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Development of MSFD Indicators, Baselines and Target for Seabird Breeding Failure Occurrence in the UK (2012)

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Summary

1. The Marine Strategy Framework Directive (MFSD) has been developed with the aim of achieving Good Environmental Status (GES) in Europe's seas by 2020. To do this, all EU states must submit a list of environmental targets to the European Commission and put in place a supporting monitoring programme that will assess progress towards achieving these targets.

2. Seabirds have long been proposed as valuable indicators of the health of the marine environment. Seabird breeding success has been shown to be closely linked to food quality and availability. Consequently, tracking breeding failure rates for a variety of species over a broad spatial scale would provide a valuable tool with which to monitor the effect of anthropogenic activities on the wider marine environment.

3. Breeding success data were obtained from the Seabird Monitoring Programme for 17 seabird species, which were then ranked according to their sensitivity to changes in food supply.

4. Breeding failure rates for each of these species were then modelled over the period 1986-2010 to account for annual variability in sampling regime.

5. Modelled failure rates were then assessed against a target of the proportion of colonies failing not exceeding a maximum threshold in more than three out of the preceding six years.

6. Five different maximum thresholds were considered – 5% of colonies, 15% of colonies, the mean failure rate of the preceding 10 years, the mean failure rate of the preceding 15 years and the mean failure rate of the preceding 20 years.

7. The most realistic maximum threshold was felt to be the mean failure rate of the preceding 15 years, or 5% of colonies, whichever value was higher. By setting this threshold it was possible to account for long-term environmental changes which may affect breeding success, whilst also ensuring that failure to meet targets would not be driven by breeding failure at a single colony in a species with relatively few colonies.

8. Based on an initial indicator assessment and consideration of species sensitivities to changes in food supply, Arctic tern, common tern, sandwich tern, little tern and kittiwake were selected as indicators for the Greater North Sea sub-region and common tern, Arctic tern, kittiwake, lesser black-backed gull and herring gull were selected as indicators for the Celtic Seas sub-region.

9. At present in the Greater North Sea sub-region, common tern, Arctic tern, Sandwich tern and little tern are assessed as failing to meet the above target, while kittiwake meets the target. In the Celtic Seas sub-region, lesser black-backed gull and herring gull are assessed as failing to meet the above target; both tern species and kittiwake met the target.

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1. Introduction

1.1. The Marine Strategy Framework Directive

The Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC of the European Council) has been developed with the objective of achieving Good Environmental Status (GES) across Europe's marine environment by 2020 (EC 2008). GES is defined by 11 qualitative descriptors listed in the Directive. This project concerns descriptor D1 – Biological Diversity, which stipulates "Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species should be in line with prevailing physiographic, geographic and climatic conditions" (EC 2010). The MSFD specifies that European Union (EU) Member States must submit a set of environmental targets (and related indicators) to the European Commission by July 2012. By 2014, all indicators and targets should have in place a supporting monitoring programme, assessment criteria, quality standards and a process for disseminating results.

1.2 Seabird Breeding Success as an Indicator of Good Environmental Status

The study of seabirds has long been proposed as a useful indictor of the health of the marine environment (Furness & Greenwood 1993). As they sit at the apex of marine food webs, changes in seabird populations may reflect the status of organisms subsisting at lower tropic levels (Furness & Greenwood 1993; Parsons *et al* 2008). However, seabirds are long-lived species, such that population-level responses to environmental fluctuations affecting the food chain may not be apparent for a number of years (Thompson & Ollason 2001).

Seabird breeding success (which varies on an annual basis and which can be easily monitored) has been shown to be closely linked to food quality and availability (Cury *et al* 2011; Frederiksen *et al* 2005; Wanless *et al* 2005), and is therefore likely to better reflect changes in food supply than does annual variation in population size. The UK's Seabird Monitoring Programme (SMP) has collected data on seabird breeding success from colonies throughout the UK since the mid-1980s. Tracking seabird breeding colony failure rates for a variety of species over a broad spatial scale would provide a valuable tool with which to monitor the effect that anthropogenic activities are having on the wider marine environment, in particular for the lower trophic levels on which seabirds and other marine predators (including commercially important fish stocks) depend.

The occurrence of seabird breeding failure has therefore been proposed[1] as an indicator of GES criterion 1.3 "Population condition". This indicator is intended to complement another proposed indicator examining kittiwake (*Rissa tridactyla*) breeding success. This project will construct an indicator for seabird breeding failure that has a baseline and a target, enabling the Department for Environment, Food and Rural Affairs (Defra) to assess whether or not GES has been achieved under the MSFD. The indicator and target will form part of Defra's submission in July 2012 of the UK's environmental targets under Article 10 of the MSFD. Indicators and targets for UK marine birds have been proposed by a group of experts gathered from the statutory country conservation agencies and the Joint Nature Conservation Committee (JNCC). This project will test their proposal for an indicator and target on seabird breeding failure. The aim of the project will be to develop their proposal into a clear process that (i) constructs the indicator from monitoring data, that (ii) assesses

[1] Indicators proposed by Defra's *MSFD Consultation Paper: UK Initial Assessment and proposals for Good Environmental Status;* and proposed as part of a common set of indicators to be adopted by Member States in the North-east Atlantic Region (see OSPAR Commission 2012).

the indicator against a target that reflects GES, and that (iii) provides clear guidance for calculating the indicator in future years.

1.3 Objectives

The work has the following objectives:

- To derive separate indicators of seabird breeding failure for selected species at colonies around the UK based on data held by the SMP.

- To conduct a trial assessment of the proposed target ("less than 5-15% of colonies failing per year in more than three out of six years") for these indicators.

- To aggregate assessments across species to provide an overall measure of the population condition of breeding seabirds as a means of assessing GES for the Greater North Sea and Celtic Seas OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) regions[2].

[2] United Kingdom waters fall into Greater North Sea and Celtic Sea sub-regions of the North East Atlantic Marine Region set out in the MSFD. The boundaries of these sub-regions closely equate to the OSPAR Greater North Sea and Celtic Sea regions, so seabird breeding colonies were assigned to one sub-region or another according to the OSPAR regional boundaries for this project.

2. Methods

2.1 Species Selection

Species for the indicators were selected on the basis of how sensitive they are to changes in food supply and hence, to the anthropogenic activities that may affect it. Furness and Tasker's (2000) assessment of the vulnerability of species to such impacts, based on seabird size, cost of foraging, potential foraging range, ability to dive, amount of 'spare' time in the daily budget, and ability to switch diet, was adapted for this purpose (Table 1). Information on breeding success from the SMP was provided by the JNCC for 24 species. Of these six were omitted, as data were not available for a sufficient number of years or sites to merit inclusion. The species omitted from the analysis were Manx shearwater (*Puffinus puffinus*), black guillemot (*Cepphus grylle*), black-headed gull (*Chroicocephalus ridibundus*), common gull (*Larus canus*), yellow-legged gull (*Larus michahellis*), Mediterranean gull (*Larus melanocephalus*) and roseate tern (*Sterna dougallii*). Of the remaining species, Arctic tern (*Sterna paradisaea*) was the most vulnerable to changes in food supply, followed by little tern (*Sternula albifrons*). Northern gannet (*Morus bassanus*) was the least vulnerable species, followed by fulmar (*Fulmarus glacialis*). Species were grouped according to their sensitivity (Table 1).

Table 1. Assessment of species sensitivity (1 = most sensitive, 17 = least sensitive) to anthropogenic activities affecting food supply. Ranking based on information given in Furness & Tasker (2000). Red = sensitive, amber = intermediate, green = non-sensitive. The number of colonies in each sub-region are given for the Greater North Sea (GNS) and Celtic Seas (CS) sub-regions.

Species	Sensitivity rank	Number of Colonies	
		GNS	CS
Arctic Tern (*Sterna paradisaea*)	1	100	74
Little Tern (*Sternula albifrons*)	2	98	34
Common Tern (*Sterna hirundo*)	3	122	130
Sandwich Tern (*Sterna sandvicensis*)	4	29	6
Kittiwake (*Rissa tridactyla*)	5	51	33
Arctic Skua (*Stercorarius parasiticus*)	6	29	3
Great Skua (*Stercorarius skua*)	7	30	6
Atlantic Puffin (*Fratercula arctica*)	7	5	3
Razorbill (*Alca torda*)	9	8	8
Lesser Black-backed Gull (*Larus fuscus*)	10	12	44
Herring Gull (*Larus argentatus*)	10	29	125
Great Black-backed Gull (*Larus marinus*)	12	21	119
Common Guillemot (*Uria aalge*)	13	14	10
Shag (*Phalacrocorax aristotelis*)	14	21	36
Great Cormorant (*Phalacrocorax carbo*)	15	10	29
Fulmar (*Fulmarus glacialis*)	15	41	26
Northern Gannet (*Morus bassanus*)	17	6	2

2.2 Developing Indicators

To minimise the impact of year-to-year variation in the colonies which were sampled, seabird breeding failure was modelled within a Generalised Linear Model (GLM) framework with a binomial error structure. Breeding success for each colony in each year was calculated, and where this value was below 0.1 chicks per nest, the colony was assessed as having failed in that year. Breeding success or failure was modelled in relation to year and site, to account for the fact that not all sites were covered in all years. The coefficient for each year was then taken to represent the probability of breeding failure occurring at any given site within that calendar year. Year was fitted as a fixed effect factor, rather than a random effect so that the coefficients would not be constrained to follow a normal distribution.

To minimise the impact of differences in sampling rate, and ensure that breeding success was likely to be representative of the colony as a whole, minimum thresholds were set for

inclusion of data within the model. Only those colonies at which a mean of 10 nests were monitored for at least five years were considered.

So that no individual site had undue influence over the value of the coefficients, a jack-knife approach was used, dropping each site from the model in turn. Models were run for each species in each sub-region in turn. The final indicator value presented for each species, in each sub-region, in each year is the mean probability of breeding failure calculated from each run of the jack-knife.

Whilst the models minimised the impact of year to year variation in the colonies which were sampled, it was important to ensure that they were an accurate representation of the observed data. Consequently, modelled probabilities of breeding failure were plotted against the observed breeding failure rates (the proportion of sampled colonies which were assessed as failing) in each year. Where the modelled probabilities were a poor match for the observed failure rates, this is likely to be indicative of either inadequate sampling of the species in the region concerned, or of a spatial bias in the colonies monitored in the year(s) concerned. To assess the likelihood of a spatial bias in the colonies monitored, modelled probability of failure was plotted against latitude. The resultant plots were examined for clusters of colonies failing to meet the target.

2.3 Assessment of Indicators Against Targets

The purpose of this indicator is to determine the impact of anthropogenic activity on the breeding success of seabirds. However, widespread breeding failures would occasionally be expected to occur at a regional scale in response to other factors, for example heavy summer rainfall. Indeed, many species of seabird are adapted to cope with breeding failure as a result of such fleeting and anomalous environmental factors (Cury *et al* 2011). To account for this background variation in breeding failure, the maximum target for achieving GES is that breeding failure occurs at no more than 15% of colonies in three out of the previous six years. However, some species may be more prone to breeding failure than others. Consequently, a threshold of 15% may not accurately reflect a “poor” breeding season for some species. Therefore to assess GES, we also considered a 5% breeding failure threshold and a threshold based on rolling 10, 15 and 20 year mean failure rates.

To indicate the severity of breeding failure, an alerts-style system was used, similar to that developed for the Wetland Bird Survey (Atkinson *et al* 2006). Where the breeding failure target was exceeded for three out of the previous six years, an “amber alert” was issued for that species in that sub-region. If the target was exceeded for four or more of the previous six years, a “red alert” was issued. In all other circumstances, the species concerned were classed as “green”. Such a system makes it possible to quickly and visually assess the frequency of breeding failures in seabird populations.

An assessment of the target was carried out for each species, in each sub-region in each year since 1991 (the earliest year for which a complete run of six years was available).

All statistical analyses were carried out in R version 2.11.0 (R Development Core Team 2012).

3. Results

3.1. Breeding Failure

For each year between 1986 and 2010, the breeding failure indicator (the proportion of colonies at which breeding success was 0.1 chicks per nest or less) was calculated for 17 species – northern fulmar, northern gannet, great cormorant, European shag, great skua, Arctic skua, common tern, Arctic tern, Sandwich tern, little tern, lesser black-backed gull, herring gull, great black-backed gull, black-legged kittiwake, common guillemot, razorbill and Atlantic puffin - in each of the sub-regions (Tables 2 & 3, Appendix 1).

High breeding failure rates were recorded in both sub regions for kittiwake, common, Arctic, Sandwich and little terns, and in the Celtic Seas sub-region for herring gull and lesser black-backed gull. For these species, breeding failure appeared to be occurring more frequently in recent years. Breeding failure was not observed in northern gannet or puffin in either sub-region, herring gull or lesser black-backed gull in the Greater North Sea sub-region or razorbill, great skua, Arctic skua or cormorant in the Celtic Seas sub-region (Appendix 1).

3.2 Maximum Thresholds for Breeding Failure

Some species are more prone to breeding failure than others and it is important to take this into account when setting maximum thresholds. The analyses presented here demonstrate that whilst some groups, like terns, experience breeding failure on a regular basis, others, for example auks, rarely fail to breed (Tables 2, 3, 4).

Using a threshold of no more than 15% of colonies experiencing breeding failure in each year means that the target is rarely missed by any species other than terns within the Greater North Sea OSPAR sub-region. To function effectively the maximum threshold for this indicator must be at or below the level of breeding failure expected in a typical year, otherwise it is not possible to detect whether breeding failure is occurring more often than would be expected by chance. This would also mean that the indicator, the proportion of colonies failing not above the maximum threshold in three out of the last six years, may miss a significant effect on species populations. With this in mind, the maximum threshold was reduced to 5%. Using a 5% threshold for these species also provides a more accurate reflection of their conservation status, with species such as lesser black-backed gull, herring gull (Table 8) and kittiwake (Tables 7 and 8) which have experienced breeding declines (Eaton *et al* 2009), now flagged up as being of concern.

By using a fixed threshold, and applying this to multiple species, it was felt that there was a danger of overlooking important ecological reasons for differences in failure rates. For example, breeding failure rates may be expected to rise or fall in response to long term changes in climate. With this in mind, three additional thresholds were considered based on 10, 15 and 20 year mean failure rates for each species. Whilst it is useful to allow for long-term ecological changes in setting the threshold, it is also desirable that the threshold remains relatively stable on a year to year basis. The rolling 10 year mean threshold appeared less stable for many species than either the 15 or 20 year mean thresholds (Appendix 1), this was particularly evident for both the Arctic tern and herring gull (Figures A23 and A35). However, the 15 and 20 year mean thresholds produced remarkably similar failure rates (Appendix 2), and in the absence of a longer time-series over which to compare the data, the 15 year mean threshold is recommended.

However, in species where breeding failure is a relatively rare occurrence, there is a danger that failure to meet the indicator target, based on an observed average could be driven by

chance events at a single colony. With this in mind, it is recommended that the minimum value for this threshold is set at 5%.

The recommended maximum threshold is that the percentage of colonies experiencing breeding failure does not exceed the mean percentage of colonies failing over the preceding 15 years, or 5%, whichever value is greater.

Table 2. Modelled probability of breeding failure within the Greater North Sea sub-region for each species between 1986 and 2010.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
1986	0.52	0.15	0.00	0.00	0.00	0.00	NA	0.00	0.00	NA	NA	NA	0.00	0.00	NA	0.00	0.00
1987	0.45	0.46	0.00	0.41	0.00	0.00	0.00	0.00	0.00	NA	NA	NA	0.00	0.00	NA	0.00	0.00
1988	0.67	0.07	0.16	0.42	0.13	0.51	0.00	0.00	0.00	NA	NA	NA	0.00	0.00	NA	0.00	0.00
1989	0.33	0.29	0.30	0.44	0.04	0.06	0.00	0.00	0.00	0.00	0.00	NA	0.00	0.00	NA	0.00	0.00
1990	0.78	0.33	0.46	0.59	0.06	0.49	0.00	0.00	0.00	0.00	0.00	NA	0.00	0.00	NA	0.00	0.00
1991	0.21	0.48	0.41	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.32	0.26	0.07	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.40	0.22	0.21	0.23	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
1994	0.28	0.20	0.21	0.38	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.32	0.71	0.21	0.46	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.54	0.40	0.40	0.47	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.61	0.63	0.27	0.69	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.57	0.57	0.11	0.53	0.18	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
1999	0.33	0.40	0.22	0.34	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.37	0.55	0.07	0.22	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.48	0.57	0.03	0.00	0.27	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.63	0.49	0.46	0.19	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
2003	0.71	0.48	0.31	0.00	0.22	0.65	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.07	0.00
2004	0.82	0.81	0.56	0.21	0.53	1.00	0.00	0.00	0.08	0.00	0.00	0.75	0.03	0.18	0.00	0.56	0.00
2005	0.58	0.81	0.42	0.45	0.04	0.34	0.00	0.00	0.08	0.00	0.00	0.75	0.00	0.18	0.00	0.07	0.00
2006	0.28	0.55	0.27	0.3	0.03	0.11	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.05	0.00
2007	0.61	0.83	0.44	0.41	0.36	0.69	0.00	0.00	0.20	0.00	0.00	0.75	0.05	0.00	0.00	0.03	0.00
2008	0.6	0.84	0.50	0.42	0.49	0.81	0.00	0.00	0.20	NA	0.00	0.75	0.07	0.19	0.00	0.03	0.00
2009	0.12	0.88	0.21	0.39	0.06	0.00	0.00	0.00	0.05	NA	0.00	0.67	0.00	0.05	0.00	0.06	0.00
2010	0.69	0.81	0.06	0.55	0.35	0.13	0.00	0.00	0.20	0.00	0.00	0.75	0.02	0.04	0.00	0.05	0.00

Table 3. Modelled probability of breeding failure within the Celtic Seas sub-region for each species between 1986 and 2010.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
1986	0.00	1.00	0.00	0.33	0.00	0.00	NA	0.00	NA	NA	NA	0.00	NA	0.00	0.00	0.00	NA
1987	0.24	0.00	0.00	0.33	0.00	NA	NA	0.00	NA	NA	NA	NA	NA	0.00	NA	0.00	NA
1988	0.00	0.00	0.07	0.33	0.23	NA	NA	NA	NA	NA	NA	NA	0.00	0.00	NA	0.00	NA
1989	0.13	0.42	0.11	0.67	0.10	0.00	0.00	0.00	NA	NA	0.18	NA	0.00	0.00	0.00	0.00	NA
1990	0.18	0.42	0.09	0.00	0.00	0.00	0.00	0.00	NA	1.00	0.00	NA	0.00	0.00	0.00	0.00	NA
1991	0.22	0.00	0.15	0.42	0.07	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.13	0.00	0.02	1.00	0.04	NA	NA	NA	NA	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00
1993	0.06	0.00	0.09	0.42	0.04	NA	NA	0.00	0.00	0.30	0.35	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.05	0.00	0.02	0.50	0.00	NA	NA	0.00	0.00	0.05	0.11	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.14	0.00	0.08	0.42	0.04	NA	NA	0.00	0.00	0.06	0.25	0.00	0.00	0.05	0.00	0.00	0.00
1996	0.15	0.00	0.05	0.00	0.03	NA	NA	0.00	0.00	0.11	0.27	0.00	0.00	0.02	0.00	0.00	0.00
1997	0.09	0.00	0.10	0.00	0.04	NA	NA	0.00	0.00	0.27	0.20	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.19	0.00	0.03	0.00	0.04	NA	NA	0.00	0.00	0.50	0.47	0.00	0.00	0.05	0.00	0.00	0.00
1999	0.02	0.00	0.02	0.00	0.00	NA	NA	0.00	0.00	0.02	0.22	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.01	0.42	0.01	0.00	0.00	NA	NA	0.00	0.00	0.00	0.04	0.00	0.00	0.02	0.00	0.00	0.00
2001	0.10	0.42	0.06	0.00	0.04	NA	NA	0.00	0.00	0.03	0.16	0.00	0.00	0.09	0.00	0.00	0.00
2002	0.18	0.00	0.07	0.42	0.04	NA	NA	0.00	0.00	0.08	0.10	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.04	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.18	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.07	0.00	0.02	0.00	0.18	0.00	0.00	0.00	0.00	0.18	0.07	0.00	0.00	0.13	0.00	0.00	0.00
2005	0.12	0.11	0.03	0.00	0.04	0.00	0.00	0.00	0.00	0.11	0.13	0.00	0.00	0.12	0.00	0.00	0.00
2006	0.11	0.19	0.03	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.33	0.45	0.08	0.00	0.00
2007	0.27	0.00	0.04	0.42	0.58	0.00	0.00	0.00	0.00	0.02	0.09	0.00	0.33	0.02	0.08	0.00	0.00
2008	0.05	0.00	0.04	0.42	0.54	0.00	0.00	0.00	0.00	0.41	0.11	0.00	0.33	0.00	0.08	0.00	0.00
2009	0.09	0.00	0.09	0.42	0.12	0.00	0.00	0.00	0.00	0.16	0.15	0.00	0.00	0.00	0.08	0.00	0.00
2010	0.00	1.00	0.00	0.33	0.00	0.00	NA	0.00	0.00	0.04	0.18	0.00	0.00	0.00	0.08	0.00	0.00

Table 4. Mean annual breeding failure rates in Greater North Sea (GNS) and Celtic Seas (CS) OSPAR sub-regions, based on modelled values to remove effect of year to year variation in the sites which were monitored. Species listed in order of their sensitivity to anthropogenic activities affecting food supplies.

	GNS	CS	Mean
Arctic Tern	0.49	0.11	0.30
Little Tern	0.51	0.16	0.34
Common Tern	0.25	0.05	0.15
Sandwich Tern	0.36	0.26	0.31
Kittiwake	0.11	0.09	0.10
Arctic Skua	0.22	0.00	0.11
Great Skua	0.00	0.00	0.00
Atlantic Puffin	0.00	0.00	0.00
Razorbill	0.03	0.00	0.02
Lesser Black-backed Gull	0.00	0.16	0.08
Herring Gull	0.00	0.16	0.08
Great Black-backed Gull	0.30	0.00	0.15
Common Guillemot	0.01	0.04	0.02
Shag	0.03	0.04	0.03
Great Cormorant	0.00	0.02	0.01
Fulmar	0.04	0.00	0.02
Northern Gannet	0.00	0.00	0.00

3.3 Trial Assessment of Indicator Target and Alerts

The target for this indicator was that breeding failure should occur in no more 15% of colonies for terns, and no more than 5% of colonies for other species, in more than three out of the preceding six years. With this in mind, an “alerts-style” approach was used, with a “red alert” issued where the target is exceeded in four or more of the preceding six years and an “amber alert” issued where the target was exceeded in three of the preceding six years, to highlight a species at risk of missing the target. The status of species which fail in fewer than three years in six is set to “green”.

Using the targets described above, in the Greater North Sea sub-region in 2010 a red alert was issued for seven species – Arctic tern, little tern, common tern, Sandwich tern, razorbill, great black-backed gull and fulmar (Table 5) – whilst all other species were assessed as having met their targets, an amber alert was issued for kittiwake, Arctic skua and shag (Table 5).

In the Celtic Seas sub-region in 2010 a red alert was issued for four species – Sandwich tern (Table 6), kittiwake, great black-backed gull and cormorant (Table 5) – whilst all other species were assessed as having met their targets – an amber alert was issued for common guillemot.

Historically, seabird breeding failure has occurred more commonly in the Greater North Sea sub-region than in the Celtic Seas sub-region. Prior to 2010, the indicator target was not met in the Celtic Seas sub-region for kittiwake in 2008 and 2009, great black-backed gull between 2006 and 2009, shag in 2006 and cormorant in 2007 (Table 5). In the Greater North Sea sub-region, the indicator target was not met for Arctic skua between 2005 and 2009, kittiwake in 2008, shag in 2009, fulmar between 2006 and 2009, common tern between 2004 and 2009, Sandwich tern between 2004 and 2009, and little tern or Arctic tern between 2001 and 2010.

It is also noticeable, that the number of species for which the indicator target is not being met has increased in recent years (Figure 1). In the Celtic Seas the number of species failing to meet the target increased from one in 2001 to five in 2010. Over this period, lesser black-backed gull, in 2009, and shag, in 2006, also missed the indicator target (Table 5). In the Greater North Sea sub-region, the number of species failing to meet their target increased from two in 2001 to seven in 2010.

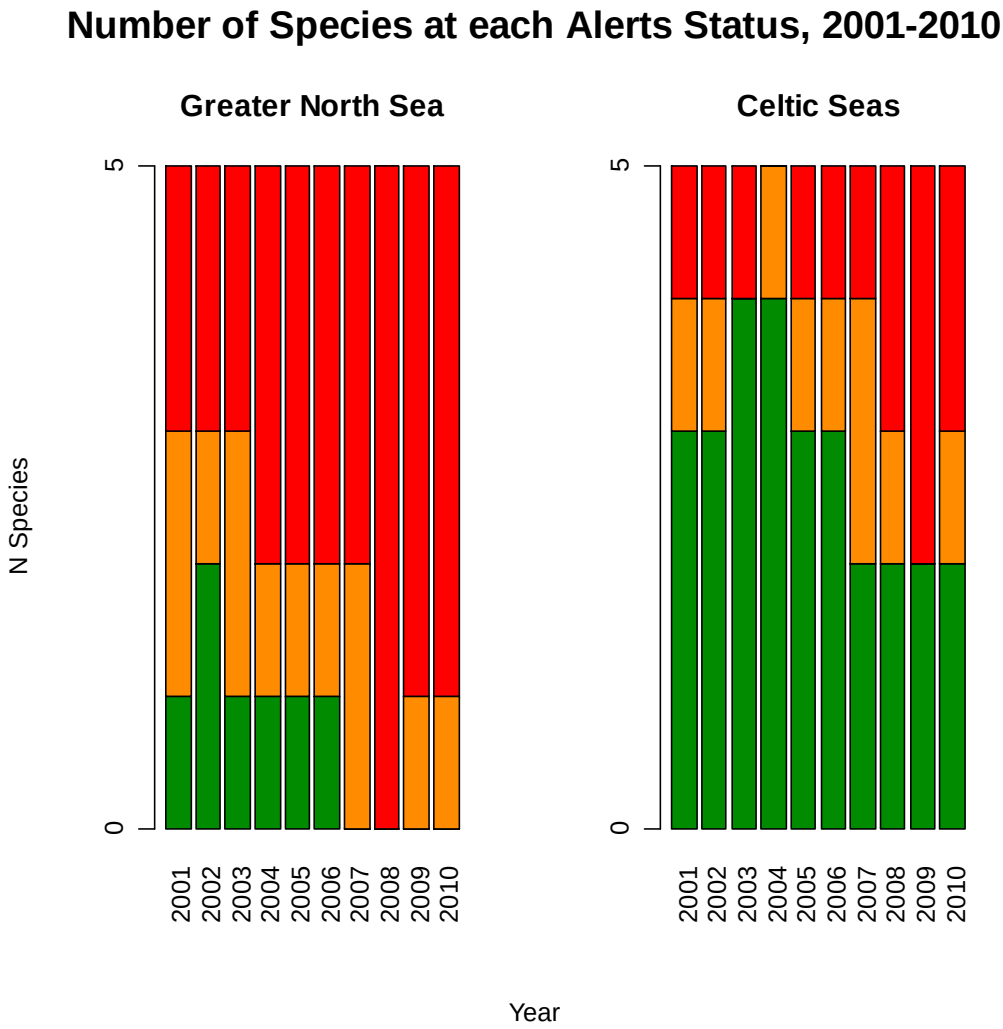

Figure 1. Number of species achieving red, amber and green alerts status in each year between 2001 and 2010 in the Greater North Sea and Celtic Seas sub-regions.

Table 5. Assessment of breeding failure indicator against the target the percentage of colonies failing in more than three out of the previous six years for the Celtic Seas sub-region does not exceed the mean percentage failing over the preceding 15 years or 5%, whichever is higher. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators in each region highlighted in red boxes.

	Arctic Tern[1]	Little Tern[1]	Common Tern[1]	Sandwich Tern[1]	Kittiwake[1]	Arctic Skua[1]	Great Skua[2]	Atlantic Puffin[2]	Razorbill[2]	Lesser Black-backed Gull[1]	Herring Gull[1]	Great Black-backed Gull[1]	Common Guillemot[2]	Shag[2]	Great Cormorant[2]	Fulmar[2]	Northern Gannet[2]
GREATER NORTH SEA																	
2001	RED	RED	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2002	RED	RED	AMBER	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2003	RED	RED	AMBER	GREEN	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2004	RED	RED	RED	GREEN	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2005	RED	RED	RED	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	AMBER	GREEN
2006	RED	RED	RED	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN
2007	RED	RED	RED	AMBER	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN
2008	RED	RED	RED	RED	RED	RED	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	AMBER	GREEN	RED	GREEN
2009	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	RED	GREEN	GREEN	AMBER	GREEN	RED	GREEN	RED	GREEN
2010	RED	RED	RED	RED	AMBER	AMBER	GREEN	GREEN	RED	GREEN	GREEN	RED	GREEN	AMBER	GREEN	RED	GREEN
CELTIC SEAS																	
2001	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2002	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2003	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2004	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2005	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	AMBER	RED	AMBER	GREEN	AMBER	GREEN	GREEN	GREEN
2006	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	AMBER	RED	RED	GREEN	RED	GREEN	GREEN	GREEN
2007	GREEN	GREEN	GREEN	GREEN	AMBER	NA	NA	GREEN	GREEN	AMBER	RED	RED	GREEN	AMBER	GREEN	GREEN	GREEN
2008	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	AMBER	RED	RED	AMBER	AMBER	AMBER	GREEN	GREEN
2009	GREEN	GREEN	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	RED	RED	RED	AMBER	AMBER	RED	GREEN	GREEN
2010	GREEN	GREEN	GREEN	RED	RED	NA	NA	GREEN	GREEN	AMBER	RED	RED	AMBER	GREEN	RED	GREEN	GREEN

[1] target is the percentage of colonies failing in more than three out of the previous six years does not exceed the mean percentage failing over the preceding 15 years [2] target is no more than 5% of colonies failing in more than three out of the previous six years.

3.4 Identifying Indicator Species

Table 5. Suitability of seabird species as indicators for each North East Atlantic Marine Region sub-region. Species were unsuitable due to insufficient data or poor model fit. Species listed in order of their sensitivity to anthropogenic activities affecting food supplies.

Species	Indicator suitability	
	Greater North Sea	Celtic Seas
Arctic Tern	Yes	*Yes*[3]
Little Tern	Yes	No[1]
Common Tern	Yes	*Yes*[3]
Sandwich Tern	Yes	No[1]
Kittiwake	Yes	Yes
Arctic Skua	Yes	No[1]
Great Skua	No[2]	No[1]
Atlantic Puffin	No[1]	No[1]
Razorbill	No[1]	No[1]
Lesser Black-backed Gull	No[1]	Yes
Herring Gull	No[1]	Yes
Great Black-backed Gull	No[1]	Yes
Common Guillemot	Yes	No[1]
Shag	Yes	Yes
Great Cormorant	No[1]	Yes
Fulmar	Yes	Yes
Northern Gannet	Yes	No[1]

[1] Insufficient data available to make assessment
[2] Poor model fit
[3] Whilst model fit for Common and Arctic Terns within the Celtic Seas OSPAR region was poor, it is likely that this could be improved with more consistent monitoring effort.

Of the 17 species considered as indicators 10 were identified as suitable indicators in the Greater North Sea OSPAR sub-region and eight were identified as suitable indicators in the Celtic Seas OSPAR sub-region (Table 9).

In the Greater North Sea OPSAR sub-region, of the 10 species identified as suitable indicators, four – fulmar, northern gannet, shag and common guillemot – were assessed as having low sensitivity to fisheries by Furness and Tasker (2000, Table 1). Arctic skua is restricted to the north of the sub-region, around Orkney and Shetland. Given that the aim of these indicators is to assess GES within the sub-regions as a whole, it would therefore be inappropriate to include Arctic skua. **Therefore, the proposed indicator species for the Greater North Sea OSPAR region are kittiwake, little tern, Sandwich tern, common tern and Arctic tern.**

In the Celtic Seas OSPAR region, of the eight species identified as suitable indicators, four – fulmar, great cormorant, shag and great black-backed gull – were assessed as having low sensitivity to fisheries by Furness and Tasker (2000, Table 1). Only kittiwake, Arctic and common terns were assessed as having a high sensitivity to fisheries. Whilst model fit for common and Arctic terns in the Celtic Seas sub-region was poor, the large number of colonies being monitored to some extent suggests that with a more consistent effort, this species would be suitable indicator. Lesser black-backed gulls and herring gulls were both assessed as being moderately sensitive to fisheries. Given established links between chick growth and fish availability within the diet (Annett & Pierotti 1989, 1999) these species may also be suitable indicators. **Therefore, the proposed indicator species for the Celtic Seas**

OSPAR sub-region are kittiwake, common and Arctic terns (subject to improved monitoring), lesser black-backed gull and herring gull.

3.5 Setting Targets for GES

The most recent indicators for the Greater North Sea OSPAR sub-region show all five species, other than kittiwake, as having “red” status. Given historical patterns in the data, it would be unrealistic to expect all five to meet the target. However, GES could reasonably be said to have been achieved following fewer of these species being subject to a “red” alert. This should include kittiwake achieving “green” status and at least two of the tern species achieving “amber status”.

In the Celtic Seas OSPAR sub-region, kittiwake and herring gull have “red” status, lesser black-backed gull has “amber” status and common and Arctic terns have “green” status. It is likely that following improved monitoring effort the status of common and Arctic terns will change. As with the Greater North Sea sub-region, it would be unrealistic to expect all five species to meet their target in any given year and GES could be said to have been achieved following an improvement in the status of these species. This should include kittiwake and one of herring gull or lesser black-backed gull achieving “green” status.

4. Discussion

4.1 Current Status of Indicator Species

There is strong variation in the tendency of seabird colonies to fail, both within and between species. Some species, for example terns, appear to experience breeding failure at a colony level relatively frequently, whilst for others, such as auks and gulls, breeding failure is a rarer event.

Breeding failed at colonies within the Greater North Sea sub-region more frequently than within the Celtic Seas sub-region. This difference may partially arise from the fact that monitoring effort for most species is highest in the Greater North Sea sub-region. This is reflected in a comparison of the model fit for species in each region. Overall, models for the Greater North Sea sub-region were a better fit for the data than models for the Celtic Seas sub-region. For six species within the Celtic Seas sub-region - fulmar, great cormorant, shag, common tern, Arctic tern and great black-backed gull – the modelled probability of breeding failure was consistently lower than the observed rate of breeding failure. This is likely to reflect patchiness in the data and a need for increased, and more consistent, monitoring effort within the Celtic Seas sub-region if this indicator is to be of value.

Seabird breeding success can vary spatially, often at a finer scale than the sub-regions (Cook *et al* 2010, 2011b). It is possible that the high level of breeding failure recorded in tern species results from this spatial variation and that it is driven by variation in local conditions rather than by pressures acting at regional scale. Indeed a recent study of kittiwakes breeding on small islands 100km apart found different levels of breeding success between the populations, despite both being subject to similar nutritional stresses (Kitaysky *et al* 2010). As the purpose of the indicator is to determine whether pressures acting at a regional level are driving seabird breeding failure, it is important to ensure that failure to meet the targets is not driven by factors acting at a local level. However, there was no spatial bias evident in the distribution of failing colonies (Appendix 1).

There appeared to be phylogenetic differences in the levels of breeding failure recorded. Whilst for some groups, like auks, breeding failure was a fairly rare occurrence, it was far more common amongst other species groups, notably terns (Appendix 1). This may indicate sensitivity to the choice of colonies for the indicator. Terns often desert colonies in response to local disturbances or impacts on food supply (Shealer & Kress 1991; Holt 1994; Cook *et al* 2011a). The current thresholds may mean that small, poorly established colonies, which are not representative of what is happening at a regional level, are included in the analysis. This is particularly obvious with the Common tern in the Celtic Seas OSPAR sub-region, where some of the larger colonies are monitored relatively infrequently.

4.2 How Can We Achieve GES?

At present in the Greater North Sea sub-region, four out of the five indicator species have not met their targets, whilst in the Celtic Seas sub-region, two out of the five have not met their targets. There is also a strong possibility that Arctic and common terns may not meet their targets in the Celtic Seas sub-region once an improved monitoring regime has been put in place. In order to achieve GES, it will be necessary to substantially reduce the risk of breeding failure for these species in both sub-regions.

Breeding failure is likely to be driven by a variety of different factors, and the relative contribution of each of these to the probability of breeding failure occurring is poorly understood. Availability and access to food supplies is likely to play a key role, and this may be exacerbated by fisheries. Predation, both by mammalian predators (Clode & MacDonald

2002; Stapp 2002; Lock 2006) such as rats, mice and mink, and by other seabirds, such as gulls and skuas (Oro & Martinez-Vilalta 1994; Stenhouse & Montevecchi 1999; Bearhop *et al* 2001; Votier *et al* 2004) may also make a significant to breeding failure in these species. Likewise, disturbance by humans, acting as "predation-free predators" (Beale & Monahan 2004) may also have an impact. Finally, weather conditions may also impact on the probability of breeding failure, for example, by limiting the availability of suitable nesting habitat (Thompson & Furness 1991) and access to food (Finney *et al* 1999).

In order to achieve GES, it is important to understand the contribution made by each of these factors to the probability of breeding failure. This will allow us to partition effects, for example fisheries and mammalian predation, that we can have some control over, from those, such as climate, which we have little control over. The complementary kittiwake breeding success indicator (Dadam *et al* 2012) is an important step in this direction.

Existing statistical methodologies would allow us to investigate the relative contribution of fisheries, predation and climate to the probability of breeding failure (Freeman & Newson 2008). By doing this, we would be able to use models to inform conservation efforts in order to achieve GES. It may be possible to identify a suite of different options that could result in GES being attained, and the cost-effectiveness of each of these options could be evaluated.

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Appendix 1

Breeding Failure Indicators Species Accounts

In order to account for year to year variability in sampling intensity, the indicator for each species is based on a modelled probability of breeding failure in any given year.

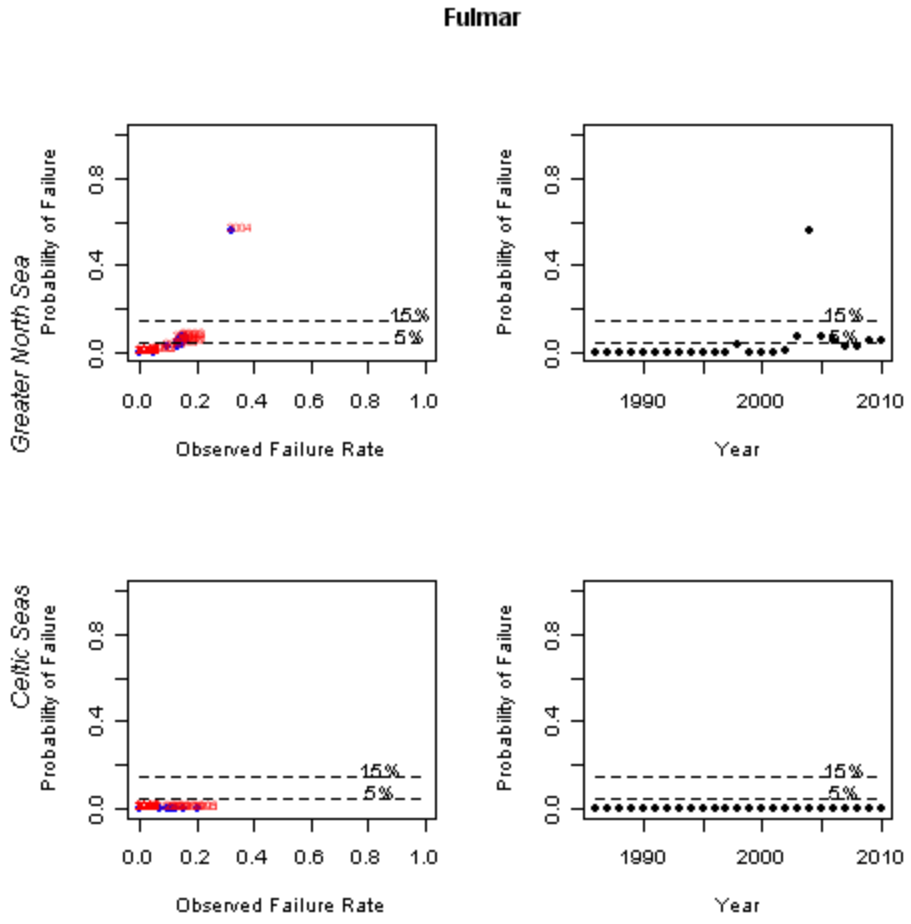

Figure A1 Breeding failure indicators for fulmar in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The probability of breeding failure did not exceed the maximum allowable failure (15%) rate during any year within the Celtic Seas sub-region (Figure A1). Within the Greater North sub-region the maximum allowable failure rate was exceeded in 2004 only, when the probability of breeding failure was 56% (Figure A1). Were the maximum allowable failure rate to be lowered to 5%, in the Greater North Sea sub-region, this value would be exceeded in an additional five years – 2003, 2005, 2006, 2009 and 2010 – when between 6% and 8% of colonies failed (Figure A1). Modelled failure rates appeared a reasonable match for observed failure rates in both regions, with a correlation of 0.79 in the Greater North Sea sub-region and a correlation of 0.69 in the Celtic Seas sub-region.

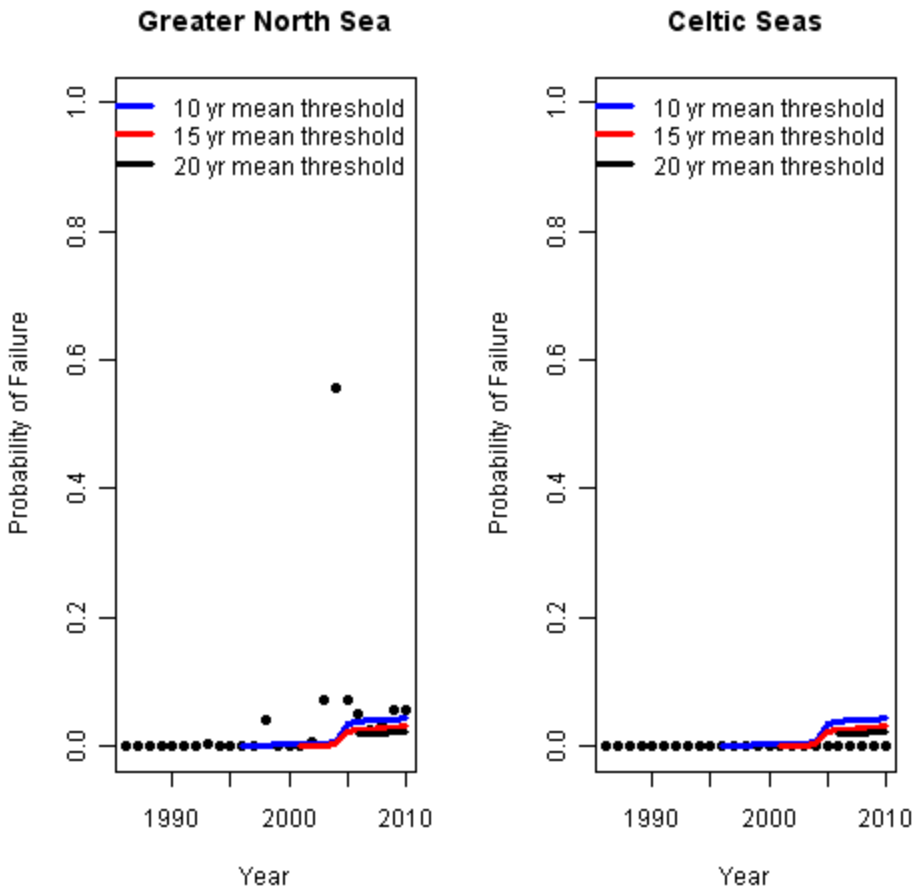

Figure A2 Breeding failure indicators for fulmar in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The rolling 10, 15 and 20 year mean failure rates showed a similar pattern, initially close to 0, before increasing slightly in 2005 and reaching 5% for the 10 year rolling mean, 4% for the 15 year rolling mean and 3% for the 20 year rolling mean. In the Celtic Seas sub-region breeding failure rates did not exceed the 10, 15 or 20 year mean failure rates in any year. In the Greater North Sea sub-region, the 10 year mean failure rate was exceeded in eight years – 1998, 2002, 2003, 2004, 2005, 2006, 2009 and 2010. In addition to these years, the 15 and 20 year mean failure rates were exceeded in 2007 and 2008 (Figure A2).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A3) and in 2010 there were no obvious clusters of failing colonies (Figure A3).

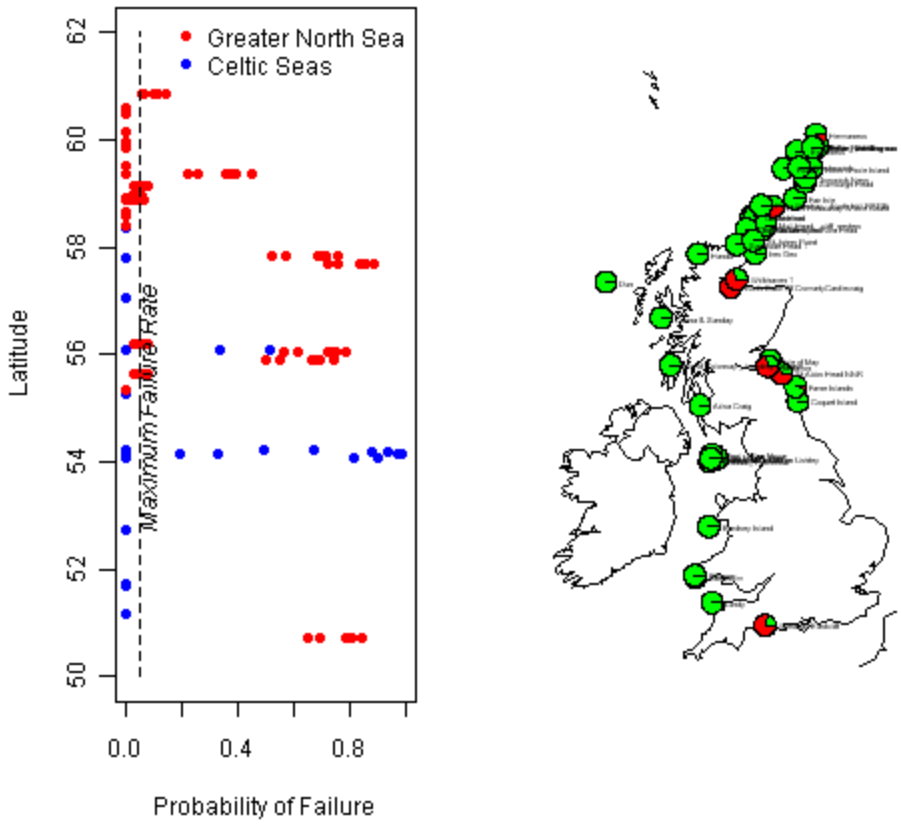

Figure A3 (left) Plot of modelled probability of breeding failure against latitude for fulmar between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

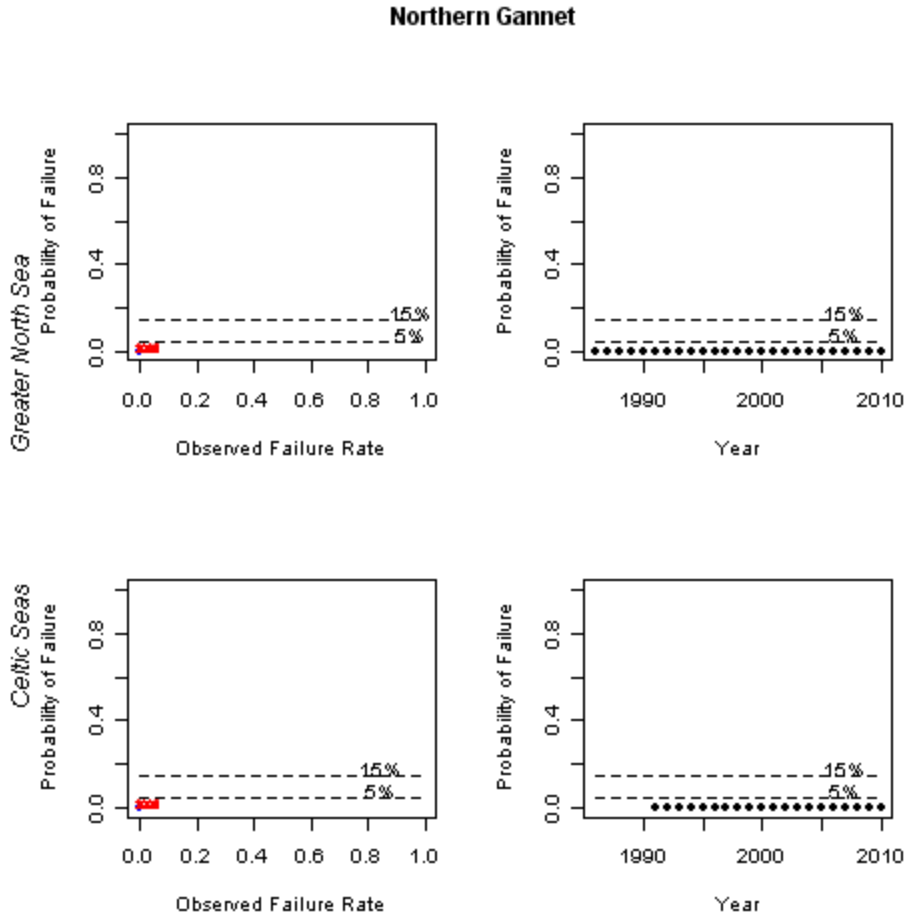

Figure A4 Breeding failure indicators for northern gannet in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

Breeding failure was not recorded at any northern gannet colony in either the Celtic Seas or the Greater North Sea sub-region between 1986 and 2010 (Figure A4). As data were available for only two colonies within the Celtic Seas sub-region, northern gannet should not be viewed as an appropriate indicator species for this sub-region.

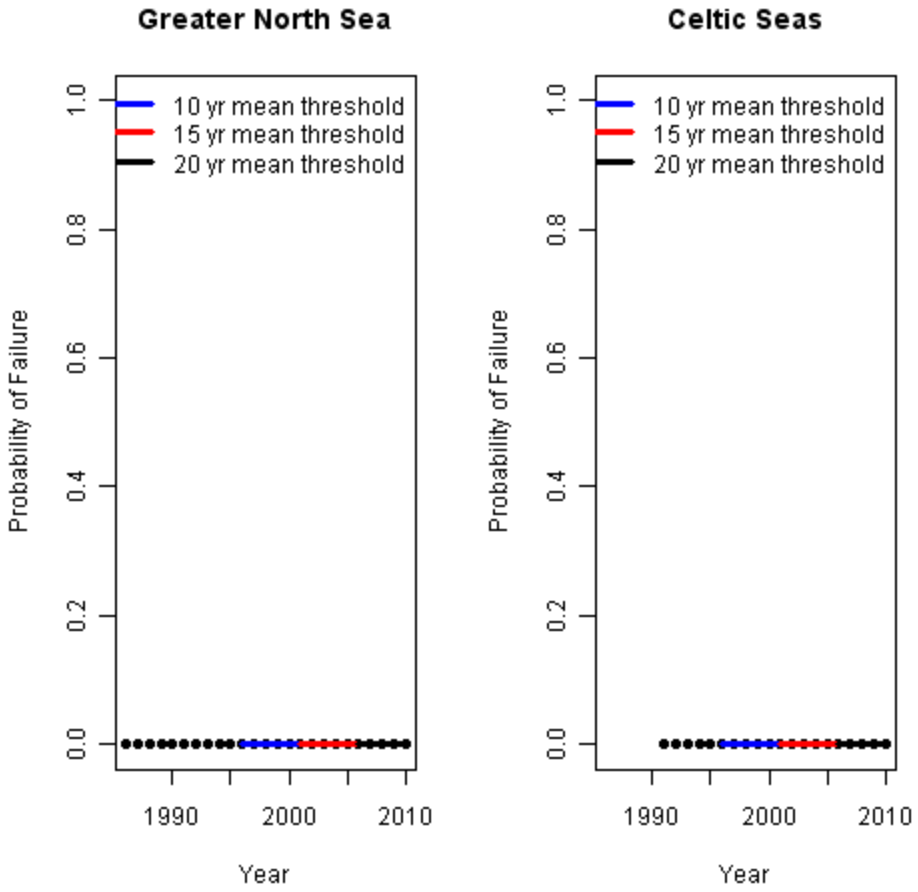

Figure A5 Breeding failure indicators for northern gannet in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year rolling mean failure rates remained at 0 for all years. They were not exceeded in either sub-region in either year (Figure A5).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A6) and in 2010 there were no obvious clusters of failing colonies (Figure A6).

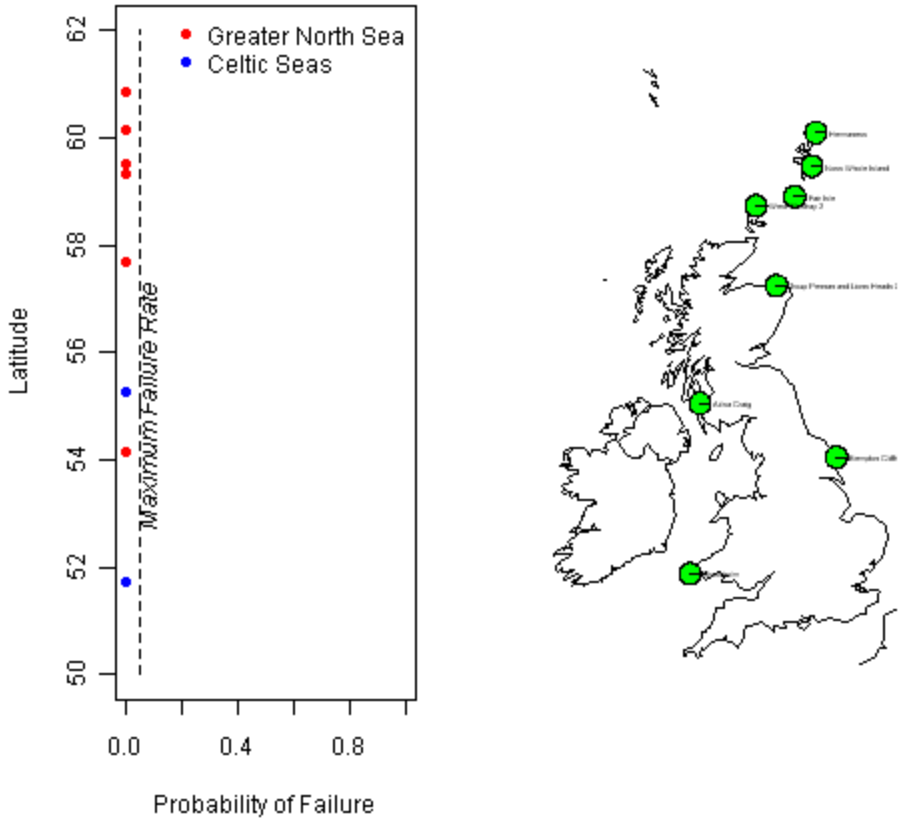

Figure A6 (left) Plot of modelled probability of breeding failure against latitude for northern gannet between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

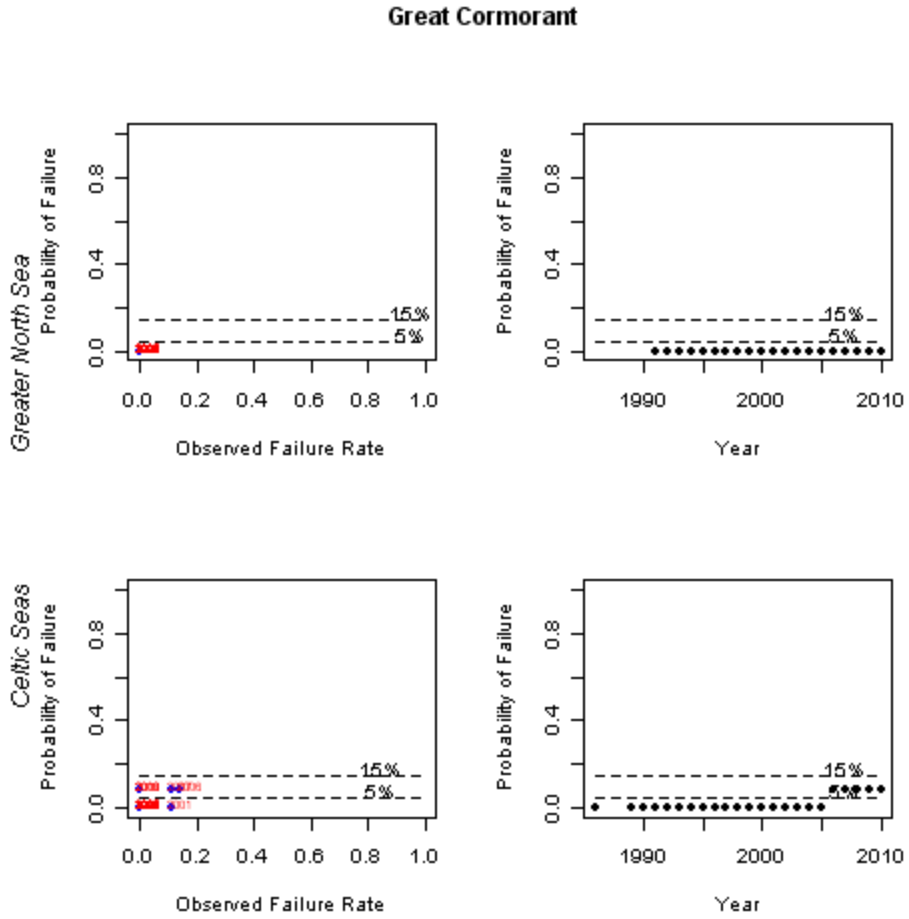

Figure A7 Breeding failure indicators for great cormorant in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The probability of breeding failure for great cormorant did not exceed the maximum allowable failure rate in either the Celtic Seas or the Greater North Sea sub-region between 1986 and 2010 (Figure A7). Breeding failure was not recorded at any great cormorant colony in the Greater North Sea region over this time period. In the Celtic Seas sub-region the modelled probability of breeding failure was 8% between 2006 and 2010, below the maximum allowable threshold of 15%, but above the lower threshold of 5% (Figure A7).

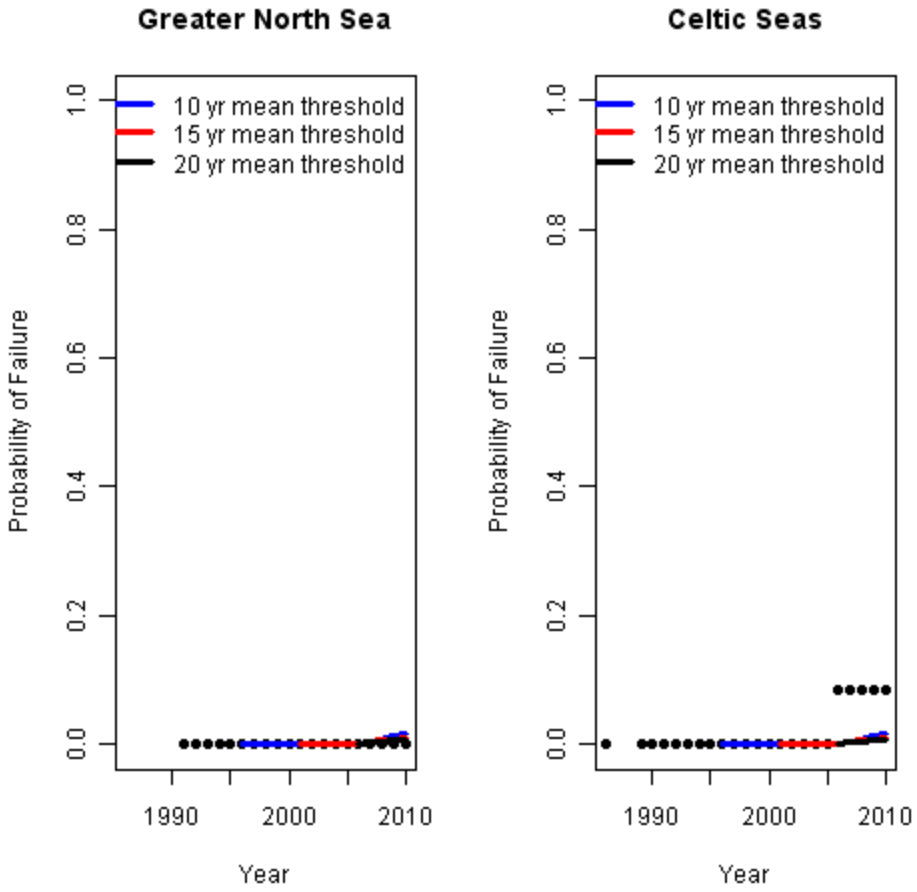

Figure A8 Breeding failure indicators for great cormorant in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year rolling mean failure rates remaind close to 0 for most of the study period. All three showed slight rises towards the end of this period and by 2010, the 10 year rolling mean failure rate had reached 2% , and the 15 and 20 year rolling means had reached 1%. In the Greater North Sea sub-region, none of the rolling mean failure rates were exceeded in any year. In the Celtic Seas sub-region, all three rolling mean failure rates were exceeded in 2006, 2007, 2008, 2009 and 2010 (Figure A8).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A9) and in 2010 there were no obvious clusters of failing colonies (Figure A9).

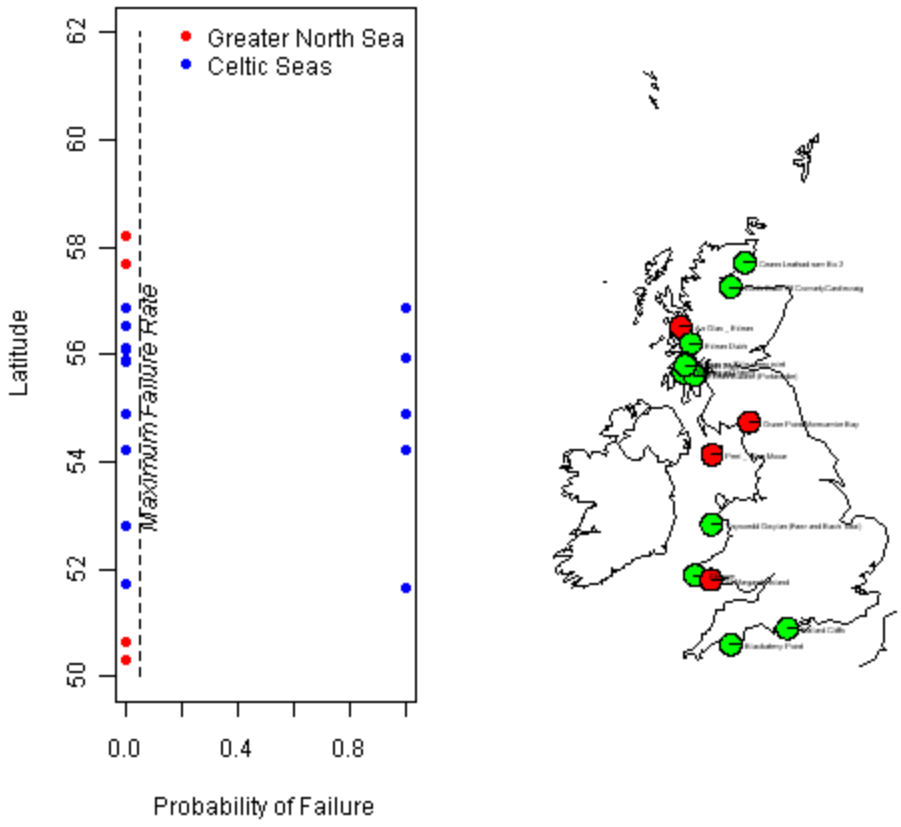

Figure A9 (left) Plot of modelled probability of breeding failure against latitude for great cormorant between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

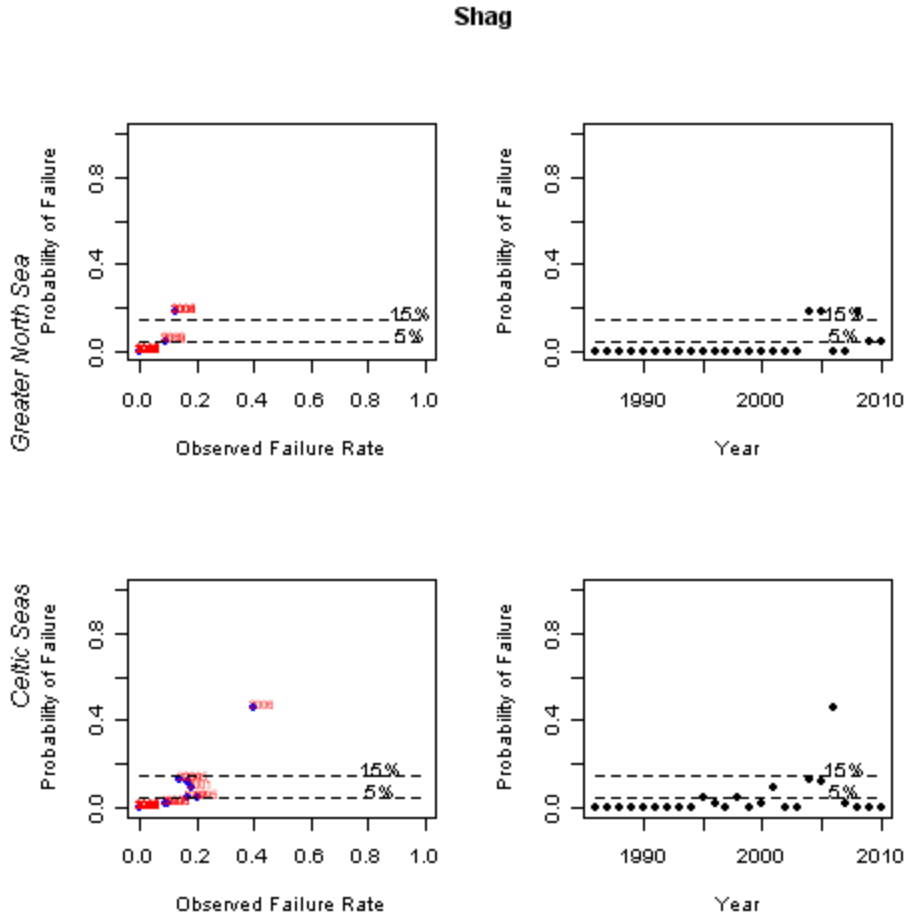

Figure A10 Breeding failure indicators for shag in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The modelled probability of failure rate exceeded the maximum allowable failure rate in 2004, 2005 and 2008 in the Greater North Sea sub-region, with probabilities of breeding failure between 18 and 19% and 2006 in the Celtic Seas sub-region, when the probability of breeding failure was 46% (Figure A10). Assuming a lower 5% threshold, the maximum allowable failure rate would also have been exceeded in 2009 in the Greater North Sea sub-region and 2001, 2004 and 2005 in the Celtic Seas sub-region (Figure A10). Modelled failure rates appeared a reasonable match for observed failure rates in both regions, with a correlation of 0.94 in the Greater North Sea sub-region and a correlation of 0.87 in the Celtic Seas sub-region.

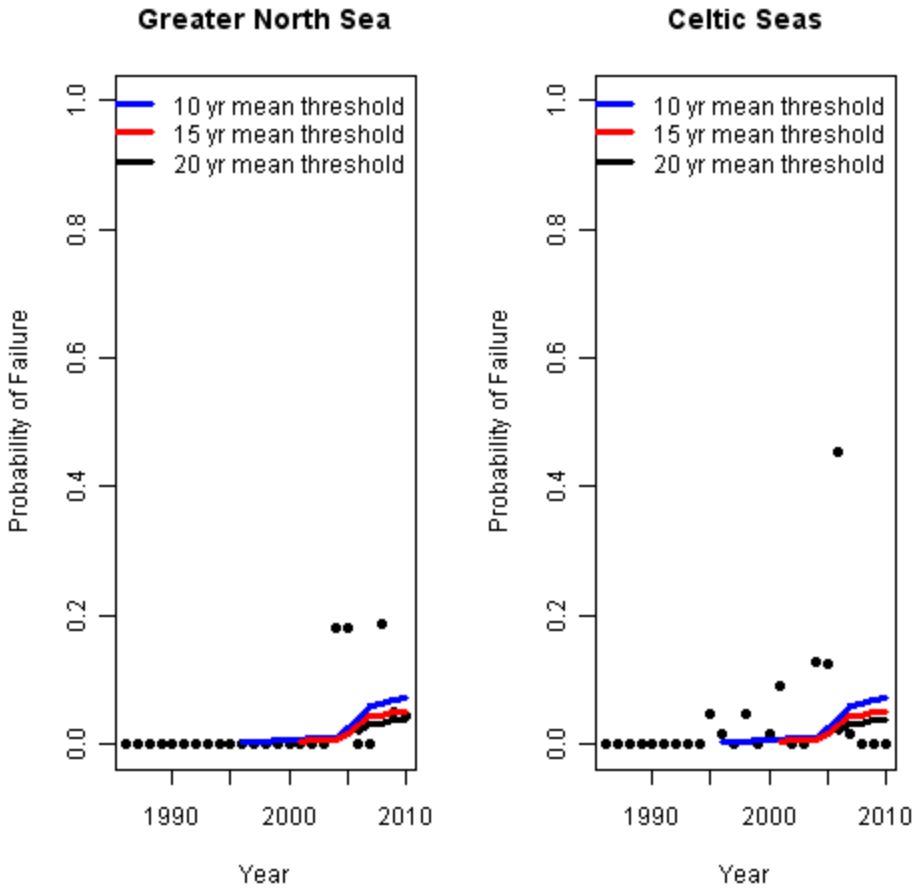

Figure A11 Breeding failure indicators for shag in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year rolling mean failure rates remaind close to 0 until 2005. After 2005, All three showed rises and by 2010, the 10 year rolling mean failure rate had reached 7% , the 15 year rolling mean failure rate had reached 5% and the 20 year rolling mean had reached 4%. In the Greater North Sea sub-region, the 10 year rolling mean failure rate was exceeded in 2004, 2005 and 2008. The 15 and 20 year rolling mean failure rates were also exceeded in 2009. In the Celtic Seas sub-region, all three rolling mean failure rates were exceeded in 1995, 1996, 1998, 2000, 2001, 2004 and 2005 (Figure A11).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A12) and in 2010 there were no obvious clusters of failing colonies (Figure A12).

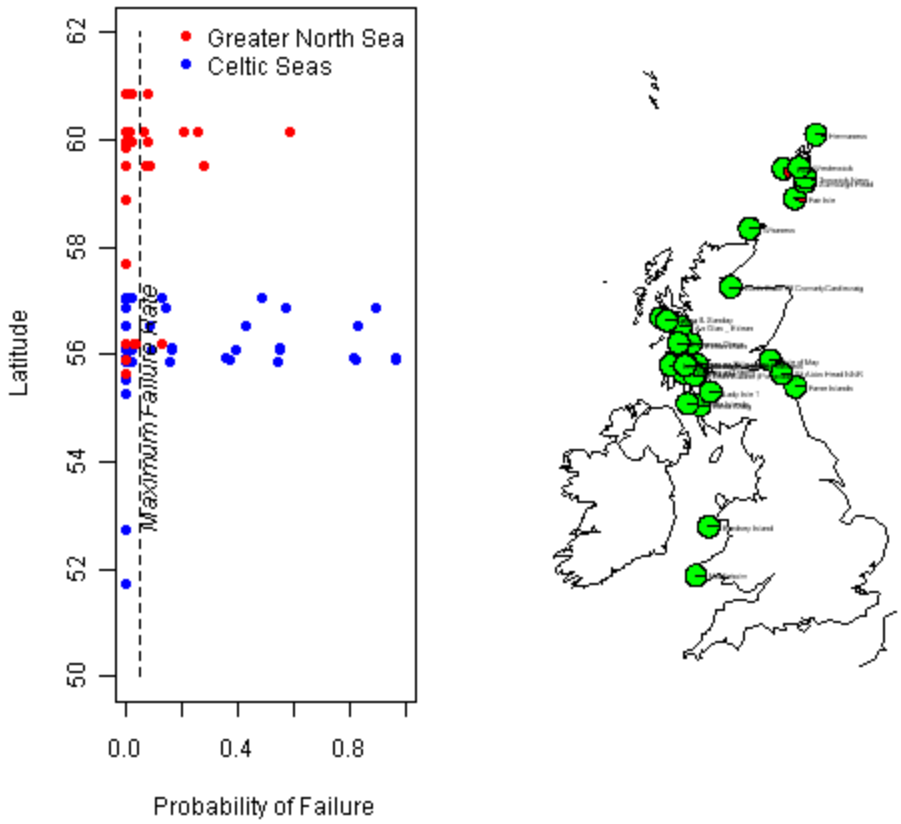

Figure A12 (left) Plot of modelled probability of breeding failure against latitude for shag between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

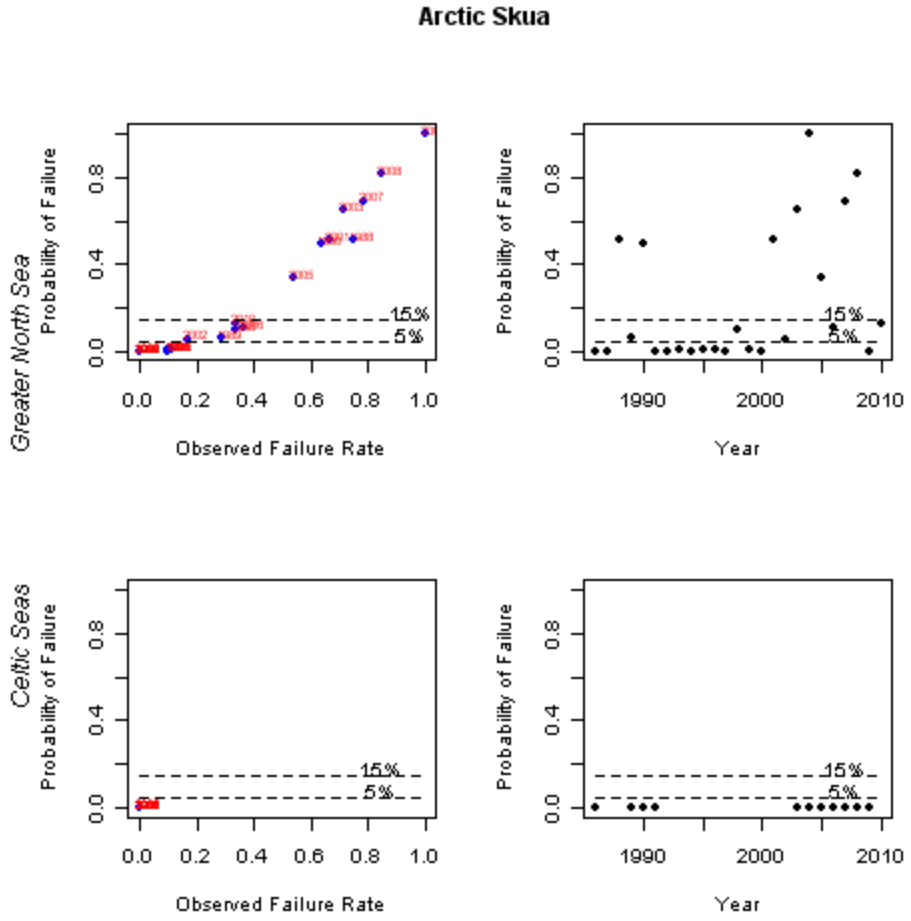

Figure A13 Breeding failure indicators for Arctic skua in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The modelled probability of failure rates exceeded the maximum allowable failure rate for Arctic Skua in the Greater North Sea sub-region in 1988, 1990, 2001, 2003, 2004, 2005, 2007 and 2008. The failure rate was particularly high in 2004 when all monitored colonies failed and 2008 when 82% of colonies failed (Figure A13). Assuming a lower 5% threshold, the failure rate would also have exceeded the maximum allowable rate in 1989, 1998, 2002, 2006 and 2010 (Figure A13). There were insufficient data to properly assess breeding failure within the Celtic Seas sub-region. Modelled failure rates appeared a reasonable match for observed failure rates with a correlation of 0.96 in the Greater North Sea sub-region.

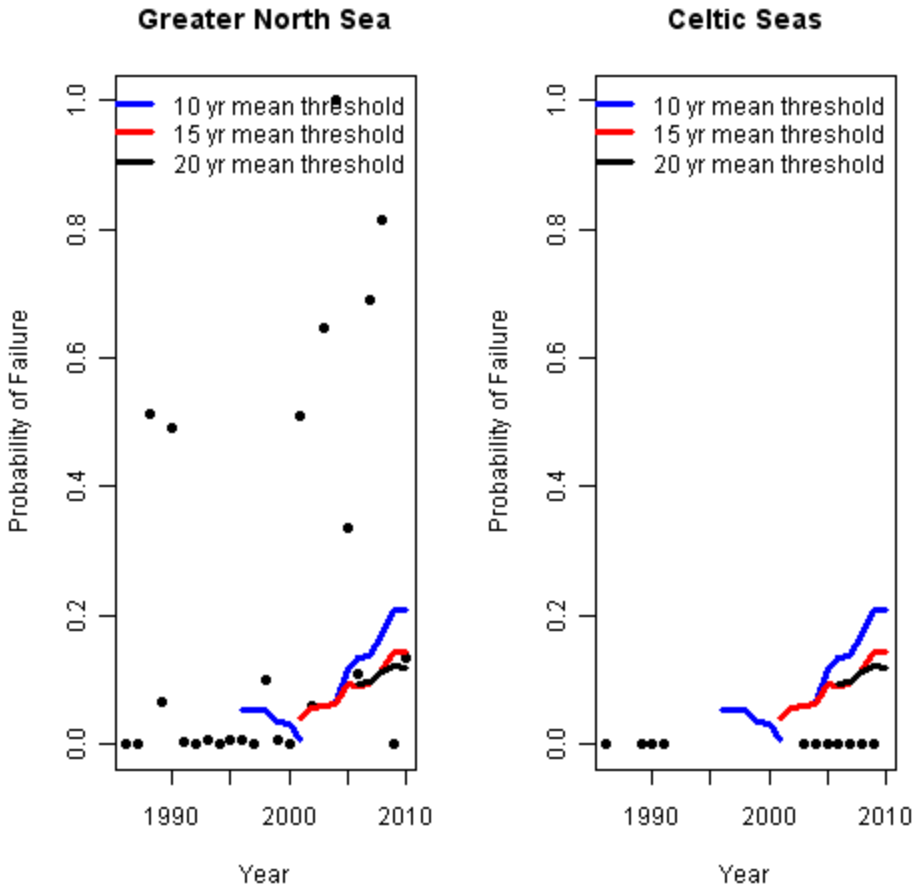

Figure A14 Breeding failure indicators for Arctic skua in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, and 15 year rolling mean failure rates increased between 2001 and 2010, with the 10 year mean failure rate reaching21 % and the 15 year mean failure rate reaching 14%. The 20 year rolling mean failure rate was more stabel over the five years for which it has bee calculated, showing a more modest rise, from 10% to 12%. In the Greater North Sea sub-region, the 10 year rolling mean failure rate was exceeded in 1998, 2001, 2002, 2003, 2004, 2005, 2007 and 2008. The 15 year rolling mean failure rate was also exceeded in 2006, and the 20 year mean rolling failure rate was also exceeded in 2010. In the Celtic Seas sub-region, none of the rolling mean failure rates were exceeded (Figure A14).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A15) and in 2010 there were no obvious clusters of failing colonies (Figure A15).

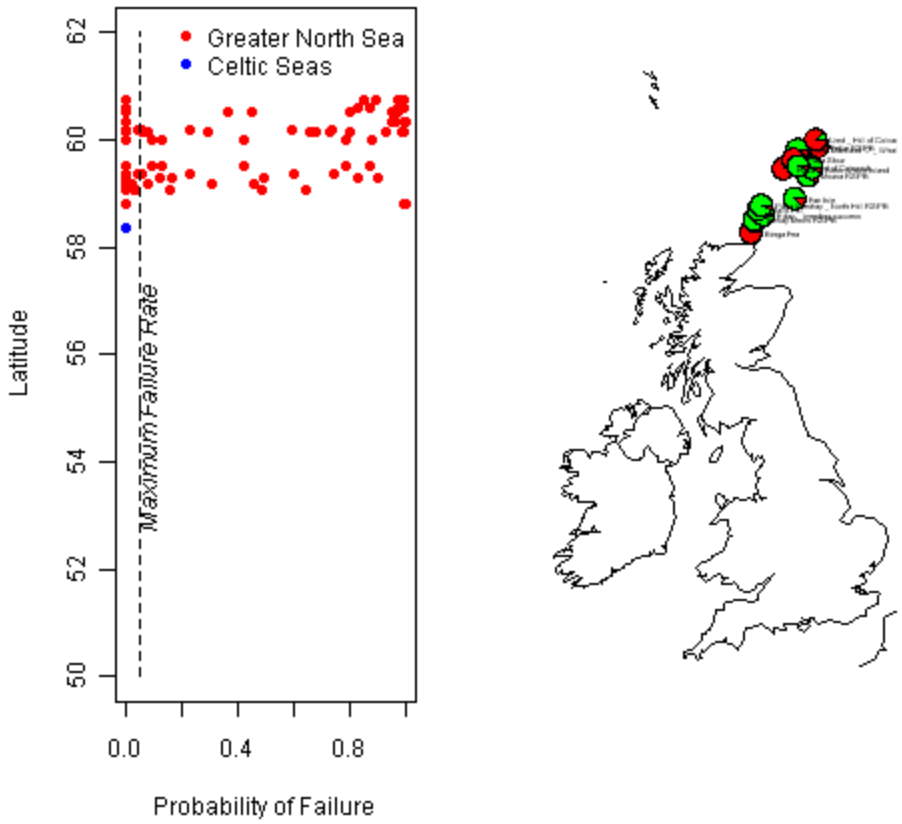

Figure A15 (left) Plot of modelled probability of breeding failure against latitude for Arctic skua between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

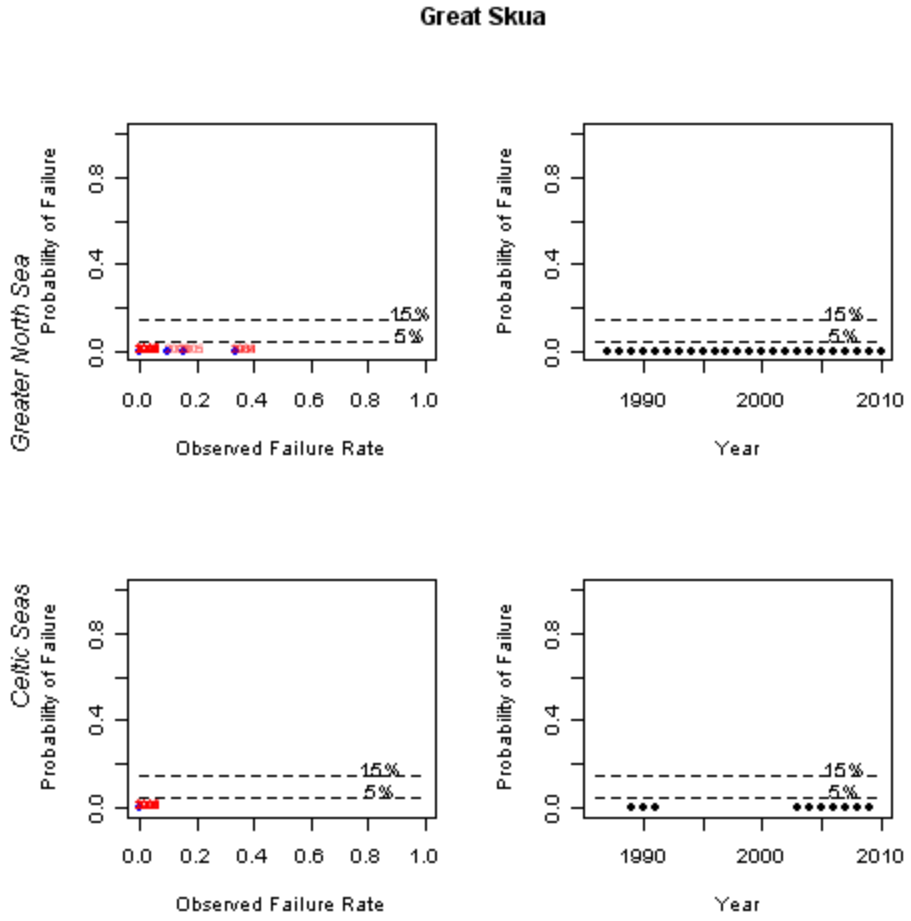

Figure A16 Breeding failure indicators for great skua in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The probability of breeding failure did not exceed the maximum allowable level in either sub-region between 2006 and 2010 (Figure A16). However, there were insufficient data to assess breeding failure within the Celtic Seas sub-region and the model for the Greater North Sea sub-region was a poor fit for the data.

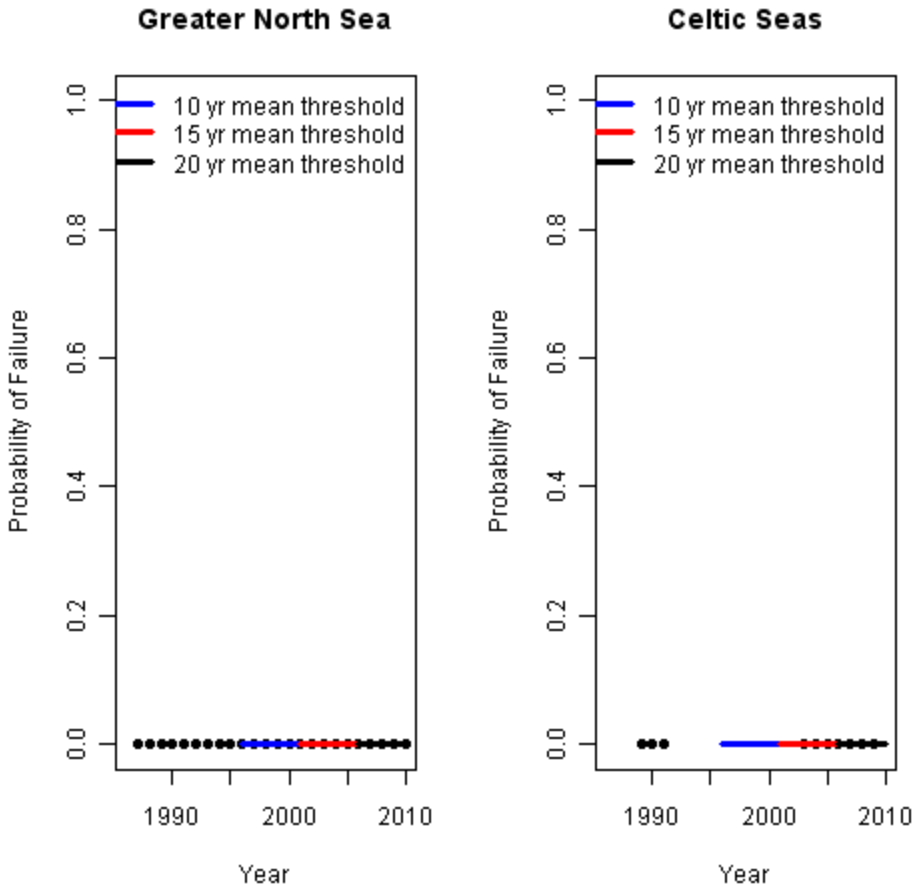

Figure A17 Breeding failure indicators for great skua in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year rolling mean failure rates remained at 0 for all years. They were not exceeded in either sub-region in either year (Figure A17).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A18) and in 2010 there were no obvious clusters of failing colonies (Figure A18).

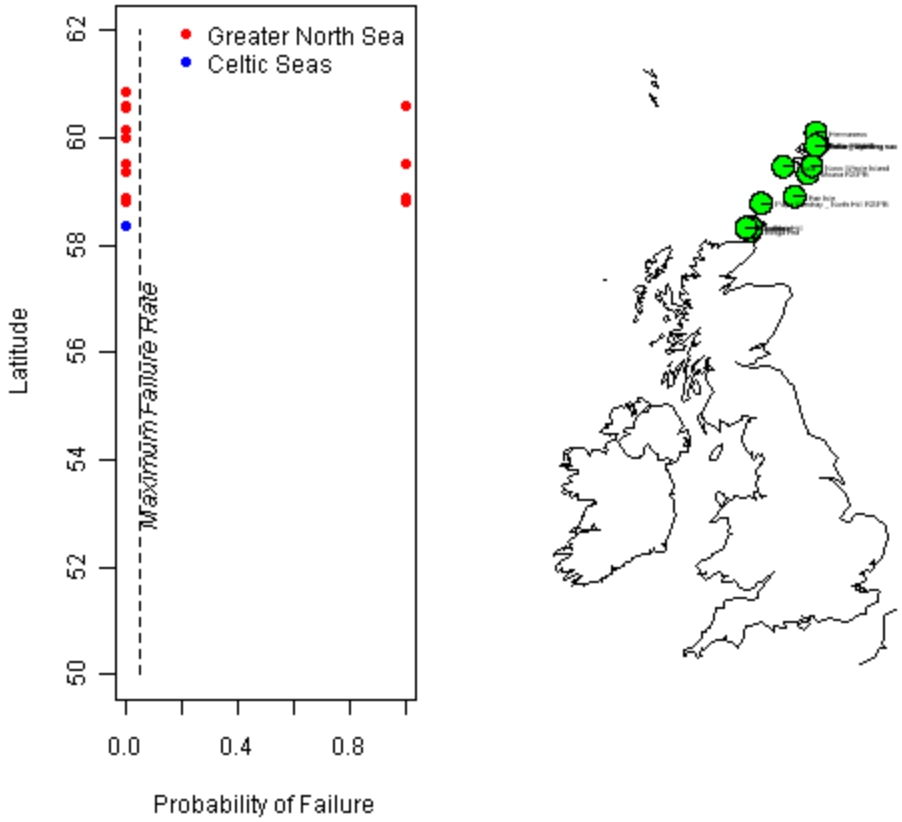

Figure A18 (left) Plot of modelled probability of breeding failure against latitude for great skua between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

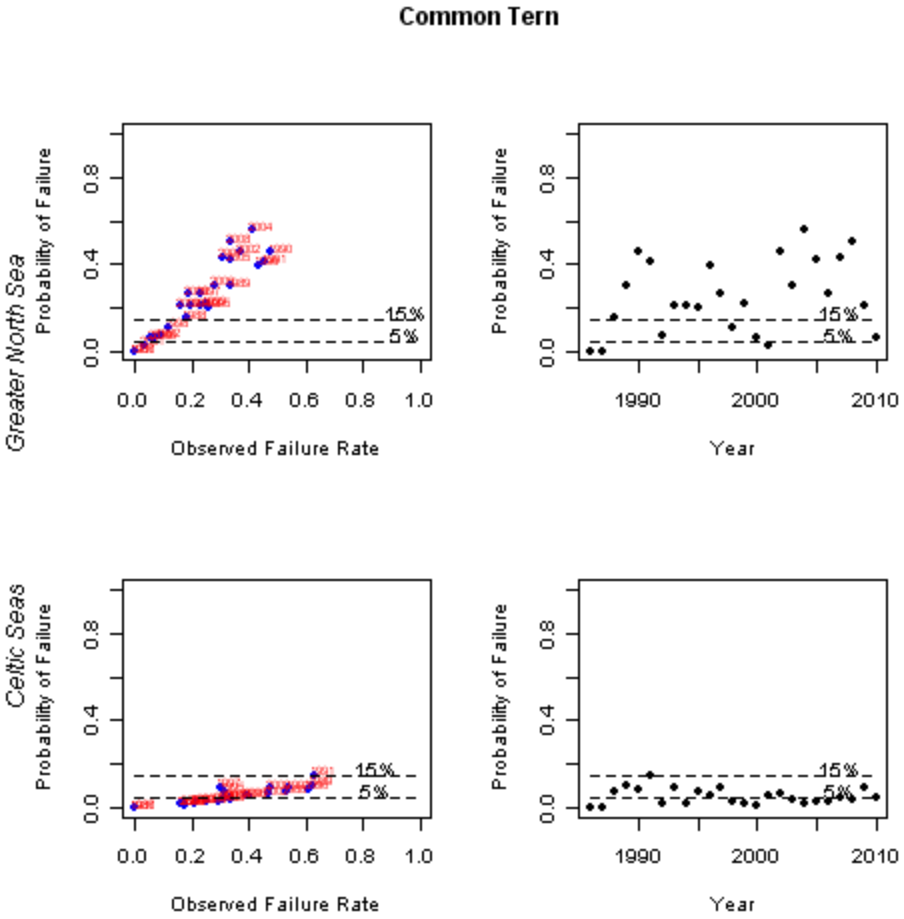

Figure A19 Breeding failure indicators for common tern in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The probability of breeding failure exceeded the maximum allowable level in the Greater North Sea sub-region in 1988, 1989, 1990, 1991, 1993, 1994, 1995, 1996, 1997, 1999, 2002, 2003, 2004, 2005, 2006, 2007, 2008 and 2009 (Figure A19). The highest probability of breeding failure was observed in 2004, when 56% of colonies were predicted to fail (Figure A19). Assuming a lower indicator target of 5%, the probability of breeding failure would have exceeded the maximum allowable level in every year apart from 1986, 1987 and 2001 (Figure A19). The model for the Greater North Sea sub-region was a good fit for the observed data with a correlation of 0.93.

The probability of failure within the Celtic Seas sub-region did not exceed the maximum failure rate between 1986 and 2010. A lower 5% target was exceeded in 1988, 1989, 1990, 1991, 1993, 1995, 1996, 1997, 2001, 2002 and 2009 (Figure A19). However, the model appeared to severely under-fit the data.

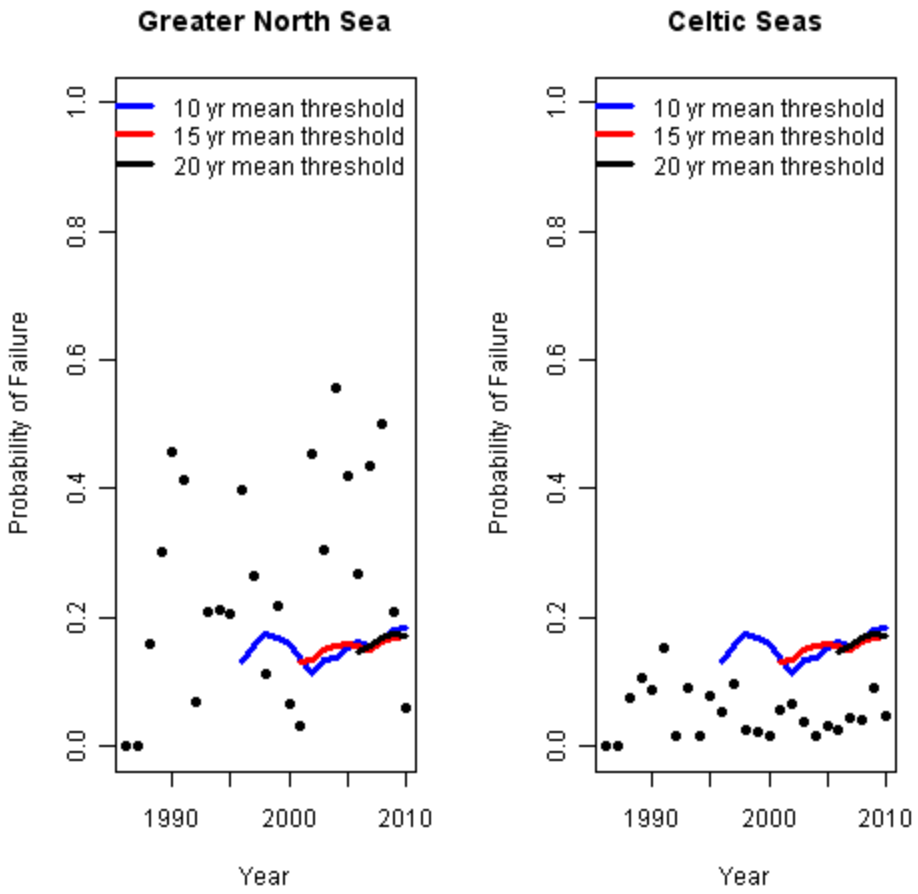

Figure A20 Breeding failure indicators for common tern in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 15 and 20 year mean failure rates appeared more stable that the 10 year mean failure rate, which showed a great deal of movement up and down. In the Greater North Sea sub-region all three rolling mean failure rates were exceeded in every year, apart from 1999, 2000, 2001 and 2010. In the Celtic Seas sub-region, none of the rolling mean failure rates were exceeded in any year (Figure A20).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A21) and in 2010 there were no obvious clusters of failing colonies (Figure A21).

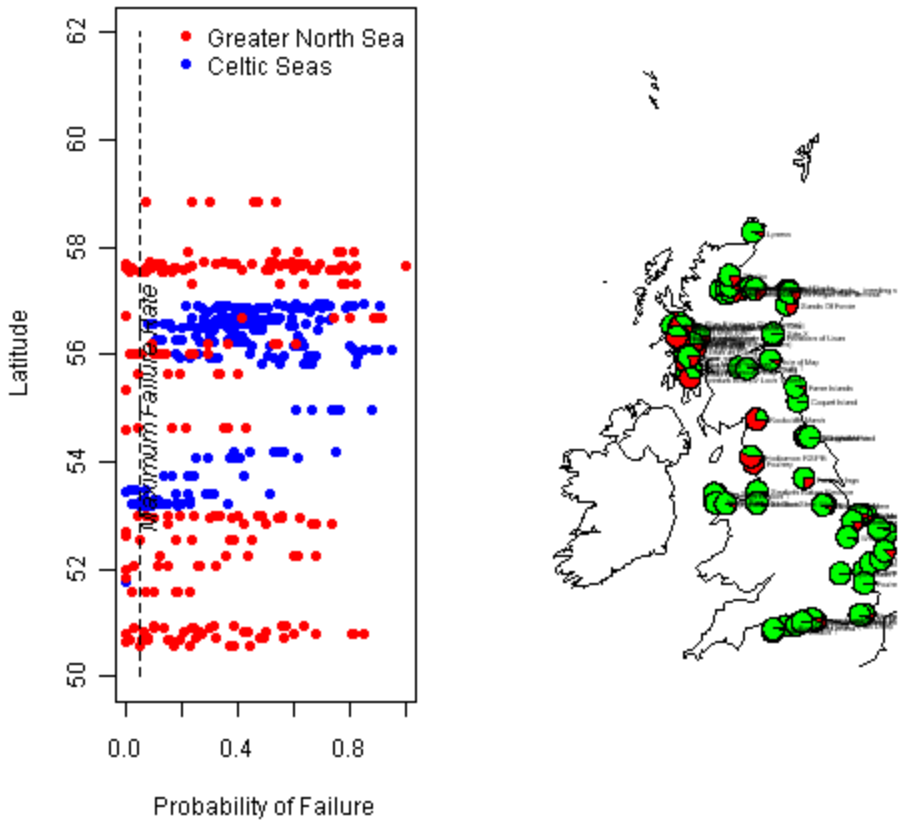

Figure A21 (left) Plot of modelled probability of breeding failure against latitude for common tern between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

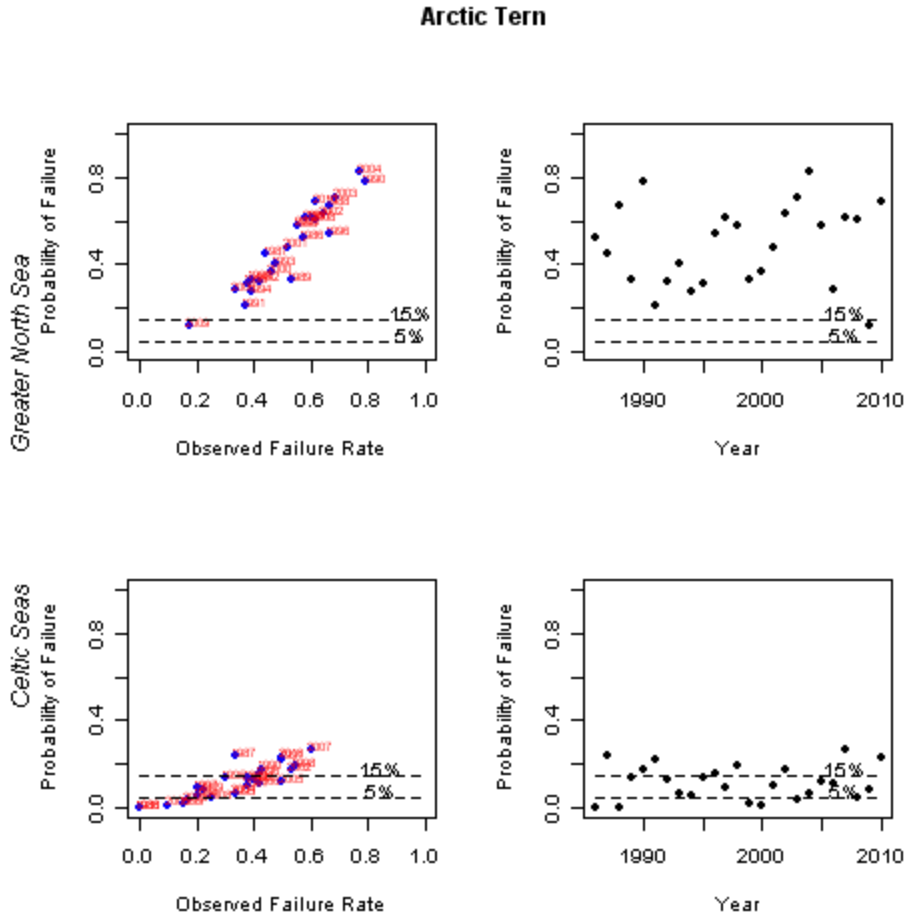

Figure A22 Breeding failure indicators for Arctic tern in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The probability of breeding failure exceeded the maximum allowable level in the Greater North Sea sub-region in every year apart from 2009, when 12% of colonies failed (Figure A22), although this was still above an alternative 5% threshold. The fitted data were a good match for the modelled data, with a correlation of 0.94. In the Celtic Seas sub-region, the probability of breeding failure exceeded the maximum allowable rate in 1987, 1990, 1991, 1996, 1998, 2002, 2007 and 2010 (Figure A22). Assuming a lower 5% threshold, the maximum allowable rate would have been exceeded in 1989, 1992, 1993, 1994, 1995, 1997, 2004, 2005, 2006 and 2009 (Figure A22). However, the model for the Celtic Seas appeared more likely to under-fit the data in comparison with the model for the Greater North Sea.

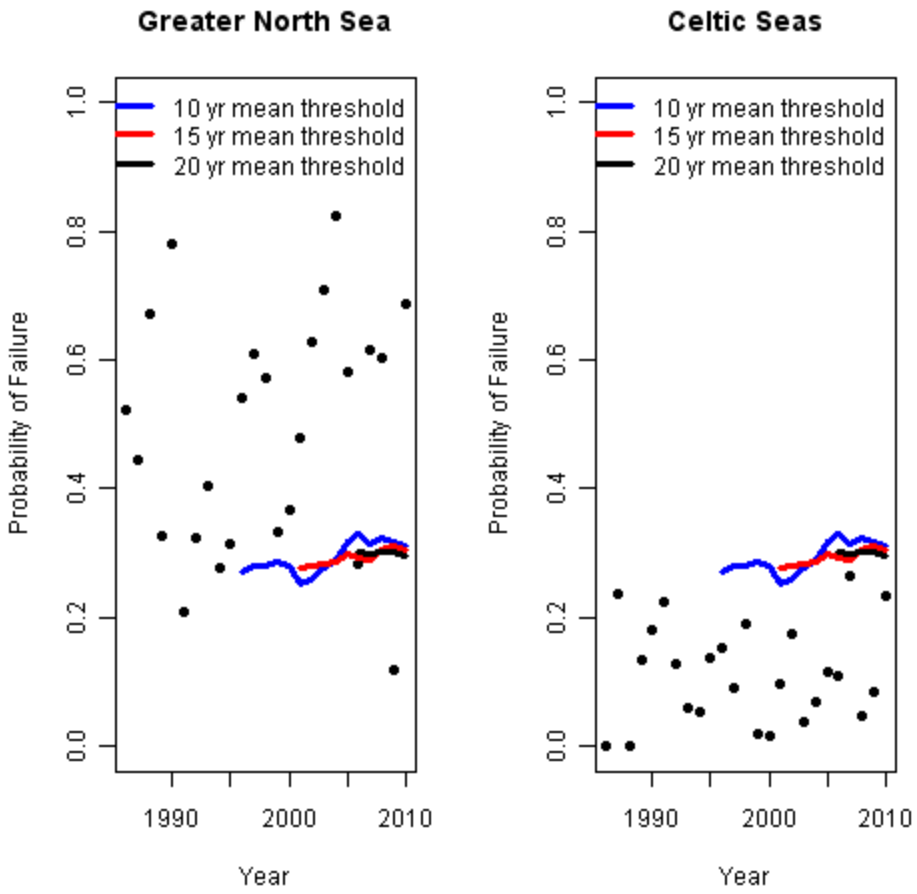

Figure A23 Breeding failure indicators for Arctic tern in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 15 and 20 year mean failure rates appeared more stable that the 10 year mean failure rate, which showed a great deal of movement up and down. In the Greater North Sea sub-region all three rolling mean failure rates were exceeded in every year, apart from 2009 and 2006. In the Celtic Seas sub-region, none of the rolling mean failure rates were exceeded in any year (Figure A2 3).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A24) and in 2010 there were no obvious clusters of failing colonies (Figure A24).

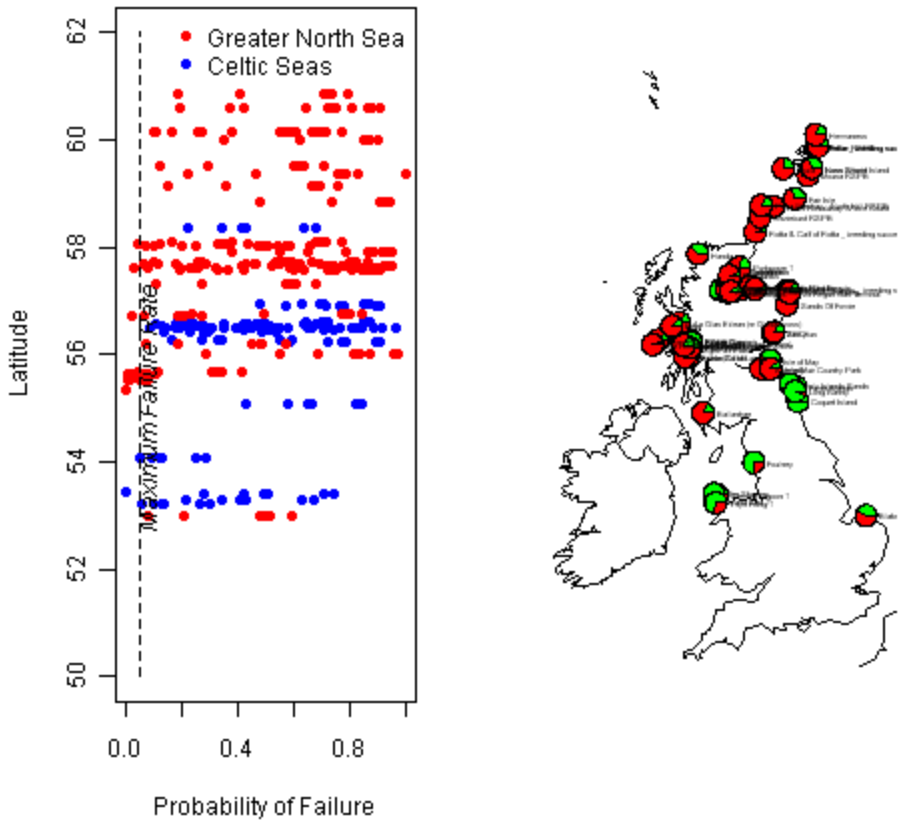

Figure A24 (left) Plot of modelled probability of breeding failure against latitude for Arctic tern between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

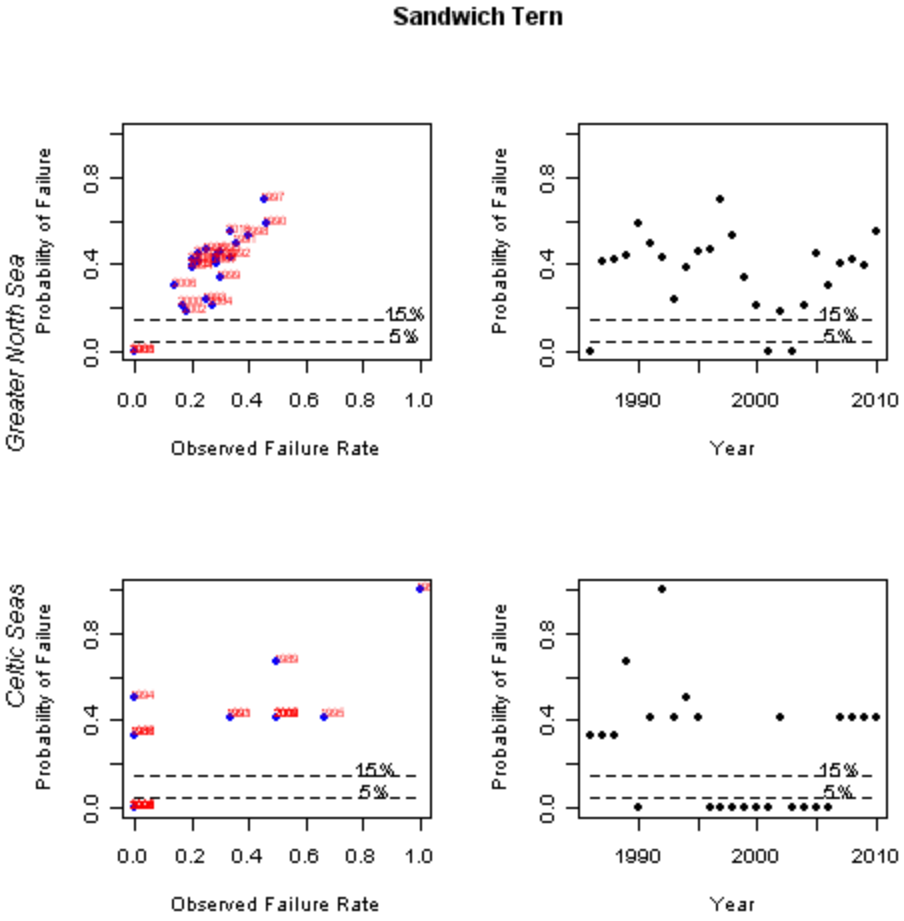

Figure A25 Breeding failure indicators for Sandwich tern in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The probability of breeding failure exceeded the maximum allowable level in the Greater North Sea sub-region in every year apart from 1986, 2001 and 2003 (Figure A25). The modelled data were a good fit for the data, with a correlation of 0.89. The probability of breeding failure in the Celtic Seas sub-region exceeded the maximum allowable level in 1986, 1987, 1988, 1989, 1991, 1992, 1993, 1995, 2002, 2007, 2008, 2009 and 2010 (Figure A25). However, as these failure rates are based on three sites only, Sandwich tern should not be considered as an appropriate indicator species for the Celtic Seas sub-region.

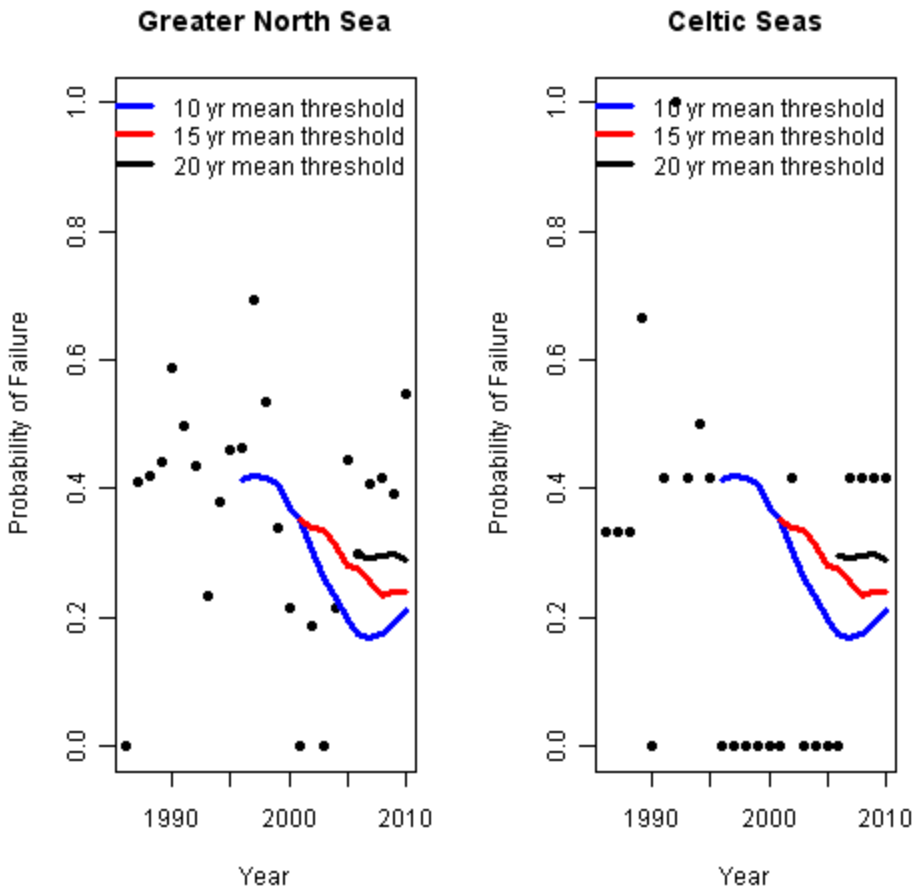

Figure A26 Breeding failure indicators for Sandwich tern in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 15 and 20 year mean failure rates appeared more stable that the 10 year mean failure rate, which showed a great deal of movement up and down. In the Greater North Sea sub-region all three rolling mean failure rates were exceeded between 2005 and 2010. In the Celtic Seas sub-region, all three of the rolling mean failure rates were exceeded in 2002, 2006, 2007, 2008, 2009 and 2010 (Figure A26).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A27) and in 2010 there were no obvious clusters of failing colonies (Figure A27).

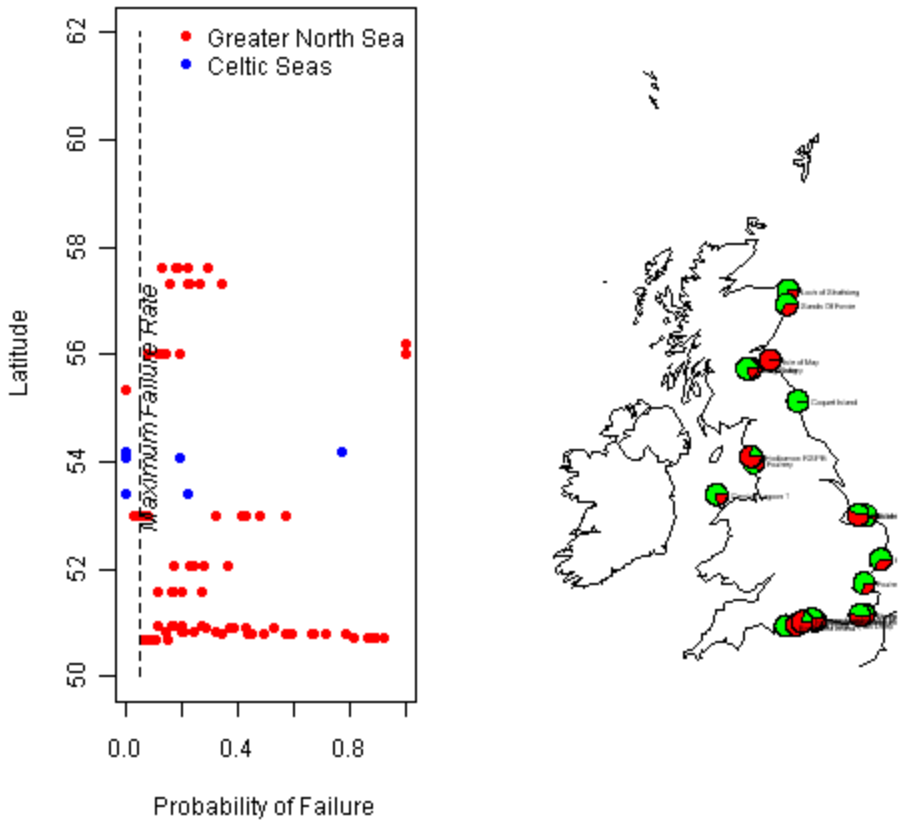

Figure A27 (left) Plot of modelled probability of breeding failure against latitude for Sandwich tern between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

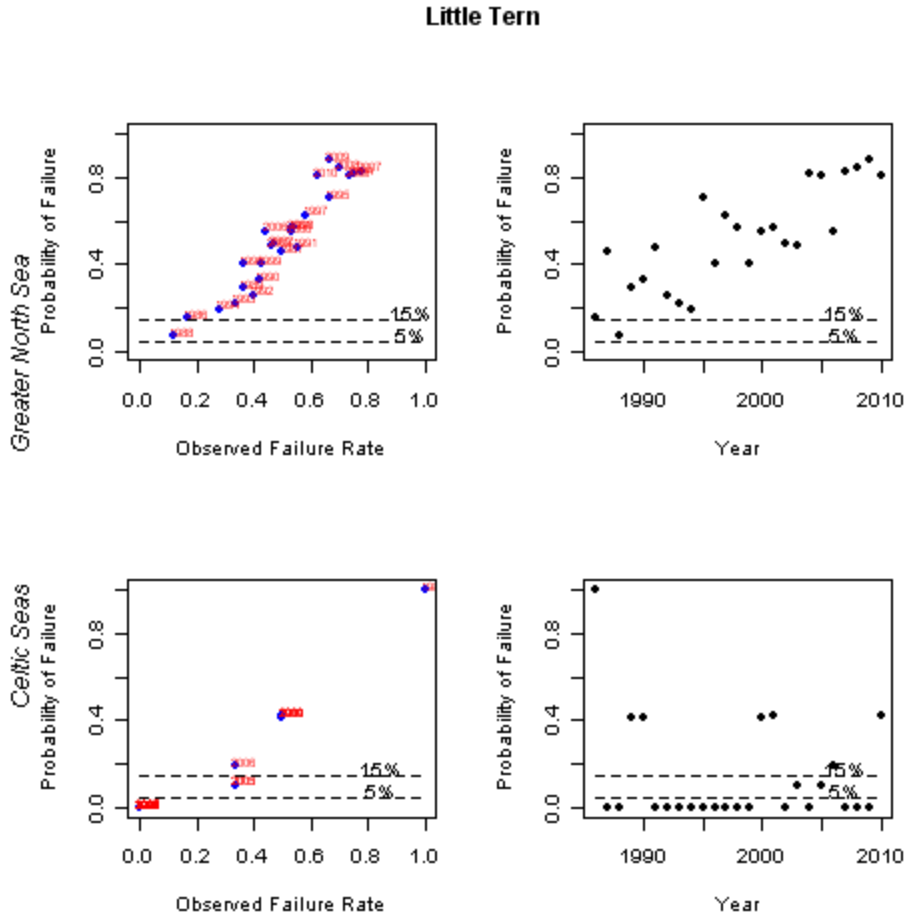

Figure A28 Breeding failure indicators for little tern in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The probability of breeding failure in the Greater North Sea sub-region exceeded the maximum allowable level (15%) in every year apart from 1988, when 8% of colonies failed (Figure A28). The modelled probabilities were a good fit for the data, with a correlation of 0.95. The probability of breeding failure in the Celtic Seas sub-region exceeded the maximum allowable level (15%) in 1986, 1989, 1990, 2000, 2001, 2006 and 2010 (Figure A28). However, as these values are based on only three colonies, little tern should not be considered as an appropriate indicator species for this sub-region.

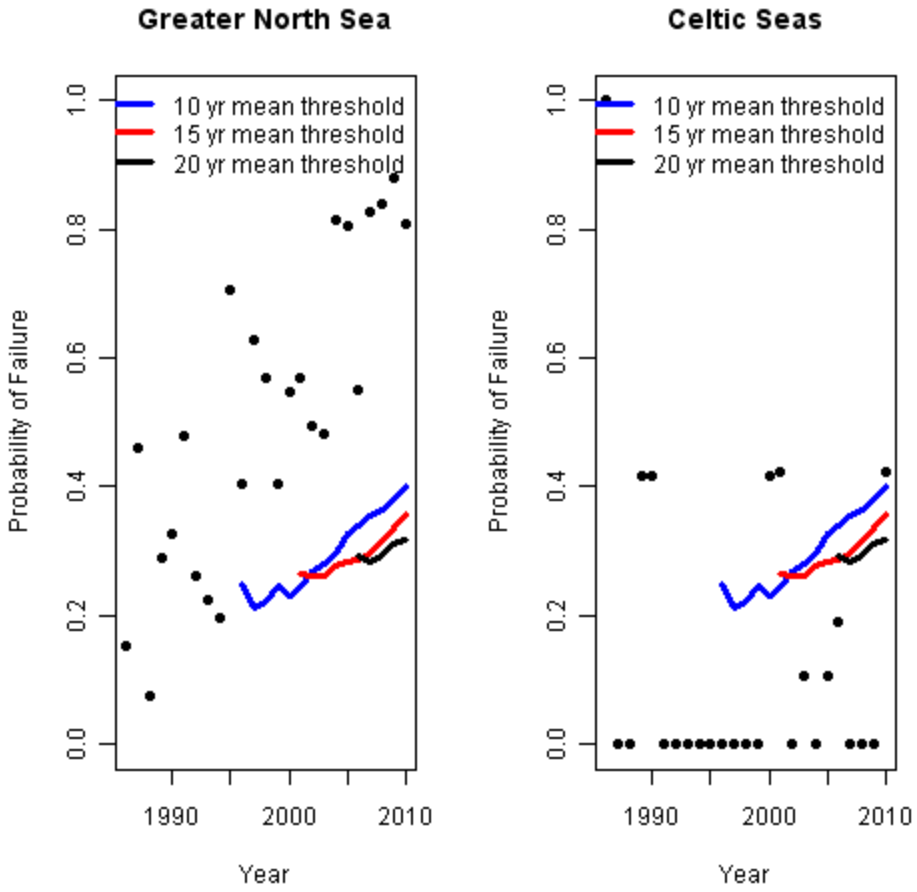

Figure A29 Breeding failure indicators for little tern in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year mean rolling average breeding failure rates all increased through time. By 2010, the mean 10 year breeding failure rate had reached 40%, the 15 year rate had reached 35% and the 20 year rate had reached 32%. In the Greater North Sea sub-region, the mean failure rates were exceeded in every year. In the Celtic Seas sub-region, the mean failure rates were exceeded in 2000, 2001 and 2010 (A29).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A30) and in 2010 there were no obvious clusters of failing colonies (Figure A30).

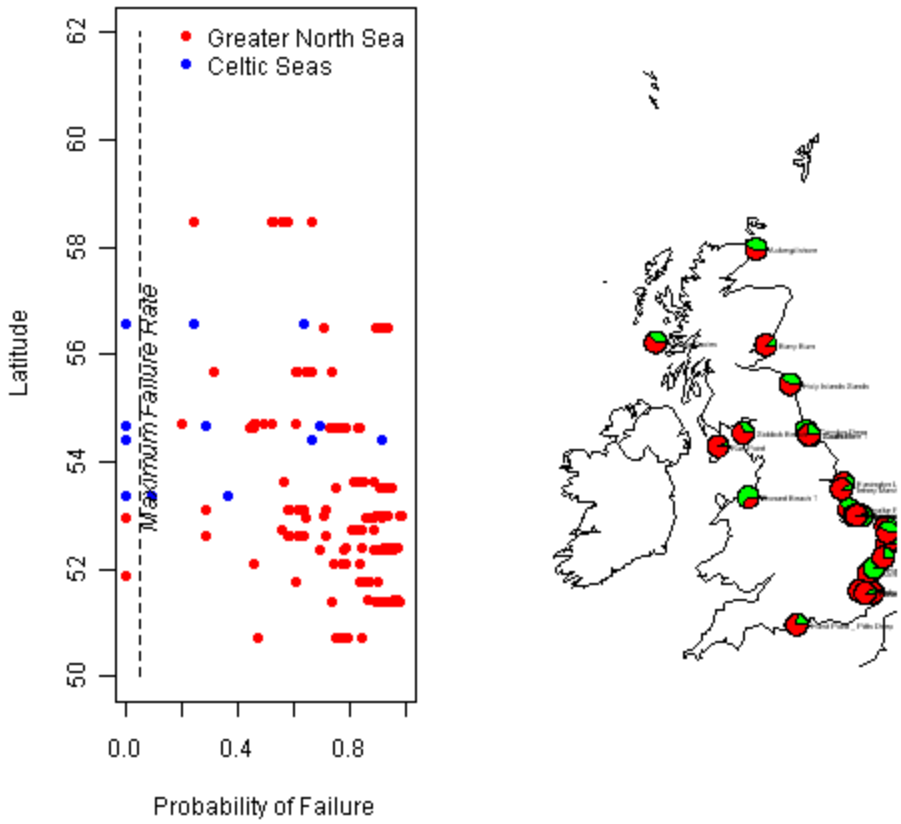

Figure A30 (left) Plot of modelled probability of breeding failure against latitude for little tern between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

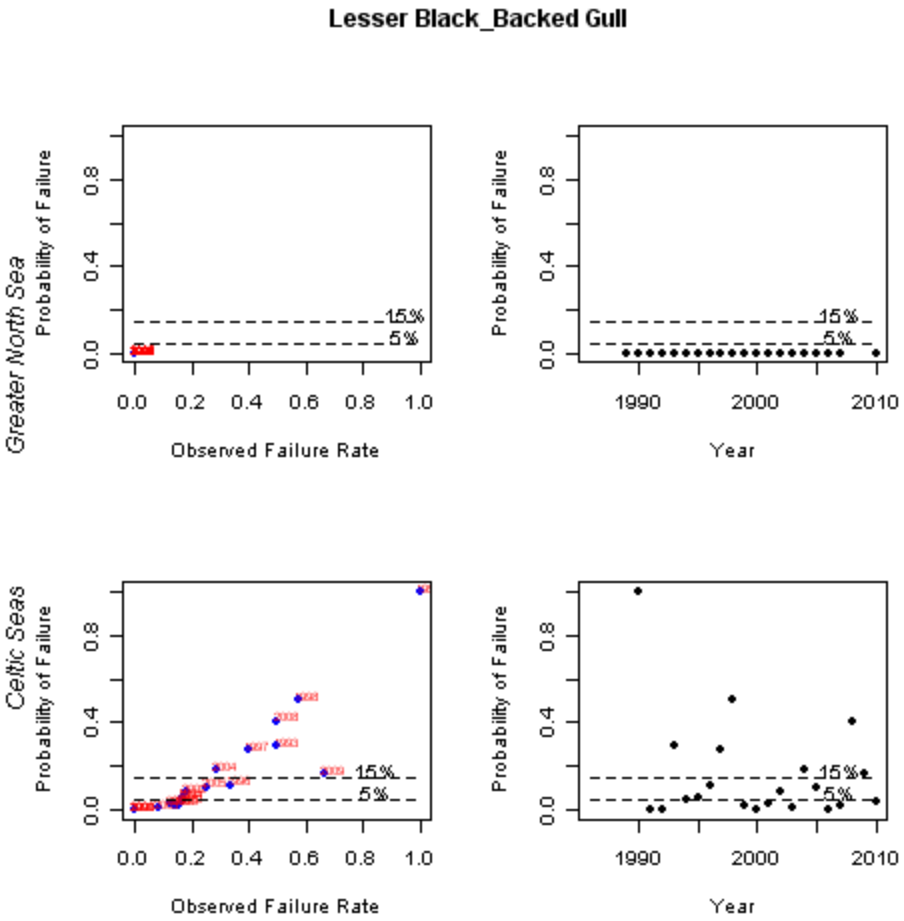

Figure A31 Breeding failure indicators for lesser black-backed gull in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

Probability of breeding failure in the Celtic Seas sub-region exceeded the maximum allowable rate in 1990, 1993, 1997, 1998, 2004, 2008 and 2009 (Figure A31). Assuming a lower, 5% threshold the maximum allowable rate would also have been exceeded in 1994, 1995, 1996, 2002 and 2005 (Figure A31). The modelled probabilities were a good fit for the observed data. Breeding failure was not recorded within the Greater North Sea sub-region between 1986 and 2010 (Figure A31). However, as data covered only four colonies, lesser black-backed gull should not be considered an appropriate indicator species in this sub-region.

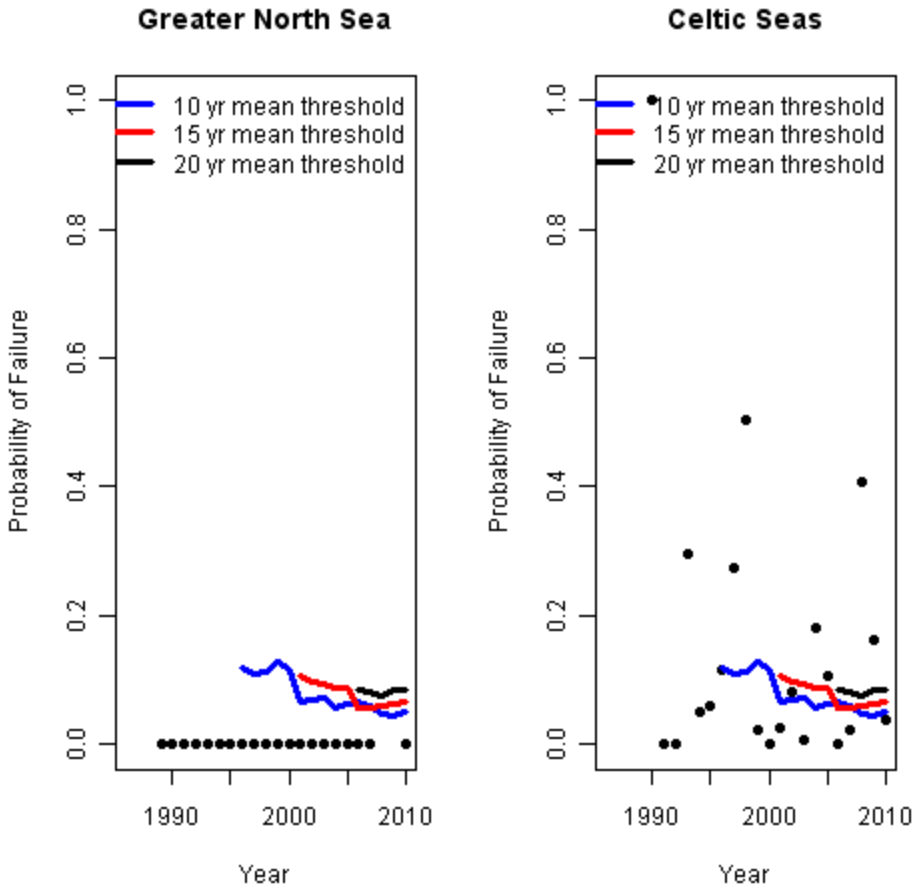

Figure A32 Breeding failure indicators for lesser black-backed gull in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year mean rolling average breeding failure rates all declined through time. By 2010, the mean 10 year breeding failure rate had reached 5%, the 15 year rate had reached 7% and the 20 year rate had reached 8%. In the Greater North Sea sub-region, the mean failure rates were not exceeded in any year. In the Celtic Seas sub-region, all three mean failure rates were exceeded in 1996, 1997, 2004, 2005, 2008 and 2009 (A32) and the 10 year mean failure rate was also exceeded in 2003.

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A33) and in 2010 there were no obvious clusters of failing colonies (Figure A33).

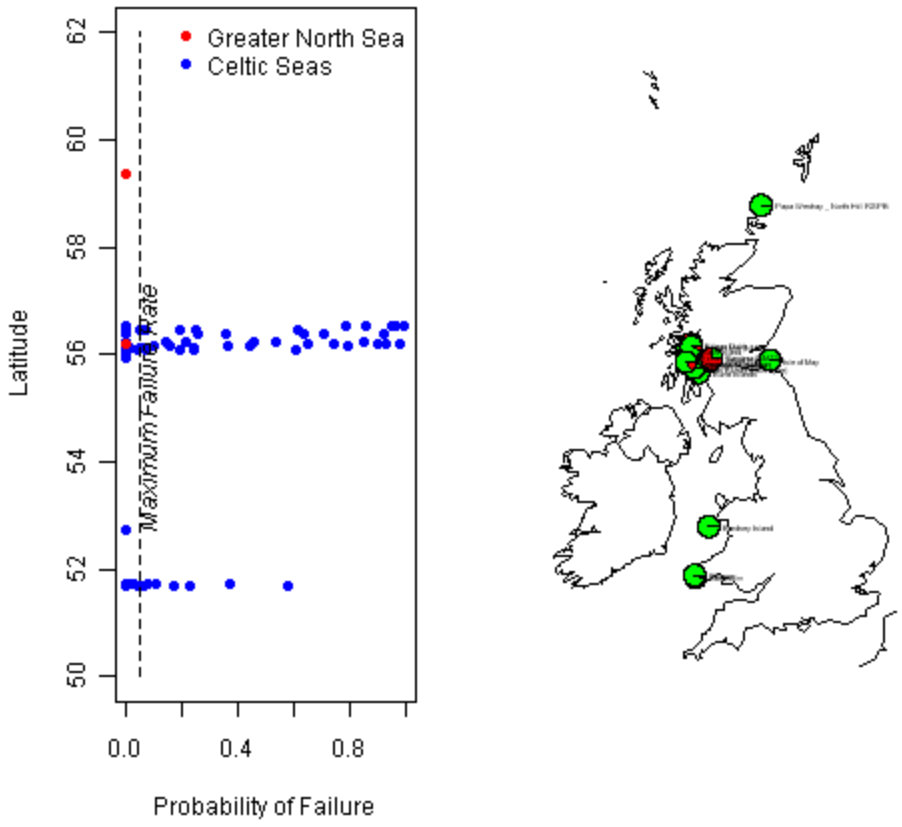

Figure A33 (left) Plot of modelled probability of breeding failure against latitude for lesser black-backed gulls between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

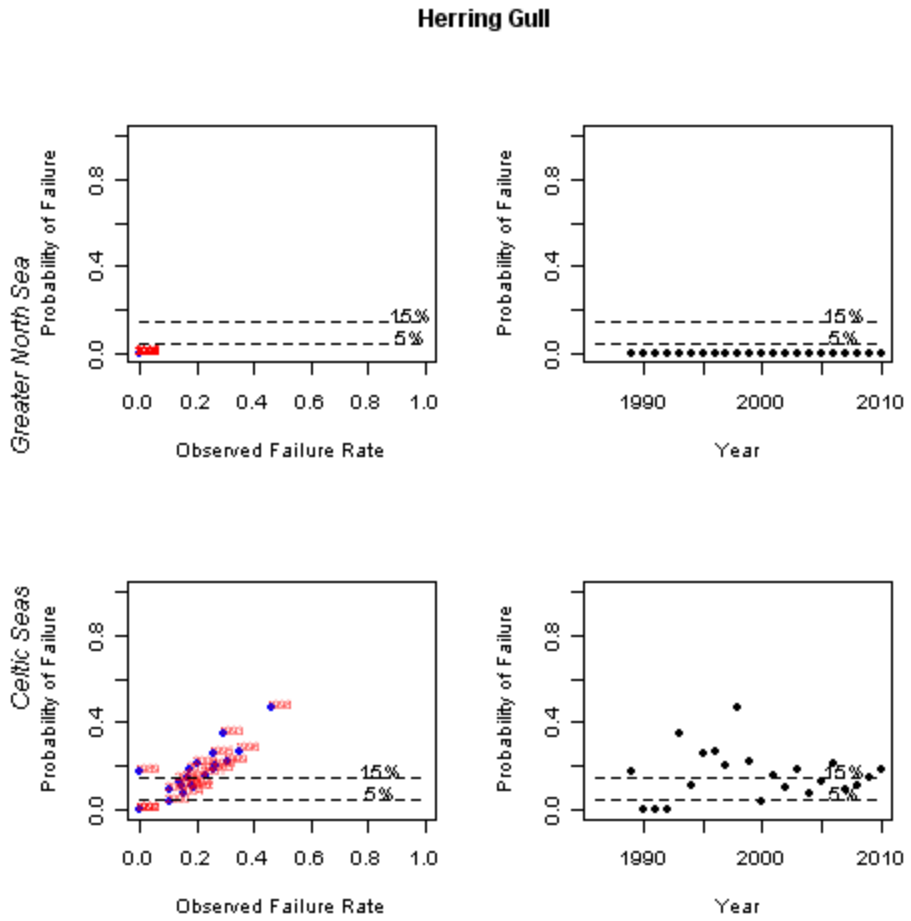

Figure A34 Breeding failure indicators for herring gull in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

Probability of breeding failure in the Celtic Seas sub-region exceeded the maximum allowable rate in 1989, 1993, 1995, 1996, 1997, 1998, 1999, 2001, 2003, 2006 and 2010 (Figure A34). Assuming a lower, 5% threshold the maximum allowable rate would also have been exceeded in 1994, 2002, 2004, 2005, 2007, 2008 and 2009 (Figure A34). The modelled probabilities were a good fit for the observed data. Breeding failure was not recorded within the Greater North Sea sub-region between 1986 and 2010 (Figure A34). However, as data covered only four colonies, herring gull should not be considered an appropriate indicator species in this sub-region.

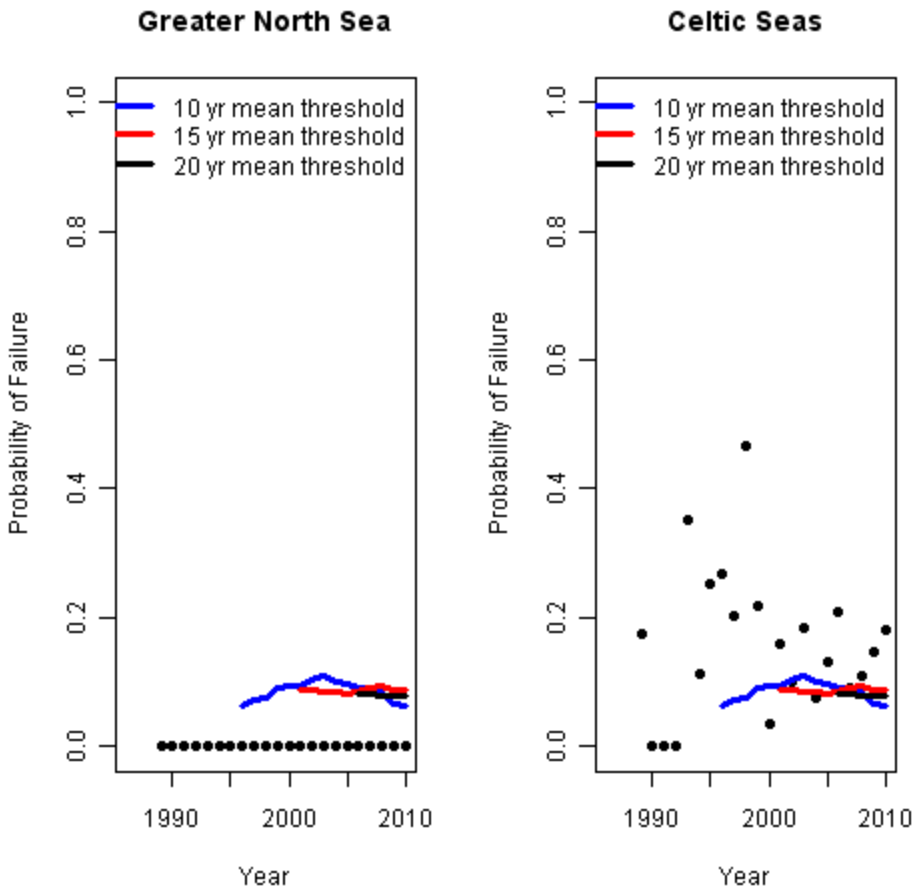

Figure A35 Breeding failure indicators for herring gull in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10 year mean failure rate rose between 1996 and 2003 and then fell between 2003 and 2010. In contrast, the 15 and 20 year mean failure rates remained stable throughout the study period. In the Greater North Sea sub-region, none of the mean failure rates were exceeded in any year. In the Celtic Seas sub region, the mean failure rates were exceeded in every year apart from 2000, 2003 and 2005 (Figure A35).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A36) and in 2010 there were no obvious clusters of failing colonies (Figure A36).

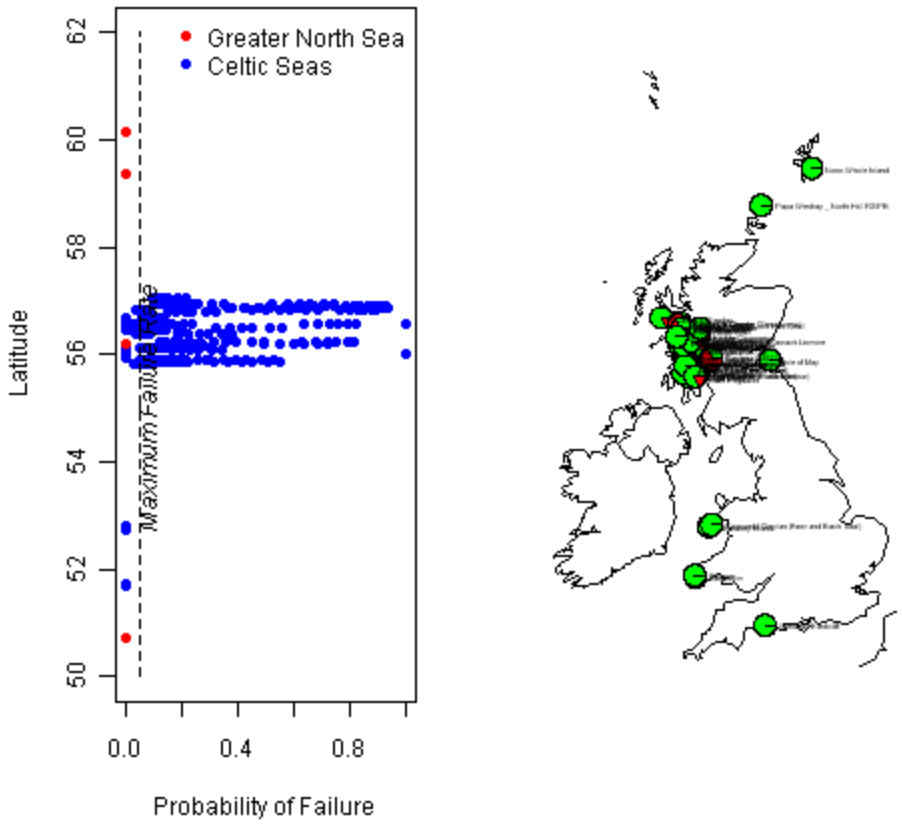

Figure A36 (left) Plot of modelled probability of breeding failure against latitude for herring gulls between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

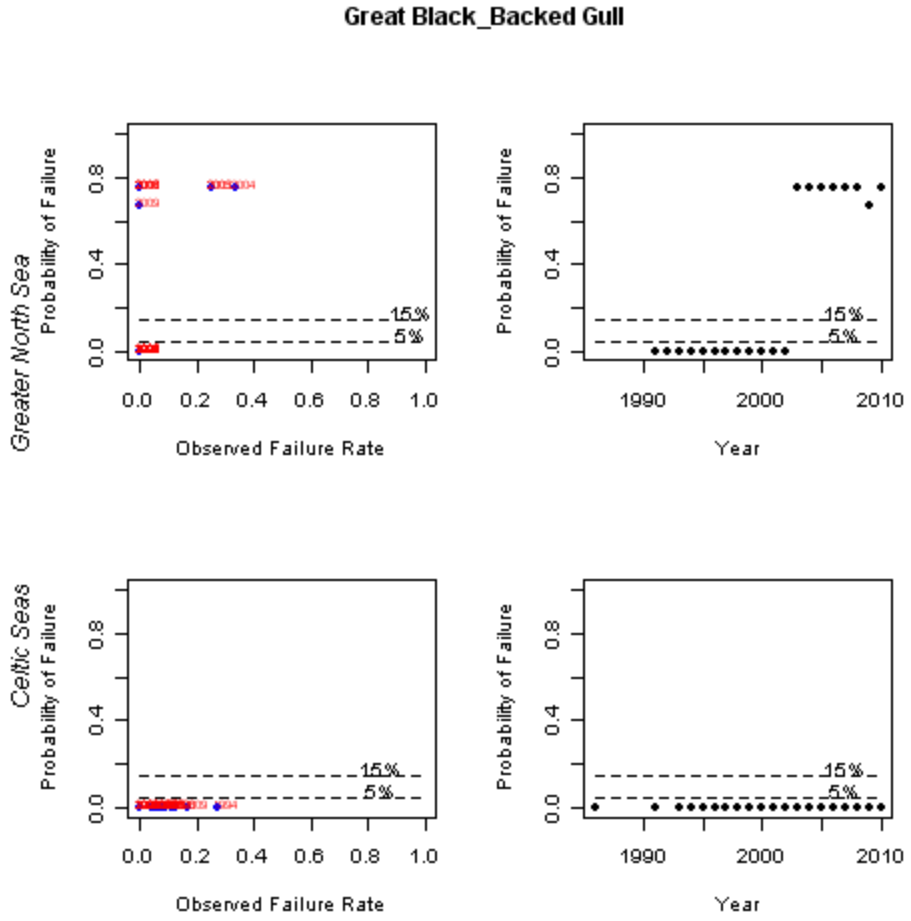

Figure A37 Breeding failure indicators for great black-backed gull in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

Probability of breeding failure did not exceed the maximum allowable rate in the Celtic Seas sub-region between 1986 and 2010 (Figure 25). However, the model appeared to under-fit the data. In the Greater North Sea sub-region the maximum failure rate was exceeded between 2003 and 2010 (Figure 25). However, as this is based on data from four colonies only, great black-backed gull should not be considered and appropriate indicator species for the Greater North Sea sub-region. There was no evidence that failure to meet the indicator target was driven by spatial bias in the colony selection (Figure 26).

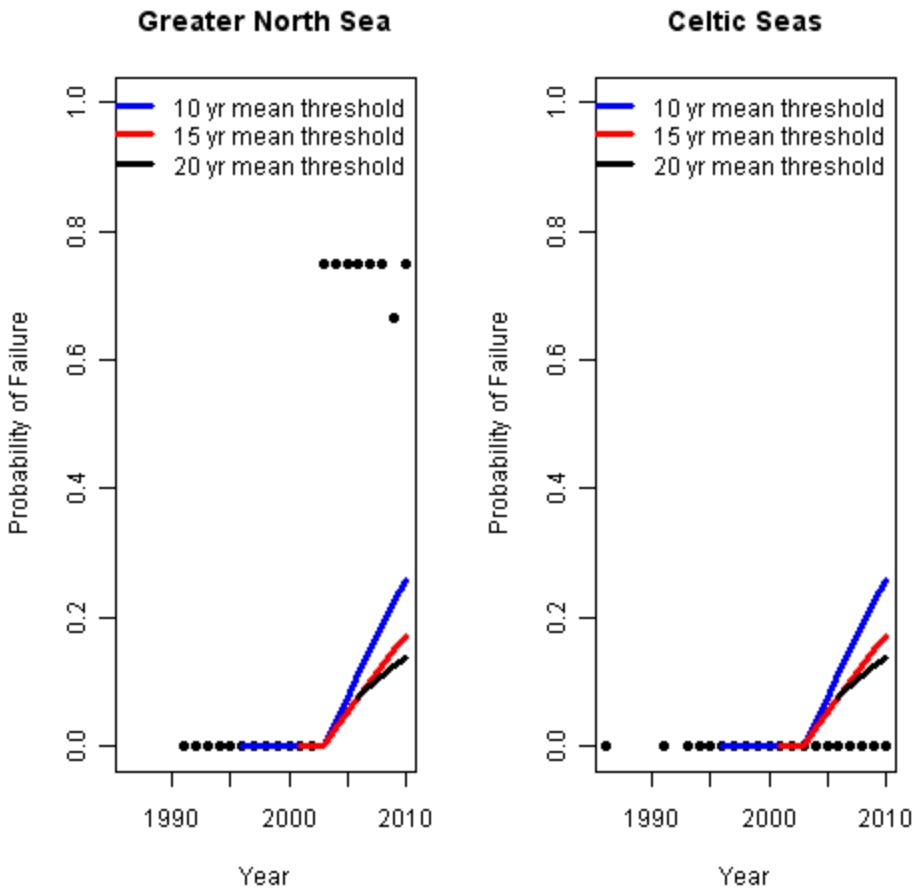

Figure A38 Breeding failure indicators for great black-backed gull in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year mean breeding failure rates rose dramatically 2003 and 2010, with the 10 year mean failure rate reaching 26%, the 15 year rate reaching 17% and the 20 year rate reaching 14%. In the Greater North Sea sub-region all three mean failure rates were exceeded between 2003 and 2010. In the Celtic Seas sub-region, they were not exceeded in any year (Figure A38).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A39) and in 2010 there were no obvious clusters of failing colonies (Figure A39).

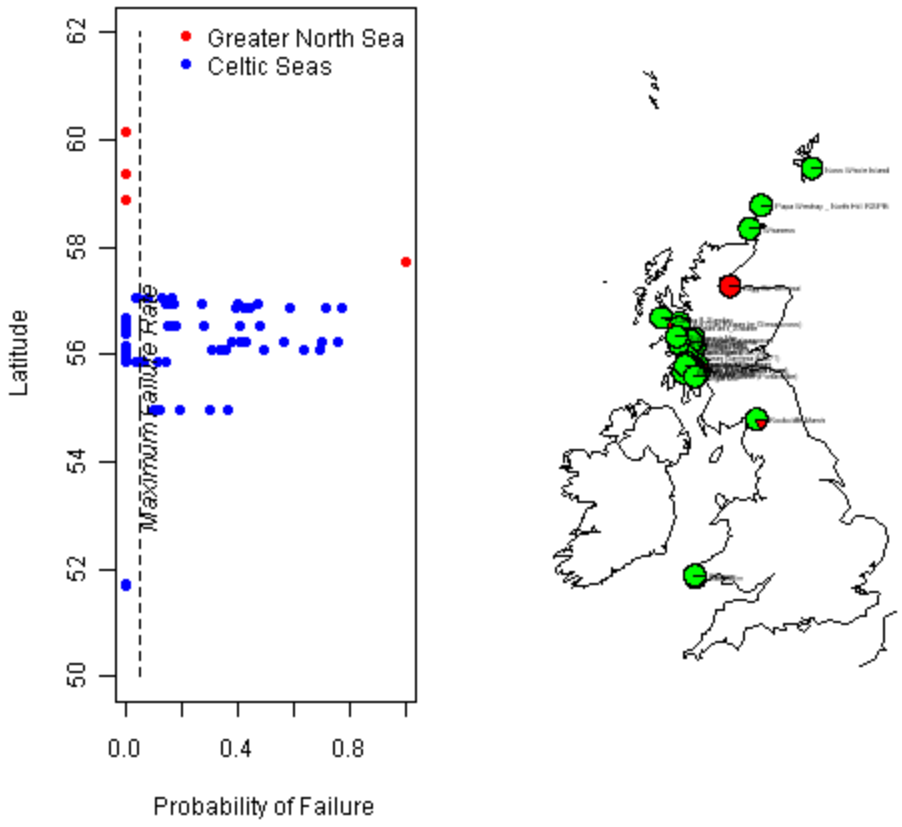

Figure A39 (left) Plot of modelled probability of breeding failure against latitude for great black-backed gulls between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

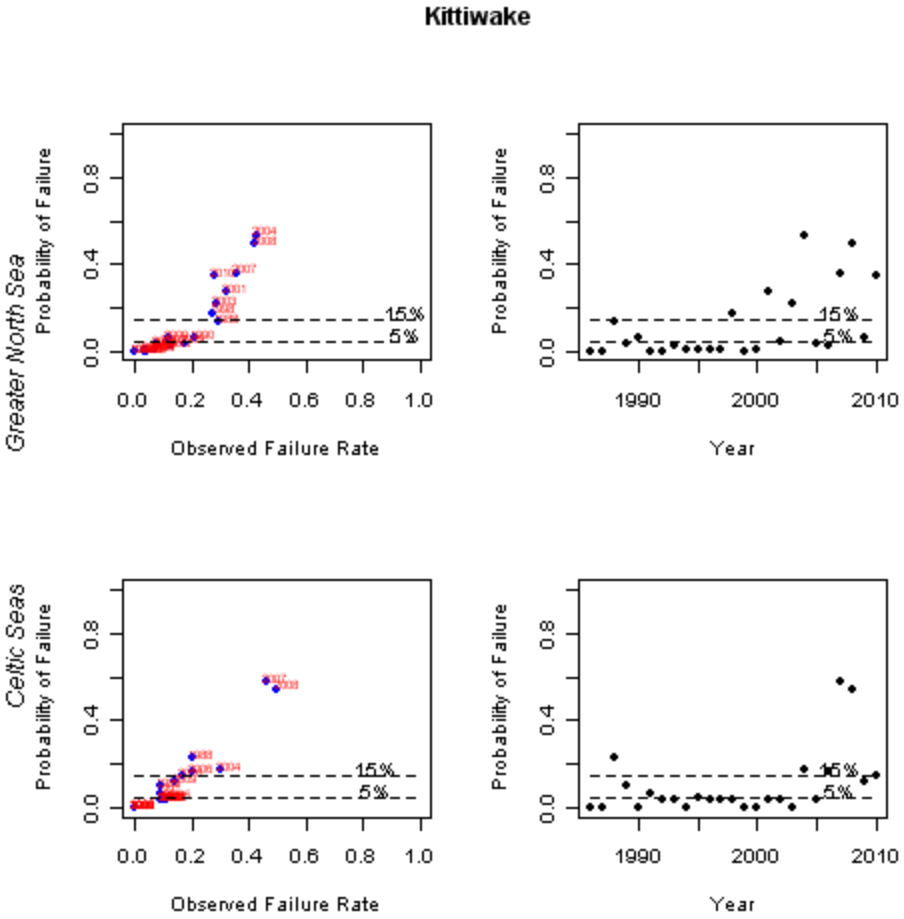

Figure A40 Breeding failure indicators for kittiwake in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The probability of breeding failure exceeded the maximum allowable level in the Greater North Sea sub-region in 1998, 2001, 2003, 2004, 2007, 2008 and 2010 (Figure A40). Assuming a lower, 5% threshold, the maximum failure rate would also have been exceeded in 1988, 1990 and 2009 (Figure 27). The model was a good fit for the observed data with a correlation of 0.92. In the Celtic Seas sub-region the probability of breeding failure exceeded the maximum allowable failure rate in 1988, 2004, 2006, 2007, 2008 and 2010 (Figure A40). Assuming a lower threshold of 5%, the maximum allowable failure rate would also have been exceeded in 1989, 1991 and 2009 (Figure A40). The modelled probabilities were a good match for the observed data with a correlation of 0.95.

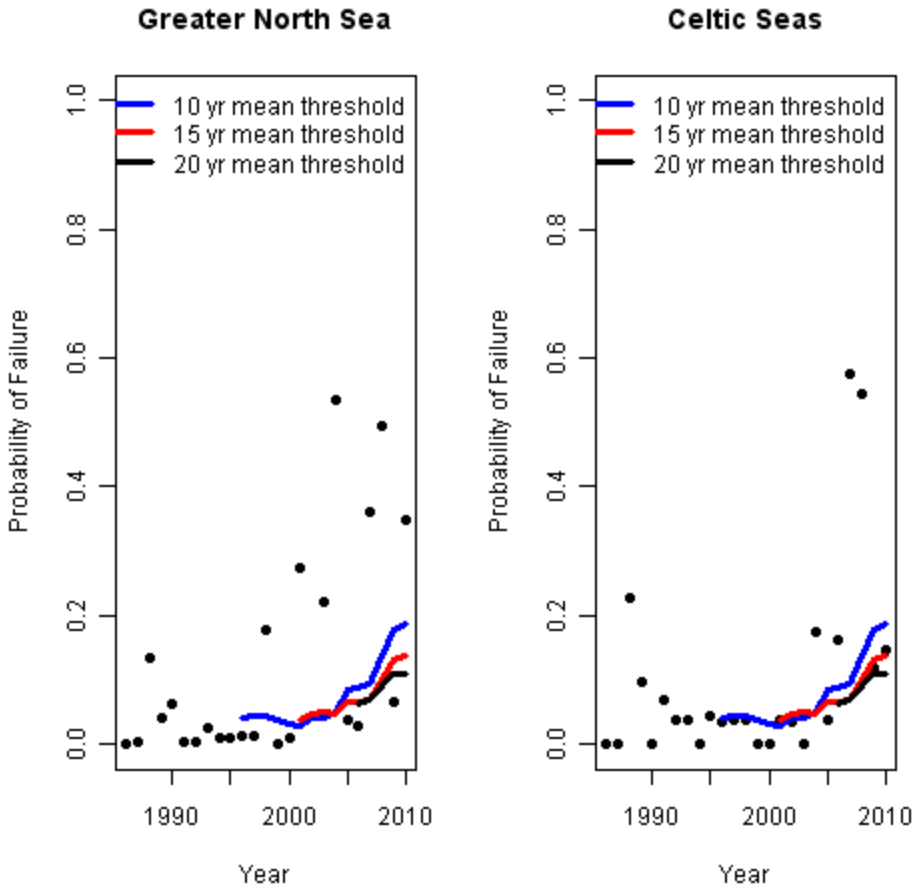

Figure A41 Breeding failure indicators for kittiwake in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year mean annual failure rates all increased by 2010, with the 10 year rate reaching 19%, the 15 year rate reaching 14% and the 20 year rate reaching 11%. In the Greater North Sea sub-region, all three rates were exceeded in 1998, 2001, 2002, 2003, 2004, 2007, 2008 and 2010. In the Celtic Seas sub-region all three rates were exceeded in 2004, 2006, 2007 and 2008. The 15 year and 20 year rates were also exceeded in 2010 (Figure A41).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A42) and in 2010 there were no obvious clusters of failing colonies (Figure A42).

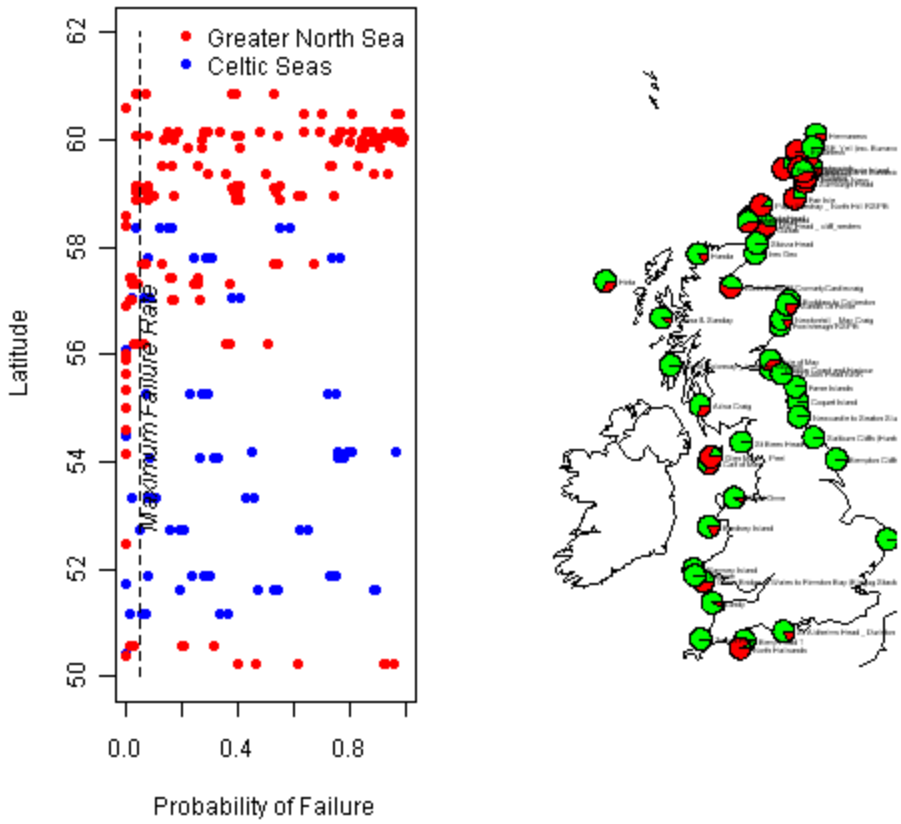

Figure A42 (left) Plot of modelled probability of breeding failure against latitude for kittiwake between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

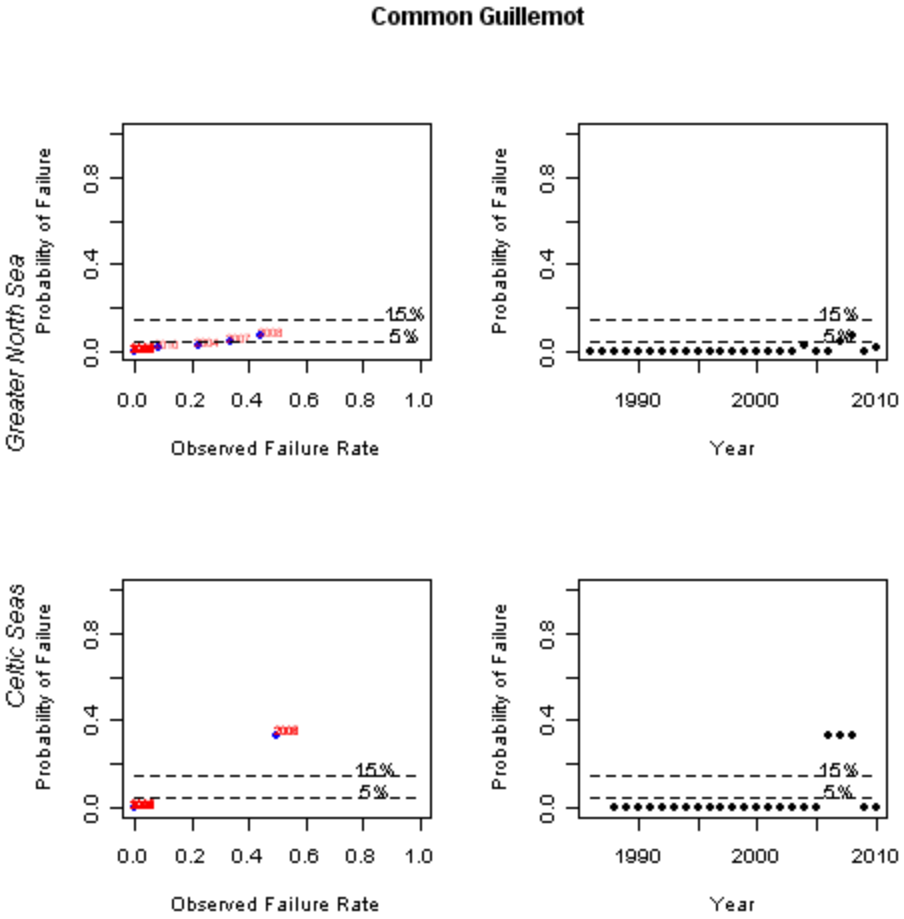

Figure A43 Breeding failure indicators for common guillemot in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The probability of breeding failure did not exceed the maximum allowable level in the Greater North Sea sub-region in any year between 1986 and 2010 (Figure A43). Assuming a lower threshold of 5%, the failure rate would exceed the maximum allowable level in 2008 when 8% of colonies failed (Figure A43). The model for the Greater North Sea sub-region appeared to slightly under-fit the data. The maximum failure rate in the Celtic Seas sub-region was exceeded in 2006, 2007 and 2008 (Figure A43). However, as these data are based on three colonies only, common guillemot should not be considered an appropriate indicator species in this region.

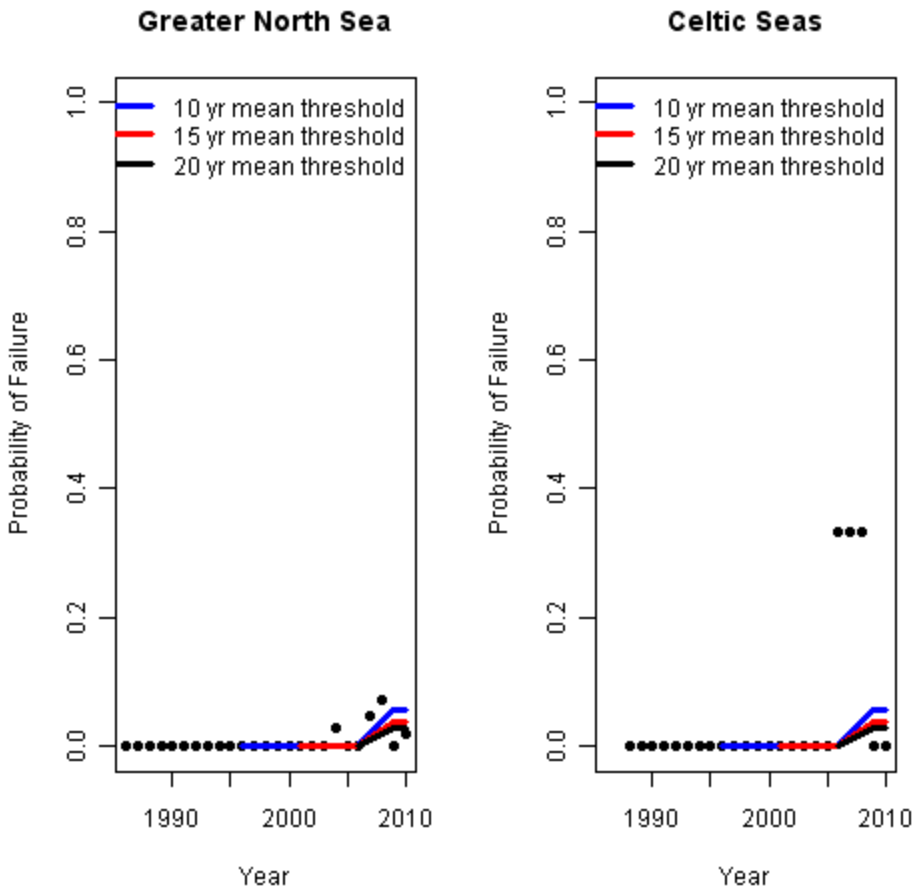

Figure A44 Breeding failure indicators for common guillemot in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year mean annual failure rates increased between 2006 and 2010, with the 10 year rate reaching 6%, the 15 year rate reaching 4% and the 20 year rate reaching 3%. In the Greater North Sea sub-region, all three rates were exceeded in 2004, 2007 and 2008. In the Celtic Seas sub-region, all three rates were exceeded in 2006, 2007 and 2008 (Figure A44).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A45) and in 2010 there were no obvious clusters of failing colonies (Figure A45).

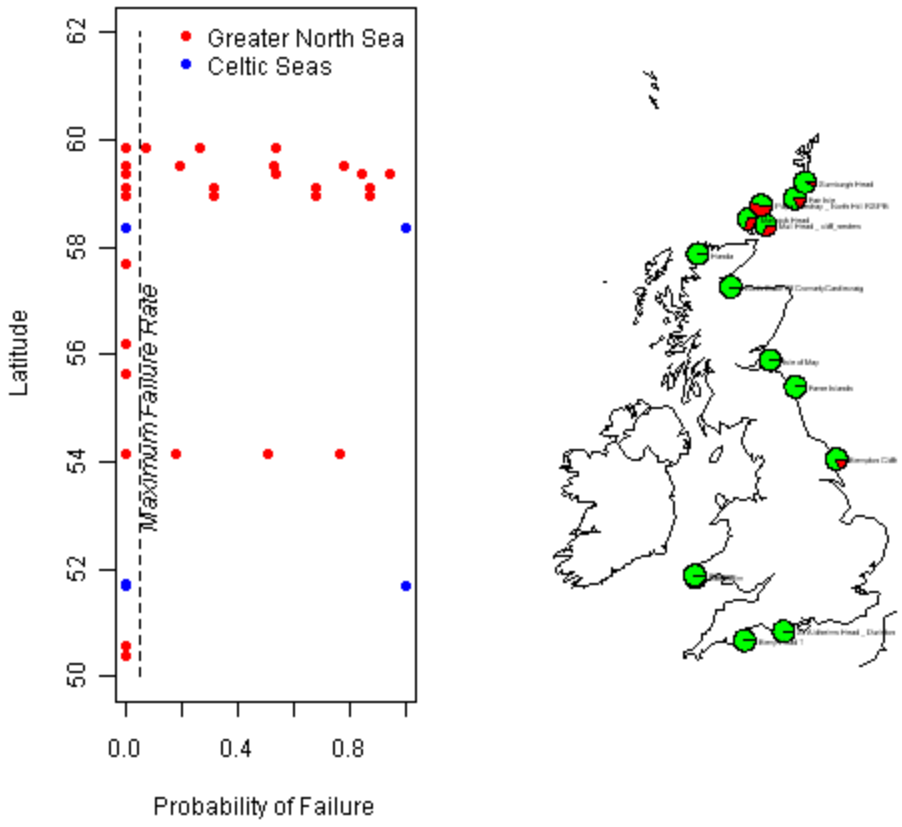

Figure A45 (left) Plot of modelled probability of breeding failure against latitude for common guillemot between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

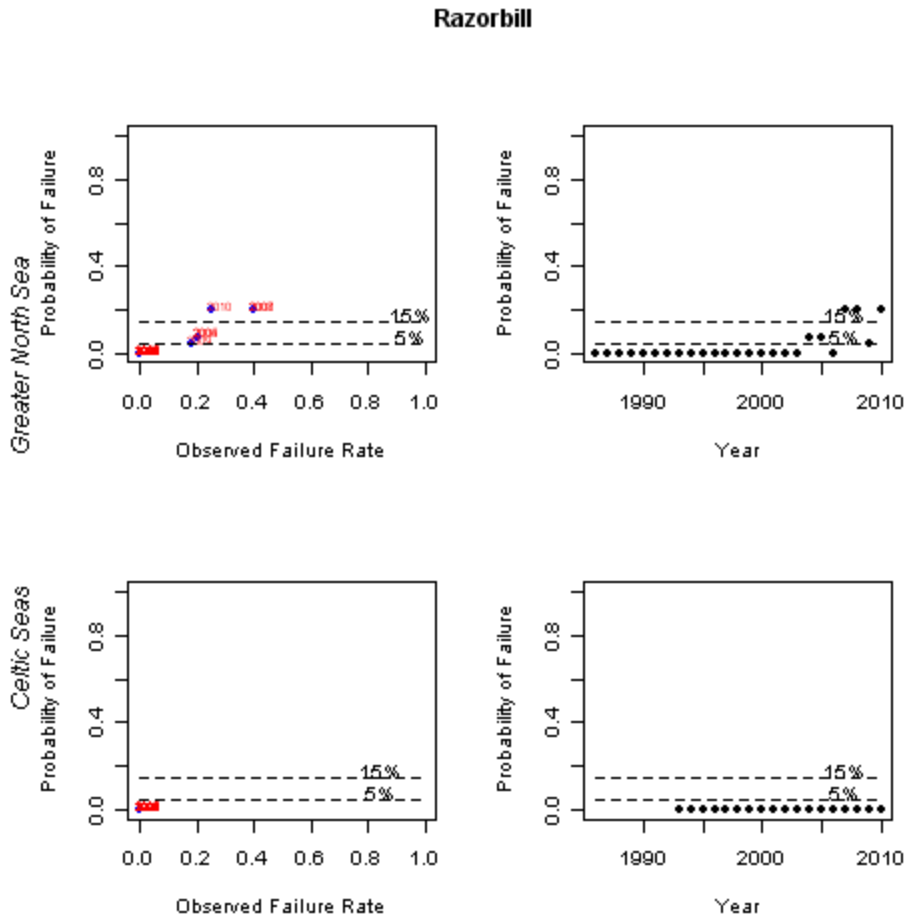

Figure A46 Breeding failure indicators for razorbill in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets of 5% of colonies failing and 15% of colonies failing are also plotted to enable comparisons to be made between these values.

The maximum failure rate for razorbill in the Greater North Sea sub-region was exceeded in 2007, 2008 and 2010 and was not exceeded in the Celtic Seas sub-region (Figure A46). However as the data cover only five colonies in the Greater North Sea sub-region and two colonies in the Celtic Seas sub-region, razorbill should not be considered an appropriate indicator species.

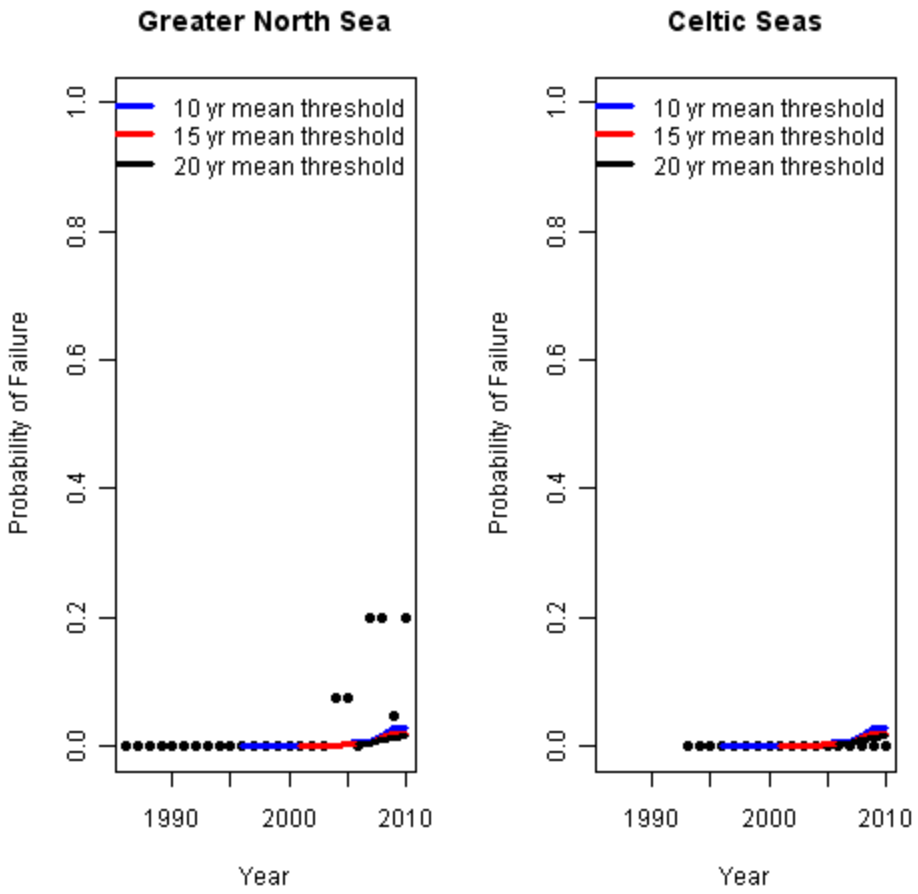

Figure A47 Breeding failure indicators for razorbill in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year mean annual failure rates increased between 2006 and 2010, with the 10 year rate reaching 3%, the 15 year rate reaching 1% and the 20 year rate reaching 1%. In the Greater North Sea sub-region, all three rates were exceeded in 2004, 2005, 2007, 2008 and 2010. In the Celtic Seas sub-region, none of the rates were exceeded in any year (Figure A47).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A48) and in 2010 there were no obvious clusters of failing colonies (Figure A48).

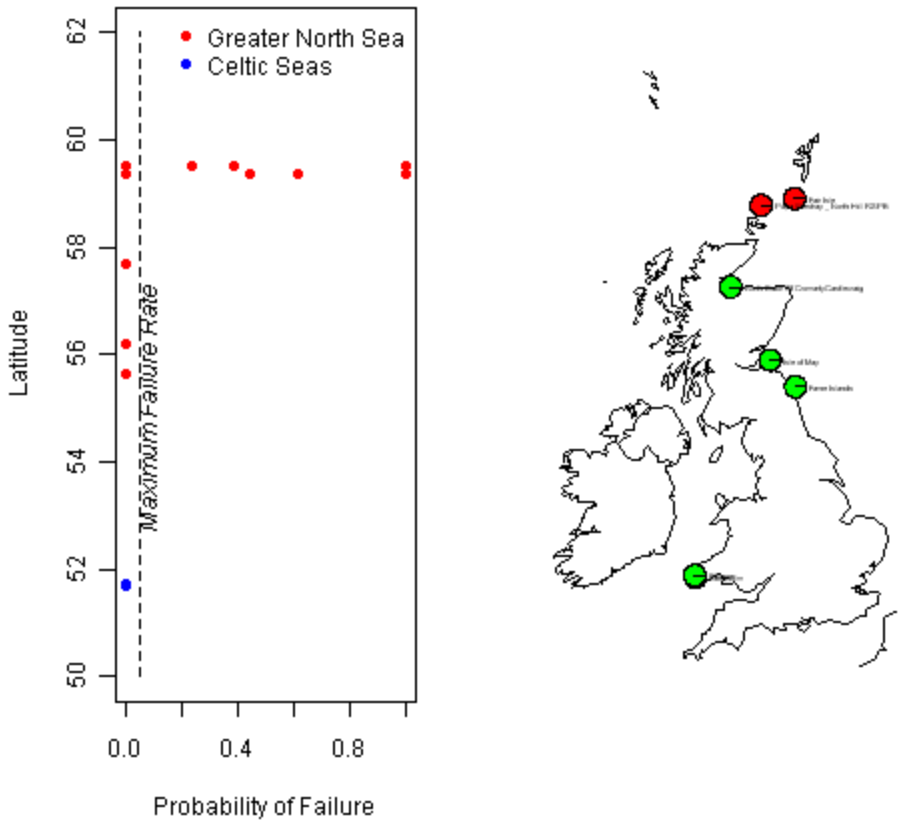

Figure A48 (left) Plot of modelled probability of breeding failure against latitude for razorbill between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

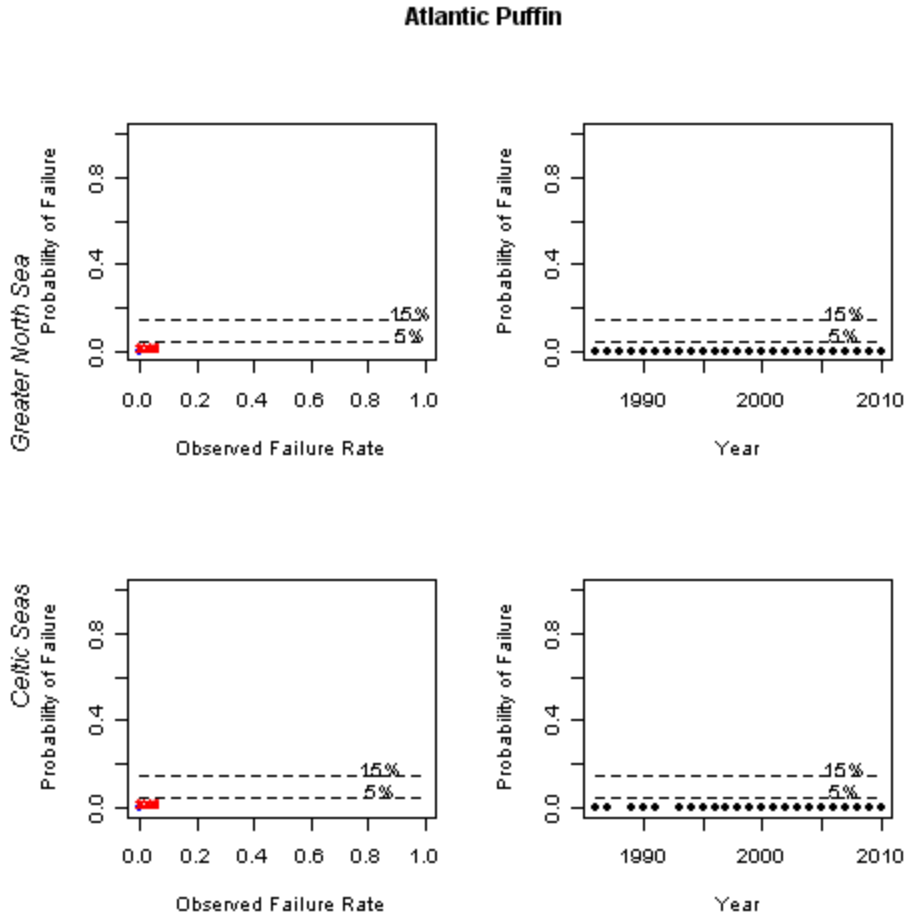

Figure A49 Breeding failure indicators for Atlantic puffin in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year.

Breeding failure was not recorded in either sub-region between 1986 and 2010 (Figure A49). However, as data cover only three colonies in the Greater North Sea sub-region and one colony in the Celtic Seas sub-region, Atlantic puffin should not be considered an appropriate indicator species.

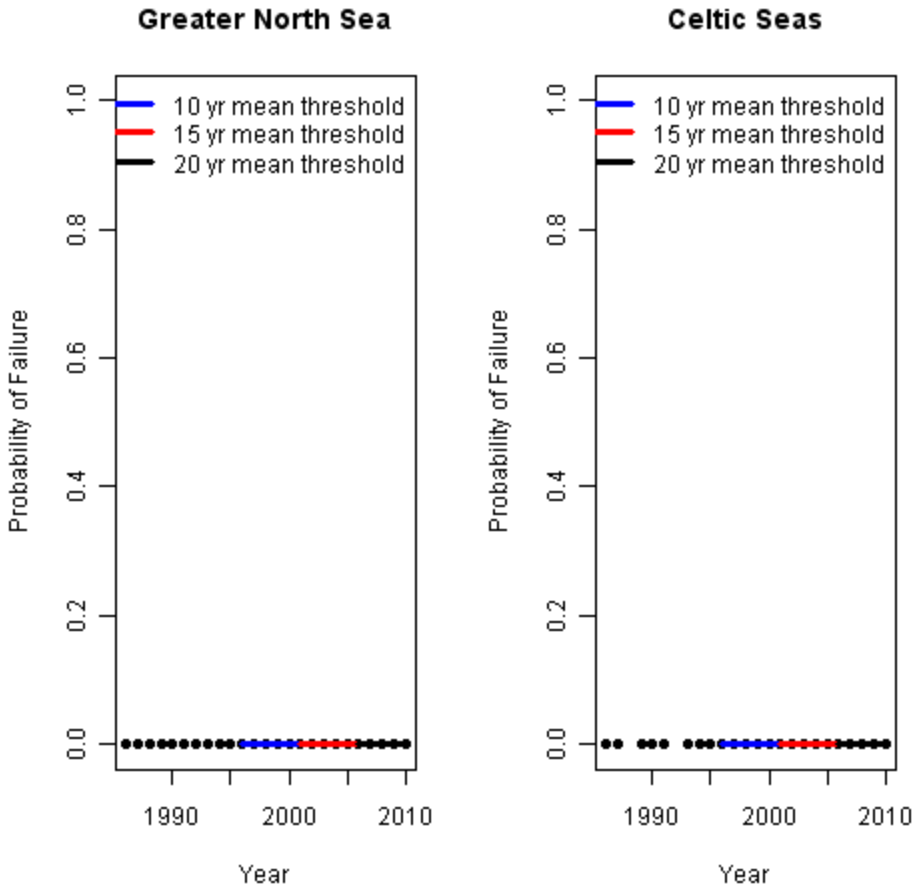

Figure A50 Breeding failure indicators for Atlantic puffin in the Celtic Seas and Greater North Sea sub-regions. Left hand plots show the modelled probability of failure rate in relation to the observed failure rate in each year and the right hand plots show the probability of any given colony failing in each year. Potential indicator targets based on rolling 10, 15 and 20 year mean annual failure rates.

The 10, 15 and 20 year rolling mean failure rates remained at 0 for all years. They were not exceeded in either sub-region in either year (Figure A50).

There were no obvious signs of spatial bias in the proportion of colonies experiencing breeding failure. Between 2005 and 2010, failure rates were distributed fairly evenly with respect of latitude in both sub-regions (Figure A51) and in 2010 there were no obvious clusters of failing colonies (Figure A51).

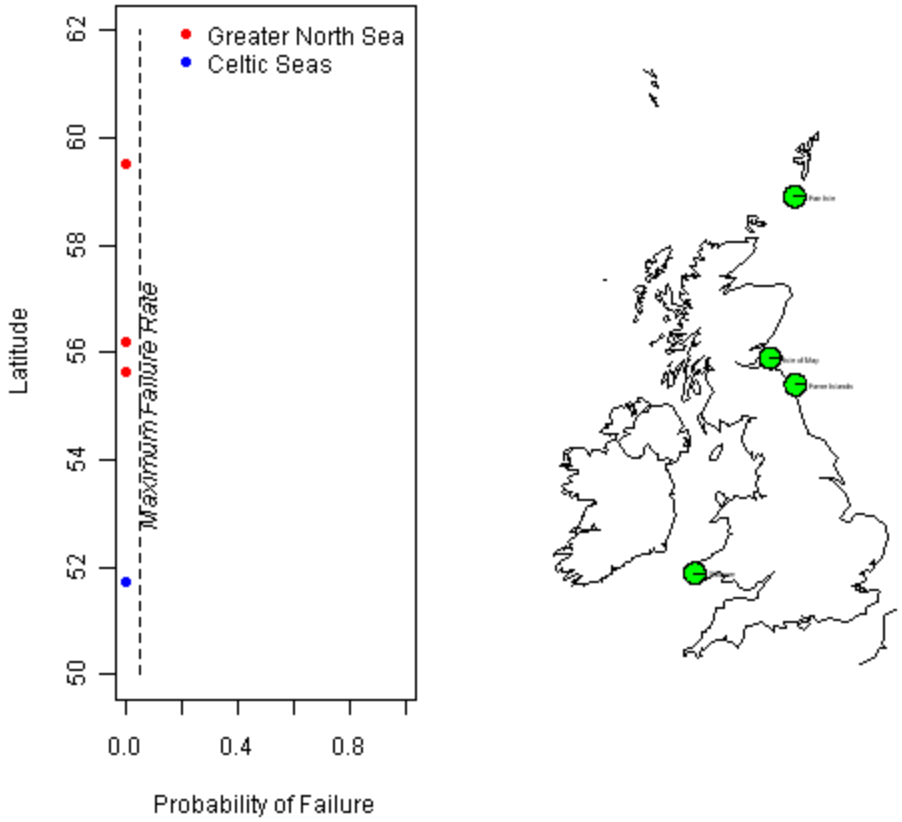

Figure A51 (left) Plot of modelled probability of breeding failure against latitude for Atlantic puffin between 2005 and 2010. Where failure to meet the target is driven by a cluster of colonies at similar latitude, this is likely to indicate a spatial bias in the data and consideration must be given as to how best to group these colonies for use in the indicator. (right) Map of colonies contributing to indicator, with modelled probability of failure at each colony in 2010 represented by a pie chart (red shows probability of failure, green shows probability of not failing).

Appendix 2

Species alerts status in relation to different breeding failure thresholds

Table A1 Assessment of breeding failure indicator against the target of less than 15% of colonies failing in more than three out of the previous six years for the Greater North Sea sub-region. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
1991	RED	RED	RED	RED	GREEN	GREEN	NA	GREEN	GREEN	NA	NA	NA	GREEN	GREEN	NA	GREEN	GREEN
1992	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	NA	GREEN	GREEN	NA	GREEN	GREEN
1993	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	NA	GREEN	GREEN	NA	GREEN	GREEN
1994	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	NA	GREEN	GREEN	NA	GREEN	GREEN
1995	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	NA	GREEN	GREEN	NA	GREEN	GREEN
1996	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
1997	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
1998	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
1999	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2000	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2001	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2002	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2003	RED	RED	AMBER	RED	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2004	RED	RED	RED	RED	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2005	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN
2006	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN
2007	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN
2008	RED	RED	RED	RED	RED	RED	GREEN	GREEN	GREEN	NA	GREEN	RED	GREEN	AMBER	GREEN	GREEN	GREEN
2009	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	NA	GREEN	RED	GREEN	AMBER	GREEN	GREEN	GREEN
2010	RED	RED	RED	RED	AMBER	AMBER	GREEN	GREEN	AMBER	NA	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN

Table A2 Assessment of breeding failure indicator against the target of less than 15% of colonies failing in more than three out of the previous six years for the Celtic Seas sub-region. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
1991	AMBER	AMBER	GREEN	RED	GREEN	NA	NA	NA	NA	NA	NA	NA	NA	GREEN	NA	GREEN	NA
1992	AMBER	GREEN	GREEN	RED	GREEN	NA	NA	NA	NA	NA	NA	NA	NA	GREEN	NA	GREEN	NA
1993	GREEN	GREEN	GREEN	RED	GREEN	NA	NA	NA	NA	NA	NA	NA	GREEN	GREEN	NA	GREEN	NA
1994	GREEN	GREEN	GREEN	RED	GREEN	NA	NA	NA	NA	NA	GREEN	NA	GREEN	GREEN	GREEN	GREEN	NA
1995	GREEN	GREEN	GREEN	RED	GREEN	NA	NA	NA	NA	GREEN	GREEN	NA	GREEN	GREEN	GREEN	GREEN	NA
1996	GREEN	GREEN	GREEN	RED	GREEN	NA	NA	NA	NA	GREEN	AMBER	NA	GREEN	GREEN	GREEN	GREEN	GREEN
1997	GREEN	GREEN	GREEN	RED	GREEN	NA	NA	NA	NA	GREEN	RED	NA	GREEN	GREEN	GREEN	GREEN	GREEN
1998	GREEN	GREEN	GREEN	AMBER	GREEN	NA	NA	GREEN	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
1999	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2000	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2001	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2002	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2003	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2004	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2005	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2006	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2007	GREEN	GREEN	GREEN	GREEN	AMBER	NA	NA	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2008	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN
2009	GREEN	GREEN	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN
2010	GREEN	GREEN	GREEN	RED	AMBER	NA	NA	GREEN	GREEN	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN

Table A3 Assessment of breeding failure indicator against the target of less than 5% of colonies failing in more than three out of the previous six years for the Greater North Sea sub-region. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
1991	RED	RED	RED	RED	GREEN	GREEN	NA	GREEN	GREEN	NA	NA	NA	GREEN	GREEN	NA	GREEN	GREEN
1992	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	NA	GREEN	GREEN	NA	GREEN	GREEN
1993	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	NA	GREEN	GREEN	NA	GREEN	GREEN
1994	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	NA	GREEN	GREEN	NA	GREEN	GREEN
1995	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	NA	GREEN	GREEN	NA	GREEN	GREEN
1996	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
1997	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
1998	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
1999	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2000	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2001	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2002	RED	RED	RED	RED	GREEN	AMBER	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2003	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2004	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2005	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN	AMBER	GREEN
2006	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN
2007	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN
2008	RED	RED	RED	RED	RED	RED	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	AMBER	GREEN	RED	GREEN
2009	RED	RED	RED	RED	RED	RED	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	RED	GREEN	RED	GREEN
2010	RED	RED	RED	RED	RED	RED	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	AMBER	GREEN	RED	GREEN

Table A4 Assessment of breeding failure indicator against the target of less than 5% of colonies failing in more than three out of the previous six years for the Celtic Seas sub-region. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
1991	RED	AMBER	RED	RED	GREEN	NA	NA	NA	NA	NA	NA	NA	NA	GREEN	NA	GREEN	NA
1992	RED	GREEN	RED	RED	GREEN	NA	NA	NA	NA	NA	NA	NA	NA	GREEN	NA	GREEN	NA
1993	RED	GREEN	RED	RED	GREEN	NA	NA	NA	NA	NA	NA	NA	GREEN	GREEN	NA	GREEN	NA
1994	RED	GREEN	RED	RED	GREEN	NA	NA	NA	NA	NA	AMBER	NA	GREEN	GREEN	GREEN	GREEN	NA
1995	RED	GREEN	RED	RED	GREEN	NA	NA	NA	NA	RED	AMBER	NA	GREEN	GREEN	GREEN	GREEN	NA
1996	RED	GREEN	RED	RED	GREEN	NA	NA	NA	NA	RED	RED	NA	GREEN	GREEN	GREEN	GREEN	GREEN
1997	RED	GREEN	RED	RED	GREEN	NA	NA	NA	NA	RED	RED	NA	GREEN	GREEN	GREEN	GREEN	GREEN
1998	RED	GREEN	RED	AMBER	GREEN	NA	NA	GREEN	GREEN	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
1999	RED	GREEN	AMBER	GREEN	GREEN	NA	NA	GREEN	GREEN	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2000	RED	GREEN	AMBER	GREEN	GREEN	NA	NA	GREEN	GREEN	RED	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2001	RED	GREEN	AMBER	GREEN	GREEN	NA	NA	GREEN	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2002	RED	GREEN	AMBER	GREEN	GREEN	NA	NA	GREEN	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2003	AMBER	AMBER	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2004	AMBER	AMBER	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	GREEN	GREEN
2005	RED	RED	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN
2006	RED	RED	GREEN	GREEN	GREEN	NA	NA	GREEN	GREEN	AMBER	RED	GREEN	GREEN	RED	GREEN	GREEN	GREEN
2007	RED	AMBER	GREEN	GREEN	AMBER	NA	NA	GREEN	GREEN	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	GREEN
2008	GREEN	AMBER	GREEN	GREEN	RED	GREEN	GREEN	GREEN	GREEN	AMBER	RED	GREEN	AMBER	AMBER	AMBER	GREEN	GREEN
2009	GREEN	GREEN	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	RED	RED	GREEN	AMBER	AMBER	RED	GREEN	GREEN
2010	GREEN	AMBER	GREEN	RED	RED	NA	NA	GREEN	GREEN	AMBER	RED	GREEN	AMBER	GREEN	RED	GREEN	GREEN

Table A5 Assessment of breeding failure indicator against the target of the percentage of colonies failing in more than three out of the previous six years for the Greater North Sea sub-region does not exceed the mean percentage failing over the preceding 10 years. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
1996	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	GREEN
1997	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	GREEN
1998	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	GREEN
1999	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	GREEN
2000	RED	RED	RED	RED	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	GREEN
2001	RED	RED	AMBER	AMBER	GREEN	AMBER	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	GREEN
2002	RED	RED	RED	AMBER	AMBER	NA	NA	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	GREEN
2003	RED	RED	AMBER	GREEN	RED	NA	NA	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	AMBER	GREEN
2004	RED	RED	RED	GREEN	AMBER	AMBER	GREEN	GREEN	RED	GREEN	GREEN	AMBER	RED	GREEN	RED	GREEN	GREEN
2005	RED	RED	RED	AMBER	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	RED	AMBER	GREEN
2006	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	RED	RED	GREEN
2007	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN
2008	RED	RED	RED	RED	RED	RED	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	AMBER	GREEN	RED	GREEN
2009	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	AMBER	GREEN	RED	GREEN
2010	RED	RED	RED	RED	AMBER	AMBER	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN

Table A6 Assessment of breeding failure indicator against the target of the percentage of colonies failing in more than three out of the previous six years for the Celtic Seas sub-region does not exceed the mean percentage failing over the preceding 10 years. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
1996	GREEN	GREEN	GREEN	RED	GREEN	NA	NA	NA	NA	GREEN	RED	NA	GREEN	GREEN	GREEN	GREEN	RED
1997	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	NA	NA	AMBER	RED	NA	GREEN	GREEN	GREEN	GREEN	RED
1998	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	RED	RED	AMBER	GREEN	AMBER	GREEN	GREEN	RED
1999	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	GREEN	RED	AMBER	GREEN	AMBER	GREEN	GREEN	RED
2000	GREEN	GREEN	GREEN	GREEN	RED	NA	NA	RED	GREEN	GREEN	RED	GREEN	GREEN	RED	GREEN	GREEN	RED
2001	GREEN	GREEN	GREEN	GREEN	RED	NA	NA	RED	GREEN	AMBER	RED	GREEN	GREEN	RED	GREEN	GREEN	RED
2002	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2003	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	GREEN	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2004	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	GREEN	AMBER	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2005	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2006	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	AMBER	RED	GREEN	GREEN	RED	GREEN	GREEN	RED
2007	GREEN	GREEN	GREEN	GREEN	AMBER	NA	NA	RED	GREEN	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2008	GREEN	GREEN	GREEN	GREEN	RED	GREEN	RED	RED	GREEN	AMBER	RED	GREEN	AMBER	AMBER	AMBER	GREEN	RED
2009	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	RED	RED	GREEN	RED	RED	GREEN	AMBER	AMBER	RED	GREEN	RED
2010	GREEN	GREEN	GREEN	RED	GREEN	NA	NA	RED	GREEN	AMBER	RED	GREEN	AMBER	GREEN	RED	GREEN	RED

Table A7 Assessment of breeding failure indicator against the target of the percentage of colonies failing in more than three out of the previous six years for the Greater North Sea sub-region does not exceed the mean percentage failing over the preceding 15 years. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
2001	RED	RED	AMBER	AMBER	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	GREEN
2002	RED	RED	AMBER	GREEN	GREEN	AMBER	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	GREEN	GREEN
2003	RED	RED	AMBER	GREEN	AMBER	AMBER	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	AMBER	GREEN
2004	RED	RED	RED	GREEN	AMBER	AMBER	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN	RED	AMBER	GREEN
2005	RED	RED	RED	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	AMBER	GREEN	GREEN	RED	AMBER	GREEN
2006	RED	RED	RED	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	RED	RED	GREEN
2007	RED	RED	RED	AMBER	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN
2008	RED	RED	RED	RED	RED	RED	GREEN	GREEN	RED	NA	GREEN	RED	AMBER	AMBER	GREEN	RED	GREEN
2009	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	RED	GREEN	RED	GREEN
2010	RED	RED	RED	RED	AMBER	AMBER	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN

Table A8 Assessment of breeding failure indicator against the target of the percentage of colonies failing in more than three out of the previous six years for the Celtic Seas sub-region does not exceed the mean percentage failing over the preceding 15 years. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
2001	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	AMBER	RED	AMBER	GREEN	RED	GREEN	GREEN	RED
2002	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	GREEN	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2003	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	GREEN	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2004	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	GREEN	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2005	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	GREEN	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2006	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	AMBER	RED	GREEN	GREEN	RED	GREEN	GREEN	RED
2007	GREEN	GREEN	GREEN	GREEN	AMBER	NA	NA	RED	GREEN	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2008	GREEN	GREEN	GREEN	GREEN	RED	GREEN	RED	RED	GREEN	AMBER	RED	GREEN	AMBER	AMBER	AMBER	GREEN	RED
2009	GREEN	GREEN	GREEN	AMBER	RED	GREEN	RED	RED	GREEN	RED	RED	GREEN	AMBER	AMBER	RED	GREEN	RED
2010	GREEN	GREEN	GREEN	RED	RED	NA	NA	RED	GREEN	AMBER	RED	GREEN	AMBER	GREEN	RED	GREEN	RED

Table A9 Assessment of breeding failure indicator against the target of the percentage of colonies failing in more than three out of the previous six years for the Greater North Sea sub-region does not exceed the mean percentage failing over the preceding 20 years. Green indicates that target has been met or exceeded, Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
2006	RED	RED	RED	GREEN	AMBER	RED	GREEN	GREEN	GREEN	GREEN	GREEN	RED	GREEN	GREEN	RED	RED	GREEN
2007	RED	RED	RED	AMBER	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED	GREEN	GREEN	GREEN	RED	GREEN
2008	RED	RED	RED	RED	RED	RED	GREEN	GREEN	RED	NA	GREEN	RED	AMBER	AMBER	GREEN	RED	GREEN
2009	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	RED	GREEN	RED	GREEN
2010	RED	RED	RED	RED	AMBER	RED	GREEN	GREEN	RED	NA	GREEN	RED	GREEN	RED	GREEN	RED	GREEN

Table A10 Assessment of breeding failure indicator against the target of the percentage of colonies failing in more than three out of the previous six years for the Celtic Seas sub-region does not exceed the mean percentage failing over the preceding 20 years. Green indicates that target has been met or exceeded; Amber indicates that target has not been met in three out of the previous six years and Red indicates that target has not been met in four or more of the past six years. Species taken forward as indicators highlighted in red boxes.

	Arctic Tern	Little Tern	Common Tern	Sandwich Tern	Kittiwake	Arctic Skua	Great Skua	Atlantic Puffin	Razorbill	Lesser Black-backed Gull	Herring Gull	Great Black-backed Gull	Common Guillemot	Shag	Great Cormorant	Fulmar	Northern Gannet
2006	GREEN	GREEN	GREEN	GREEN	GREEN	NA	NA	RED	GREEN	GREEN	RED	GREEN	GREEN	RED	GREEN	GREEN	RED
2007	GREEN	GREEN	GREEN	GREEN	AMBER	NA	NA	RED	GREEN	AMBER	RED	GREEN	GREEN	AMBER	GREEN	GREEN	RED
2008	GREEN	GREEN	GREEN	GREEN	RED	GREEN	RED	RED	GREEN	AMBER	RED	GREEN	AMBER	AMBER	AMBER	GREEN	RED
2009	GREEN	GREEN	GREEN	AMBER	RED	GREEN	RED	RED	GREEN	RED	RED	GREEN	AMBER	AMBER	RED	GREEN	RED
2010	GREEN	GREEN	GREEN	RED	RED	NA	NA	RED	GREEN	AMBER	RED	GREEN	AMBER	GREEN	RED	GREEN	RED