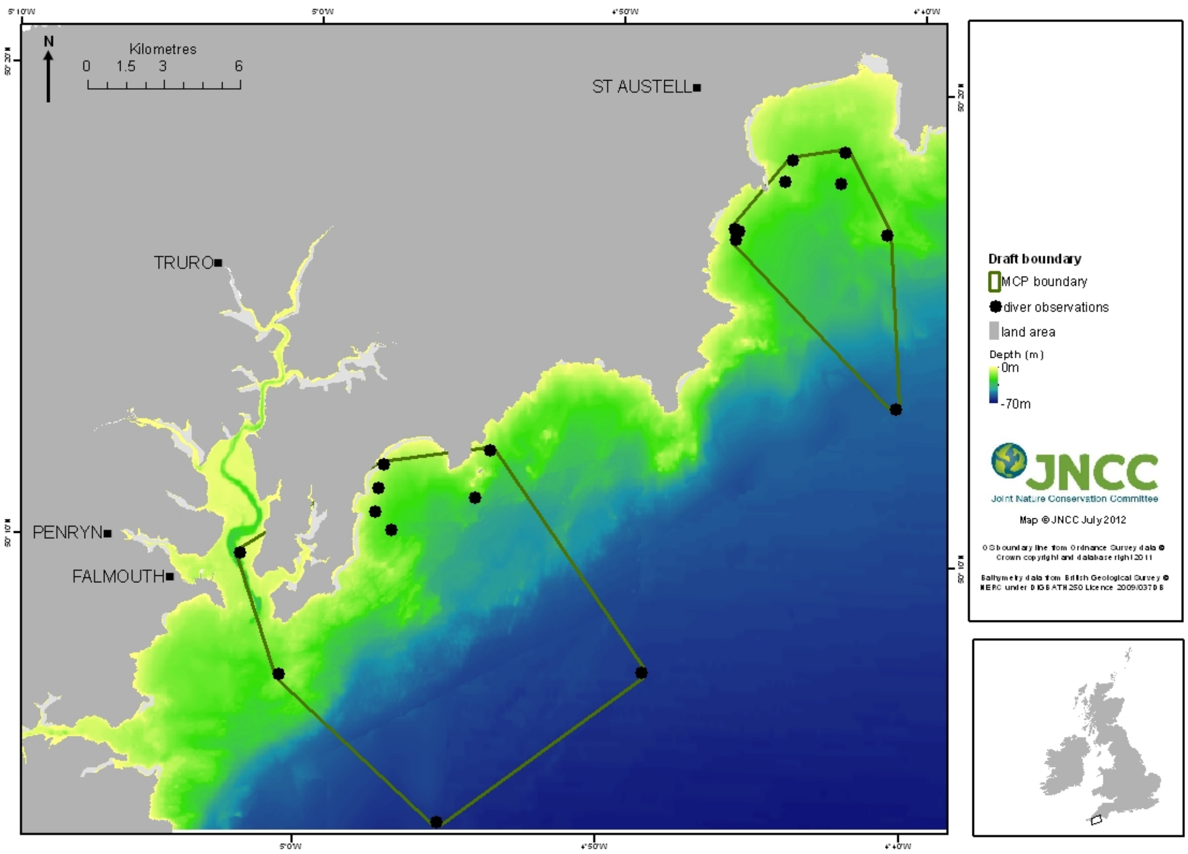

Figure B.3. Boundary Option 3: an MCP drawn around all diver observations from aerial surveys. All observations from the three aerial surveys of divers (all three species of diver, plus those unidentified to species) are shown, with the exception of three observations at the extreme east and west of the AoS. The highest counts of divers and grebes came from shore-based counts which are not shown on this map. This boundary is only indicative and would need to be redrawn if this boundary is selected to define the extent of an SPA.

Option 4: KDE and maximum curvature on shag distribution

A sufficient number of shags was recorded during aerial survey to apply KDE and maximum curvature to define a boundary, as was used to define the boundaries of the Outer Thames Estuary SPA and the Liverpool Bay/Bae Lerpwl SPA (O'Brien *et al* 2012). Two KDE (kernel density estimation) surfaces were created, one using only shag observations and the other using observations identified as shag/cormorant, as well as shag. The majority of observations recorded as cormorant/shag were likely to be shag but a more precautionary approach is to use only those observations identified as shag. This is, however, likely to be an underestimate of the numbers of shag in South Cornwall. Maximum curvature was used to identify a threshold density for each KDE surface. For shag only, the threshold density, around which the boundary was drawn, was 0.603 birds.km^{-2}. For the KDE surface comprising shag and cormorant/shag observations, the threshold density was 0.381 birds.km^{-2}. The boundaries are shown in Figure B.4 and Figure B5. Neither boundary includes sections of coastline that are known to support important numbers of divers and grebes, e.g. in Carrick Roads, Veryan Bay and Gerrans Bay. The shag boundary (Figure B.4) is more conservative, as it does not include observations recorded as cormorant/shag. Analyses presented here are preliminary and further analysis is required if Natural England wish to consider this approach further.

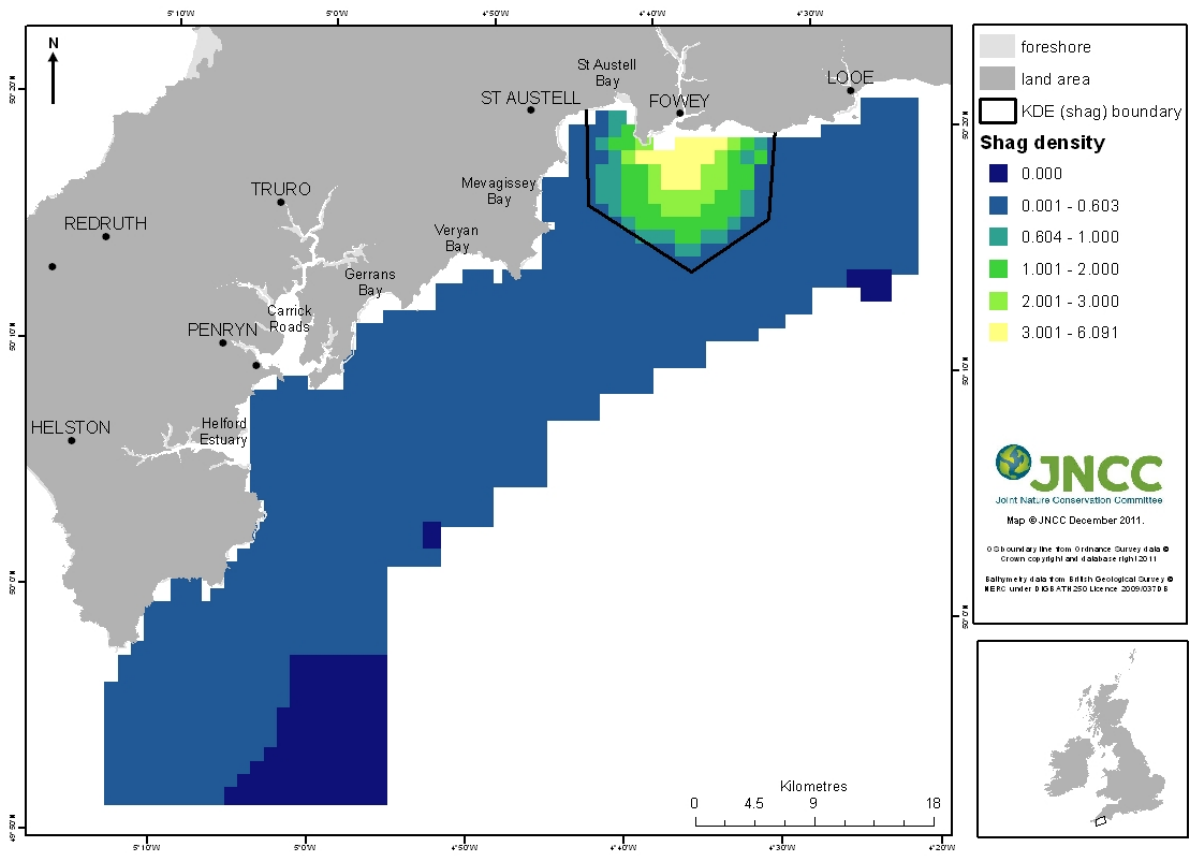

Figure B.4. Boundary Option 4a: a boundary drawn using standard KDE and maximum curvature methods for only shag observations. The threshold density was 0.603 birds.km^{-2}. The boundary was drawn around all cells on the KDE surface with a value greater than the threshold density. This boundary is indicative only and further analysis and redrawing of the boundary would be required if this approach is selected to define the extent of an SPA.

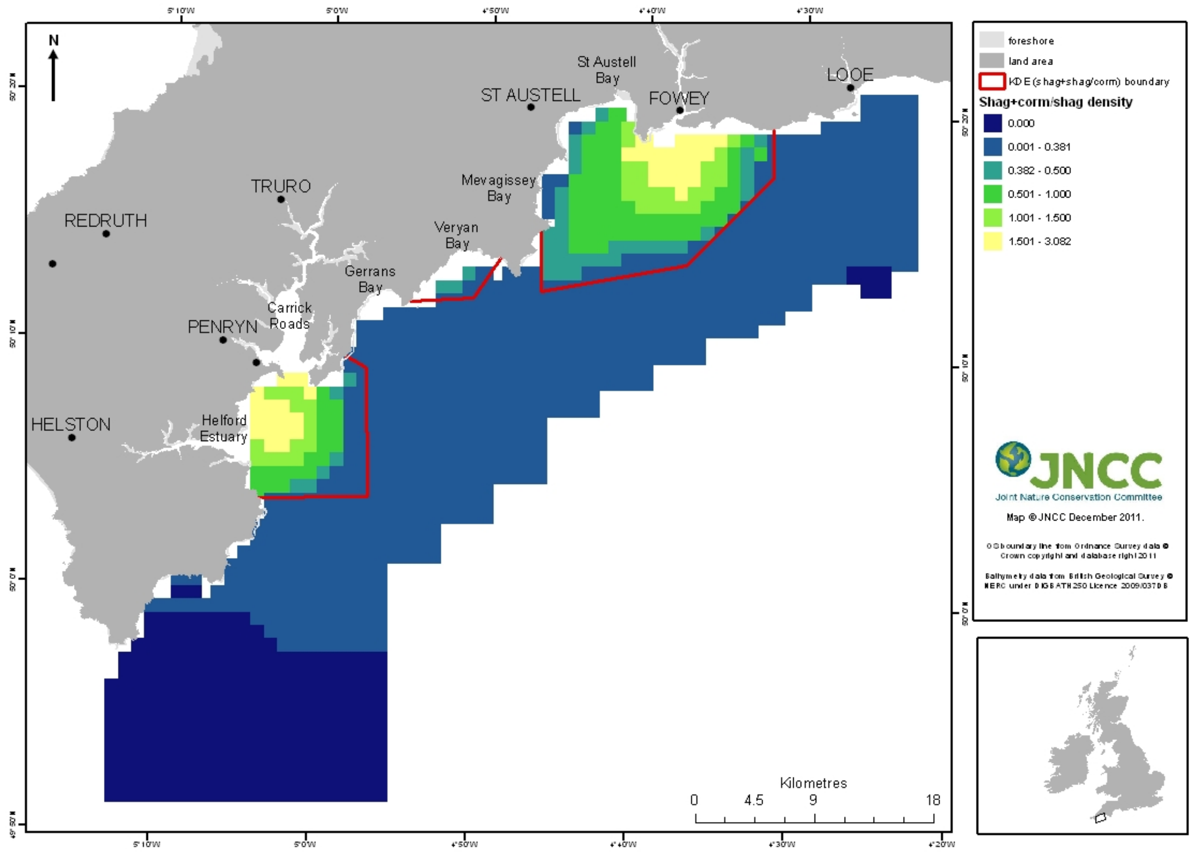

Figure B.5. Boundary Option 4b: a boundary drawn using standard KDE and maximum curvature methods for shag and cormorant/shag observations, combined. The threshold density was 0.381 birds.km^{-2}. The boundary was drawn around all cells on the KDE surface with a value greater than the threshold density. This boundary is only indicative and further analysis and redrawing of the boundary would be required if this approach is selected to define the extent of an SPA.

Table B.1. Issues and risks associated with each of the five South Cornwall Coast boundary options.

	Advantages	Disadvantages
OPTION 1: 2km band parallel to the coast	• All birds counted from shore will be within the boundary as the limit of detection of shore counts is considered to be 2km • The boundary encompasses most diver observations recorded from aerial survey	• There have been no studies demonstrating that the maximum distance a bird on the sea can be detected and identified from shore is 2km, i.e. 2km is an arbitrary distance and there could be an argument for using a band of 1km, 1.5km or >2km. • Birds further offshore are not included within the boundary. Aerial surveys recorded a few divers >2km from the coast. • The boundary does not follow the distribution of birds in the marine area, but is a generic distance, irrespective of how the birds are using the sea in south Cornwall. • This method has not been used previously in SPA boundary setting and has never undergone independent expert review
OPTION 2: Use a depth contour to define the boundary	• The boundary is based on the divers' habitat, rather than a generic distance from the coast, irrespective of the sea depth. • It is a robust objective evidence-based approach to boundary setting, using existing boundaries for great northern divers in Scotland to inform the SCC boundary. • The maximum curvature option presents a repeatable and objective method to define a depth cut-off. • The boundary includes all the bays shown by shore-based counts to regularly support high numbers of black-throated divers, black-necked grebes and great northern divers and includes almost all observations of divers from aerial survey.	• Few divers were recorded on aerial surveys in south Cornwall, compared with shore-based counts. One possible explanation for this is that divers were aggregating close inshore, in areas that were not surveyed during aerial surveys (as the aircraft climbed or banked close to shore). If this were true, the bathymetry contour boundary could be considered to define an excessively large area, though it should also be noted that a few diver observations occurred in deeper water than that encompassed by this boundary, lending weight to the appropriateness of the boundary. Furthermore, it does not necessarily follow that divers never occur in deeper water, just that few were detected there during the three aerial surveys undertaken. • This approach assumes that divers in South Cornwall are constrained to the same sea depths as great northern divers in Scotland, though there is no evidence available that would counter this assumption. • Other habitat information, such as sediment type, does not vary sufficiently across the AoS to be useful in boundary setting • This approach assumes the concentrations of black-necked grebes and black-throated divers occur sufficiently close inshore to be contained within the great northern diver boundary. This is a reasonable assumption, as the literature indicates that black-throated divers tend to occur on shallower sea than great northern divers and wintering black-necked grebes use inshore shallows in bays and channels.
OPTION 3: polygon around the diver observations	• All diver observations from aerial survey are included within the boundary • The boundary is directly informed by the distribution of some of the diver observations, but not all.	• Areas shown by shore-based counts to hold large numbers of both species of diver and black-necked grebes are not included within the boundary. • Many observations of Annex I species are not included within the boundary, in areas such as Veryan Bay. • Unlikely to be sufficient numbers of divers within this small boundary to meet the Stage 1.1 1% thresholds.
OPTION 4: use shag distribution to inform a boundary	• Can use an established method that has undergone independent expert review and has already been used to delineate boundaries for inshore SPAs in England (Outer Thames Estuary and Liverpool Bay SPAs). • The boundary would include most observations of shag. • South Cornwall is thought to be one of the most important areas for wintering shag in England, although the evidence base is incomplete.	• Shags are not present in nationally or internationally important numbers and do not meet the Stage 1.1/1.2/1.3 guidelines. A Stage 2 judgement would need to be made to include shag within an SPA. • The boundary is informed by only one year of data (2 aerial surveys in 2007). • Lack of evidence for shag distribution (only one year of data) and would require shag to be included using a Stage 2 judgement rather than boundary being informed by Stage 1.1 species. • Evidence base for South Cornwall being important for wintering shag at UK scale is incomplete. • The boundary does not include areas known to hold high numbers of divers and grebes.

Appendix C

A possible seaward boundary for the South Cornwall Coast informed by the distribution of Scottish great northern divers over a range of sea depths

Summary

The sea adjacent to south Cornwall regularly supports nationally important numbers of black-throated divers, great northern divers and black-necked grebes and is being considered for possible identification as a Special Protection Area (SPA). Delineating the seaward limit to the possible SPA is not straightforward, as few divers and grebes were recorded during aerial survey, making existing boundary setting methods for inshore SPAs unsuitable. A possible alternative approach to boundary delineation is presented here, using the distribution of great northern divers in relation to bathymetry in Scottish areas of search to define a possible seaward limit to the South Cornwall Coast.

C.1 Introduction

Great northern diver distribution in winter is largely in marine habitats, where it occurs singly or in small groups (Snow and Perrins, 1998) but occasionally in large concentrations (del Hoyo *et al* 1992). It occurs in sheltered bays and inlets as well as exposed rocky coasts (del Hoyo *et al* 1992; Snow and Perrins, 1998). Its diet in winter is largely small fish and benthic-dwelling crustaceans and molluscs (del Hoyo *et al*, 1992).

Three aerial surveys of the sea area adjacent to south Cornwall were undertaken, two in the 2006/07 winter and one in the 2008/09 winter. All three surveys recorded low numbers of divers (maximum of 11 individuals, population estimate derived from distance sampling of 51 individuals), when compared with counts made from land (115 black-throated divers, *Gavia arctica,* and 74 great northern divers, *Gavia immer*). Given the low numbers of divers detected from aerial surveys in south Cornwall, the established method of defining a boundary based on aerial survey records could not be used and an alternative method is required. While shore-based counts revealed high numbers of divers (and grebes) within the area of search, they cannot be reliably used to identify a seaward boundary because the maximum seaward extent to shore-based counts is not precisely quantified. Great northern divers (GND) have been regularly recorded during aerial surveys in Scotland. By quantifying the relationship between GND and their habitat in Scotland, it is possible to infer how GNDs are distributing themselves over their habitat in south Cornwall. Predictive habitat distribution models have been used to define boundaries for wintering divers in German and Danish waters and this approach is currently being used to identify marine areas for consideration for possible classification as SPAs in the UK for breeding terns and red-throated divers (*Gavia stellata*) by JNCC (Dean *et al* 2008; Garthe *et al* 2012; Petersen *et al* 2006; Wilson & Parsons, 2012). However, these models are dependent on good quality environmental covariate data at the appropriate scale. Many of the potential environmental covariates that might explain variation in GND density in Scottish waters were not available during the winter period and for the area close inshore to south Cornwall. Sediment type, which might influence the distribution of a benthic feeding species such as GND, did not vary sufficiently across the South Cornwall AoS to be useful in predicting GND density. The only environmental covariate that has been demonstrated to explain some variation in GND distribution is sea depth, e.g. 87% of GND records in southeastern USA were on water less than 40 metres deep (Haney, 1990).

Aerial survey data of GNDs in Scotland have been used to inform draft boundary locations for areas in Scotland that the Scottish Government and SNH may wish to consider for possible classification as SPAs. In these areas, GND were recorded in sufficient numbers on aerial survey to allow standard inshore boundary setting methods to be used, as described in O'Brien *et al* (2012) and used to define the boundaries of the Outer Thames Estuary SPA and Liverpool Bay/Bae Lerpwl SPA. By looking at the bathymetry of the areas contained within the draft GND boundaries in Scotland it is possible to define a draft boundary for the South Cornwall Coast that has similar bathymetry characteristics to the Scottish areas.

This Appendix describes how GNDs distribute themselves over sea of different depths around Scotland and uses that relationship to define boundary options for any possible SPA off the South Cornwall Coast.

C.2 Methods

Twenty-two Scottish inshore areas were surveyed by at least three aerial surveys over at least two winters between 2001-2010. Of these, 16 inshore areas recorded at least one GND. Survey effort varied greatly among these 16 areas of search (AoS), in size of area surveyed, in number of surveys carried out and in distribution of effort through the winter period (November to March inclusive).

Other species of waterbird, such as common scoter (*Melanitta nigra*) have been shown to move further offshore, to deeper water, as the winter period progresses due to their sessile prey becoming depleted. Although less likely for a species that preys on mobile species, if GNDs do move further offshore during the winter, areas that were surveyed late in the winter will show GNDs using deeper water than areas that were surveyed earlier in the winter. To test for this potential bias, box plots of distance to coast and sea depth by month for raw GND observations were created.

A histogram of the number of GND observations in different depth classes was created but to remove any bias due to some areas being surveyed more frequently than others, GND observations from a single survey from each area of search was used. The survey in each area during which the greatest number of GND were recorded was used in the histogram.

Sea depth at the locations where GND were observed during aerial surveys was found by using the Spatial Analyst extension in ESRI ArcGIS 10 to allocate a sea depth from Defra's bathymetric data raster at a resolution of one arc second (licence no: Defra012012.002) to each GND observation. Data from all areas of search combined were sorted, firstly by depth from shallowest to deepest, and then by the number of GND recorded at that location, from largest to smallest. The cumulative number of birds was calculated, starting from the shallowest location and moving to the deepest location. Cumulative number of birds was converted to cumulative proportion

Box 1. Methods for boundary delineation for inshore SPAs.

1. A minimum of three parallel line transect aerial surveys were flown over the area of search during at least two winters. Observers recorded birds in distance bands. Distance sampling methods (Buckland *et al* 2001) were used to generate an estimate of the number of GND for each survey.
2. A density surface was created for each aerial survey by smoothing the raw observations using kernel density estimation and then scaling the surface such that the sum of the whole density surface was the same as the GND population estimate for that survey. The density surface comprised 1km x 1km cells with a density estimate in each cell.
3. A mean density surface was created by overlaying all density surfaces from each survey and taking the mean.
4. Maximum curvature was used to identify a density threshold, with all cells on the mean density surface with a density greater than the threshold being included within the SPA boundary. Maximum curvature identifies the point where there is a change in the relationship between the rate of change in the size of an area and the cumulative number of birds it hosts.
5. A boundary was drawn such that all cells on the mean density surface with a density greater than the threshold density were within the boundary.

See O'Brien *et al* (2012) for more details.

of the total number of GNDs observations and was plotted against sea depth. This allows calculation of the proportion of the Scottish GND observations that occurred in water shallower than a particular depth. The maximum depth over which 95% of the Scottish GND observations were recorded was therefore determined.

Using raw observations of GND from aerial surveys does not take in to account potential pseudoreplication effects due to multiple surveys of the same area. Any pseudoreplication can be removed by using mean density surfaces rather than raw observations. Mean density surfaces have been used to draw draft boundaries around areas that SNH and the Scottish Government may wish to consider classifying as SPAs for GND. See Box 1 and O'Brien *et al* (2012) for details of how a mean density surface and a boundary were created for each area of search. All of the 1km x 1km cells on the mean density surface that had their centres within the boundary were used to assess GND distribution in relation to bathymetry in Scotland. Cells outside the boundary were excluded.

The centre point of each 1km x 1km cell was allocated a sea depth value from Defra's bathymetric data raster at a resolution of one arc second (licence no: Defra012012.002). Since cells on the mean density surface were 1km x 1km, density was equivalent to number of GND in that cell. The relationship between the number of GND in a cell and sea depth at the centre point of that cell was analysed in the same way as the raw observations and sea depth, described above.

The proportion of GNDs over different depth water, derived using the mean density surfaces, was used to define two draft boundaries for the possible South Cornwall Coast SPA. Firstly, the maximum sea depth over which 95% of the GND were contained, according to the mean density surfaces, was identified and this depth contour was used to draw a draft boundary in the sea adjacent to south Cornwall. Secondly, maximum curvature (O'Brien *et al*, 2012) was used to identify a threshold depth, which was then used to draw a draft boundary. As the size of a protected area increases from just 1km^2, initially the numbers of birds within the protected area increases rapidly, as high bird density areas are included, and then more slowly as lower bird density areas are included. Maximum curvature defines the sea depth where there is a transition from rapid increase to slower increase in bird numbers.

C.3 Results

Shore based counts in south Cornwall recorded many more divers than aerial survey. Figure C.1 shows the areas surveyed during aerial surveys, with the gap between the coast and survey area apparent. Birds that were aggregated within 1-2km of the coast would have been picked up by shore-based counts but not by aerial surveys as the aircraft banked or climbed on approach to land.

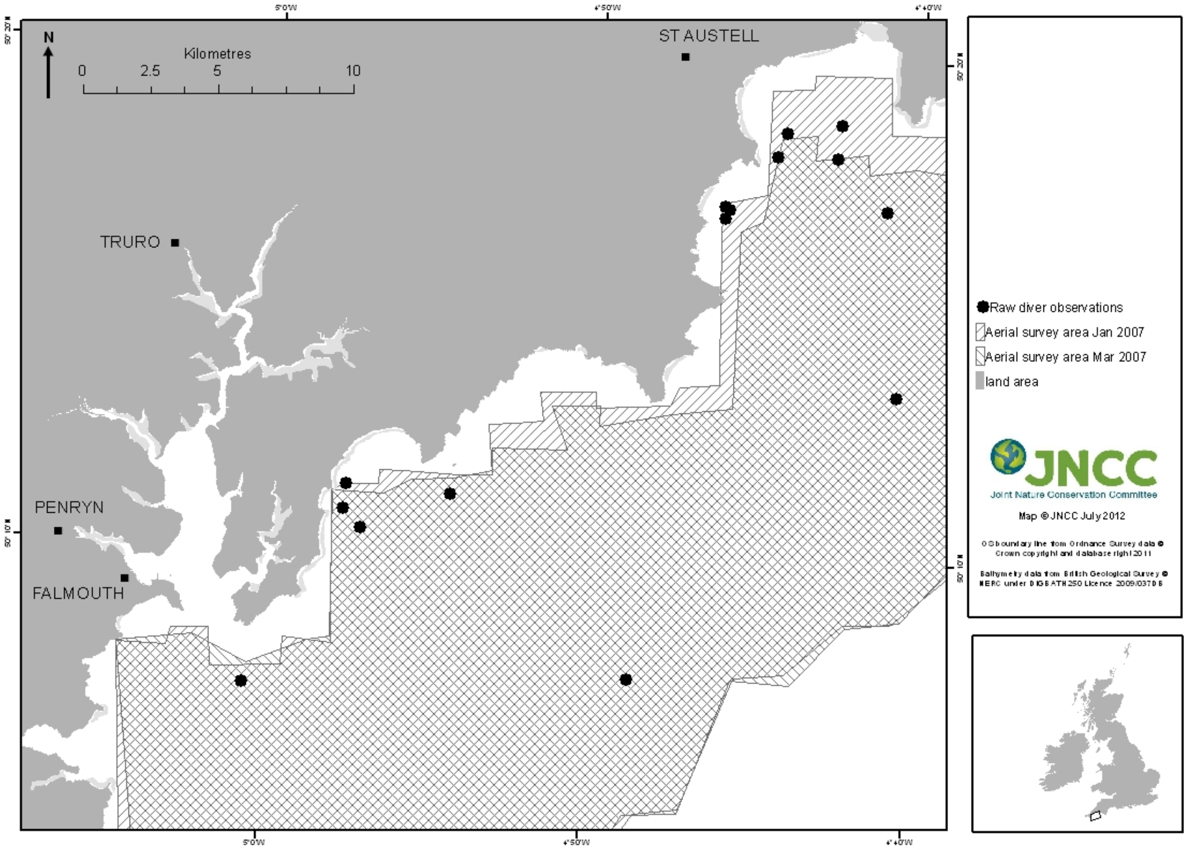

Figure C.1. A map of south Cornwall showing areas that were surveyed by aerial surveys in January 2007 and March 2007, plus raw observations of divers from aerial surveys of south Cornwall. The white area between the survey areas and the coast of Cornwall were not surveyed from aircraft and aggregations of birds in these areas would not have been picked up during aerial surveys.

The relationship between GND distribution, as recorded by aerial surveys around Scotland, and sea depth was assessed and used to inform draft boundaries for GND in south Cornwall. The number of GND recorded in different areas around Scotland varied greatly. This can be attributed in part to survey effort and size of the survey area but GND density also varied across areas. A total of 3,170 GNDs were recorded in eleven areas during Scottish aerial surveys although this includes counts from repeated surveys of the same area (Table C.1). Low numbers of GND were also recorded in another four areas but were recorded too infrequently to be included within this analysis (GND population estimate of <50 individuals; <1% of GB population threshold). Red-throated divers and unidentified diver spp. were also regularly recorded in the Moray Firth. Since the unidentified diver spp. could be red-throated or great northern divers, and there could potentially be a spatial bias in distribution of unidentified diver spp., GND data from the Moray Firth were not used in this analysis. GND were never recorded in the other six areas of search.

Table C.1. Number of great northern diver raw observations from aerial surveys conducted during winter months between 2001-2010 in eleven areas of search. The number of times the area was surveyed in that month is given in parentheses. The number of raw observations have not been corrected for varying survey effort among areas and months and so do not necessarily reflect the relative importance of each area for GND.

Area	Dec	Jan	Feb	Mar	Total no. raw obs
Broad Bay		38 (2)	11 (1)		49
Coll & Tiree		220 (2)	251 (4)		471
East Shetland		76 (3)	67 (2)		143
Loch Indaal		27 (2)	12 (1)		39
Luce Bay	18 (2)	29 (1)	154 (3)		201
Mull		22 (2)	40 (3)		62
North Orkney	24 (1)	126 (2)	28 (1)		178
Outer Hebrides	186 (2)	265 (1)	301 (5)		752
Scapa Flow	110 (1)	372 (3)	70 (2)	18 (1)	570
Sound of Gigha		134 (1)	273 (4)	203 (1)	610
Wester Ross	27 (2)	34 (2)	34 (2)		95
Total	**365 (8)**	**1,343 (21)**	**1,241 (28)**	**221 (2)**	**3,170**

As expected, GND showed no tendency to move further offshore as the winter progressed. Median depth and distance to coast of GND observations did not vary markedly across the four months of winter survey, December to March (Figure C.2). However, GND were observed further from the coast and over deeper water at some areas of search, compared with others. Median distance to coast and median sea depth of GND observations did vary across different areas of search (Figure C.2).

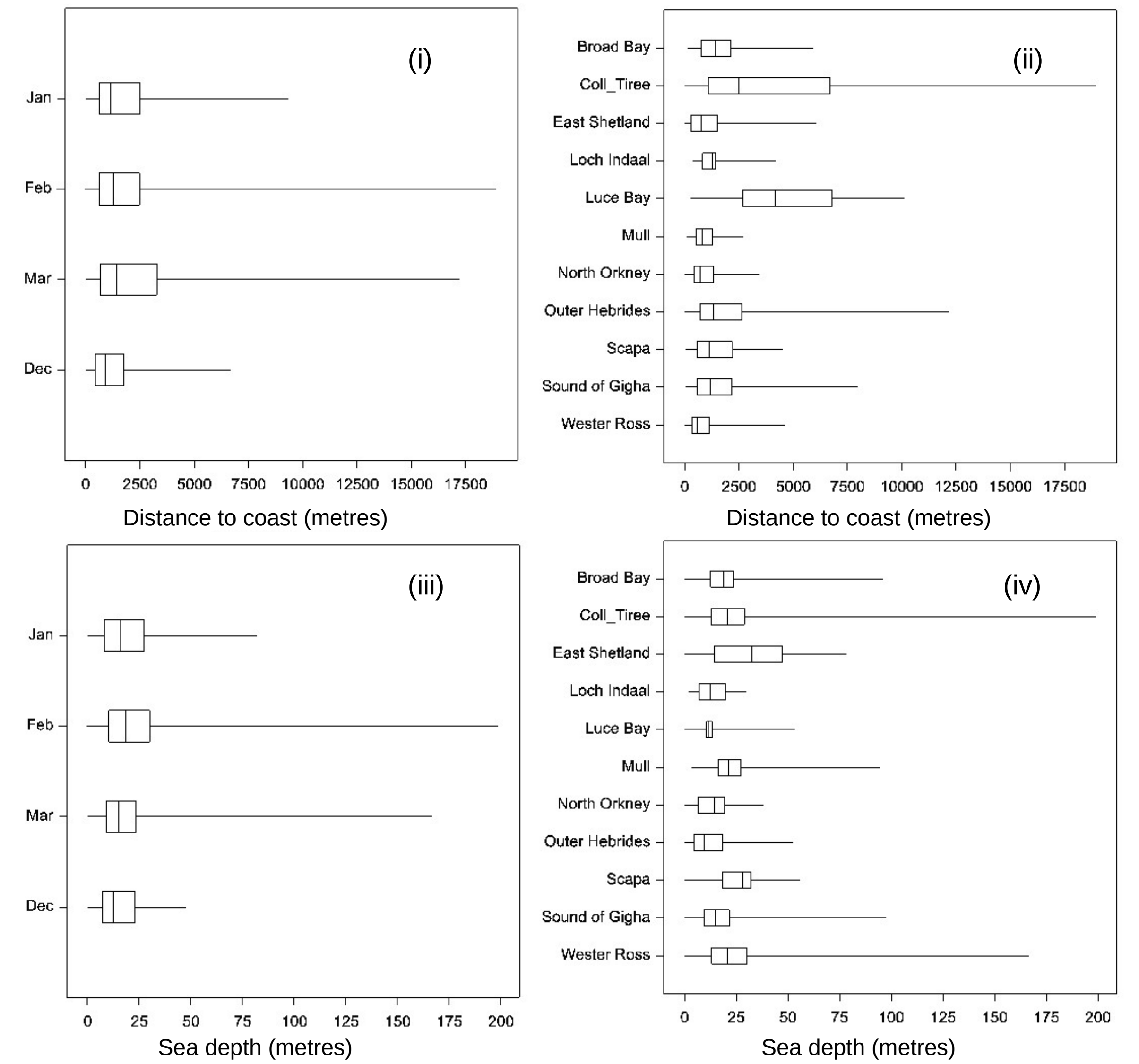

Figure C.2. Box plots (showing median, interquartile range and maximum and minimum values) for (i) distance to coast of GND observations by month, (ii) distance to coast by area, (iii) sea depth of GND observations by month, and (iv) sea depth of observations by area.

The depth profile of the south Cornwall AoS shows a broadly similar median and range to the 11 Scottish AoS (Figure C.3).

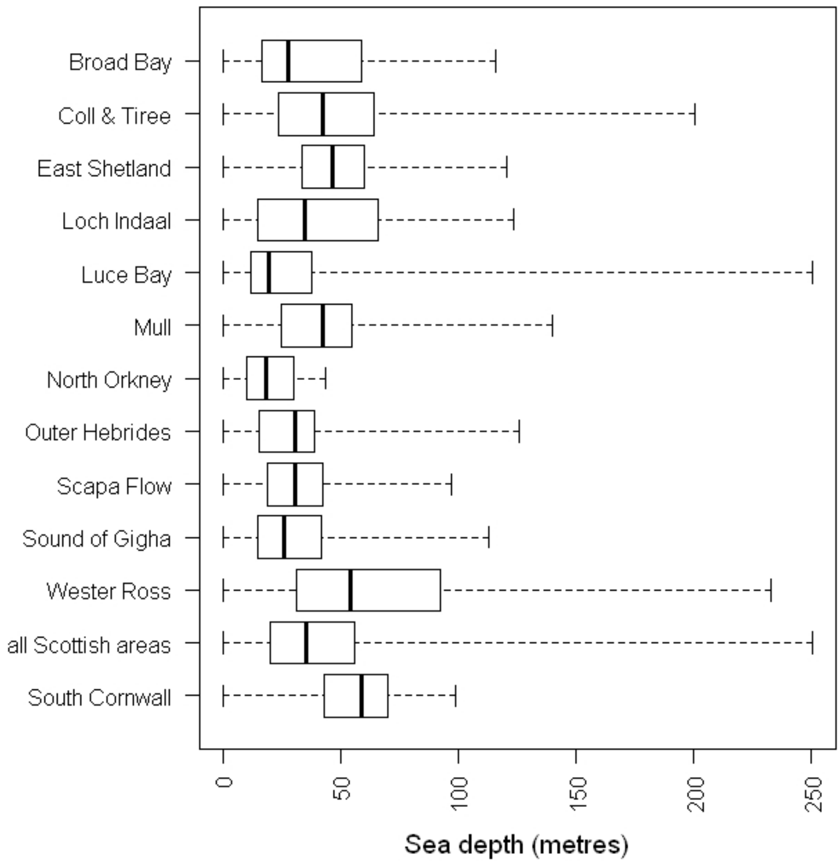

Figure C.3. Box plots (showing median, interquartile range and maximum and minimum values) of water depths for the whole extent of the Scottish AoS used in the analysis and of the south Cornwall AoS.

GND occurred in greater numbers over shallower water, with GND in Scotland most frequently being recorded over sea depths of 10-14.9m (Figure C.4). The numbers of GND in the shallowest two classes may have been under recorded due to aerial surveys not being able to record birds very close to shore, as the aircraft banked or climbed on approach to land. While most GND observations were on water shallower than 35m, a few birds were recorded on very deep water, with one GND seen in water 199m deep, off Coll and Tiree. This histogram uses only 1,196 of the GND observations, as only data from a single survey from each area were included, to remove any potential bias caused by uneven sampling effort across areas of search.

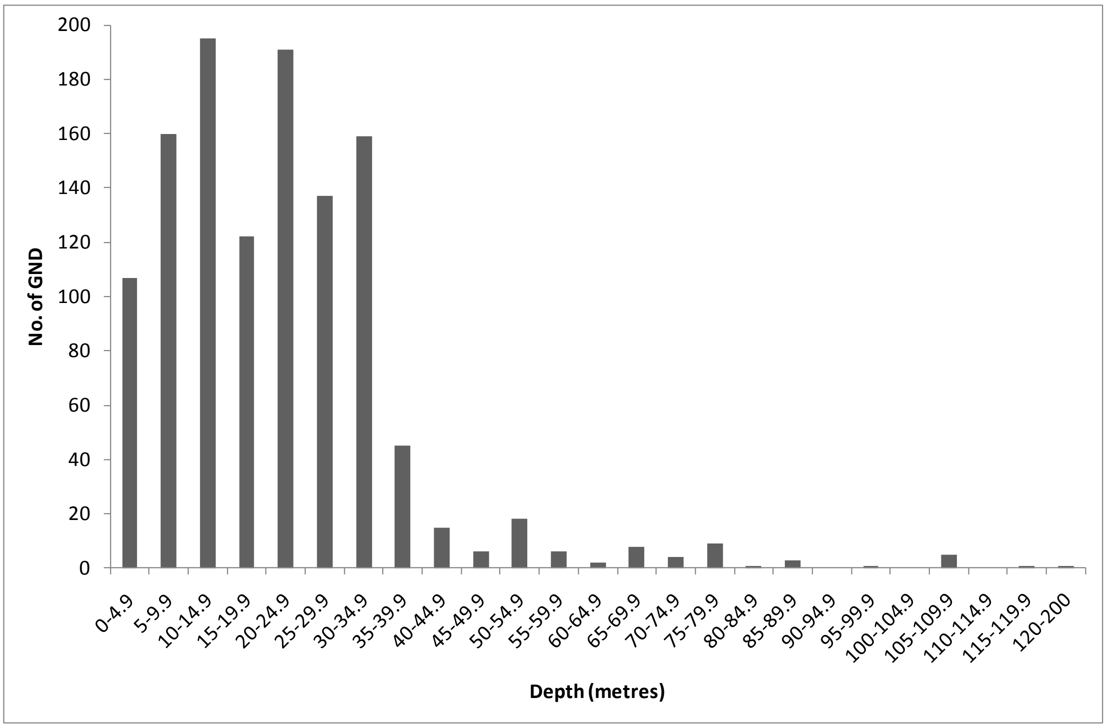

Figure C.4. Histogram of the number of raw GND observations in each depth class, using data from a single survey from each of the 11 areas of search.

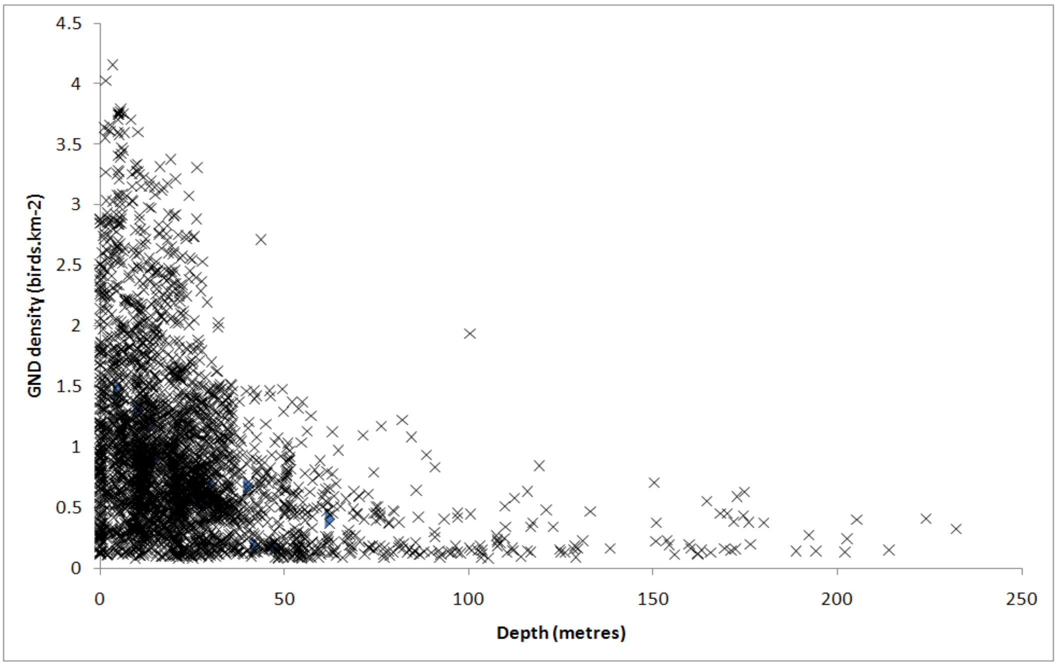

Figure C.5. Changes in GND density with sea depth, showing that the relationship between GND density and depth is not linear.

GND in Scotland occurred in higher numbers on shallower water and lower numbers on deeper water (Figure C.4), but the relationship between the density of GND (from the mean density surfaces) and depth is not linear (Figure C.5). GNDs occurred at high and low density in shallow water but only at low density in deeper water. This precludes using a statistical regression approach to quantify the relationship between sea depth and GND density in Scotland and therefore it was not possible to predict GND density in south Cornwall as the shallower sea areas off the coast of south Cornwall could potentially support high or low densities of GND. Therefore a different approach was adopted, that used the cumulative proportion of GNDs recorded on water of different depths.

The cumulative number of raw observations of GND were concentrated over shallow water, with 95% of the GND observations on water shallower than 43 metres (Figure C.6).

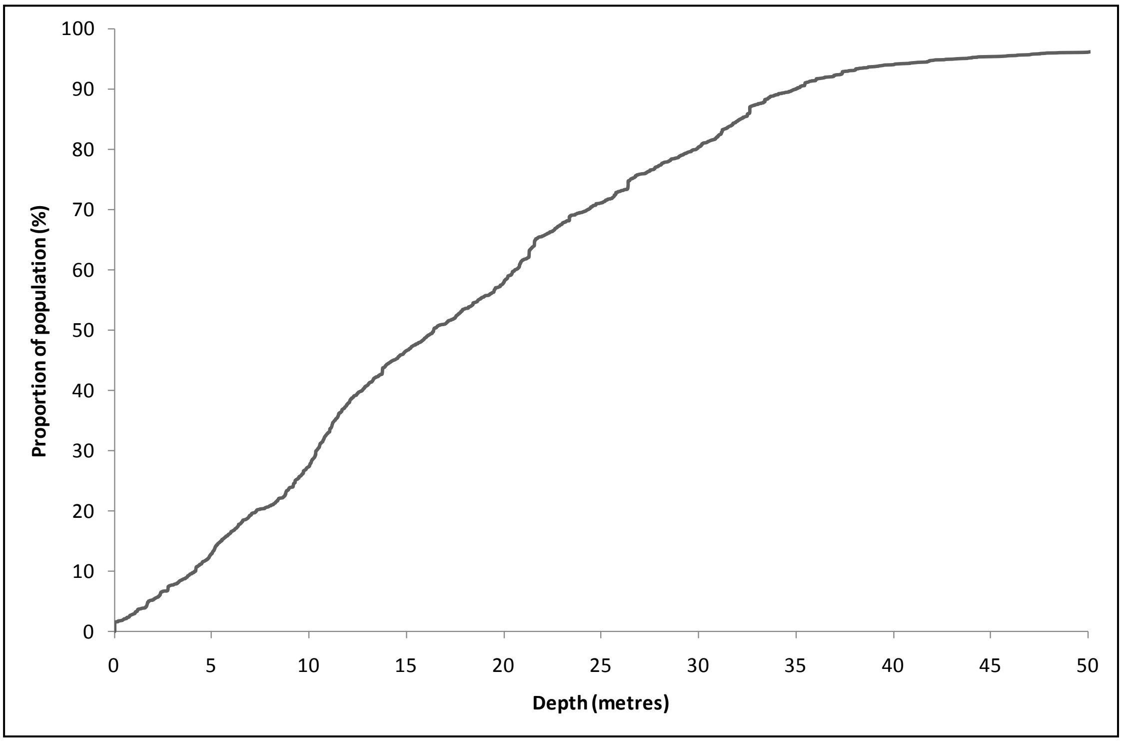

Figure C.6. The proportion of Scottish GND raw observations in water of different depths. 95% of GND observations were on water shallower than 43m.

Figure C.6 does not take into account the potential psuedoreplication effects from multiple surveys of the same areas. As explained in the methods, using the mean density surfaces removes this effect. Figure C.7 shows that the mean density surfaces gave a very similar result to the raw GND observations. The results indicate that 95% of GNDs assessed in Scottish AoS, according to the mean density surfaces, were located in water shallower than 44m.

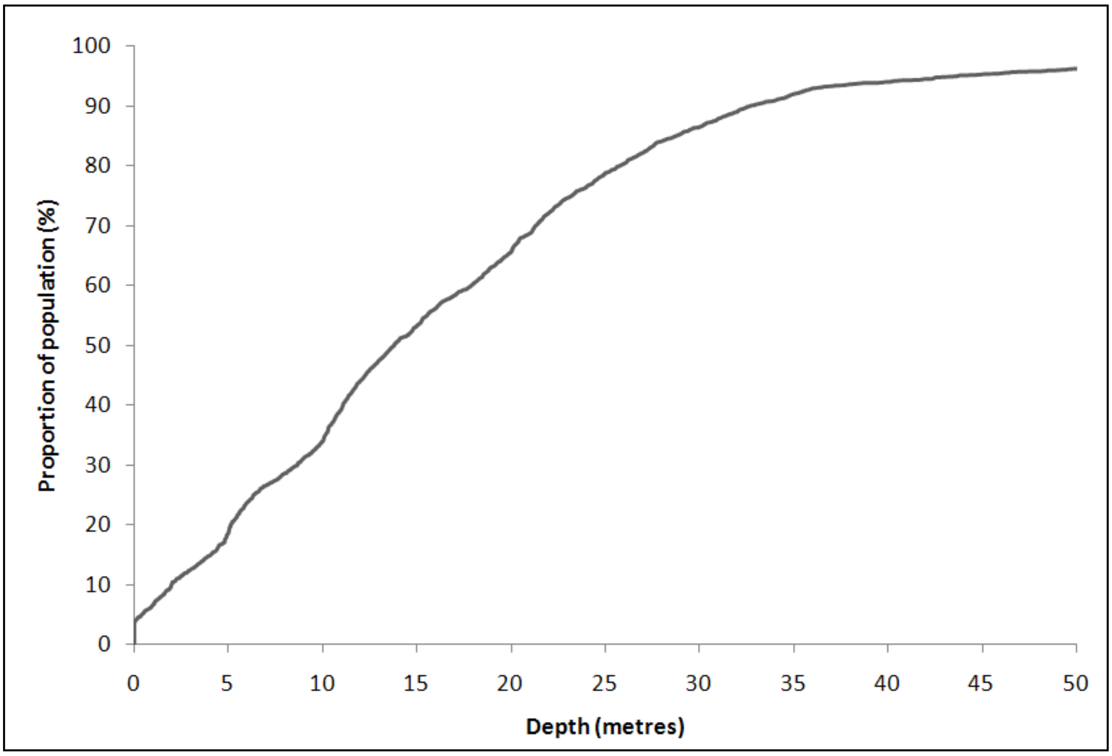

Figure C.7. The proportion of Scottish GND (based on mean density surfaces) over different depth water. 95% of GNDs, according to the mean density surfaces, were over water shallower than 44m.

Since 95% of GNDs is a somewhat arbitrary cut-off, maximum curvature was applied to the curve in Figure C6 to identify the point where there was a change in the relationship between the rate of increase in GND numbers and depth.
Figure C.8 shows the point of maximum curvature against sea depth, at 48.6m. The results indicate that 95.9% of the GND population assessed in Scottish AoS were found in water shallower than 48.6m.

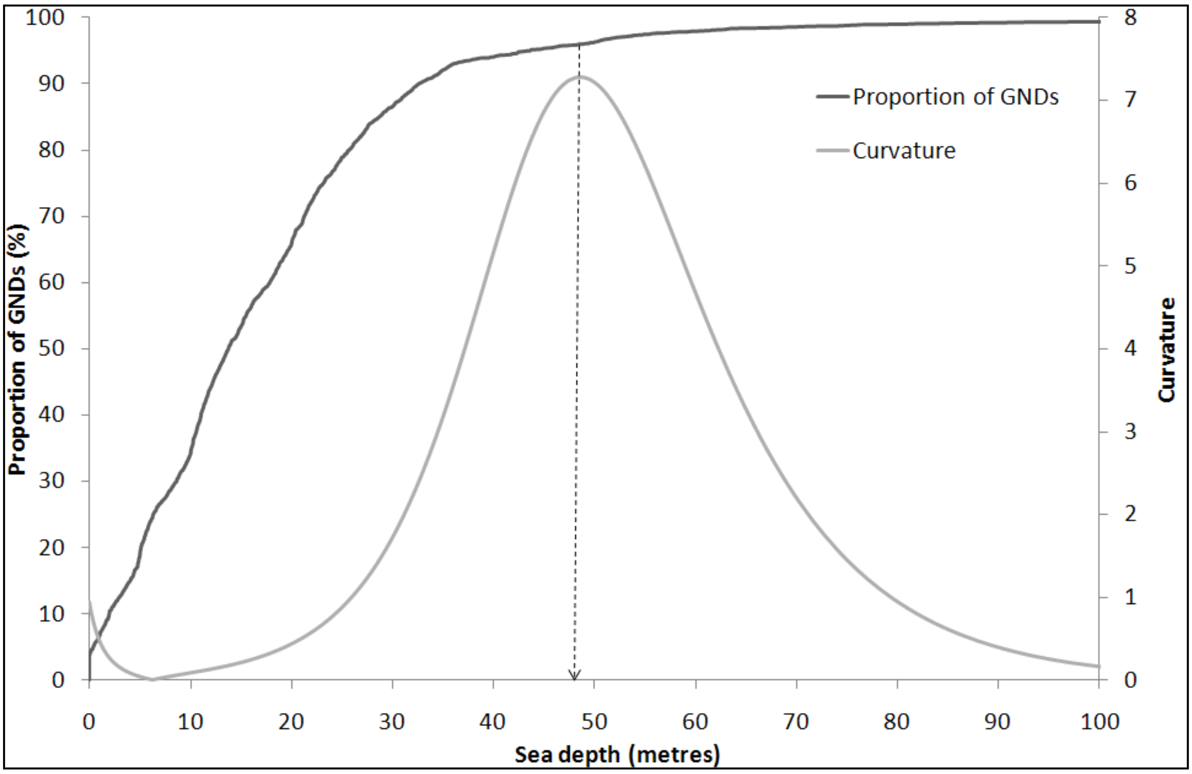

Figure C.8. The proportion of GNDs (based on mean density surfaces) over different depth water and curvature at different sea depths. Maximum curvature was at 48.6m. This is the point of transition from number of GNDs rapidly increasing with increasing sea depth, to increasing more slowly.

Figure C.9 shows two draft boundaries that are based, respectively, on the 44m depth contour (95% of GNDs in water shallower than 44m) and the 49m depth contour (the point of maximum curvature) in the sea adjacent to the south coast of Cornwall. Following the established conventions set out in Webb and Reid (2004), a smoothed boundary line was derived from bathymetry data, which included a 250m buffer to account for error in assigning locations of birds obtained from aerial surveys, and which follows parallels of latitude or meridians of longitude or as diagonals between two points to provide a practical boundary. Raw observations of all divers (GND, black-throated diver, red-throated diver and unidentified diver spp.) recorded on aerial survey are also shown on the map and all of these, except three observations, were within the 44m depth contour boundary.

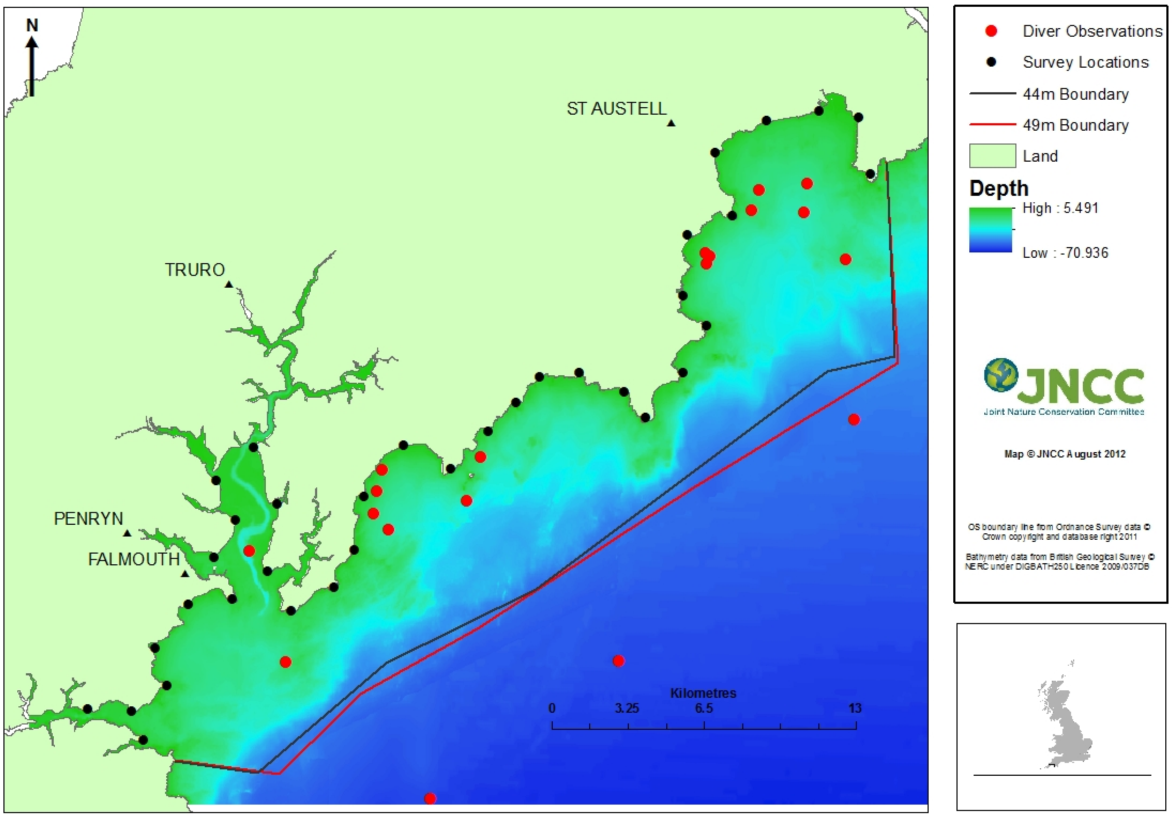

Figure C.9. A map of south Cornwall showing draft boundary options that follow the 44m depth contour (95% of GNDs were on water shallower than 44m) and the 49m depth contour (the point of maximum curvature) as well as raw observations of divers from aerial surveys of south Cornwall. This map is not intended to represent the landward extent of possible boundaries; land-based survey locations have simply been circumscribed.

C.4 Discussion

GND in Scotland favour shallow water with 95% of birds using water less than 44m deep. The nature of GND distribution in Scotland, i.e. of most birds using relatively shallow water and a few birds using much deeper water, is similar to that recorded in south Cornwall, where more GND were recorded during shore-based counts over shallow water than on aerial surveys over deeper water. Haney (1990) found similar depth preferences of GND in the southeastern United States, with 87% of GND in water shallower than 40 metres and more GND in the 0-20 metre depth class than the 20-40 metre depth class. Warden (2010) modelled the bycatch of wintering great northern divers caught in gillnets while foraging off the USA Atlantic coast based on commercial fisheries monitoring data. That study found geographical differences; within the Northeast region great northern diver bycatch peaked at 15-35m depth (61% expected), followed by 32% at ≥ 35 m bottom depth, while only 6% of bycatch is associated with shallow areas of < 15 m. For the Mid-Atlantic, bycatch was modelled to peak in areas <15m (66%), followed 33% at 15-35 m bottom depth. Only 1 % of the bycatch was expected for areas of ≥ 35 m depth.

Analysis of the raw GND observations and of the mean density surfaces that were used for identifying areas for possible classification as SPAs in Scotland for this species gave very similar results, with 95% of the GND population in water shallower than 43m and 44m, respectively. This suggests that existing methods for boundary placement for inshore SPAs, such as those used for the Outer Thames Estuary SPA and Liverpool Bay/Bae Lerpwl SPA, not surprisingly perhaps, identify similar areas to the raw observations, while removing issues of pseudoreplication and uneven survey effort (O'Brien *et al* 2012).

Data from all eleven areas of search were used to inform the boundary options, despite there being variation in topography and relative use of waters of varying depths between areas of search (Figures C.2 & C.3). In theory, it may be possible to characterise the topography of the South Cornwall area of search, for example, by using Principle Component Analysis and variables such as slope, aspect, current, etc. The same approach could be used for each of the Scottish areas to identify those areas that are most similar to south Cornwall and then to selectively use data from these areas to inform the boundary in south Cornwall. However, selecting areas to include or exclude from the comparison in this way would ultimately be arbitrary and therefore could not be justified. In fact, despite the existence of site to site variation in median depth and range, the south Cornwall AoS clearly is broadly similar to the range of depths surveyed in Scottish AoS. In addition, those depths of water that GND in the Scottish AoS used are available to divers in the south Cornwall AoS. The significance of any differences in depth profile between AoS should not be interpreted too far; the extents of the AOS themselves were selected to encompass the likely maximum range of bird aggregations (largely in relatively shallow water) but, due to local geography, some AoS also included significant areas of deeper water, including waters where it was unlikely that many birds would actually be found.

This approach identified the maximum depth that supported 95% of Scottish GNDs. The cut-off of 95% of the population is an arbitrary threshold but 95% is a commonly and widely used threshold in statistics. Drawing a boundary along a depth contour that encompasses 100% of the Scottish GND population is unrealistic as a very few Scottish GND observations were over very deep water. This would result in a boundary in south Cornwall covering a huge area that is unlikely to be used by GND to any great extent. Alternatively, a different cut-off value could be used, e.g. 90% of Scottish GNDs. This would give a draft boundary that follows the 33m depth contour. However, this cut-off value would be harder to justify than using a cut-off of 95%.

The mathematical procedure of maximum curvature is one approach for identifying a cut-off in a relationship between two variables and has been used for boundary setting for inshore SPAs (O'Brien *et al* 2012). In that case, maximum curvature identified the point where there is a change in the relationship between the rate of change in the size of an area and the cumulative number of birds it hosts. However, in the case of boundary setting for south Cornwall, maximum curvature identified the point of transition from number of GNDs rapidly increasing with increasing sea depth, to increasing more slowly. This approach offers an objective, repeatable approach to boundary setting that has been used elsewhere in English waters to identify marine SPAs for inshore aggregations of wintering divers. It may have been preferable to apply maximum curvature to bird density data (as in O'Brien *et al*, 2012) rather than to depth but the paucity of diver records obtained from aerial surveys dictated an alternative approach.

The novel approach presented here has been developed as aerial surveys off south Cornwall failed to record many divers. There are three possible explanations for this. Firstly, observers could have missed birds during the surveys. Alternatively, divers were present only at very low densities during the surveys. A third possibility is that, due to the relatively few aerial surveys undertaken, an unrepresentative sample was taken, i.e. significant use of areas further offshore at other times cannot be ruled out.

It is very unlikely that observers missed large numbers of divers during the surveys. Aerial surveyors undergo extensive training and different observers were used on the three surveys of south Cornwall. GNDs are large birds and are unlikely to have been missed. GNDs and red-throated divers have been successfully recorded on many aerial surveys around the coast of the UK and have been successfully used to define SPAs for red-throated divers in the Outer Thames Estuary and Liverpool Bay. GNDs have been recorded in

sufficient numbers on aerial surveys around Scotland to allow existing inshore boundary setting methods to be used to define draft boundaries around aggregations of GNDs. It should be noted therefore, that the boundary selection method presented here for south Cornwall may not be the appropriate solution in other areas.
The most likely explanation for the paucity of diver records from aerial surveys of south Cornwall is that GND were aggregating close inshore, in areas that were not surveyed during aerial surveys. There is a strip of sea of 1-2km width between the high water mark and the edge of the aerial survey extent, shown in Figure C.1. Visual aerial surveys are conducted at a height of 250ft above the sea but aircraft are required to climb or bank on approach to land to maintain the minimum flight height of 250ft. Consequently, observers are either too high to consistently survey the sea adjacent to the coast or, if the aircraft banks, one observer can no longer continue to observe the sea. If GND were aggregated in this area, they would go undetected by aerial surveys. Further support for GND aggregating very close to shore is the fact that the few divers observed during aerial surveys were close to land (with the exception of a few observations that were further offshore), and that shore-based counts recorded many more GND than aerial survey. However, it does not necessarily follow that GND never occur in deeper water, just that few GND were detected during the three aerial surveys undertaken. Shore-based counts of Broad Bay (Outer Hebrides, Scotland) carried out in the same month as aerial surveys, recorded almost three times as many GND as aerial surveys, suggesting that aerial surveys can under record the numbers of GND. Aerial surveys also sample a small part of the total sea area as birds distant from the line transects will be under recorded. Distance sampling methods (Buckland *et al* 2001) model the rate of decline in detection rate with distance from the line transect and correct for the number of missed birds. However, if GND in south Cornwall were already at low density, distance sampling methods may not be applicable as too few birds will be recorded. The population estimate obtained by shore-based counts, of 74 birds in south Cornwall, is lower than any area in Scotland for which a GND draft boundary has been drawn.

Ninety five percent of GNDs were recorded on water shallower than 44m, regardless of whether raw GND observations were used in the analysis or whether GND densities from the mean density surfaces were used to describe the cumulative GND population. The GND densities were taken from a grid of 1km x 1km cells and the centre point of those cells were assigned a depth value from a depth raster. Consequently, there could potentially be a mismatch of up to 500m between the location of a GND and the centre point of the cell at which depth was assigned. This potential effect has not biased the assessment of distribution of the GND population informed by GND densities as a very similar result prevailed when using raw GND observations.

Black-throated divers were rarely recorded and black-necked grebes were never recorded during aerial surveys around the UK. Consequently, the approach used for GND cannot be used for these species. However, black-throated divers and red-throated divers tend to occur on shallower sea than great northern divers (Durinck *et al* 1994; Haney, 1990; Petersen *et al* 2003; Warden, 2010) and wintering black-necked grebes use inshore shallows in bays and channels, as well as freshwater and salt lakes (del Hoyo *et al* 1992; Snow & Perrins, 1998). Furthermore, there are physiological reasons why larger animals are able to dive deeper and longer than smaller ones, related to the rates at which oxygen is stored and consumed (Butler and Jones, 1982). It is most likely therefore, that a boundary based on GND habitat requirements would encompass most black-throated divers and black-necked grebes.

Improvements to estimating the distribution of GND in south Cornwall in the future could be made by exploiting recent technological advances in aerial survey methods. Digital stills and digital video offer improved estimates of waterbird numbers (Buckland *et al* 2012). Digital surveys are flown at a higher altitude, allowing continuation of survey into the intertidal area, in contrast to visual aerial survey. Additionally, model-based methods of analysing digital data, that incorporate environmental covariates such as sea depth, are likely to give a more complete picture of the distribution of GND in south Cornwall (Buckland *et al* 2012).

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Appendix D

An assessment of diver and grebe coastal distributions in South Cornwall Coast: analysis of shore-based count sectors

Summary

Natural England asked JNCC to assess the relative importance of 35 count sectors within the South Cornwall Coast AoS for black-throated diver, great northern diver and Slavonian grebe. A species-specific threshold number of birds was determined using maximum curvature, such that below the threshold, disproportionately long stretches of coastline were required to capture the same number of birds. Only six count sectors were found to have numbers of all three species below their thresholds; the remaining 29 count sectors all supported numbers of at least one of the three species, in excess of their maximum curvature thresholds.

D.1 Introduction

The South Cornwall Coast AoS regularly supports wintering aggregations of black-throated diver and great northern diver in excess of 1% of their GB wintering population estimates, and aggregations of Slavonian grebe around 1% of its GB wintering population estimate. Subsequent to the completion of most of the analyses presented in this report, NE asked JNCC to assess whether there were gaps in the distribution of divers and grebes along the AoS that may not warrant inclusion within a potential SPA boundary.

This Appendix describes analyses of the relationship between cumulative bird numbers and length of coastline occupied, using the point of its maximum curvature to identify a threshold number of birds below which divers and grebes were considered to be too sparse to warrant inclusion within a boundary. Maximum curvature is a useful mathematical tool for identifying the point of change in the relationship between two variables and has been used previously to identify a density threshold for boundary location for both the Liverpool Bay/Bae Lerpwl SPA and Outer Thames Estuary SPA (O'Brien *et al* 2012), and to identify a sea depth threshold of great northern divers (this study: Appendix C).

D.2 Methods

In December and February in each of the winters 2009/10 and 2010/11, counts were made of divers and grebes on the sea in 35 count sectors along the coast from the Helford Estuary to St Austell Bay (see 3.2.2 for more details). A population estimate for the whole area of search for each species was determined, firstly, by summing the number of individuals of that species recorded at each count point on each survey. Secondly, a mean of peak (MoP) estimate for each species was calculated by taking the sum of individuals from either the first or second survey each winter, whichever was higher, from each of the two winters and taking the mean of these. The Slavonian grebe population was estimated using WeBS data for the corresponding period. To assess the relative importance of each count sector, a mean of peaks was calculated for each individual count sector, rather than the whole area of search. For each count sector, the higher count from both winters was used in calculating the mean of these two counts. The sum of this count sector mean of peaks was greater than the area of search mean of peaks but is not a valid estimate of the numbers of birds using the area due to the possibility of double counting. A flock may move from one count sector to another between December and February, thereby overestimating the total number of birds using the area of search. However, when considering the relative importance of each count sector, it is important to capture peak use of a count sector, whether used in December or February.

Some count sectors are larger than others, so higher counts in some areas could be attributable to surveying a larger area. Ideally, counts would be converted to densities but the area of sea surveyed was unknown. Instead, an abundance measure was used, being the number of birds in each count sector divided by the length of coastline of each count sector, i.e. number of birds per km of coastline surveyed. The aim here was to identify a threshold of this abundance measure below which birds were considered to be too infrequent to warrant inclusion in a potential site boundary.

The maximum curvature technique was used to identify this threshold as follows. For each species, the count sector-specific means of peaks were ranked from highest to lowest and then cumulatively added. This was then converted to a proportion of the total cumulative number of birds, and was plotted against cumulative length of coastline associated with each count sector. An exponential and double exponential model was fitted to the curve (see O'Brien *et al*, 2012 and Appendix C of this study for more information). The model that best fitted the cumulative bird curve was used to identify the point of maximum curvature, i.e. the point of diminishing returns where an increasingly long length of coastline would be needed in order to be able to keep adding birds to the potential SPA at the same rate. The point of maximum curvature was used as a threshold to determine potential SPA boundary placement, such that count sectors with a mean of peaks equal to or greater than the threshold should be included within a potential SPA boundary and those sectors with a mean of peaks less than the threshold did not warrant inclusion. Finally, the number of species (maximum of three: great northern diver, black-throated diver, Slavonian grebe) that exceeded their respective thresholds at each count sector was assessed and mapped.

D.3 Results

D.3.1 Black-throated diver

Both the exponential and double exponential models fitted the curve of cumulative number of black-throated divers against cumulative length of coastline equally well and both models identified the point of maximum curvature at three birds (Figure D.1, Figure D.2).

Figure D.2 identifes a point of maximum curvature at 25km that corresponds to a bird abundance per count sector of 3 birds. The count sectors supporting an average of 3 or more black-throated divers accommodated 93.7% of the birds within 25km of coastline. A further 71km of coastline comprising count sectors supporting fewer than 3 birds, i.e. less than the point of maximum curvature threshold, would be needed to capture the remaining 6.3% of birds.

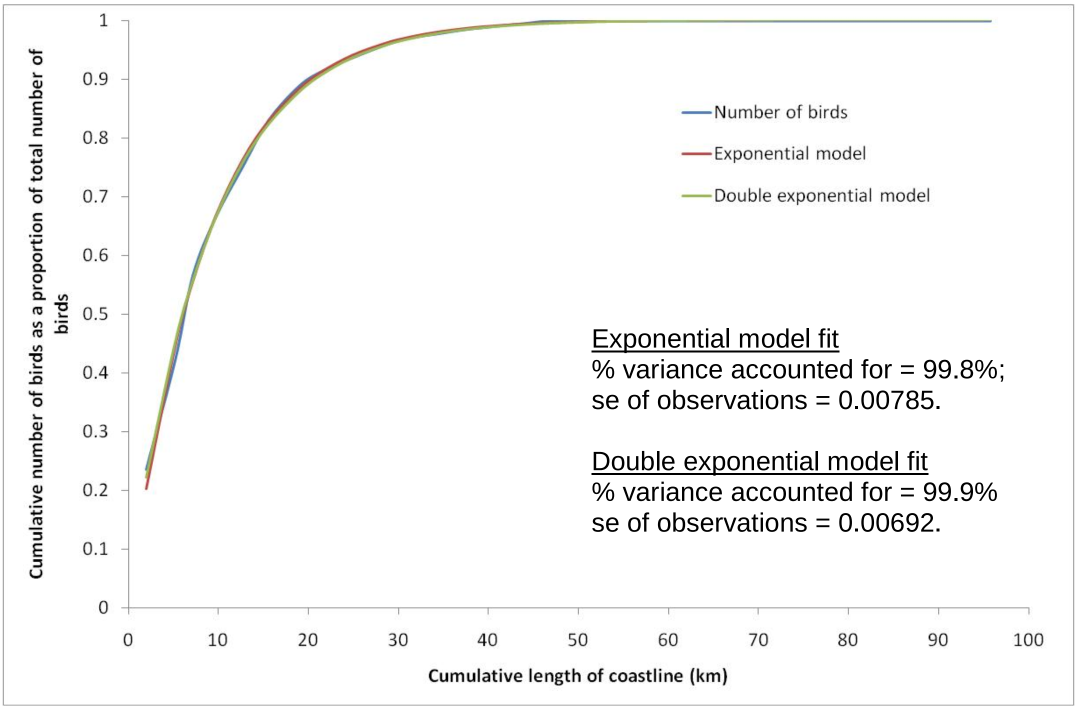

Figure D.1. Fit of the exponential and double exponential model to the observed cumulative number of black-throated divers against cumulative length of coastline, showing both models fitted the observed data well, according to the standard error of observations and percentage of variance accounted for.

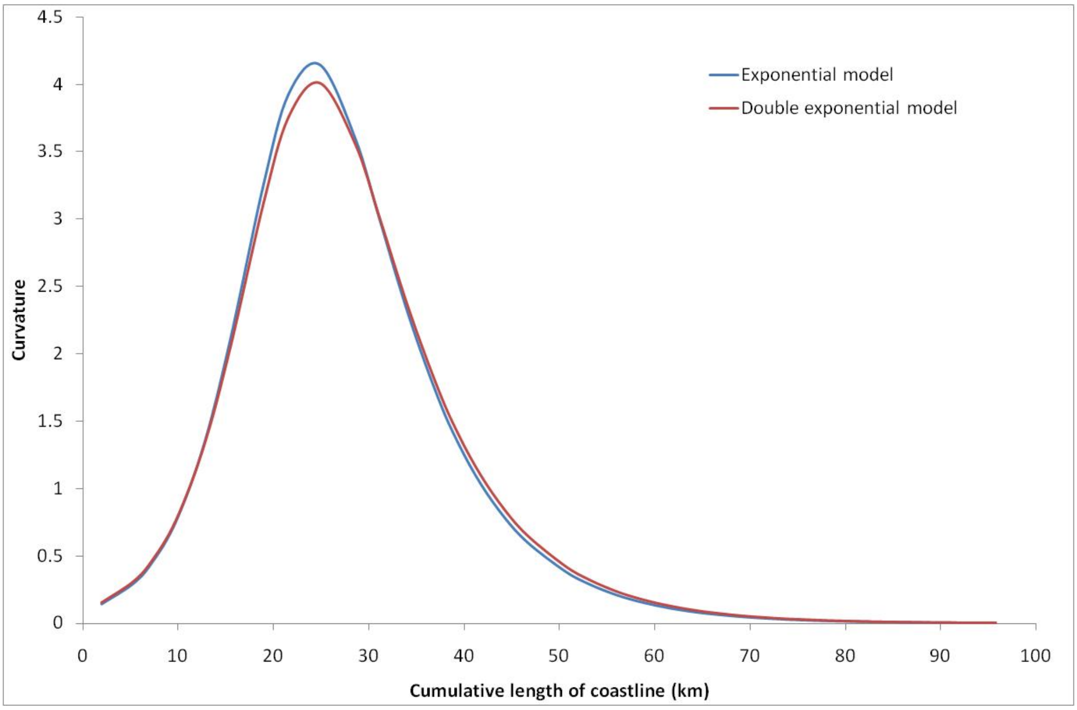

Figure D.2. Curvature of the exponential and double exponential models for black-throated divers, showing the point of maximum curvature for both models is at a cumulative length of coastline of 25km which corresponds to a threshold of three birds.

Black-throated divers were recorded in relatively few count sectors but in large flocks of up to 30 birds. Ten count sectors had a mean of peaks greater than or equal to the threshold of three birds (Figure D.3). Twenty-five count sectors had a mean of peaks below the maximum curvature threshold of three birds with no black-throated divers recorded at 18 of the count sectors.

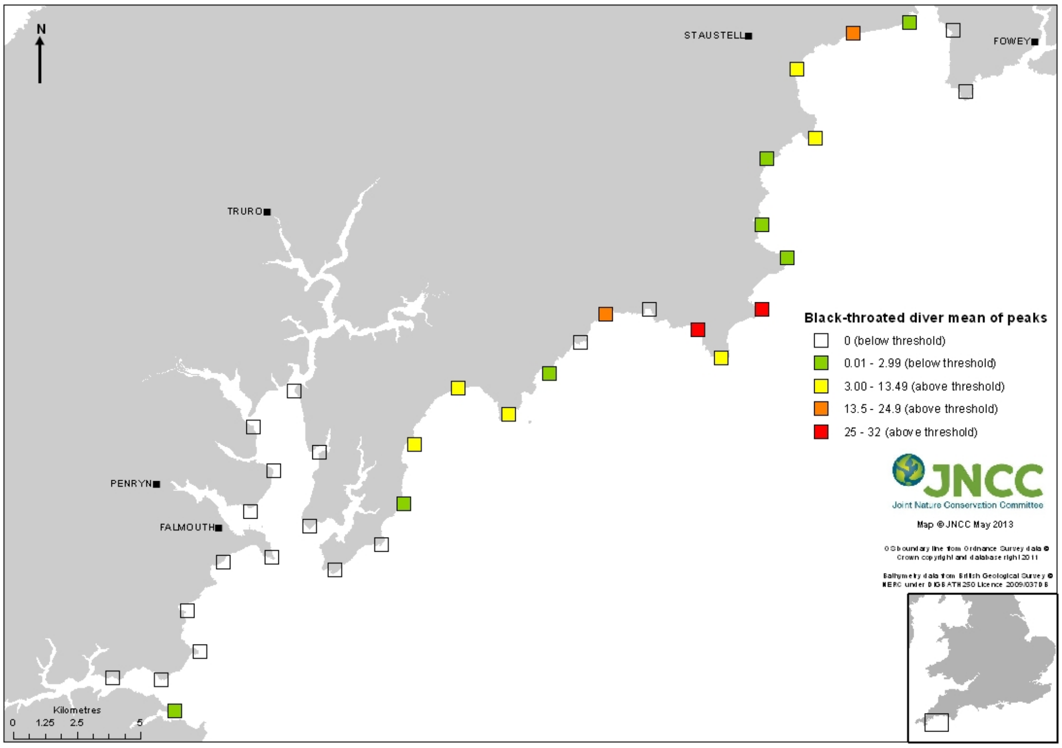

Figure D.3. Mean of peaks of black-throated divers from the 35 count sectors in the South Cornwall Coast area of search, with sectors where no black-throated diver were seen indicated by empty squares and sectors with a mean of peaks below the threshold of three birds indicated by green squares.

D.3.2 Great northern diver

Great northern divers were spread throughout the count sectors in relatively similar numbers, when compared with the more aggregated black-throated diver distribution. The plot of cumulative number of divers against corresponding coastline does not reach a clear asymptote (Figure D.4). Although the double exponential model was a slightly better fit to the observed cumulative number of birds it did not indicate a clear point of maximum curvature although there is possibly a point at approximately 93km (Figure D.5). The exponential model was flattened but did have a peak at around 62km, corresponding to a threshold of 1.5 birds. 89% of great northern divers were within 62km of coastline (Figure D.4); a further 34km of non-contiguous coastline would be needed to capture the remaining 11% of birds.

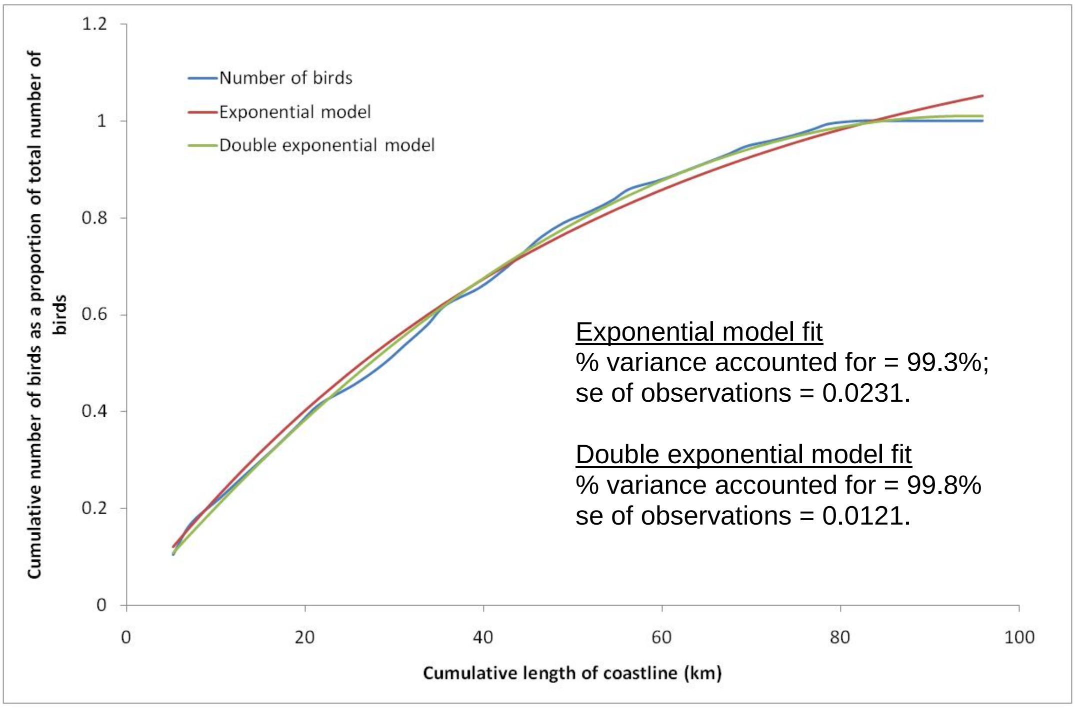

Figure D.4. Fit of the exponential and double exponential model to the observed cumulative number of great northern divers against cumulative length of coastline, showing both models fitted the observed data reasonably well but the double exponential was a slightly better fit, according to the standard error of observations and percentage of variance accounted for.

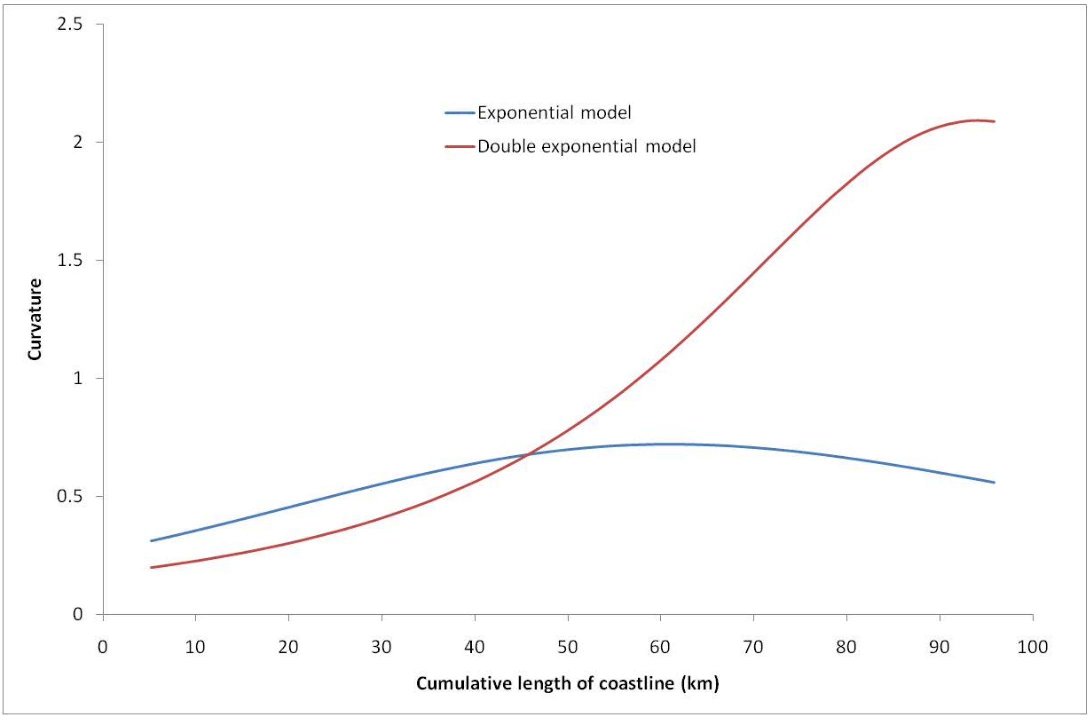

Figure D.5. Curvature of the exponential and double exponential models for great northern divers, showing neither model follows a bell-shaped curve, making it difficult to identify a point of maximum curvature.

Great northern divers occurred in relatively low numbers (largest flock of nine birds) but were more widely spread throughout the area of search, in comparison with black-throated divers (Figure D.6). No great northern divers were seen at only five count sectors; a further five count sectors had low numbers of great northern divers, below the maximum curvature threshold of 1.5 birds. The remaining 25 count sectors supported numbers of great northern divers equal to or greater than the maximum curvature threshold.

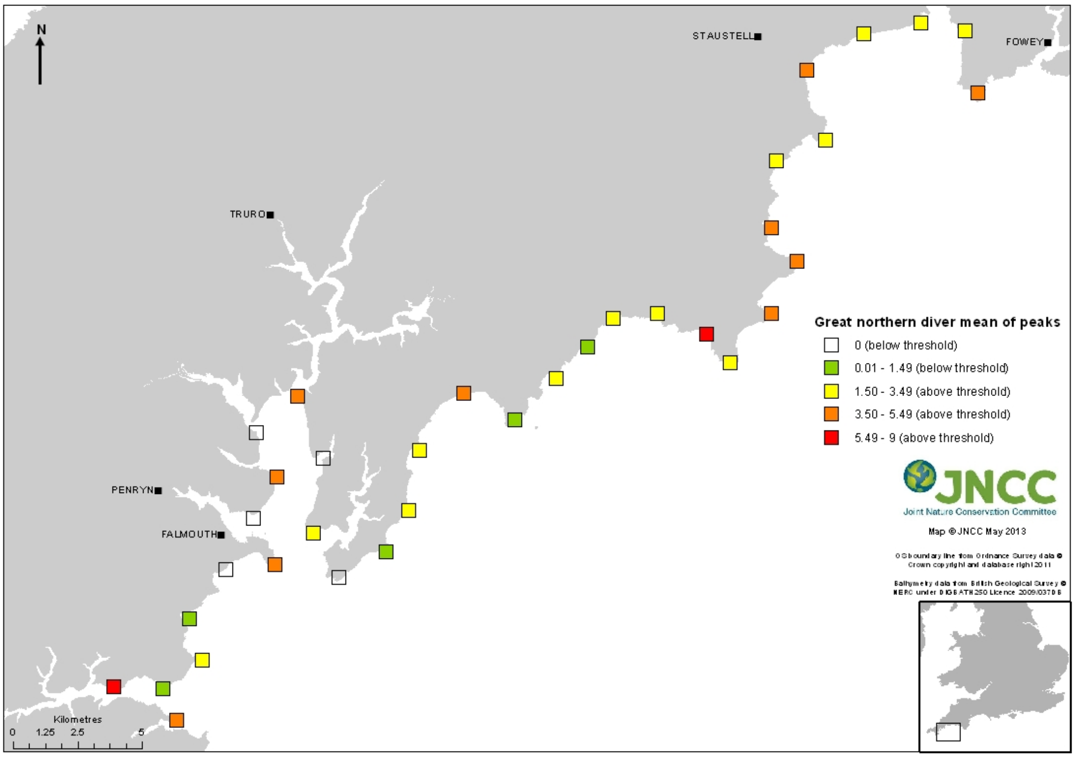

Figure D.6. Mean of peaks of great northern divers from the 35 count sectors in the South Cornwall Coast area of search, with sectors where no great northern diver were seen indicated by empty squares and sectors with a mean of peaks below the threshold of 1.5 birds indicated by green squares.

D.3.3 Slavonian grebe

Both the exponential and double exponential models fitted the observed data reasonably well but the double exponential was a slightly better fit, according to the standard error of observations and percentage of variance accounted for (Figure D.7). The observed data had a ‘shoulder’ as it reached an asymptote which neither model was able to fit particularly well (Figure D.7). The double exponential model returned a threshold of 0 birds, which makes no biological sense (Figure D.8). A threshold of 0 birds would mean all count sectors would be equal to or above the threshold, even if no Slavonian grebes were recorded there. The exponential model indicated a point of maximum curvature at around 30km of coastline, corresponding to a threshold of 0.5 birds (Figure D.8).

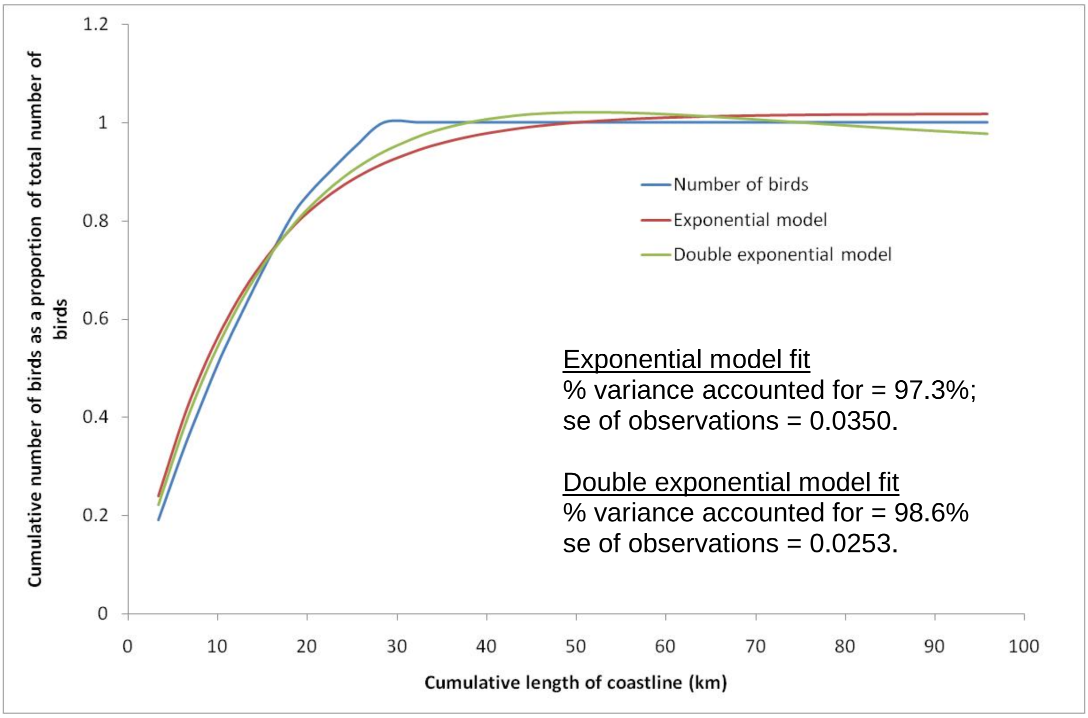

Figure D.7. Fit of the exponential and double exponential model to the observed cumulative number of Slavonian grebe against cumulative length of coastline.

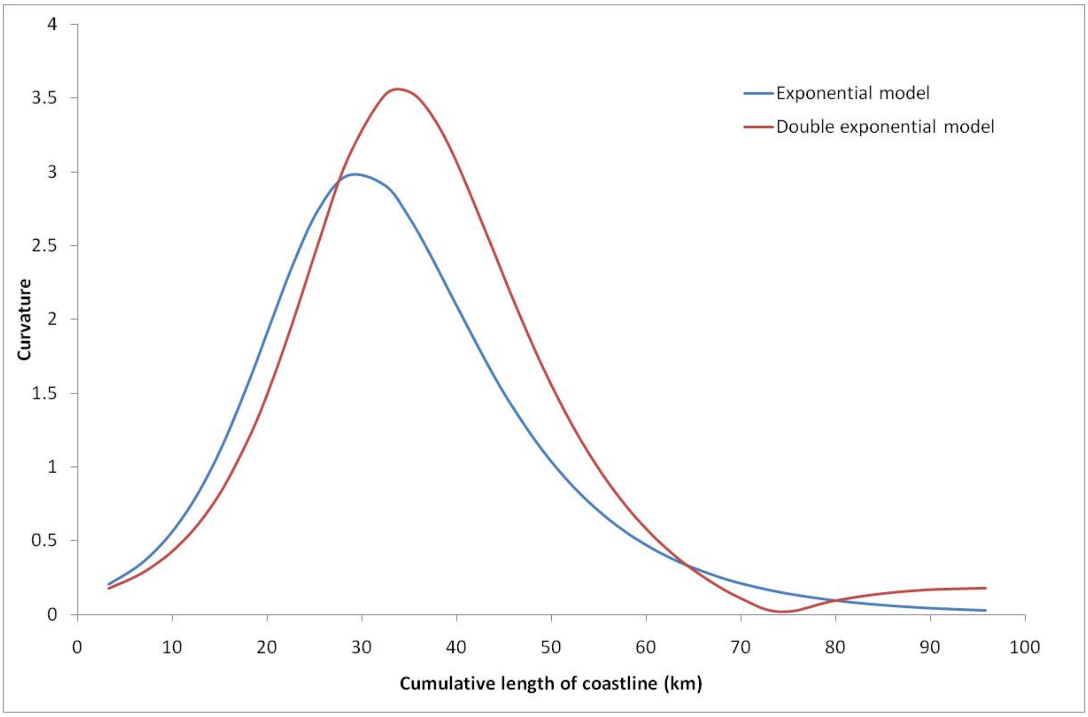

Figure D.8. Curvature of the exponential and double exponential models for Slavonian grebe, showing both models follow a bell-shaped curve.

In common with great northern diver, Slavonian grebe did not occur in large aggregations. The largest aggregation recorded was just two birds. However, as with black-throated diver, they were absent from two-thirds of count sectors (Figure D.9). Slavonian grebe met or exceeded the threshold in 11 count sectors and was absent from the remaining 24 count sectors.

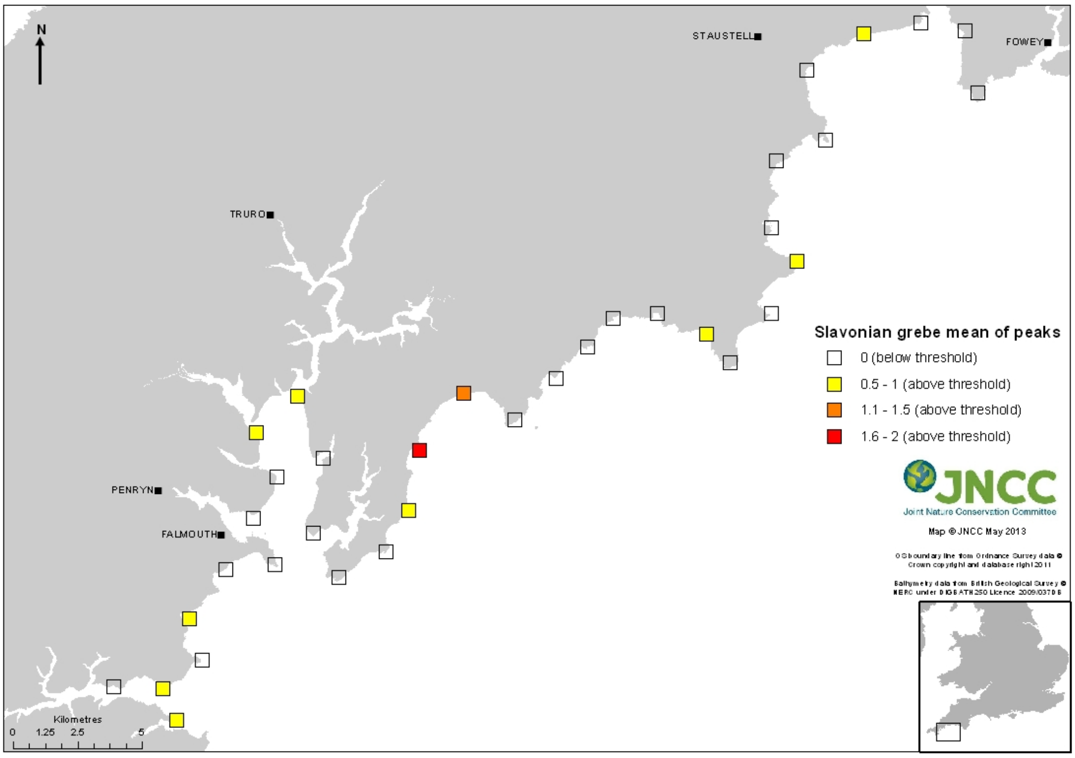

Figure D.9. Mean of peaks of Slavonian grebe from the 35 count sectors in the South Cornwall Coast area of search, with sectors where no Slavonian grebe were seen indicated by empty squares. Since the threshold was 0.5 birds, all sectors in which Slavonian grebe were recorded were above the threshold.

Each of the three species distribution maps shown above were overlaid, with a species being classed as ‘present’ if it was recorded in numbers in excess of its maximum curvature threshold at that count sector. All three species were either present in low numbers, below their maximum curvature thresholds, or were absent altogether, at only six count sectors (Figure D.10). Most count sectors held one species in excess of its maximum curvature threshold. Four count sectors supported all three species in excess of their maximum curvature thresholds.

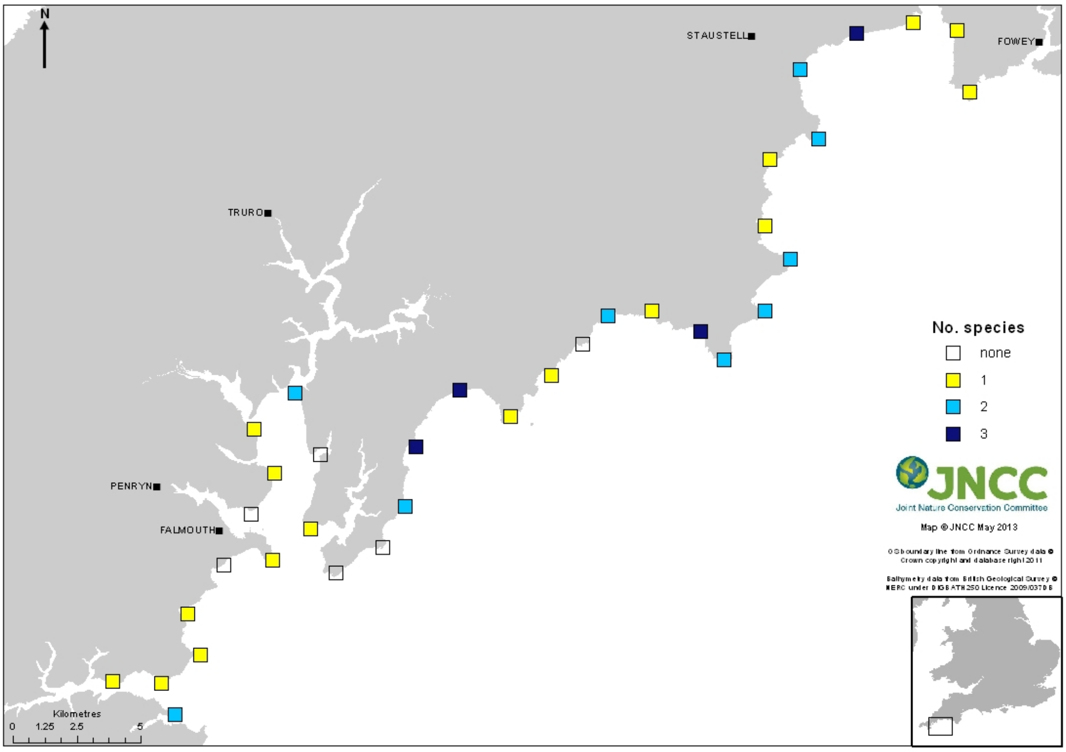

Figure D.10. The number of species present in excess of their maximum curvature thresholds at each count sector, indicated by coloured squares, with a maximum of three species present indicated by a dark blue square. No species were present in excess of their thresholds at six count sectors, as indicated by the empty squares. Species maximum curvature thresholds were black-throated diver = 3 birds; great northern diver = 1.5 birds; Slavonian grebe = 0.5 birds.

D.4 Discussion

Existing boundary setting methods for marine SPAs for wintering inshore aggregations of waterbirds usually include all cells on the density surface that exceed the maximum curvature threshold within the boundary (O'Brien *et al* 2012). Some cells with a density below the threshold are frequently also included during the process of producing a pragmatic and simple boundary. In the case of the South Cornwall Coast area, it would be difficult to draw a boundary that excludes the six count sectors that did not support any species in excess of their thresholds, while including all other count sectors. Such a boundary might be complex and difficult to implement.

A clear point of maximum curvature was evident for the cumulative number of black-throated diver, with both exponential and double exponential models providing a good fit to the observed data. Cumulative numbers of both great northern diver and Slavonian grebe had a less clear point of maximum curvature, although with careful model selection, a point of maximum curvature was identified for both species.

D.5 Conclusion

Most of the count sectors held a sufficient number of divers or grebes regularly present to exceed the maximum curvature threshold for at least one species, thereby meriting inclusion within the potential SPA boundary. Numbers of birds in six count sectors did not exceed any of the maximum curvature thresholds and the possible SPA boundary does not necessarily need to include these sectors. However, a boundary needs to be workable on the ground, ideally following lines of latitude and longitude and having few vertices (Webb and Reid, 2004). It is therefore pragmatic to include the sectors with low or zero counts, which are surrounded by sectors with higher counts. The same principle was used for the classified Outer Thames Estuary SPA and Liverpool Bay/Bae Lerpwl SPA in which all areas with densities greater than the thresholds were included within the boundary, along with other lower density areas where it facilitated drawing a simpler boundary (O'Brien *et al* 2012).

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