ICES WGSE REPORT 2010

Report of the
Working Group on Seabird Ecology (WGSE)

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Contents

Executive summary

The ICES Working Group on Seabird Ecology met from 15 to19 March 2010 at ICES HQ, Copenhagen. Chaired by Jim Reid (UK), eight participants attended the meeting with remote contributions from a further five; eight nations were represented.

The objective of the meeting was to consider nine Terms of Reference and to make recommendations for further action where appropriate. With more Terms of Reference than attendees, and no work carried out intersessionally, not all Terms of Reference given the group were addressed at the meeting and some were not addressed in as much detail as would have been preferred. Each attendee largely worked on one chapter of the report, although contributions to all chapters were made by most of the group and feedback was offered in regular plenary sessions. Issues addressed by the Terms of Reference included seabird bycatch in fisheries, an OSPAR Ecological Quality Objective for seabird populations, a report of case studies of the tracking of seabirds using data loggers, a review of literature on the associations between foraging seabirds and other top predators, a review of progress with the identification of marine Special Protection Areas for seabirds, and a consideration of the possible consequences of climate change on parasites hosted by seabirds.

The report comprises nine chapters, each addressing one Term of Reference, plus introductory material and other information contained in Annexes, including two recommendations for further action by ICES.

An updated application of the OSPAR Ecological Quality Objective for 12 seabird populations in OSPAR region III is presented in the report. This indicator failed to reach its reference level in 11 of the 24 years for which data are available. The reasons why some seabird populations have not fared well in recent years are various but climate change and fisheries effects have probably played a role. It should be noted, however, that there is some uncertainty associated with the value of the indicator as confidence intervals around many seabird population estimates are wide. In view of the value of the Ecological Quality Objective as a relatively simple to understand indicator of the health of the wider marine environment, the report recommends that it be further developed and applied to other OSPAR regions, with annual updates being channelled via the Working Group on Seabird Ecology.

The report presents new information and an updated review of the problem of seabirds being incidentally caught in fishing gear, which can cause significant mortality in some seabird populations. The European Union has committed to establishing a Plan of Action to mitigate this bycatch in its waters, but progress has been slow and it has missed its own deadline for doing this. The report recommends that a workshop be convened in autumn 2010 to bring together the key players, the EU, scientists and fishers among them, who could best inform the compilation of a Plan of Action in order to effect swifter progress towards reducing seabird bycatch.

1   Introduction

Participation

The following members of the Working Group on Seabird Ecology (WGSE) attended and participated in the meeting (see Annex 1 for full details):

- Orea Anderson   UK
- Tycho Anker-Nilssen   Norway
- Rob Barrett   Norway
- John Chardine   Canada
- Morten Frederiksen   Denmark
- Jim Reid (Chair)   UK
- Mark Tasker   UK
- Richard Veit   USA

Seven persons were nominated members of the group and one person was invited by the WG Chair to attend this year's meeting. The authority to nominate persons not yet nominated by national delegates was again considered by the group to be an extremely useful tool.

The following members and non-members of WGSE also contributed to the meeting and/or report by correspondence: Pep (J. M.) Arcos (Spain), Mark Bolton (UK), Thierry Boulinier (France), Francis Daunt (UK), Ben Dean (UK), Euan Dunn (UK), Stefan Garthe (Germany), Kerstin Kober (UK), Ian Mitchell (UK), Sue O'Brien (UK), Matt Parsons (UK), Martin Poot (Netherlands), Iván Ramírez (Portugal), and Linda Wilson (UK).

Terms of Reference

The 2009 Statutory meeting of ICES gave the Working Group on Seabird Ecology [WGSE] the following Terms of Reference:

a) Review progress with further development of the OSPAR ecological quality objective (EcoQO) for seabird populations, and provide an updated evaluation of the EcoQO in Ospar region III;

b) Update and extend the review of studies of the distribution and habitat associations of seabirds in ICES waters based on remote tracking of individual birds;

c) Review progress towards a Community Plan of Action to reduce seabird bycatch in EU waters, and report any new data on fishing effort and seabird bycatch in these waters;

d) Explore the use of demographic, behavioural and physiological data as early warning systems of population change in seabirds;

e) Review the predicted interactions between parasites and climate change on seabirds;

f) Review and summarize the literature on foraging interactions among seabirds, cetaceans, and predatory schooling fish, especially tuna, mainly in North Atlantic waters but with relevant material from all oceans;

g) Review methodological approaches applied in, and progress with, the identification of marine protected areas for birds in EU waters;

h) Report by 15 March on potential contributions to the high priority topics of ICES Science Plan by completing the document named "SSGEF_workplan.doc" on the SharePoint site. Consider your current expertise and rank the contributions by High, Low or Medium importance;

i) Prepare contributions for the 2010 SSGEF session during the ASC on the topic areas of the Science Plan which cover: Individual, population and community level growth, feeding and reproduction; The quality of habitats and the threats to them; Indicators of ecosystem health.

With one exception, all Terms of Reference were addressed by WGSE. It was not possible to consider ToR d) because of the fewer than usual numbers of participants in the meeting. For the same reason, some ToRs were not considered in as much detail as the group would have preferred.

Note on bird names

Throughout the text we use official English names for bird species; scientific and English names are listed in Annex 2.

Acknowledgements

The Working Group on Seabird Ecology wishes to thank ICES Secretariat for excellent facilities in ICES HQ in Copenhagen; Maria Lifentseva was especially helpful during the meeting and in the production of this report. WGSE also thanks the National Environmental Research Institute, Aarhus University for hosting the meeting on one day. The following persons and organisations provided support, information and data to enable the EcoQO for Ospar region III to be compiled: for the meeting: the JNCC Seabird Monitoring Programme partners: BirdWatch Ireland, The British Trust for Ornithology, Centre for Ecology and Hydrology, Countryside Council for Wales, Department of Agriculture, Fisheries and Forestry (Isle of Man), Department of Environment, Heritage and Local Government (Republic of Ireland), States of Guernsey Government, Joint Nature Conservation Committee, Manx Birdlife, Manx National Heritage, The National Trust, National Trust for Scotland, Natural England, Northern Ireland Environment Agency, The Royal Society for the Protection of Birds, Scottish Natural Heritage, The Seabird Group, Shetland Oil Terminal Environmental Advisory Group, Scottish Wildlife Trust; and other organisations and volunteers throughout Britain and Ireland.

WGSE thanks the following for providing access to unpublished information: Carsten Egevang, Kasper Johansen, Jeremy Madeiros, Ævar Petersen, Paul Thompson, and Steve Votier.

2 Recent progress with the OSPAR EcoQO for seabird populations

For the last ten years, WGSE has contributed to develop an EcoQO for the status of seabirds within the OSPAR area. Application of the resulting system in OSPAR Region III indicates that it is scientifically sound and performing well according to the main intentions of this EcoQO. As illustrated in last year's report (ICES 2009), a rather high proportion of the seabird populations in several OSPAR areas are currently changing at rates beyond expected and desirable levels. WGSE therefore recognises there is an urgent need for implementing the proposed EcoQO across the OSPAR regions and, in this context, to employ the improved statistical framework for assess-

ing population trends that is applied in the revised analysis for OSPAR III presented in section 2.2 of this chapter.

2.1 Further development of the EcoQO

A workshop to develop a Seabird Ecological QUality INdicator (WKSEQUIN) was requested by OSPAR's Biodiversity Committee (BDC). The Workshop was organised by the ICES WGSE, in collaboration with the UK's Joint Nature Conservation Committee (JNCC) and the German Delegation on the BDC. WKSEQUIN was held in Lisbon on 8–9 March 2008 and hosted by Sociedade Portuguesa para o Estudo das Aves (SPEA). The aim of the workshop was to continue the development previously carried out by WGSE, of an EcoQO on Seabird population trends as an index of seabird community health, and in doing so, to produce at least one EcoQO with its associated indicator, target, and limit as an example of what others might look like.

Based on the results of WKSEQUIN (ICES 2008), ICES advised OSPAR to adopt a single EcoQO: "Changes in breeding seabird abundance should be within target levels for 75% of species monitored in any of the OSPAR regions or their subdivisions." The aims of the EcoQO should be to ensure the intrinsic health of seabird communities, and to provide triggers for appropriate action.

Separate EcoQO indicators were proposed for each OSPAR region or region, each consisting of species-specific trends in abundance of a number of species where good quality monitoring data were available. Data were immediately available to construct an indicator for OSPAR III (ICES 2008), which has been updated herein (see below).

Data were also available for OSPAR region V but as yet, no indicator for this region has been produced. Further data collation is required to construct indicators for OSPAR regions II and IV. A subdivision of OSPAR I and expansion of monitoring in some of its subareas is required before sufficient data will be available to construct a robust indicator.

In a background document on the EcoQO presented by the German Delegation to the OSPAR Working Group on Marine Protected Areas Species and Habitats (OSPAR 2009) they concluded:

- The EcoQO on seabird population trends has been demonstrated to work in OSPAR III;
- Further work is required to collate data in OSPAR II and IV: a depository for data is needed to be nominated within OSPAR II, IV and V;
- Further work is required in OSPAR II, IV and V to set up analytical models for estimating trends in each species and to set reference and target levels for each regional species.

At MASH 2009 Germany offered "to consider facilitating the collation and analysis of existing data on seabird breeding abundance for the North Sea with a view to construct specific target and reference levels for OSPAR Region II. To support this, Contracting Parties bordering the North Sea are requested to facilitate the provision of relevant data to support construction of the specific target and reference levels. Germany will circulate specifications for the data required in due course."

At MASH 2009 France offered "to support the collation of appropriate data for the construction of target and reference levels for Region IV and to clarify the needs for provision of data by other Contracting parties in the Region."

The adoption by OSPAR of the EcoQO on seabird population trends is likely to depend on it being an appropriate indicator in assessing and achieving Good Environmental Status (GES) as part of measures to be implemented under the EC Marine Strategy Framework Directive (MSFD; EU 2008). The goal of the MSFD is to achieve GES for European seas by 2020. The main guiding principles for achieving this are set out in the list of 11 qualitative descriptors contained in Annex 1 of the Directive. These cover a broad range of issues including biological diversity, seabed integrity, eutrophication, contaminants, litter and underwater noise. Task Groups have been established to promote a comparable and consistent interpretation of the concept of GES. The output of the Task Groups will be assessed by the Working Group on Good Environmental Status, which will in turn report to the Marine Strategy Coordination Group and the Marine Directors. The work is due to be completed in May 2010. Task Group 4 – 'Food webs' has recommended that the EcoQO on Seabird Population Trends be adopted as part of the indicator suite for determining GES with respect to food webs. Task group 1 – 'Biological Diversity' – has not attempted to list all potential indicators for this descriptor, but has included the EcoQO as indicator in an example of the process it is recommending for the monitoring and assessment of GES.

2.2 Updated evaluation of the EcoQO in OSPAR Region III

2.2.1 Introduction

WKSEQUIN used data from OSPAR Region III to demonstrate and test the process of determining whether the EcoQO had been achieved in a given year (ICES 2008). The indicators for the EcoQO were intra-specific trends in abundance of eight species of seabird during the period 1986–2006. Data for OSPAR Region III were collected as part of the UK and Ireland's Seabird Monitoring Programme (SMP). Reference levels for each species were derived from previous censuses of the whole OSPAR region (see Table 2.1). An upper target level of 130% of the reference level was set for all species, while a lower target level of 80% was set for species that lay one egg and a separate lower target level of 70% for species that lay more than one egg. The same targets and references are used in this update.

In updating the EcoQO we have added data from 2007–2009, included plot counts as well as whole colony counts and added four more species. Most colonies in OSPAR III were not surveyed in each year of the time series, so imputation techniques were used to estimate the missing counts. The imputation methods used in this update are different to those used in ICES (2008) – for details see section 2.2.2 below.

2.2.2 Methods

The first assessment of the EcoQO (ICES 2008) used log-linear models (through the software package TRIM) to provide estimates of trends in abundance of each species. However, such models tend to be inappropriate for the seabird species included in the EcoQO indicator because their trends exhibit little or no spatial synchrony and, for species such as terns and cormorants, a substantial proportion of colonies have undergone extinction or colonisation events.

Since WKSEQUIN, JNCC in collaboration with Biomathematics and Statistics Scotland developed an analytical 'wizard' for estimating trends in breeding numbers of individual species at various geographical scales including OSPAR Regions. The seabird trend wizard uses a modified chain method, first developed by Thomas (1993), to impute values of missing counts based on information in other years and sites (details of the Thomas method are given in Annex 3 of ICES 2008). The wizard is a small

Delphi application that retrieves counts from an Access database and generates script files and a DOS batch file that instruct R to conduct the trend analysis using the Thomas (1993) method. A further advantage of the new wizard is that the analyses can incorporate both whole colony counts and plot counts, even when they exist for the same colony in the same year.

It is important to note that the confidence intervals about the estimates obtained using the imputation procedure were typically very wide. This reflected the fact that the method is empirical, and that the intervals were based on a form of nonparametric resampling that makes only weak assumptions regarding the structure of the data.

In this update we included data from four additional species: Arctic skua, great cormorant, little tern and roseate tern. The reference levels for these species are given in Table 2.1.

Table 2.1. Species-specific reference levels for OSPAR III.

SPECIES	OSPAR III REFERENCE LEVELS		PROPORTION OF REGIONAL POPULATION IN SAMPLE	SOURCE	JUSTIFICATION FOR REFERENCE LEVEL
	ABUNDANCE[1]	YEAR			
Northern fulmar	192.295	1998–2000	7%	a	Numbers increased and range expanded throughout most of 20th century, but plateaued during Seabird 2000 in NW Scotland where there are the largest colonies in OSPAR III; however, it appears to be still increasing in Wales and possibly in SW England and Ireland.
Arctic skua	193	1986–1987	62%	b	The counts during 1986-87 provided the first comprehensive estimate of numbers breeding throughout the Region. More recently censused in 2001-02. Severe declines in breeding numbers in neighbouring OSPAR II from late 1990s onwards, suggest large negative anthropgenic impacts on food supply that has been exacerbated by increased predation and competition from great skuas. *The p*opulation estimate in 1986-87 is therefore less influenced by anthropogenic impacts than more recent estimates.
Great cormorant	9.074	1999–2001	76%	a	Most coastal breeding cormorants in OSPAR III are thought to be of the nominate sub-species. OSPAR III hosts almost one fifth of the world population of *P.c.carbo*, so higher population estimates were chosen as reference level. Note: following this estimate, in 2003, the maximum number of licences issued per year for culling cormorants in England and Wales increased from 200 to 2-3,000.
European shag	22.362	1986–1988	59%	b	Numbers were increasing throughout most of Britain and Ireland, until large mortality event (or 'wreck') as a result of severe weather during the winter of 1992/93 severely reduced breeding numbers. Therefore, the Seabird Colony Register provides the best reference level.
Herring gull	106.415	1986–1987	59%	b	Numbers were probably artificially elevated during the 1960s by uncontrolled discarding and offal discharge by fisheries. Subsequent controls were probably responsible for a large decrease during the 1970s and early 1980s. During the 1990s numbers in Ireland were severely reduced during outbreaks of botulism. The population size during the SCR was probably the least impacted by human pressures.
Great black-backed gull	10.261	1986–1988	53%	b	Similar scenario to the herring gull.

SPECIES	OSPAR III Reference levels		PROPORTION OF REGIONAL POPULATION IN SAMPLE	SOURCE	JUSTIFICATION FOR REFERENCE LEVEL
	ABUNDANCE[1]	YEAR			
Black-legged kittiwake	118.222	1985–1987	57%	b	Increased in numbers between the censuses in 1969/70 and 1985-88, but subsequent food shortages in NW Scotland may have reduced numbers there. Therefore, the SCR provides the best reference level.
Little tern	648	1986–1987	78%	b, c	The number of birds attempting to breed are highly variable from one year to the next and greatly affected by local conditions (e.g. predation). Little change in numbers breeding in the region between mid 1980s and 2000, so opted for slightly higher estimate in 1986-87.
Sandwich tern	4.610	1987–1988	95%	b, c	Mortality of birds on wintering grounds in W. Africa appears to have increased in late 1980s and early 1990s, partially through trapping. Therefore, the SCR and All-Ireland tern survey (1984) appear to provide the best reference levels.
Roseate tern	2.700	1967–1968	100%		There were very large declnes in breeding numbers during the 1970s and 1980s, mainly due to high mortality resulting from trapping on the wintering grounds in W. Africa. Therefore the 1967-68 population estimates, prior to this significant anthropogenic impact, provide the best reference level.
Common guillemot	616.975	1998–2000	74%	a	Numbers have steadily increased throughout the 1970s, 1980s and 1990s, and continue to do so throughout most of OSPAR III. Seabird 2000 provided the most recent population estimate, but depending on future changes in population size, subsequent censuses may provide a more appropriate reference.
Razorbill	135.663	1998–2001	62%	a	As for common guillemot

Source: a) Seabird 2000 (Mitchell *et al.* 2004), b) Seabird Colony Register Census (Lloyd *et al.* 1991, Mitchell *et al.* 2004), c) All-Ireland Tern Survey (Whilde 1985). [1]Unit of abundance is pairs for all species except *Alca torda* and *Uria aalge,* which are listed as the number of birds.

In ICES (2008) separate trend models were produced for data collected from Britain and from Ireland of great black-backed gull, herring gull and black-legged kittiwake in an attempt to reduce potential error from assuming synchrony between colonies when using TRIM to model the trends. For all other species, data were too sparse to produce separate trends for Britain and Ireland, so data were pooled for the whole of OSPAR region III. In the 2009 update, modelling separate trends for Britain and for Ireland did not increase the accuracy or reduce uncertainty of the resultant OSPAR regional trend for any species. For all species, data from throughout OSPAR III were pooled for trend modelling.

The accuracy and precision of the modelled regional trend for northern fulmar were increased by restricting data input from only those colonies that had been surveyed in 5 years or more during 1986–2009. Data from all other species derived from colonies that had been surveyed in 2 or more years during 1986–2009 (as in ICES 2008). This reduced the sample size for fulmar to just 7% of the total number of pairs known to breed in OSPAR III (1998–2002 census; Mitchell *et al*.2004), compared with more than 50% for all other species (Table 2.1).

Reference levels for each species are presented in Table 2.1. These same references were used in ICES (2008), except for the four additional species mentioned (Arctic skua, great cormorant, little tern and roseate tern).

2.2.3 Results

The EcoQO was not achieved in 1988, 1989, 1990, 1992 and in consecutive years during 2003–2009 (see Figure 2.1). It made little difference to the assessment whether eight (cf. ICES 2008) or 12 species were included (see Figure 2.1a and b). ICES (2008) discussed possible reasons why the ECoQO was not achieved during the late 1980s and early 1990s. This update will concentrate on why it was not achieved in 2003–2009.

a) n=8 species

b) n=12 species

Figure 2.1. The proportion of species in OSPAR III that were within target levels of abundance during 1986-2009, based on a) the same eight species as used in the assessment of EcoQO in ICES (2008), or b) with an additional four species included (see text). The EcoQO was not achieved in years when the proportion dropped below 75%.

The number of species not achieving targets during 2003–2009 increased in consecutive years from four to nine in both 2008 and 2009. In the last 2 years, the abundance of six species had fallen below their respective lower targets, while three species exceeded the upper targets. The species exceeding targets at some point during 2003-09 were great cormorant, little tern and Sandwich tern (Figure 2.2). If these three species had not exceeded their targets, the EcoQO would still not have been achieved in consecutive years between 2005 and 2009 because the abundance of four or more species fell below lower target levels.

Figure 2.2. Trends in abundance in OSPAR Region III. Fine dotted lines indicate upper and lower boot-strapped confidence limits. Bold dashed lines indicate upper and lower targets; 100 = reference level.

Roseate tern abundance has been below the lower target throughout 1986–2009, but has steadily increased during this period from 18% to 45% of the reference level.

European shag abundance was relatively lower than roseate tern in 2009 (i.e. 44% of reference level). Shag numbers have been at or below the lower target since 1993, but have been declining further since 2004.

Herring gull numbers have been in decline since the early 1970s but the reference level was set at mid 1980s level because numbers were thought to have been previously elevated by anthropogenic activities (e.g. commercial fisheries). Numbers have been steadily decreasing since 2000 and fell below target levels from 2002 onwards.

Arctic skua numbers have been below the lower target since 2005, and in 2009 were 63% of the reference level.

Black-legged kittiwake and northern fulmar numbers both fell below the target level in 2008 and 2009. Kittiwake numbers have been declining since about 2000 whereas the decline in fulmar numbers began earlier in the mid 1990s but has become steeper since 2006.

Great black-backed gull numbers have remained within target levels throughout 1986–2009 and have shown no discernable trend. Razorbill and common guillemot numbers increased steadily during the 1980s and 1990s but appear to have stabilised during 2003–2005 just below upper target levels. There are signs of a decrease in razorbill numbers in the last 2–3 years.

2.2.4 Conclusions

The failure to achieve the EcoQO in OSPAR III in consecutive years between 2003 and 2009 does represent cause for concern given that numbers of six of the twelve species sampled were all below lower target levels in 2008 and 2009 and five species showed substantial declines.

The declines in three of these species, roseate tern, Arctic skua and herring gull, have already been highlighted within the UK and have been listed on the UK Biodiversity Action Plan and on the Red list of Birds of Conservation Concern in the UK (Eaton *et al*. 2009). Roseate tern numbers have been increasing as a direct result of intensive management of colonies in Ireland. Arctic skuas are relatively scarce in OSPAR III but the trend here mirrors a steeper decline in the neighbouring Northern Isles (OSPAR II) where impacts of climate change and fishing on food supply have has been exacerbated by increased predation and competition from great skuas. The cause of the decline in herring gulls throughout the UK and Ireland is less well understood and requires further research.

The EcoQO highlights a substantial decline in shag numbers in OSPAR III. Declines have occurred in the rest of the UK but not to the same extent. Further work is urgently needed to investigate the cause of this decline.

The recent decreases in kittiwake and fulmar numbers in OSPAR III demand continued monitoring and investigation is required to determine the likely causes. Kittiwake colonies within OSPAR III have been more successful than colonies on the east coast of Britain (OSPAR II), which have been in decline in some areas since the late 1980s. A shortage of sandeels off the east coast is probably responsible for poor breeding there, but kittiwakes at colonies in western Britain tend to feed on other species of fish. More work is needed into the variation in availability of these prey species.

There is probably little for conservation managers to be concerned about regarding the increase in little and Sandwich tern numbers; it represents a successful conservation gain, following intensive management at most colonies to reduce the impacts of

predators. It would make sense to increase the reference levels for these two species. The increase in great cormorant numbers may have negative implications locally at some colonies where competition for nest sites is intense. However, the *carbo* subspecies is relatively scarce with just 52 000 pairs globally (Mitchell *et al.* 2004) and is culled both legally and illegally because of conflict with fisheries. It is probably worth monitoring the large and expanding colonies for any impacts on other species.

2.3 References

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3 Tracking studies of seabirds in ICES waters: case studies

At its 2008 meeting, WGSE formulated a Term of Reference aimed at summarizing the results of studies of the distribution and habitat associations of seabirds in ICES waters as revealed by remote tracking of individual birds. This is a very large and rapidly developing subject, and it was not possible to cover it exhaustively at the 2009 meeting (ICES 2009). Therefore, a new Term of Reference for the 2010 meeting was formulated to extend and update the review. The 2009 chapter focussed on technological and analytical issues and presented a preliminary review of published and ongoing studies using a variety of techniques to track the movements of individual birds and evaluate their habitat preferences at sea, followed by a brief summary of data analysis issues. Here, we focus more on the results and insights obtained through these studies and present a number of illustrative case studies.

3.1 Introduction

Species' distributions and habitat associations are central components of their ecology, and provide crucial underpinning data for their conservation and for the identification of protected areas. Two main methods have been employed to ascertain distribution – surveying (principally transect surveying) and individual animal track-

ing. Both methods have proven invaluable and have complementary advantages (see Table 3.1 in ICES 2009).

One important goal of animal tracking is to record an animal's location, from which population distribution is inferred. Habitat association is typically then inferred by comparing distribution with available habitat within the animal's potential range, the habitat data having been collected by other methods (e.g. remote sensing, habitat mapping). Alternatively, habitat association may be inferred directly by a data logger.

In the marine environment, there has been a particularly wide adoption of individual animal tracking as a technique for estimating distribution, because direct surveying tends to be expensive and logistically difficult. With identification of important seabird habitats being critically important for spatial planning, and helping to identify both Special Protection Areas (EU 2009) and areas of common usage by seabirds and fishery, tracking of individual birds using electronic devices is one of the most important sources of information available for these purposes.

As summarized in ICES (2009), this method has some important advantages over surveying methods, in particular the quality of information that is obtained on individuals. This includes high quality data on where an individual carries out different activities such as feeding and resting at sea, which is important in interpreting habitat associations. Animal tracking also provides invaluable information on the individual's status, including its provenance, breeding status and gender. These are all important variables in understanding the constraints under which the individual is operating, which in turn aids in the interpretation of distribution and habitat association.

Here, we review a number of recent case studies from the ICES region that illustrate what can be achieved by tracking seabirds. These case studies are selected so that they cover work on widely differing geographical scales and with different aims. We also attempt to generalise across case studies to identify some of the key insights obtained through the use of tracking technologies.

3.2 Case study 1: The global migration of the Arctic tern (Egevang *et al.* 2010)

3.2.1 Background and aims

The Arctic tern has long been suspected to have the longest annual migration of all birds, as it breeds in boreal and Arctic areas of the northern hemisphere and winters in the Southern Ocean near Antarctica. However, until very recently it was not logistically feasible to track the migration of such a small bird (weighing not much more than 100 g) over such vast distances and throughout the annual cycle. The availability of miniature geolocators (see ICES 2009 and next section) changed this, and the Greenland Institute of Natural Resources, in collaboration with the Icelandic Institute for Natural History and the British Antarctic Survey, decided to carry out such a study in 2007–2008. The main aim of the study was to map the annual migration of the Arctic tern and to identify whether there were any areas of specific importance to the species during the many months individuals spend at sea, usually out of sight of land.

3.2.2 Technological and analytical approach

The study used geolocators (light loggers) from British Antarctic Survey weighing 1.4 g (model Mk14). These loggers were attached to a standard plastic leg ring. 50 adult

breeders were equipped with loggers in NE Greenland, and 20 in Iceland during the 2007 season. Researchers managed to recapture 10 of these birds in Greenland and one in Iceland during 2008. Considerably more birds were observed back at the colonies, but some did not breed, some nests could not be located (Arctic terns do not exhibit nest fidelity within colonies), and some birds were too shy to capture. Migration tracks were plotted and measured after smoothing. Relationships with habitat variables (biological productivity, prevailing wind patterns) were assessed informally.

3.2.3 Main findings

Figure 3.1. Interpolated geolocation tracks of 11 Arctic terns tracked from breeding colonies in Greenland (n = 10 birds) and Iceland (n = 1 bird). Green = autumn (postbreeding) migration (August–November), red = winter range (December–March), and yellow = spring (return) migration (April–May). Map courtesy of C. Egevang, Greenland Institute of Natural Resources.

While the large-scale patterns of Arctic tern migration were known, the study resulted in several completely novel findings: 1) Perhaps most surprisingly, birds were found not to migrate directly to the South Atlantic after the breeding season, but instead to spend most of August (an average of 24.6 days) in the central North Atlantic (Figure 3.1) in an area that previously was not known to be important for seabirds. Satellite telemetry shows that biological productivity in this area is high; 2) After reaching W Africa, the birds split into two groups, one following the African coast

south and the other one crossing to South America; 3) All 11 birds spent most of the northern winter in the Weddell Sea, east of the Antarctic Peninsula (although three birds first made an excursion into the Indian Ocean sector of the Southern Ocean). This area is also highly productive; 4) Average speed was higher during northward than southward migration (520 vs. 330 km day-1). This was probably due to wind assistance, as the S-shaped track is consistent with prevailing wind patterns; 5) The overall annual migration was even longer than expected, on average 70 900 km.

This study has thus provided a much deeper insight into the migration ecology of a seabird with a truly global range. While the findings do not have direct management implications, they make it clear that Arctic terns, in common with other long-distance migrants, rely on sufficient food being available at several widely separated areas of the Atlantic and Southern Oceans, and thus that threats to any of these areas could be critical for the species. Furthermore, the study highlights the ecological importance of a previously unknown staging area in the central N Atlantic, an area that also seems to be important for other seabirds (see below).

3.3   Case study 2: Spatial association between Northern gannets and fishing vessels (Votier *et al.* 2010)

3.3.1   Background and aims

In common with many other seabirds, northern gannets exploit fisheries discards extensively. However, it is not clear to what extent individual birds rely on discards, and the interactions between birds and the main source of discards, highly mobile trawlers, is poorly understood. One of the aims of this study was to use high-precision tracking of seabirds and fishing vessels to quantify whether birds adjust their behaviour in relation to the presence and activity of trawlers.

3.3.2   Technological and analytical approach

Breeding northern gannets were studied at a colony in Wales in 2006. 37 birds were equipped with GPS loggers weighing 65 g (model GPSlog, earth & OCEAN Technologies, Kiel), and 32 of these were successfully recaptured. 23 complete foraging trips were recorded, with location fixes every 3 minutes. Fishing vessel activity was recorded using VMS (Vessel Monitoring System), which provides a high-resolution location every 2 hours. Gannet foraging behaviour was quantified by calculating track tortuosity and speed, and relationships with environmental covariates (including long-term mean vessel density) were assessed using generalised linear mixed models.

3.3.3   Main findings

Figure 3.2. Tracks of two gannets in the Celtic Sea showing derived ground speed and spatio-temporal relationships with current fishing vessel activity. In the right-hand panels, grey symbols indicate location of contemporaneous fishing vessels and green symbols indicate when the bird was within 2 hours and 5 km of a vessel. The left-hand panels indicate derived ground speed. Map courtesy of S.C. Votier, University of Plymouth.

Gannets foraged in the Celtic Sea SW of the colony, an area where fishing activity is high. Foraging behaviour was affected by vessel presence: on the larger spatial scale (>10 km), birds flew faster and more direct when vessels were nearby. On the smaller scale, interactions were more variable, and some individuals seemed to react posi-

tively to the presence of trawlers (Figure 3.2). Stable isotope analyses confirmed that there was large inter-individual variation in the birds' dependence on discards.

These various lines of evidence thus suggested that some individual northern gannets rely heavily on fisheries discards during the breeding season, whereas others feed exclusively on natural prey. This has implications for the management of discarding activities in relation to seabirds, particularly if, as has been suggested, low-quality individuals (i.e. those with a shorter lifespan and lower likelihood of successful reproduction) consume more discards and less natural prey than high-quality individuals. The population-level impact of reducing discard availability may thus be less than could be extrapolated from e.g. the mean proportion of discards in gannet diet.

3.4   Case study 3: Mapping foraging and wintering areas of rare and endangered species

Rare and endangered seabird species pose several difficult problems in relation to conservation. One of them is that because of their rarity, there are very few observations of these species at sea and the foraging and wintering areas important for them are very poorly known. Tracking studies offer what's often the only solution to this problem, although sample sizes tend to remain low. There are thus a number of very recent cases where tracking has been applied to rare species in the North Atlantic (within or outside ICES waters). Most of this work is not yet published, but with the help of the respective researchers we here summarise preliminary results for two such species, the ivory gull and the cahow or Bermuda petrel.

3.4.1   Ivory gull wintering areas (Gilg & Strøm unpublished)

The ivory gull is a rare and endangered species which breeds dispersed throughout the circumpolar high Arctic (Gilg *et al.* 2009). Very little is known about its migration and wintering areas, mainly because of its rarity, although it is thought to be closely associated with the presence of sea ice throughout the annual cycle. There are concerns that as the winter distribution of sea ice shrinks with increasing global temperatures, ivory gulls may have trouble finding suitable wintering areas. Similarly, distances between breeding sites and the summer ice edge are likely to increase, leading to increased foraging costs for ivory gulls.

In 2007 and 2008, breeding ivory gulls were tagged using satellite tags in NE Greenland, Svalbard and Franz Josef Land. Maps showing raw locations of 15 Svalbard   and   Franz   Josef   Land   birds   are   available   at http://ivorygull.npolar.no/ivorygull/en/index.html. Generally, transmitters provided data for several months, in some cases until the next breeding season. While some birds moved east into the Russian sector of the Arctic Ocean, most individuals seemed to spend the winter around South Greenland and in the Labrador Sea. These latter areas are among the most southerly where high sea ice concentrations occur, and suitable wintering habitat for ivory gulls may not be available in the future in this region.

3.4.2   Cahow foraging areas during the breeding season (Madeiros & Carlile unpublished)

The cahow provides another illustrative example. Thought to be extinct since the early 1600s, cahows were rediscovered in the 1950s, nesting on tiny islets in Bermuda Harbor. They have since increased to *c*. 200 birds through intensive management. With such small numbers, they had never been observed at sea until about 1995, and

to date, virtually all of the sightings have been made in a restricted area at the edge of the Gulf Stream off Cape Hatteras, North Carolina.

In 2009, geolocators were deployed on 12 adult cahows, which were followed on foraging trips during the nesting season. The birds consistently travelled from Bermuda to the North American continental slope, between North Carolina and Nova Scotia (Figure 3.3, J. Madeiros & N. Carlile, unpublished). It seems these cephalopod specialists use the slope and the Gulf Stream boundary as a reliable source of their specialized prey. This tracking technology seems the only feasible way to determine the critical habitat needs of a rare species such as this one.

Figure 3.3. Feeding trips of 3 female cahows during the post-egg laying period, January 2009. J. Madeiros & N. Carlile, unpublished.

In general, tracking of individuals has a large potential as a tool for locating important areas for rare species. It is highly likely that the use of this tool will expand in the coming years, and the prospects for improving conservation efforts for these species at sea are thus good.

3.5 New insights from tracking studies

3.5.1 Identification of previously unknown at-sea hot spots

As mentioned above, the area of the central North Atlantic used by the migrating Arctic terns in late summer (Egevang *et al.* 2010) was not previously known to be of importance to seabirds. This area is east and south-east of the Grand Banks of Newfoundland, towards the Mid-Atlantic Ridge (41–53° N, 27–41° W). However, other

recent tracking studies indicate that Arctic terns are not the only birds using this area. Preliminary data from tracking of Atlantic puffins from Vestmannaeyjar in south Iceland indicate that they spend the winter in roughly the same area as that used by the Arctic terns in late summer (A. Petersen, unpublished). Northern fulmars breeding in Orkney, north Scotland were tracked using geolocators, and many of these birds spent part of the winter in areas east of the Grand Banks, but largely north-west of the area frequented by Arctic terns (P.M. Thompson, unpublished), as did fulmars satellite-tracked from Arctic Canada (Mallory *et al.* 2008). Little auks tracked from a colony in noerth-east Greenland also showed a very similar distribution to the northern fulmars in winter (A. Mosbech *et al.*, unpublished).

There are also other cases where tracking has led to unexpected discoveries of 'new' areas of importance to birds. For instance, adult Atlantic puffins breeding in the North Sea were previously thought to winter mainly within the North Sea. However, a recent study using geolocators has shown that some birds migrate into the Atlantic west of Scotland for part of the winter (Harris *et al.* 2010). Similarly, satellite tracking of Atlantic puffins breeding in the northern part of the Norwegian Sea showed that the birds travelled north-east to the Barents Sea soon after breeding, whereas ring recoveries only indicate that adult birds spend the winter in the opposite direction, usually far south-west of their breeding sites (Anker-Nilssen and Aarvak 2009). Likewise, roseate terns breeding in Massachusetts have been shown to stop over near Bermuda during their northwards (spring) migration, rather than migrate directly from South America as had been assumed (C. Mostello *et al.*, unpublished).

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4 Recent progress in addressing the problem of seabird bycatch in European Union waters

In response to a request by the European Commission, the problem of incidental catch of seabirds in fisheries in EU waters was reviewed by WGSE in 2008 (ICES 2008,

chapters 3–5), and an update with new information was provided by WGSE in 2009 (ICES 2009, chapter 4). The initial review concluded that although there were few data to indicate the true extent of seabird bycatch in EU waters, enough information existed to recognize that there is indeed a problem, and that the EU should develop and implement an European Community Plan of Action (EC-PoA) aimed at reducing this bycatch, and investigating the issue further. This work was used by ICES in providing advice on the issue to the European Commission.

This chapter provides an update on progress made in managing this important source of mortality for seabirds in EU waters and adds new information on the issue that has come to light since the publication of the WGSE 2009 report. Absence of comment can be taken to mean that no new information is available.

4.1 Progress towards an EC-PoA-Seabirds

There appears to have been relatively little progress on this issue in 2009 and the European Commission missed its own deadline for the development and adoption of an EC-PoA for Seabirds. The plan is currently in the Commission's work plan for adoption in April 2011. WGSE reiterates the need for an EC-PoA, and notes that there remains a critical need for more systematic data collection of seabird bycatch data throughout EU waters.

Apart from insufficient internal capacity, an obstacle to the Commission making timely progress on the development of an EC-PoA has been the absence of any obligation on Member States to collect and report data on seabird bycatch, following the failure of any such requirement to be included in the revised EU Data Collection Regulation (Council Regulation (EC) No 199/2008).

To help galvanise action and to focus efforts on key areas and impacts, in September 2009 BirdLife International provided DG Mare with a *European Community Plan of Action (ECPOA) for reducing incidental catch of seabirds in fisheries* (Birdlife International 2009). This represented a 'shadow plan' based on the FAO Best Practice Technical Guidelines (agreed by FAO-COFI in March 2009, FAO 2009) and included a demonstration (based on literature review) of some of the economic benefits of applying mitigation measures. BirdLife's initiative contributed to a Policy Statement on the issue being made at November Council (2009). However, this Statement made no formal mention of a Plan or the FAO guidelines and did not commit to emergency measures for the most threatened species. Moreover, the Policy Statement did not acknowledge the importance of addressing bycatch in gill-nets.

Since the November Council, the Commission has committed to the point that the Policy Statement was indeed a precursor to a formal plan. DG Mare has outlined the following framework and timetable for adoption (by 2011) of a plan.

Early in 2010, DG Mare produced ToR for an impact assessment of incidental catches of seabirds in Community waters (only). The main aim of the study will be to assess existing mitigation measures and their effectiveness in key areas where incidental catches of seabirds are occurring (the Grand Sol, western Mediterranean, Maltese and Greek waters, for longline fisheries; Baltic and eastern North Sea, concerning gillnet fisheries) and make recommendations for best practice mitigation measures and their implementation. The study should be based on direct consultation with the fleets operating in those areas.

The study will include the collection and analysis of existing information concerning the identified 'hotspots', will assess the cost associated with the use of available miti-

gation measures and the socio-economic and environmental impacts of their use in the specific fisheries. Results delivered should make a considerable contribution to future decision making.

4.1.1   Terms of reference of the study

The following general tasks are to be carried out for each one of the areas subject of the study:

1) Overall description and, where appropriate, assessment of the magnitude of the problem, as defined in FAO's Best Practice Technical Guidelines;

2) Assess the existence and combination of mitigation measures in place, their effectiveness, and other measures likely to be effective;

3) Description of how the problem is perceived by fishing industry;

4) Assess the costs associated with available mitigation measures taking into account other relevant studies from outside EU waters;

5) Assess the readiness of fishing industry to introduce new mitigation measures and effectiveness of existing incentives (e.g. eligibility of European Fisheries Fund EFF);

6) Provide recommendations.

The contract to carry out the study was awarded to the UK Marine Resources Assessment Group (MRAG) who will deliver their report in autumn 2010. The methodology will involve a questionnaire, supplemented with visits to the respective countries and interviews with the fishermen and other fishing industry representatives, fishery institutes, conservationists, etc. Only limited at-sea work will be carried out.

WGSE welcomes the comprehensive approach of this study but draws attention to the following key points:

- While it is important to start with the 'hotspots' identified by BirdLife and reflected in the MRAG study, there are likely to be other places in Community waters that are under-studied and may harbour undetected bycatch problems.

- By the same token, trawl and gillnet fisheries (which are currently data-poor in terms of seabird bycatch) need further investigation.

- An impact assessment may also miss occasional events (such as the mass bycatch of Balearic shearwaters that occurs from time to time), and here the insights and knowledge of seabird experts will be key to filling gaps that the fishing sector might not provide.

- While it is encouraging and vital that gillnet fisheries are now getting the attention they deserve, these types of fisheries are widespread and often prosecuted by inshore fishers in small boats, and it is important to capture their impact as well as the more concentrated offshore sector.

- Addressing the potential economic benefits of applying mitigation measures, particularly in longline fisheries, should also be part of any impact assessment, and a balance to the *costs* of applying mitigation.

4.2   The external dimension of the EC-PoA

The Commission's priority focus is clearly on Community waters (the MRAG study applies only to this region) and their intention is presumably to address the bycatch

of seabirds by EC-flagged vessels operating in *external* waters through their routine engagement with Regional Fisheries Management Organisation (RFMOs).

Critical areas in which progress needs to be made in the RFMOs, and in which the EC can lead are improvement of data collection protocols and strengthening (better coverage) of observer programmes. It is therefore important that the Commission addresses and outlines its strategy for dealing with this external dimension of the EC-PoA; otherwise it will not meet the full aspirations and intent of the FAO Best Practice Technical Guidelines.

4.3 Technical Conservation Measures Regulation (TCMR)

DG Mare has signalled the intent that, when drafting the EC-PoA, it may include new legislative provisions under the Technical Conservation Measures Regulation. This would address the call for more urgent and binding measures for critical interactions, as flagged up by BirdLife International.

The Ministers, having failed to adopt the TCMR at Nov (2009) Council, now have 18 months to set rules for a new TCMR by mid-2011, including possible seabird measures. The EC-PoA would identify the measures and best legislative framework, possibly the TCMR. However the TCMR does not cover the Mediterranean and Baltic Seas, which have their own regulations and which are among the worst bycatch hotspots (see below). There might be a need to apply different tools to these regions. This could be particularly significant in the case of the Baltic gillnet problem.

4.4 New information on seabird bycatch in longline fisheries

There is little new information available since the last WGSE report of 2009 on seabird bycatch among EU longline fisheries. However, some new data from Spanish pelagic longline fisheries were submitted to The International Commission for the Conservation of Atlantic Tunas (ICCAT) Standing Committee on Research and Statistics meeting in 2009. Moreover, new estimates of total seabird bycatch in some fisheries covered in previous WGSE reports have recently been compiled based on new effort data.

4.4.1 Western Mediterranean – pelagic fleet

Observers were placed on 58 Spanish longline vessels targeting swordfish (*Xiphias gladius*), bluefin tuna (*Thunnus thynnus*) and albacore (*Thunnus alalunga)* in the Western Mediterranean. Garcia-Barcelona *et al.* (2009) reported 4 786 466 hooks observed throughout January 2000 to December 2008. An average total bycatch of 0.038 birds/1000 hooks was observed, with annual effort between these years being 13 164 660 hooks. As bycatch rates were much higher around the Columbretes Islands, effort data from this region were removed from the total effort reported above (i.e., 2.3 million hooks per year removed). A separate figure of bycatch is reported below for the Columbretes Islands. This resulted in an estimated total seabird bycatch of the fleet per year of 413 birds, of which an estimated 152 were Cory's shearwaters, based on an estimated bycatch rate of 0.014 birds/1000 hooks (Garcia-Barcelona *et al.* 2009).

4.4.2 Columbretes Islands – demersal and pelagic fleets

Observer data were reported from 1998–1999 in both pelagic and demersal fleets. 88 812 hooks were observed, and a bycatch rate of 0.16–0.69 birds/1000 hooks was reported (Belda and Sanchez 2001). With 2.3 million hooks set in the pelagic fishery and 1.8 million set in the demersal fishery, a total bycatch estimate of *c.* 656–2829 birds caught per year can be extrapolated.

4.4.3   Spanish Gran Sol – demersal fleet

More recent data has also been reported for this fishery. Barros, in BirdLife International (2009), report a total bycatch estimate of 1.008 birds/1000 hooks caught, with a total estimated mortality of all seabird species of 56 307 birds per year. The majority of these are comprised of greater shearwater (0.546 birds/1000 hooks and 39 908 birds per year), with northern fulmar ranked second in terms of total numbers of birds killed (estimated 0.277 birds/1000 hooks and 9.493 birds per year).

Barros, in BirdLife International (2009), also stated that on days when the observer asked deck lighting to be switched off, bycatch was virtually eliminated. Use of deck lighting is thus a major cause of seabird bycatch, and switching lights off (except for position lights) would be a very efficient - and a highly cost-effective - mitigation measure. Of course this could only be done if human safety is not compromised.

BirdLife International (2009) notes that reduction of deck lighting is specified by the Spanish Regulation of 2006 on longline mitigation measures (see footnote 13) but is clearly not currently being complied within the Gran Sol fishery. Article 7 of the Regulation specifies that: *Setting shall be done preferably between dusk and dawn; vessel external lights must be reduced to those strictly necessary for navigation and fishing purposes.* No other mitigation measures (such as bird-scaring lines or line-weighting) are used in this fishery. Fishermen seem very reluctant to use bird-scaring lines, claiming that they often get entangled with the fishing gear, and that they are very difficult to use in bad weather conditions. The scale of bycatch in the Gran Sol exposes lack of compliance with a key recommendation in the 2006 Spanish regulation. It also points up the potential for similar bycatch in the wider area and south to Macaronesian waters.

4.4.4   Maltese demersal longline fleet

Interviews with Maltese fishermen indicated that the bycatch rate of Cory's shearwater by demersal longline vessels operating in Maltese waters could equate to 8.5–10% of the population being killed annually (Dimech *et al.* 2008). The number of birds reported caught ranged from 0–50 per year, with an average of 1.41 birds/demersal fisherman per year. Hence, Dimech *et al.* (2008) estimated total annual mortality of 1237 birds per year for the fleet as a whole. Cory's shearwaters have a very high risk of interaction with both demersal and pelagic longline fisheries as well as a high risk of interaction with trawl and gillnet fisheries. Hence, these figures are a potentially significant cause for conservation concern.

4.5   New information on seabird bycatch in non-longline fisheries

In addition to bycatch in longline fisheries, large numbers of seabirds and other top predators are caught in other types of fisheries where sea areas offer good feeding resources for both humans and seabirds (e.g., Davoren 2007; Karpouzi *et al.* 2007). As Tasker *et al.* (2000) highlight, virtually all types of fishing gear may catch seabirds. Bycatch of birds in trawled, fixed or even lost fishing gear occurs worldwide (Tasker *et al.* 2000; Bull 2007; Žydelis *et al.* 2009). However, the effects on bird populations are largely unknown. The scale of the bycatch varies with many factors, including time and location of fishing, fishing method, behaviour of the target species, nature and abundance of seabird prey, and demography of the seabird populations. Only a brief overview of the numbers of birds and the species mainly affected in fisheries other than longlining is presented here.

4.5.1 Species and numbers of birds caught in gillnet fisheries

4.5.1.1 Baltic Sea

There are relatively few large boats using gillnets in the Baltic Sea, but there is a large number of small boats fishing shallow, coastal waters of every country in the region, most prominently in the Baltic Sea (Žydelis *et al.* 2009).

In the Baltic, seaducks such as common eider and common scoter, divers, grebes, and auks are caught and killed mostly in fixed nets. Also, Steller's eider, classified as Vulnerable by IUCN (IUCN 2007) and greatly decreasing in numbers, is affected (Žydelis *et al.* 2006) Substantial mortality of some species occurs locally; for example, an estimated 1000 long-tailed duck and velvet scoter die annually in fixed-net fisheries for flatfish and cod *Gadus morrhua* in the Gulf of Gdańsk , Poland (about 10–20% of the wintering populations combined). Meissner *et al.* (2001) noted that drowning in nets was the commonest source of mortality of birds on the Polish coast, and some 14 000 ducks, chiefly common eider and common scoter, were killed annually in the same type of fisheries along the east coast of Schleswig-Holstein, representing up to 17% of the maximum winter population (Žydelis *et al.* 2009). Estimates for the annual proportion of greater scaup caught in European gillnets range between 2% and >10% with an overall mean of 5.2% of the flyway population size (Žydelis *et al.* 2009).

4.5.1.2 North Sea and adjacent waters

There is less information available on bird bycatch in the coastal fisheries in the North Sea compared with the Baltic. Existing studies, however, suggest that the most frequently affected birds are auks, especially the common guillemot. The degree of bycatch in the region varies. It is assumed not to be significant around Britain and Ireland; here, impacts of seabird bycatch tend to be localized. Gillnets set in late winter in Cornwall, have taken an annual bycatch of hundreds of razorbills and common guillemots, possibly reaching 1000, although the birds probably derive from a wide catchment area, diluting any possible population effect. Studies around Wales and Scotland found no evidence of widespread impact, with the exception of sites where nets were set immediately beside colonies (Tasker *et al.* 2000).

Bycatch mortality has also been studied in large, artificial coastal lakes in the Netherlands (IJsselmeer and Markermeer): Žydelis *et al.* (2009) quotes an estimate of at least 50 000 waterbirds drowned in gillnets each year during the 1980s and 1990s. Species where more than 5% of their local numbers were annually trapped in the nets were red-breasted merganser, tufted duck, greater scaup, common pochard, common goldeneye, smew, and goosander. A more recent study, conducted using on-board observers in 2002–2003, suggested somewhat lower mortality between 10 000 and 15 000 birds per year; however sampling effort was less intensive than that of earlier study (Žydelis *et al.* 2009).

4.5.1.3 North-west Spain (ICES Region IX)

Mortality in gillnets has also been reported from northwest Spain. This mainly affects European shags (*c.* 3 000 birds thought to be caught in Galicia annually) and auks (*c.* 2000 birds per year; Arcos *et al.* 1996). The Iberian population of common guillemot declined from about 20 000 pairs in the first half of the 20th century to fewer than 10 pairs at the end of that century. The main reason for this appears to be mortality caused by synthetic fishing nets when these were introduced in the 1960s (Munilla *et al.* 2007).

4.5.1.4 Mediterranean Sea

In the Mediterranean, there is very little information about seabird bycatch by fisheries other than longlining. However, the available information suggests that gillnets and other bottom gear could pose a threat to some species, particularly the Mediterranean subspecies of the European shag. Louzao and Oro (2004) conducted a questionnaire study of seabird bycatch on several fishing gears from the Balearic Islands and almost 60% of bycatch was due to nets. In Greece, up to 500 Yelkouan shearwaters were recently reported to have been caught in a single drift net (Mom/The Hellenic Society for the Study and Protection of the Monk Seal, 2008 unpublished data), thus highlighting the threat that this type of gear could pose to shearwaters.

4.5.1.5 North-east Atlantic

An extremely high common guillemot bycatch in Norway is considered to have been responsible for large declines at some colonies. Ringed bird recoveries also suggest that fisheries bycatch is a substantial and increasing source of bird mortality in the North Sea (Žydelis *et al.* 2009). Gillnets set for cod off northern Norway killed large numbers of Brunnich's and common guillemots between 1965 and 1985. In early spring 1985, the estimated kill of both species combined exceeded 100 000 birds. In the same area, summer driftnet fisheries for salmon drowned thousands of local breeding birds; numbers of common guillemot in the colony at Hjelmsøy declined from 220 000 in 1965 to 10 000 by 1985, and Brunnich's guillemot declined from >2000 to 220 individuals. The fishery was closed in 1989 to conserve salmon *Salmo salar* stocks (Tasker *et al.* 2000).

4.5.1.6 North-west Atlantic

On the east coast of Canada, gillnets were set in surface waters for salmon and in deeper waters for cod up to 100 km or more from the coast. Pursuit-diving alcids such as common guillemots and Atlantic puffins were the most vulnerable to entrapment in gillnets and other fixed gear. Brunnich's guillemots, black guillemots, razorbills, greater shearwaters, sooty shearwaters, and northern gannets are also drowned. Annual mortality in Witless Bay (Newfoundland) was estimated at 13–20% (around 20 000–30 000 guillemots) of the local breeding population in the early 1970s, falling to about 3-4% by the 1980s. By contrast, only 0.25–1.6% of the much larger local breeding population of Atlantic puffins was caught in fixed gear. Approximately 12% of Newfoundland's razorbill population was killed annually between 1981 and 1984, plus 2% of the western Atlantic gannet population. Offshore gillnets set during summer, autumn, and winter also drowned non-breeding seabirds, including little auks (Piatt and Nettleship 1985, Piatt and Nettleship 1987, Piatt *at al*. 1984). With the closure of the northern cod and Atlantic Salmon fisheries in the 1990s, seabird bycatch was much reduced.

Total numbers of incidentally caught seabirds in gillnets in near-shore and offshore Newfoundland waters were estimated after the fisheries closures for the years 2001, 2002 and 2003 by Benjamins *et al*. (2008). The most commonly captured seabirds were guillemots, and shearwaters, although other species were also captured in smaller numbers. As many as 2000–7000 guillemots, more than 2000 shearwaters, and tens to hundreds of northern fulmars, northern gannets, double-crested cormorants, divers, eiders, razorbills, Atlantic puffins, black guillemots, and little auks were estimated to have been captured annually in the area during 2001–2003, although catches varied considerably from year to year. Davoren (2007) estimated that the gillnet fishery for cod on the north-east coast of Newfoundland during July and August 2000–2003 certainly drowns 1936–4973 guillemots annually (0.2–0.6% of the breeding population),

but the actual mortality could be as much as 3053–14 054 birds per year (0.4–1.7% of the breeding population).

Palka and Warden (2007) collated data of bird bycatch for different types of fisheries for US Northwest Atlantic waters (north of South Carolina) for the period 1989–2006. In gillnet fishing, 2715 victims were registered, shearwaters, divers and cormorants being the mostly affected groups (51.3%, 19.2% and 15.2% of all birds, respectively).

4.5.1.7 Eastern Pacific

Takekawa *et al.* (1990) noted a decline of more than 50% in common guillemot numbers in central California over 4–6 years in the early 1980s, whereas the adjacent population of northern California remained relatively unchanged. The decline in the former was caused primarily by the rapid growth of an intensive nearshore gillnet fishery, combined with a switch from twine to monofilament nets , and compounded by mortality from oil spills and a severe El Niño event   (Tasker *et al.* 2000). In the salmon gillnet fishery in Prince William Sound (Alaska), Wynne *et al.* 1991, cited in Bull 2007) estimated that 1486 seabirds were killed in nets in 1990.

4.5.2 Species and numbers of birds caught in trawl fisheries

Almost no information is available on seabird bycatch in trawl fisheries within EU waters. One small study reported northern gannets present as bycatch in the argentine *Argentina silus* and herring *Clupea harengus* trawl fisheries operating off the north and north-east coasts of Scotland (Pierce *et al.* 2002). Gannets were observed caught in nets as they were hauled, with 21 observed in two hauls in the herring fishery near Shetland and 20 in two hauls in the argentine fishery. Pierce *et al.* (2002) estimated that around 620 and 160 gannets may have been caught in the herring and argentine fisheries, respectively that year. Assuming 10% survival, they calculated that in total 700 birds might be killed in both fisheries annually.

Significant bycatch events are well documented in numerous trawl fleets outside of EU waters. For example, data collected in the South African hake *Merluccius* spp. fleet from 2004–2005, indicated that ca. 18 000 birds were being killed each year (Watkins *et al.* 2006). They reported that 85% of mortality resulted from birds being killed by interactions with warp cables (i.e. wings being wrapped around the cable resulting in drowning), with 15% resulting from birds becoming entangled in the nets themselves.

It is this latter figure that has the greatest significance for trawl fleets operating in EU waters. This is because, while the majority of seabirds occurring in EU waters are not the larger Procellariiformes so often associated with trawl warp bycatch, there remains the potential for even smaller, more agile seabird species to become caught and drowned/crushed in nets on the set or the haul. Birds are attracted to nets being set if they are not cleaned sufficiently prior to setting. Equally, many more birds are attracted to nets on the haul as offal discharge begins, while fish are being removed and processed. Birds will attempt to take offal and discards discharged near to the net and become caught. Equally they can become caught as they attempt to take fish and other catch from the net itself as it is hauled aboard. While there is potential for this interaction to exist, no data is currently available from within the EU trawl fleets. However, the potential for impacts is potentially high, and it remains of immediate and critical importance to collect observer data from trawl fleets operating in EU waters to ascertain whether or not such a problems does indeed exist.

4.5.2.1 Trawl bycatch in fisheries outside the EU

Sullivan *et al.* (2006) estimated that more than 1500 seabirds, predominantly black-browed albatross, classified as Endangered (IUCN 2007), 12 southern royal albatross (Vulnerable), and nine white-chinned petrels (Vulnerable), were killed by finfish trawlers operating off the Falkland Islands during 2002/2003. Significant levels of mortality were also recorded on the Patagonian Shelf, north of the islands. Birds were killed after being dragged underwater by the warp cable while feeding on factory discharge at the stern of the vessel. Sullivan *et al.* (2006) conclude that the incidence of mortality caused by the many large trawling fleets around the world that discharge factory waste and attract large bodied seabirds (e.g. albatross and large petrels) requires immediate investigation.

González-Zevallos *et al.* (2007) studied the interaction between seabirds and warp cables in the high-seas Argentine hake *Merluccius hubbsi* trawl fishery operating in Golfo San Jorge, Argentina. Thirteen seabird species exploited food made available by fishing operations. The most frequent seabirds (% occurrence, mean maximum number per haul) were kelp gull (98.1%, 348.5) and black-browed albatross (96.1%, 132.2). A total of 53 individuals of several species were killed through interactions with nets and cables, resulting in a total cable mortality rate of 0.14 birds per haul. Considering the fishery's fishing effort, the estimated total number of birds killed during the study was 2703, of which 306 were killed due to contacts with warp cables (255 kelp gulls and 51 black-browed albatross).

4.5.3 Species and numbers of birds caught in driftnet fisheries

There is potential for seabirds to be caught incidentally in driftnets (Northridge 1991). High bycatch of migrant Brunnich's guillemots during autumn were reported from a driftnet fishery for Atlantic salmon off western Greenland during the 1960s and 1970s. Bycatch incidences were shown to be fairly variable over space and time, and exceptionally high catches were considered to result from feeding convergences of guillemots and atlantic salmon on capelin *Mallotus villosus* Tasker *et al.* 2000).

Before the 1993 UN moratorium on high seas drift netting, some 500 000 birds were drowned annually in this type of fishery in the North Pacific. Most of these were Sooty shearwaters and Short-tailed shearwaters which bred in the southern hemisphere. Two main fisheries were involved, one for salmon (between 60 000 and 137 000 km of net set per year) and one for squid (an estimated 2.85 million km of net set per year). The formerly abundant shearwater populations declined in the early 1990s with significant reductions in numbers recorded at sea off California. Mortality of black-footed albatross amounted to about 2% of the world population *per annum*. Nets killed *c*. 8% of marbled murrelet autumn populations in Barkley Sound, British Columbia. Off Japan, 1650 ancient murrelets were found drowned in inshore nets in 1990. Further offshore, bycatch of Japanese murrelets was recorded in the Korean squid fishery, considered to represent 1.5–15.2% of the breeding population of this endangered species.

Much of the Mediterranean Sea is not considered "high-seas" because it lies within the territorial waters of surrounding countries. Driftnet fisheries are still prosecuted in the Mediterranean although the EU banned driftnetting for tuna in 1998 (see :

http://ec.europa.eu/fisheries/press_corner/press_releases/archives/com98/com98_11_en.htm

It is likely that the Critically Endangered Balearic shearwater may be impacted by driftnet and other fisheries in the Mediterranean, such that their conservation status

is negatively affected yet further. WGSE has not had the opportunity to thoroughly review the extent to which driftnets are still used in EU waters and what is known about seabird bycatch in these fisheries.

4.6 Assessing fishing effort and monitoring of seabird bycatch in EU waters

Some data on fishing effort, in the form required to estimate total bycatch for a fleet (i.e. number of thousand hooks set for the fleet per year, or number of trawls set for the fleet per year) are available, but this appears limited to the pelagic longline fleets for tuna and tuna-like species, which are required to report such data international under the ICCAT agreement. Nevertheless, even within this regional reporting system, problems of data interpretation and validation remain, as data may not be reported adequately, consistently or rapidly enough for seabird bycatch analyses to take place.

Often problems stem from where data are reported as total tonnage caught, but where there may be not sufficient data on observer effort to convert total catch of target fish into fishing effort, as required for estimating total seabird bycatch for a fleet. In trawl fisheries this may be; trawls per day, length of trawl time, number of trawls set per year and per vessel. Equally, gillnet fisheries need to achieve a standardised reporting of effort and centralised means of data collection, before any reasonable extrapolations of total seabird mortality within these fisheries can be calculated within EU waters.

4.7 New data on seabird bycatch mitigation measures for use in EU fleets

A considerable body of work has been ongoing internationally in the field of seabird bycatch mitigation and improvements and qualifiers of earlier methods have developed since the last comprehensive review compiled in WGSE 2008 report (ICES 2008). Some older technologies, which showed some early promise, have ultimately not been adopted, and in their place, some new technologies are being considered. Birdlife International has produced a set of Bycatch Mitigation Fact Sheets, which describe the range of potential mitigation measures available to reduce seabird bycatch in both longline and trawl fisheries; these are available at:

http://www.rspb.org.uk/ourwork/policy/marine/international/publications.asp

The intention is that these be revised on a regular basis, as new products and techniques come online. The Fact Sheets assess the effectiveness of each measure, highlight their limitations and strengths, and make best-practice recommendations for their effective adoption. WGSE considers these fact sheets to be a valuable contribution to the goal of reducing unnecessary losses of seabirds in fishing gear.

In addition to the Seabird Bycatch Mitigation Fact Sheets, BirdLife International (2009) EC-PoA Seabirds 'shadow plan' details the species most at risk from bycatch within EU waters and highlights the techniques most appropriate for addressing bycatch in a variety of fleets. It also details potential mitigation requirements under the future EC-PoA for seabirds, noting that a suite of mitigation measures has proven to be more effective than one measure used in isolation within the fisheries currently using mitigation measures worldwide. The toolbox of mitigation options (Table 4.1) is intended to provide just such a suite, but with a minimum of two measures in each box to be considered as mandatory to effectively mitigate against seabird bycatch among fisheries operating in EU waters with proven seabird bycatch incidences.

Table 4.1. Mitigation options for various species in different types of fishery.

Species at risk	Pelagic longline	Demersal longline	Trawl
Cory's shearwater	Bird-scaring line, LW, night-setting	Bird-scaring line, ILW, night-setting, offal management	Bird-scaring line, offal management
Balearic shearwater		Bird-scaring line, ILW, night-setting, offal management	Bird-scaring line, offal management
Yelkouan shearwater		Bird-scaring line, ILW, night-setting, offal management	Bird-scaring line, offal management

Notes:

(1) Preferably two bird-scaring lines should be deployed simultaneously, and each should meet minimum design and operational criteria for effectiveness as deterrents

(2) LW = Line weighting (weighted swivels or 'safe leads')

(3) ILW = Integrated line-weighting

(4) Night-setting should always be accompanied by minimising deck-lighting, to avoid

attracting seabirds to the vessel

(5) Species/fisheries mitigation measures can be supplemented, as appropriate, by

designating Special Protected Areas (EU 2009, see Chapter 7), with fisheries management restrictions on gear use

4.8 New information on seabird bycatch mitigation measures for longline fisheries

4.8.1 Bait pods

'Bait pods' are a relatively new development in reducing seabird bycatch in longline fisheries (see http://fishtekmarine.com/baitpods.php), and not mentioned in previous WGSE reports. The 'Bait Pod' is made of durable polycarbonate plastic and is designed to fit either around the bait and the hook or just the hook itself. The line is set with the pods covering the bait and hook and once safely underwater, the pod opens by a pressure sensor and exposes the bait and hook. The pod is retained on the line and can be used many times. Pods are cheap and easy to fit after the hooks are baited. The pods protect the bait from scavenging seabirds, thereby significantly decreasing bait loss and seabird bycatch. This technology is currently in final stages of development and testing, and is believed to be close to wider mainstream production.

4.8.2 Safe leads

Adding lead weight swivels to a longline increases the sinking rate of the line, thereby reducing the opportunity for seabirds to grab the baited hook. However, lead swivels present a serious health and safety issue for fishers using them: if the long line is stretched for any reason (e.g., a large shark has been hooked) and then this tension is quickly released, the lead swivel can fly back towards the vessel as high speed, and can cause serious injury or death. As a alternative to lead swivels, Fishtek in co-operation with Birdlife International has developed a 'Safe Lead' which is designed to grip the line with only 5 kg of tension and will release from the line or move up and down the line if the 5 kg is exceeded. Tests have shown that this reduces the speed of the line 'whip-back' to non-injurious rates. Sea-trials are currently underway to test safe leads and if successful should significantly increase the take-up rate of this important mitigation measure.

4.8.3 Bait-setting capsule/Underwater baited hook

A recent development in the toolbox of seabird bycatch mitigation for use in longline fisheries, the 'Underwater Baited Hook' is operated by placing a baited hook in a capsule chamber, then mount the capsule in a docking station that is fixed to the vessel. There, it is secured to a carriageway by spectra rope attached to pulleys and operated by hydraulics. With the press of a button, the hydraulics propel the capsule down the carriageway, out of which the capsule freefalls to a pre-programmed depth. At the end of the descent, the system reverses the hydraulics, flushing the baited hook from the capsule through a spring-loaded door. The capsule then returns to the docking station to be set again. The aim is to release baited hooks beneath the lower limit of propeller turbulence, so that the turbulence forms a curtain of opaque water above the sinking bait, shielding it from the eyes of scavenging seabirds.

It may enable fishing at any time of the day or night cycle, and in all seasons - including in seabird breeding seasons, when attacks are most intense. It also allows government regulators to monitor fishing vessel compliance in the absence of an onboard observer. In March 2009, researchers set 300 underwater baited hooks and ran extremely successful trials. Results showed that bait quality and bait retention on hooks were not affected by the new method of deployment, so that use of the device is unlikely to affect the catch rates of target and non-target fish species. Further details on this device and stages of development can be found at: http://www.smartgear.org/smartgear_winners/2009/grand_prize_winner_2009/.

4.9 New information on seabird bycatch mitigation measures for non-longline fisheries

Recently, Bull (2007) assessed mitigation methods to reduce and avoid seabird bycatch in terms of their ability to reduce bycatch rates and their economic viability for longline, trawl and gillnet fisheries worldwide. Factors influencing the appropriateness and effectiveness of a mitigation device include the fishery, vessel, location, seabird assemblage present and season of year. Seabirds interact differently with fisheries depending on the type of fishery and the gear used. As yet, there is no single solution to reduce or eliminate seabird bycatch across all fisheries - a combination of measures is required, and even within a fishery there is likely to be refinement of techniques by individual vessels in order to maximize their effectiveness at reducing seabird bycatch. Urgent investigation is needed into more effective measures at reducing seabird interactions namely with trawl nets and gillnets. Clearly, a mitigation method that reduces bycatch to non-significant levels is of little value if for some reason (e.g. crew safety, unpractical) it is not readily used by fishers. Those mitigation methods that are likely to be adopted by the fishing industry are those which provide operational benefits, do not increase safety hazards to crew, and do not decrease fishing efficiency (e.g. Melvin *et al*. 1999). All these factors must therefore be considered when designing a mitigation protocol (Bull 2007). Besides general considerations such as managing offal and discards through retention or strategic dumping or closing of fishing for a specific season or period, special mitigation measures should be used in trawl and gillnet fisheries.

4.9.1 Trawl fisheries

In trawl fisheries, seabirds often collide with the net monitoring (net-sonde) cable and the trawl warps, or birds become tangled in the net (while attempting to feed) when it is at the surface during setting and hauling. Relatively few published studies report on methods to reduce seabird bycatch in trawl fisheries. As such, the recommenda-

tions and discussion are based on relatively recent observations (some anecdotal), pilot tests, and trials undertaken in the Falkland Islands, Bering Sea, South Georgia and Australian trawl fisheries (Bull 2007). The results of Bull's (2007) review indicate that a combination of absence of a net monitoring cable (for example by using hull-mounted acoustic net monitors), paired bird-scaring lines (for details see Sullivan *et al.* 2004), retention of offal during fishing operations (especially during setting and hauling), and reducing the time the net is on (or near) the surface, are likely to be the most effective regime at this point in time to mitigate seabird bycatch in trawl fisheries.

BirdLife International Seabird Bycatch Mitigation Fact-sheets highlight a number of potential techniques that can mitigate for the effects of net entanglements of birds. Namely, these include adequate cleaned on nets prior to net-shooting, offal management, net binding, net weighting, and appropriate deck lighting, as potential means of bycatch reduction in trawl fisheries (see Fact-sheet 14,

http://www.rspb.org.uk/Images/FS_14_tcm9-224651.pdf).

4.9.2 Gillnet fisheries

In gillnet fisheries seabirds are most often caught in the nets when diving for prey (Kirchhoff 1982, Melvin *et al.* 1999, Bull 2007). Most studies that have investigated mitigation methods for gillnetting have focused on the impact of this fishery on marine mammals, with little work on seabirds.

Melvin *et al.* (1999) examined several strategies to reduce seabird bycatch, primarily of common guillemots and rhinoceros auklets, in a coastal salmon drift gillnet fishery in Puget Sound, Washington (USA). Their goal was a significant reduction in seabird bycatch without a concomitant reduction in target catch or an increase in the bycatch of any other species. They compared fish catch and seabird bycatch in nets modified to include visual alerts (highly visible netting in the upper net) or acoustic alerts (pingers), with traditional monofilament nets set throughout the normal fishing hours over a 5 week fishing season. Catch and bycatch varied significantly as a function of gear. The results of the study identify three complementary tools to reduce seabird bycatch in the Puget Sound drift gillnet fishery - gear modifications, abundance-based fishery openings, and time of day restrictions - for a possible reduction in seabird bycatch of up to 70–75% with no significant reduction in target fishing efficiency. Although these tools are based on local conditions and will therefore vary among years and locations, all might be exportable to other coastal gillnet fisheries worldwide.

Trippel *et al.* (2003) infused nylon nets with barium sulphate or other metal compounds that have acoustical detection features for reducing small cetacean bycatch. Experimental results show that they can be effective in reducing the bycatch of both, harbour porpoise *Phocoena phocoena* and greater shearwater, though it has not been ascertained if this is because of their acoustic reflectivity, increased stiffness, or greater visibility over conventional gillnets. Some Newfoundland inshore fishers are of the opinion that white monofilament gillnets do not catch as many guillemots and puffins as those dyed olive green or blue; white nets may increase their visibility to birds. Anecdotal information suggests that white nets do not affect fish catch rates.

Mentjes and Gabriel (1999) conclude for gillnet fishing in the western Baltic Sea that it is obviously impossible to reduce the local and temporal bycatch problem by means of different gillnet constructions or by tactical measurements. Only the temporary avoidance of fishing grounds that host large numbers of ducks, or the change to

longlining as the catch method may be an effective solution. Clearly, however, the latter solution might have significant consequences for seabird species that are vulnerable to being caught on longlines.

4.10 New information on existing seabird bycatch mitigation measures

4.10.1 Underwater Setting Chute

The WGSE report from 2008 covered underwater setting devices (USDs). As mentioned above, there has been considerable progress in this field, specifically in relation to Bait Pods and the Bait-setting Capsule; recently developed by FishTek & BirdLife International, and Amerro Engineering & the Australian Antarctic Division, respectively. However, other USDs, such as chutes and funnels, have been less successful in uptake among the wider fishing communities. For example, Mustad, the main producer of the underwater setting funnel, is believed to no longer manufacture this product. USDs that have less impact to the structural integrity of the vessel concerned like the Bait Pod and Bait-setting capsule, appear to have superseded the more expensive and consequential changes required by the funnel and chute USDs.

4.10.2 Bait-casting/throwing machines

These devices are used in pelagic longline fisheries to project the baited branchlines some distance from the longline, thus reducing the chance of gear entanglement and allowing more rapid sinking rates because the lines are not continuously under tension. Although not specifically designed to reduce seabird bycatch, studies have reported lower bycatch rates when these devices are used (Klaer and Polacheck 1998).

The original Bait-casting machine (BCM), developed by Gyrocast Pty Ltd, improved fishing efficiency and, if used correctly, had the potential to reduce the risk of seabird bycatch. Gyrocast BCMs had a five second cycling time, variable power control, the ability to cast hooks up to 23 metres, directional control (i.e. able to switch between port and starboard) and a gimballed mount to compensate for vessel movement (Brothers *et al*. 1999). These features help to reduce bait loss to birds and seabird bycatch by allowing fishermen to 'place' baited hooks under the protection of a streamer line, even in strong winds. Gyrocast machines were highly engineered and were therefore expensive to manufacture. Despite this, uptake within the pelagic longline industry was good (Brothers *et al*. 1999).

Before long cheaper alternative brands appeared on the market that were adopted by the industry. Unfortunately, these new machines only incorporated the labour saving features of BCMs and not the features that helped to reduce bycatch (they are mainly used to straighten branch lines to reduce tangling). They had no control over distance or direction hooks were cast and the arc of the cast resulted in interference with streamer lines, or baited hooks landing outside the protection of streamer lines.

In theory, BCMs improve fishing efficiency by:

- Reducing tangles in branchlines
- Reducing bait loss by avoiding propeller turbulence
- Reducing bait losses to seabirds by better positioning of hooks below streamer lines

Trials of the early BCMs (Gyrocast), indicated that these machines substantially reduced bait loss to seabirds) provided bait was consistently landed beneath streamer lines (Brothers *et al*. 1999). As mentioned, later models of BCMs have not incorporated the key features necessary to reduce seabird bycatch, in particular distance con-

trol. Currently, there is inadequate data to quantify the effectiveness of the current version of these machines.

Best practice recommendations

The original Gyrocast machine showed great promise as an aid to reducing seabird bycatch, however, these devices are no longer in production. Current models of BCM are designed to improve fishing efficiency and should not be regarded as seabird by-catch mitigation measures. The BCMs currently used lack control over casting power. Consequently, the arc of the cast can interfere with streamer lines and bait may be landed well beyond the location of the streamer line. The ability to adjust the distance and direction of cast are critical performance features of BCMs and should be built into future machines if they are to be regarded as contributing to the reduction of seabird bycatch.

4.10.3 Fish oil

The use of oil extracted onboard from bycatch shark and applied over the stern of the vessel as a deterrent to seabirds, especially shearwaters and other burrow-nesting petrels, from entering the area in which they could gain access to baited hooks, was previously put forward as a potential method of mitigation for seabird bycatch. However, given the recent significant advances in a large number of alternative sea-bird bycatch mitigation measures (see above), it would seem pertinent to revise this as a potential option of seabird bycatch mitigation by the WGSE, in light of current threatened status of many shark species, and given the number of alternative meth-ods to mitigate seabird bycatch now available.

4.11 Conclusion

As a result of this review and update of new information, WGSE consider that it would be beneficial if a workshop were to be held sometime in 2010, at which stake-holders and seabird experts could bring all relevant information together on seabird bycatch. The ultimate goal of the workshop and its products would be to facilitate the preparation of the EC-PoA by the Commission in a timely manner and consistent with the current DGMARE workplan deadline of April 2011 to adopt such a plan. A proposal for such a workshop is made in Annex 5.

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5 Interactions between parasites and climate change on seabirds

At the 2007 WGSE meeting, the group proposed a first version of a review on ecological issues related to the circulation of pathogens and parasites in seabird populations and this topic was listed as a term of reference for the 2008 and 2009 meetings. An important issue that emerged from these reports, the interaction between parasites and climate change on seabirds, will form the focus of this report.

5.1 Introduction

Seabirds are hosts to a large suite of pathogens and parasites (Hubalek 1994, 2004, Chastel 1988, Muzaffar and Jones 2004). Their large population sizes, high mobility and wide geographic distribution make them significant potential players in the ecol-

ogy and epidemiology of zoonotic diseases, and in several instances they have been involved in major outbreaks (e.g. Rappole and Hubalek 2003, Gerhardt 2006, Olsen *et al.* 2006, Herrmann *et al.* 2006). The highly social breeding habits and site fidelity of seabirds (Furness and Monaghan 1987) result in potentially high contact rates among conspecifics, a fundamental component of host-parasite dynamics.

Despite the recent active development of work on the ecology and evolution of host-parasite interactions (Grenfell and Dobson 1995, Hudson *et al.* 2002, Frank 2002, Thomas *et al.* 2005), relatively little information is available on seabird-parasite interactions and their epidemiological implications. Previous WGSE reports have summarised the current knowledge with a view to identifying knowledge gaps and potential avenues for research. One important area that has emerged from this work is the potential impact of climate change on host-parasite interactions. This subject is in its infancy, yet there is strong speculation that the impact of parasites and disease on seabirds may change significantly with climate change.

5.2 Effects of climate change on seabird-parasite interactions

Climate change is likely to impact the circulation and prevalence of parasites and disease because vectors, generally small arthropods, are highly sensitive to weather conditions at many stages of their life-cycles (Rogers and Randolph 2006). However, even in relatively well studied species such as humans and domestic animals the likely impacts of climate change on disease or parasite prevalence are only poorly understood and impacts are difficult to predict. Therefore, assessing potential impacts on seabirds, a relatively poorly studied host-parasite system, is hugely challenging and there is currently a lack of empirical data to support predictions.

Climate change may impact the prevalence of parasites or disease in seabirds by altering a number of different parameters that can affect disease spread and persistence, including the ratio of vector numbers to host numbers (via changing vector distributions or host or vector densities, vector competence), behavioural parameters that affect transmission (such as vector biting rates and timing of emergence) and host susceptibility (Rogers and Randolph 2006). Predicting the direction of the effect of climate change on such parameters is possible, but predicting the shape of or level of responses in disease prevalence is highly problematic, especially in complex and poorly understood systems.

5.2.1 Ratio of vector numbers to host numbers and disease range expansion

Vector-borne diseases are known to be sensitive to climatic conditions and therefore the most likely mechanism by which seabird health will be impacted by climate change is via changing vector distributions and abundance. Climate warming is predicted to increase the range and incidence of vector-borne diseases. Although evidence from seabird hosts is lacking, much work has been done on the potential effects of climate change on the distribution of tick species responsible for the terrestrial cycle of human Lyme disease, such as *Ixodes scapularis* (Ogden *et al.* 2005). Other arthropod vectors are also predicted to increase with climate warming. For example, modelling work has shown that malaria is forecast to spread into northern latitudes due to the range expansion of mosquito vectors (Martens 1999; Epstein 2000; Rogers and Randolph 2000), and bluetongue virus has spread into European livestock when climate warming enabled the major vector, *Culicoides imicola*, to expand its distribution northward (Purse *et al.* 2005). Indeed, the spread of blue tongue is probably the best example of the impact of climate change on disease spread because other biotic, social and agricultural factors were plausibly discounted. Blue tongue spread was

found to be due to increased virus persistence during the warmer winters, north-
wards expansion of the main vector transmitting blue tongue, and new transmission
by native *Culicoides* vectors (Purse *et al.* 2005).

However, although climate has been linked to changes in vector populations, even
for well studied systems such as that of zoonotic tick borne infections, e.g. tick borne
encephalitis (TBE), it is difficult to disentangle causality and correlation between tick
abundance and climate variables, and often a network of interacting factors are in-
volved (Randolph 2010). Indeed, evidence of the impact of climate change on sea-
birds is largely correlative. For example, a recent study found a striking increase in
the number of fed ticks in Adelie penguin rookeries in 2007 and hypothesised that
this was due to the longer and warmer summer (Benoit *et al.* 2009). Yet species such
as *Ixodes uriae* show clear adaptation to dramatic variations in environmental condi-
tions (Murray and Vestjens 1967, Lee and Baust 1982, Barton *et al.* 1996, Benoit *et al.*
2007) and hence interpreting correlations and predicting responses can be difficult.

Parasite prevalence and distributions and host exposure may also change in response
to climate change. North Atlantic and Arctic murres have been found to have been
infected (prevalences of 26%) with *Alcataenia longicervia*, a Pacific species of tape-
worm, since 2006. This is due to mixing of Pacific and Atlantic populations of
Euphausiid intermediate hosts (Muzaffar 2009), although the role of climate change
in this mixing is unclear. Potentially, altered prey distributions or relative abun-
dances could lead to seabirds being exposed to differing parasite abundances or spe-
cies in the future.

5.2.2   Changes in vector competence

Climate may influence the prevalence of a disease within an existing vector or alter
vector competence and therefore increase transmission potential to hosts. For exam-
ple, replication of West Nile Virus in mosquito hosts is known to be temperature lim-
ited (Kilpatrick *et al.* 2008; Reisen *et al.* 2006); competence of *Culicoides* vectors to
bluetongue virus is directly enhanced by warm temperatures (Paweska *et al.* 2002).
Climate change may lead to increased disease transmission by decreasing vector gen-
eration time or decreasing the incubation period of a pathogen (Tabachnick 2010).

5.2.3   Changes in host pathogen contact rates

Climate may alter the timing, or phenology, of overlap between host and vector. For
example, transmission potential of arboviruses may be increased due to climate
change elongating the transmission season and altering emergence behaviour. Alter-
natively, climate warming might lead to reduced disease transmission if hosts and
vectors respond differently to climate warming and a "mismatch" occurs due to tro-
phic levels responding to different cues. Transmission of disease or parasites may
also be affected by climate induced changes in host abundance. If host population
densities reduce or become unpredictable this may lead to reduced transmission po-
tential of disease and reduced vector abundance.

5.2.4   Host susceptibility

Climate change is predicted to alter species distributions and phenology, and there is
evidence that seabird declines in some areas are linked to declining food availability.
Costs of parasitism or infection are predicted to be higher when food is limited, due
to parasites directly reducing the availability of nutrients to the host, and trade-offs in
allocation of resources between maintenance, reproduction and immune function
(Ilmonen *et al.* 2000; Colditz 2008). Poor conditions during early development are

known to have long-term consequences for birds (Metcalfe and Monaghan 2001), including poorer reproductive performance (Reid *et al.* 2003) and lowered survival (Van de Pol *et al.* 2006), and therefore high parasite burdens or infections causing poor condition in nestlings may have substantial negative impacts on subsequent seabird population dynamics.

5.3 Conclusions

The role of parasitism in the ecology of natural bird populations has attracted much interest in the last two decades, notably in the fields of behavioural and population biology (Loye and Zuk 1991, Clayton and Moore 1997), but those factors are only recently being considered as potential threats to seabird populations. However, there remains considerable uncertainty about the impact of parasites on seabird hosts. Against this backdrop, the potential interactive role of climate change is potentially significant. This report has summarised the potential mechanisms whereby climate change may impact on host-parasite dynamics. However, it is clear that there is a lack of knowledge even of well studied species like humans and livestock; the level of understanding is considerably lower still for seabirds. Yet, given current predictions of future change in key environmental variables such as temperature and humidity, it is recommended that this should be the subject of future research.

In the first instance, it would be fruitful to incorporate into monitoring programmes of seabird populations that involve the handling of seabirds the collection samples that could easily be taken to enable the tracking of parasitic agents among populations at small and wide spatial scales. Such investigations can rely on molecular techniques (polymerase chain reaction, PCR, methods) or the detection of antibodies in plasma or sera samples using enzyme-linked immunosorbent assay (ELISA, Western blots). These data could then be compared to environmental conditions. However, since host-parasite dynamics are complex and difficult to predict then in addition to monitoring, more focussed studies using experimental approaches will be required.

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6 Foraging interactions among seabirds, cetaceans and pelagic fish in the North Atlantic Ocean

6.1 Introduction

Pelagic seabirds feed on zooplankton and schooling fish that are often difficult to access, as even diving birds are restricted to near-surface layers of the water column. These prey can, however, be rendered much more readily accessible to birds when they are corralled or driven to the surface by predatory fish such as tuna, or by cetaceans. Therefore, seabirds clearly benefit through paying attention to the actions of fish and cetaceans, and indeed there is a substantial literature on the observed spatial associations among these animals. This was last reviewed in Evans (1982), and, specifically for the north-west Atlantic Ocean, by Pierotti (1988).

Spatial association at sea among seabirds, cetaceans and fish is important for two reasons. First, seabirds depend to a greater or lesser extent on the actions of cetaceans and fish to drive their prey to the surface; for tropical species such as sooty terns and boobies, this dependence may be absolute, in the sense that the birds cannot obtain prey any other way. Therefore, conservation measures for birds needs also to incorporate conservation for cetaceans and fish (Weimerskirch *et al*. 2008, Hebshi *et al*. 2008). Second, because birds associate with schools of fish, they are liable to be caught and killed by commercial fisheries operations.

While on a worldwide basis there are substantial data on seabird-cetacean-fish associations, there is a relative scarcity of data from the North Atlantic. For this reason, herein we draw fairly heavily on data from other parts of the world. Often, such studies from outside the North Atlantic involve the same species that occur in the North Atlantic so are also of relevance here.

Previous authors have categorized different types of seabird feeding flocks, with the categories reflecting both the duration of the aggregation and the extent to which the various members derive benefit from the association (Ashmole 1971, Hoffman *et al*. 1981, Pierotti 1988, Camphuysen and Webb 1999). For this review, we focus on birds that converge upon groups of cetaceans or fish to forage for prey associated with those cetaceans or fish. The birds may eat the same prey species pursued by the cetaceans or fish, or other smaller prey species sought by these prey.

6.2   Seabirds and Cetaceans

6.2.1   Large whales

Flocks of seabirds commonly form about groups of whales, usually to feed upon the schools of baitfish, such as sandeels *Ammodytes* spp., herring *Clupea harengus* or capelin *Mallotus villotus* that the whales have driven to the surface or forced to aggregate into tight "balls" (Hoffman *et al*. 1981, Whitehead *et al*. 1979, Evans 1982). Perhaps the most dramatic interactions among seabirds and whales worldwide occur around feeding humpback whales (*Megaptera novaeangliae*) and gray whales *Eschrichtius robustus* (Whitehead *et al*. 1979, Obst and Hunt 1990). Humpback Whales feed on schooling fish and zooplankton such as euphausiids, and corral these prey into tight schools; they also "lunge" and "bubble feed" in such a way as to make these prey immediately available at the surface. Humpbacks are often accompanied by flocks of hundreds or even thousands of feeding shearwaters, gannets, gulls and terns. Part of the interaction among Humpback whales and seabirds (in contrast to gray whales, see below) occurs because both humpbacks and seabirds are attracted to the same coastal fishing banks because of the prey resources that are there. That is, seabirds frequent the places where humpback-seabird interactions occur even in the absence of whales. Gray whales, by comparison, are bottom feeders; they plough through the mud with their heads and stir benthic organisms into the water column that then become available to birds, so that in the absence of gray whales those areas would likely not attract birds at all. Some squid feeders, especially albatrosses, attend feeding sperm whales *Physeter macrocepahalus* but few other birds have been reported attracted to these deep water specialized feeders.

In the North Sea, the most frequent association seems to be between gannets, kittiwakes and minke whales *Balaenoptera acutorostrata* (Camphuysen and Webb 1999). These birds and whales feed on schooling fish such as sandeels and herring, and it is likely that these birds find a substantial amount of their food by noticing the actions of whales that have located schools of fish. Seabirds also feed on prey fragments in whale excrement (Evans 1982, Pierotti 1988) and this is believed to be of importance in the North Sea (Camphuysen and Webb 1999). Camphuysen and Webb (1999) distinguish between "natural assemblages" of seabirds in which it was somehow judged that the whales and seabirds were attracted independently to a prey resource, versus assemblages "with cetaceans" in which they judged the birds to have been attracted to the cetaceans rather than to the cetacean prey directly. The seabirds in the latter category constituted 4% of all feeding seabirds detected over an 11 year period 1987–1998. However, a large number of the seabirds seen feeding by Camphuysen and

Webb (1999) also fell in the "natural assemblage" category, and were associated with minke whales as well as dolphins *Delphinidae*, so this proportion may in fact be considerably higher. The dominant species in these cetacean-based assemblages of feeding birds were northern gannets (50.9%) and black-legged kittiwakes (33%), and northern fulmars (5.9%). Skov *et al.* (1995) analyzed two years of summer data (1987 and 1989) from the North Atlantic between the UK, Norway and Iceland and found a significant association among Leach's storm-petrels, Manx shearwaters and minke whales. This association was partly explained by the similarity in diet of these species, and their simultaneous selection of slope habitats, including banks and seamounts in the area. It is not known the extent to which these seabirds may be using the minke whales as cues to the location of food.

In sum, the rather limited (in space) data available show that the primary associations between whales and seabirds in ICES waters are between minke whales and gannets, kittiwakes and fulmars. The very conspicuous association among shearwaters, gannets and other seabirds and feeding humpback whales *Megaptera novaeangliae* (Whitehead *et al.* 1979, Evans 1982) in North American waters is largely absent from EU waters. The data cited above are almost entirely from OSPAR Regions I and II. The large oceanic Regions IV and V, extending south to the Azores, probably feature conspicuous associations among seabirds and cetaceans as open ocean areas are especially depauperate in the surface layers.

6.2.2   Dolphins

The dynamics of association between seabirds and dolphins are slightly different from those between seabirds and whales. Seabirds are not known to feed on dolphin excrement, and instead feed on the same prey pursued by the dolphins themselves (Evans 1982, Pierotti 1988). Associations among dolphins and seabirds are most strongly developed in the tropics (Au and Pitman 1986, Ballance *et al.* 1997, Hebshi *et al.* 2008), where many seabirds, especially Sooty Terns, Wedge-tailed Shearwaters and Parkinson's Petrels (Pitman and Balance 1992) are near obligate commensals of these animals. Tropical dolphins often occur in mixed species assemblages with tunas (Au 1991) from which they may gain advantage in foraging. Seabirds then pursue the smaller fish chased by the combined efforts of dolphins and fish.

Both Evans (1982) and Skov *et al.* (1995) found strong spatial correlation between gannets and white-beaked dolphins *Lagenorhynchus albirostris* in the North Sea and in the North Atlantic, and pointed out that both these species feed on schooling fish such as herring and mackerel *Scomber scomber*, so that the co-occurrence could be explained as co-incidental aggregation to a resource patch. Nevertheless, both dolphin schools and gannets are conspicuous and it seems possible that both animals use each other as cues to the presence of resources. Camphuysen and Webb (1999) found gannets feeding in association with both white-beaked dolphins and harbour porpoises *Phocoena phocoena* in the North Sea, and Skov *et al.* (1995) found association between Leach's storm-petrel, Manx shearwaters and pilot whales *Globicephala melas* and bottlenose dolphins *Tursiops truncatus* in the northeastern North Atlantic. Skov *et al.* also recorded a statistical association between great skuas, Arctic terns, fin whales *Balaenoptera physalus* and white-sided dolphins *Lagenorhynchus acutus*, but these last seem likely to be coincidence of selecting the same habitats.

Seabird association with dolphins is more widespread in tropical and subtropical waters, and is probably most frequent in the more southerly parts of OSPAR regions IV and V, especially near the Azores. There, large numbers of Cory's shearwaters feed over schools of common dolphins *Delphinus delphis* (Clua and Grosvalet 2001), and

these dolphin schools also often contain striped *Stenella coeruleoalba* and spinner dolphins *S. longirostris* as well as bluefin tuna *Thunnus thynnus* and yellowfin tuna *T. albacares*. All (100%) of dolphin feeding aggregations observed were followed by Cory's shearwaters, often numbering in the thousands. Thus, it appears likely that seabirds in the vicinity of the Azores, and probably to some extent in all of OSPAR Region V depend to a greater extent upon the actions of cetaceans to obtain their prey than do seabirds farther north.

In sum there are some strong statistical associations between foraging seabirds and dolphins in European waters. These are strongest in the far south of the region near the Azores, but also are found north to the North Sea and North Atlantic, where gannets especially attend schools of white-beaked dolphins.

6.2.3   Birds and seals

Seabirds often feed in association with seals (Harrison *et al.* 1990) especially sea lions and fur seals that have diets similar to the birds. For example, both seabirds and Antarctic fur seals consume Antarctic krill around subantarctic islands (Croxall and Prince 1980), and seabirds and sea lions consume euphausiids and juvenile rockfish *Sebastes* sp. in the California Current (Ainley and Boekelheide 1990). In the North Atlantic, gulls and shearwaters often attend groups of foraging grey seals *Halichoerus grypus* as they converge on schools of sandeels. Thus, there is the potential for seabirds to benefit from interactions with grey and harbour seals in European waters.

6.3   Seabirds and tuna

Seabirds often follow schools of foraging and migrating tuna in order to feed upon the smaller fish that the tuna are chasing (Au and Pitman 1986, Clua and Grosvalet 2001, Le Corre and Jaquemet 2005). Very often tuna are accompanied by dolphins, and all three (seabird, tuna, dolphin) may benefit from the association though the precise details are difficult to identify. The association between birds and tuna is most pronounced in tropical waters, but yellowfin and bluefin tuna range extensively into the subtropics, north at least in the past, to Norway and Ireland, and seabirds in European waters are likely to associate with them there. In tropical waters, the fish over which seabirds aggregate most often are bluefin, yellowfin, and skipjack *Katsuwonus pelamis* tunas.

Clua and Grosvalet (2001) describe close association (see above) among foraging aggregations of common dolphins, striped dolphins, spinner dolphins, bluefin and yellowfin tuna as well as other species of fish in waters surrounding the Azores. Cory's shearwaters are the dominant seabird at these aggregations, but the shearwaters are also joined by Bulwer's petrels, Band-rumped Storm-Petrels, gulls and terns. The dolphins and tuna corral schools of smaller fish into tightly packed "baitballs" and the shearwaters then actively pursue these. Indications are that the birds would be unlikely to be able to access these fish in the absence of the tuna and dolphins.

Figure 6.1. Co-occurrence of terns (mainly commons) and tuna on Georges Bank, September 2009. Both terns and tuna feed on herring, sandeels and other fish, and terns may use tuna as cues to presence of bait. From Goyert (2010).

Recent analyses of shipboard transects and satellite tracking of both bluefin tuna and greater shearwaters in the north-west Atlantic (Martin *et al.* unpublished) show statistically significant spatial overlap and it seems likely that the migrations and foraging trips of these vertebrates are coupled for this reason. Furthermore, spatial distributions of foraging common terns and bluefin tuna are statistically associated on Georges Bank (Figure 6.1; Goyert 2010) and this relationship is likely to hold for those European waters where tuna occur.

This close association between Cory's shearwaters and tuna may contribute to the relatively high bycatch of birds in e.g. the Mediterranean tuna fishery (see Chapter 4).

6.4   Data gaps and research needs for European waters

Coverage of OSPAR Regions II seem sufficient to identify the most important seabird-cetacean-fish associations in those areas. Surveys in those areas by Camphuysen and Webb (1999) and Skov *et al.* (1995) show that minke whale, white-beaked dolphin and harbour porpoise are the species that serve as important cues to seabirds, and that northern nannets, black-legged kittiwakes and northern fulmars are the species that make use of these cues. While there are few relevant data from OSPAR Region III, it is likely that interactions there are similar to those in Region II. Skov *et al.* surveyed the southernmost part of Region I, but there are few data from other parts of that region which includes Iceland and Svalbard. There are no available data to suggest that seabird-cetacean interactions are common in those waters. However, there are substantial data from other tropical and subtropical regions (Au and Pitman 1986, Balance *et al.* 1997, Hodges and Woehler 1994, LeCorre and Jaquemet 2005, Vaughan *et al.* 2007, Yen *et al.* 2004) to show that seabird-dolphin-tuna interactions are likely to

be extremely important in the extensive OSPAR Regions IV and V. Detailed but spatially limited data from the Azores (Clua and Grosvalet 2001) confirm the global pattern of dependence by surface feeding birds upon the actions of tuna and dolphins to drive prey to the surface.

It would also be useful to estimate proportion of food obtained by seabirds through association with cetaceans and tuna, compared to total energy needs. For some tropical and subtropical seabirds, this proportion is likely to be close to 100% (Weimerskirch *et al*. 2008, Clua and Grosvalet 2001). It is possible to estimate this proportion from survey data, as has been done for the data from Camphuysen and Webb (1999). We recommend that future surveys collect data in such a way that proportion of birds feeding over cetaceans and tuna divided by total birds feeding can be readily extracted. Similar information should could in theory be obtained from tracking of both birds and tuna or birds and cetaceans.

Table 6.1. Published associations between seabirds and whales and seabirds and tuna in European waters

	Feeding with		
Species	Large whales	Dolphins	Tuna
Shearwaters	Whitehead *et al*. 1979	Skov *et al*. 1995	Clua and Grosvalet 2001; Martin *et al*. unpublished
Storm-petrels	Skov *et al*. 1995	Skov *et al*. 1995	
Gannets	Camphuysen and Webb 1999	Camphuysen *et al*. 1995; Camphuysen and Webb 1999; Skov *et al*. 1995	
Gulls	Camphuysen and Webb 1999	Camphuysen and Webb 1999	Clua and Grosvalet 2001
Terns	Skov *et al*. 1995	Goyert 2010	Goyert 2010

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7 Identification of marine protected areas in EU waters

WGSE presented a summary of progress with the identification of marine protected areas in various countries, including some outside Europe in 2006 (ICES 2006). Two principle types of areas were addressed, Special Protection Areas (SPAs) and Impor-

tant Bird Areas (IBAs). This chapter provides a brief overview of progress with the identification and classification of marine protected areas since 2006. It is not intended as an exhaustive review of the methods applied in protected area identification, and information at the time of the meeting was available only from five Member States of the EU (UK, Germany, Spain, Portugal, and the Netherlands); the reader is referred again to ICES (2006).

SPAs should be classified for the protection of two categories of seabird species under the EU Birds Directive (EU 2009); these are those species considered to be rare or vulnerable and therefore placed on Annex I of the Directive, and those species considered to be regularly occurring migratory species. Classification of SPAs – both on land at sea - is a legal requirement for Member States of the European Union.

IBAs are those areas considered by BirdLife International to be especially important for certain species of bird, species that satisfy certain criteria that indicate their rarity or vulnerability in respect of restricted range, declining population, contracting range or other population attributes. IBAs are not a legal instrument but an accolade based on the application of criteria formulated by BirdLife International (IBA criteria are listed in Ramirez *et al*. 2008); however, in the absence of a list of possible, potential or actual SPAs, the IBA list for an EU Member State, where it exists, may be used as a reference list for the future classification of SPAs in that Member State (EU 2007).

Methodological guidelines exist for the identification of marine SPAs in the EU (EC 2007). These are guidelines, however, and as such are not prescriptive. The methods chosen to identify sites might (and do) vary among EU Member States but nevertheless they must be robust. There follows a summary of progress with the identification of areas for the protection of birds in the marine environment and a description of the methods used.

7.1   Progress with SPA and IBA identification in EU waters

The European Commission has set 2012 as a deadline by which EU Member States should classify coherent networks of SPAs. The rate at which the various European countries are working towards this varies greatly. This chapter reviews progress with the classification and identification of SPAs and IBAs in Member States to date.

7.1.1   United Kingdom

The identification of marine IBAs around the UK has been progressed as a matter of less urgency than in some other EU countries. This is largely because work in support of marine SPA classification is pursued in a coherent programme of survey, research and analysis promoted and carried out by the advisor to the UK government and devolved administrations on nature conservation, the Joint Nature Conservation Committee. The overall aim is to have identified a network of marine SPAs around the UK by 2012.

Potential SPAs are being identified within several streams of work.

7.1.1.1 Extensions to existing seabird colony SPAs

There are 92 SPAs for the protection of breeding seabirds around the UK coast. Research has indicated that those sites where certain species breed merit extension into the waters surrounding the colonies by varying amounts depending on the species present (see section 7.2.1.1). At sites where the northern fulmar breeds, SPAs should be extended by 2 km around the colony; where northern gannet breeds, also by 2 km; and at sites where auks are present (Atlantic puffin, razorbill, common guillemot) by

1 km. At Manx shearwater SPAs the extension should be at least 4 km, and more where the available evidence suggests it.

To date, 31 seabird colony SPAs have been extended around the coast of Scotland, and plans are under way for extensions of a further three in England, three in Wales, and one in Northern Ireland.

7.1.1.2 "Inshore" aggregations of waterbirds outside the breeding season

Large numbers of divers Gavidae, grebes Podicepidae, and seaduck Anatidae gather for feeding and other purposes in resource-rich inshore areas, including river estuaries, shallow bays and inlets, and sealochs around the UK during the non-breeding seasons. An ongoing, extensive survey programme covering 50 areas of search (see section 7.2.1.2) has revealed several of these that might warrant classification as SPAs. To date, one such site has been classified for its important wintering population of common scoter, Carmarthen Bay Bae Caerfyrddin in south-west Wales. A further two sites are in the process of being classified (public consultation on them has been undertaken) and are *de facto* SPAs – Liverpool Bay Bae Lerpwl "potential" SPA, a joint Wales/England site hosting important wintering populations of common scoter and red-throated diver, and Outer Thames Estuary potential SPA, holding the most important UK wintering population of red-throated diver.

Currently, a further seven inshore sites are being considered for possible classification for various species off the east and north coasts of Scotland, another one off Wales, and another off Northern Ireland. Further possible sites may be identified off England and on the west coast of Scotland. Only the most suitable sites from among this suite will eventually be classified as SPAs.

7.1.1.3 Offshore concentrations of seabirds

Based on analysis of an extensive data-set comprising at-sea records of seabirds compiled over the past three decades (see section 7.2.1.3), several important concentrations have been identified for various species at various times of year. While these areas may not in their entirety be classified, they offer a sound evidence base on which to make defensible decisions regarding offshore SPAs.

7.1.1.4 Terns in the breeding season

Five species of tern Sternidae breed in the UK (common, Arctic, roseate, Sandwich, and little). A 3 year programme of fieldwork (2009–2011) is under way at several breeding colonies throughout the UK aimed at identifying possible additional areas for SPA classification.

7.1.1.5 Breeding red-throated diver

There are 10 breeding site SPAs for the red-throated diver in Scotland. Based on 4 years of field survey and radio-tracking (2005–2008), a habitat-modelling approach (see section 7.2.1.5) is currently being developed to identify possible additional areas at-sea for its protection.

7.1.1.6 Breeding European shag

Tracking data from individual European shags at one SPA colony (the Isle of May, east Scotland – part of the Firth of Forth Islands SPA) are currently being analysed with a view to informing future possible marine SPA selection for the species. Such areas may or may not be adjacent to the breeding colonies.

7.1.1.7 Balearic shearwater

The Balearic shearwater, a Critically Endangered (IUCN 2007) species especially vulnerable to incidental mortality in long-line fisheries (see ICES 2008), breeds at several sites in the Mediterranean Sea. After breeding, birds migrate west through the Straits of Gibraltar and travel north along the Atlantic coasts of Portugal, Spain and France. Many reach the UK. 2010 will see the second of a planned 2 year field study aimed at identifying a possible SPA for the species off the south coast of England.

7.1.2 Germany

A total of 25 bird species occurs regularly in German waters. Data on their distributions, collected from ship-based surveys in the North and Baltic Seas, have been used to identify an SPA in each area; these areas were classified as SPAs in 2004 (Garthe and Skov 2006). The SPA in the Baltic Sea protects various species of divers, grebes and sea duck, and also the black guillemot; the two most important species protected in the SPA in the German North Sea are the red-throated diver and the black-throated diver.

7.1.3 Portugal

Identification of IBAs in Portuguese waters is the first step in a process that could result in the classification of SPAs here (Ramirez *et al*. 2008). Adapting the model established in the UK for the identification of marine SPAs, several types of IBA have been defined. Seventeen IBAs have been defined within the Portuguese EEZ (and a further 10 outside its EEZ).

7.1.3.1 Seaward extensions to breeding colonies

Extensions of existing IBAs for feeding, maintenance behaviours, and social interactions have been established for various species. The precise areas have been determined using information on foraging ranges (either gleaned from the literature or resulting from bird tracking) and preferred habitats of the species concerned.

7.1.3.2 Non-breeding coastal concentrations

The need for marine IBAs has been recognised for aggregations of feeding and moulting waterbirds such as divers, grebes, and benthos feeding ducks outwith the breeding season, although none appears to have been highlighted in Portuguese waters.

7.1.3.3 Areas for pelagic species

These sites comprise marine areas remote from land at which pelagic seabirds regularly gather in large numbers, whether to feed or for other purposes. These areas usually coincide with specific oceanographic features with high productivity.

7.1.3.4 Migration bottlenecks

These are usually determined by topographic features such as headlands and straits that channel the migration of seabirds along relatively narrow lines.

7.1.4 Spain

The classification of SPAs in Spain will also be informed by a BirdLife International initiative to compile an inventory of marine IBAs in Spanish waters (Arcos *et al*. 2009). Again, in accordance with the UK approach of identifying SPAs in broad categories, IBA identification took place in several strands of work aimed at including all seabird species and their varying uses of the marine environment.

7.1.4.1 Coastal non-breeding concentrations of birds

These include sites, usually in coastal and/or shallow areas, which hold feeding and moulting concentrations of waterbirds, such as divers, grebes and sea-ducks.

7.1.4.2 Offshore areas for pelagic species

Again, these sites comprise marine areas often remote from land where pelagic sea-birds regularly occur in large numbers, primarily for foraging purposes. They usually coincide with specific oceanographic features related with high biological productivity.

Eighteen coastal and offshore areas have been identified as IBAs in Spanish waters, including 14 that also qualify as colony extension or migration hotspot IBAs.

7.1.4.3 Seaward extensions to breeding colonies

Seabirds tend to nest colonially, and thus occur in high numbers at the breeding sites and their surroundings. This approach intended to account for the marine areas surrounding important seabird colonies, already identified as IBAs on land.

The sea around 37 seabird colonies has been identified for IBA extensions off Spain, including 16 that also qualify as other types of marine IBA.

7.1.4.4 Migration hotspots

These are areas that, due to geographical constrains, act as true bottlenecks for the migration of seabirds, and constrain the movements of entire bird populations (or a large share of them) during migration. Migration hotspots have received considerable attention for terrestrial species and waterfowl, but few advances have been made regarding seabirds.

Five areas have been identified as migration corridor IBAs in Spanish seas, including four that also qualify as other types of marine IBA.

7.1.5 Netherlands

In 2004, two areas in the Dutch coastal zone were classified as Natura 2000-sites – both as Special Areas of Conservation (SACs) and SPAs. These are the Delta Coast (Voordelta) and Wadden Coast (Noordzeekustzone). Lindeboom *et al.* (2005) identified a total of 12 areas in Dutch waters, including the existing two sites, that could potentially qualify for protection as marine protected areas (MPAs), three of them SPAs. Following a review by Jak *et al.* (2009), Netherlands proposes that Voordelta remains an SPA, that Wadden Coast (renamed North Sea Coast) be extended, and a new area, Frisian Front, be classified as an SPA.

Work is under way to apply marine IBA criteria to Lindeboom's *et al.* (2005) 12 areas in order to assess whether they qualify as IBAs (see below; Poot unpublished).

7.2 Methods applied in the identification of SPAs and IBAs in EU waters

What follows is a necessarily brief outline of the general methods that have been applied in the identification of SPAs and IBAs in five EU Member States. For full details of the methodologies and analytical techniques deployed the reader must consult the original sources. It will be clear that while various methods of data collection and analysis have been used in different countries the tools available to inform the issue of protected area identification are very similar.

7.2.1   United Kingdom

7.2.1.1   Extensions to existing seabird colony SPAs

Seabird distribution around six UK seabird colonies hosting nationally and internationally important numbers of seabird species was studied from ships using strip-transect methods. The data allowed geostatistical modelling (variography) and distance band analysis (Isaaks and Srivastava 1989) of the densities and distributions of four species engaged in so-called "active" behaviours - preening, bathing, and displaying. In contrast to the distribution of feeding birds, the distribution of birds engaged in "active" behaviours was largely independent of the physical or oceanographic characteristics of the colony or adjacent waters. Kriged density contours and mean modelled bird densities showed that modelled densities decreased with increasing distance from the colony. This pattern of decreasing density at greater distances from the colony was similar for all species at all six colonies and on all survey dates. Analyses of modelled densities indicated that the highest densities of common guillemot, Atlantic puffin, and razorbill occurred within 1 km from the colonies, and within 2 km for the northern gannet (McSorley *et al*. 2003, 2006). A further study using similar methodology indicated that the highest modelled densities of northern fulmar also occurred within 2 km from the colonies (McSorley *et al*. 2005).

A different approach was used to study the rafting behaviour of Manx shearwaters around their colonies. Here, birds were radio-tracked at three colony SPAs and positional data analysed using kernel contouring (Kenward *et al*. 2003). The greatest use of the waters around the colonies varied among the colonies - within 4, 6 or 9 km (McSorley *et al*. 2007, Wilson *et al*. 2009).

To date, the boundaries of 31 seabird colony SPAs in Scotland have been extended into the surrounding sea - by 1 km for Atlantic puffin, common guillemot, and razorbill, 2 km for the northern fulmar and northern gannet, and by 4 km for the Manx shearwater.

7.2.1.2   "Inshore" aggregations of waterbirds outside the breeding season

With some slight variation in, and evolution of, methodology applied to the identification of possible inshore SPAs, several areas of search are at different stages in the SPA identification process. Aerial survey of all inshore areas of search (see section 7.1.1.2) has almost been completed. In each of three years each area of search is surveyed several times usually in autumn/winter. The line transect data are subject to extensive analyses aimed at assessing numbers of birds, the extent of their distributions, and where possible boundaries might be drawn.

Broadly, the method is as follows. Distance sampling (Thomas *et al.* 2010) and extrapolation of raw counts are used to estimate the numbers of birds using each area of search, and to assess which species meet the UK SPA Selection Guidelines (Stroud *et al*. 2001). Kernel density estimation (KDE); a widely-used method to facilitate identification of hotspots by creating a smoothed surface of estimated densities in a grid (Silverman 1986), is used to smooth raw bird observations to create a modelled density surface for each area of search for these species. The point of maximum curvature (Webb 2009) of the relationship between numbers of birds and size of area required to support that number of birds is then identified; this represents the bird density at which the benefits of capturing more birds in the site are offset by a disproportionate increase in the size of area. This bird density value is then used to define boundary options for each area, such that all cells on the modelled density surface with a density greater than the maximum curvature density threshold are

included within any boundary. Boundary options might need to be altered to include any large aggregations of qualifying species recorded by shore-based surveys. Population estimates within the boundary options are re-calculated for species that meet the UK SPA Guidelines within the area of search.

7.2.1.3 Offshore concentrations of seabirds

Data on offshore seabird distribution (from 0–200 nm), collected using standardised transect methods from boats over more than 30 years (Tasker *et al.* 1984; the European Seabirds at Sea database) have been analysed with a view to identifying area at sea that might possibly be suitable as SPAs (Kober *et al.* 2010). All years of data were combined and then categorised by species and season. In order to generate continuous seabird density surface maps Poisson kriging was applied to the data (Zuur *et al.* 2008). Fifty-seven such seabird density surface maps were created. The total numbers of seabirds per species and season of the maps were compared and calibrated with populations estimated by WGSE (Barrett *et al.* 2006). A grid of 6x6km cells was generated and data were summarised per grid cell. In order to identify bird concentrations on the seabird density surface maps, a local indicator of spatial association, the Getis-Ord Gi* statistic, was calculated for each 6x6 km grid cell. Getis-Ord Gi* is larger the higher and more clustered values are around a central location. In order to delineate bird concentrations on the Getis-Ord Gi* map surfaces, two alternative threshold values were applied and compared - the top 1% and the top 5% of all Getis-Ord Gi*. Grid cells with Getis-Ord Gi* exceeding the threshold were marked and those sharing a boundary were then fused to form larger areas, equivalent to seabird "hotspots". Hotspots were identified on all density surface maps and compared against the UK SPA selection guidelines. Hotspots identified by Getis-Ord Gi* holding qualifying numbers of either a single species or a seabird assemblage were tested to determine if they occurred regularly. Of 6013 hotspots identified by the top 5% of Getis-Ord Gi*, 28 regularly held qualifying numbers of the species for which they were generated. Of 2201 hotspots identified based on the top 1% of Getis-Ord Gi*, eight regularly held qualifying numbers of the species for which they were generated. These areas were identified for Manx shearwater (breeding), northern gannet (breeding), European shag (breeding and winter), great skua (breeding), common guillemot (breeding), and Atlantic puffin (breeding). Other areas also emerged as important for certain species but not on a regular basis.

Further work and consideration of it is required before any offshore areas may be deemed suitable as SPAs for seabirds.

7.2.1.4 Terns in the breeding season

In order to identify possible additional SPAs for terns at sea habitat suitability models are being developed. These will identify those environmental variables that explain some of the variation in at-sea distributions for Arctic, common, Sandwich and roseate terns. This will be done using existing marine habitat data, along with newly collected at-sea tern distribution data from selected sites. The models will be used to predict potentially important sites in marine areas for which no tern distribution data exist. In the case of roseate terns, which are almost entirely confined to one breeding colony in the UK, model predictions will be unnecessary. For little terns, which forage very close to their colonies, shore-based observations at selected sites will determine the extent of the coastal/inshore area adjacent to the colony that is important for the birds and also to assess how consistent this is between sites. Currently, one year of a planned three years of fieldwork has been completed.

7.2.1.5 Breeding red-throated diver

There are 10 terrestrial SPAs for breeding red-throated diver in the UK. In order to identify possibly additional SPAs for the species at sea, a habitat modelling approach was used (Dean *et al.* 2008). Data were collected over 5 years around important and representative red-throated diver breeding territories in Shetland, Orkney, and the Outer Hebrides. The methods of data collection comprised: at-sea surveys of divers, visual tracking of breeding birds and foraging locations, and radio-tracking of foraging birds. The modelling approach comprised three main stages: 1) a Generalised Additive Model (GAM) was used to describe the marine habitat of the species and to predict the presence/absence of birds at sea based on a range of environmental parameters including bathymetry, tidal bed stress, wave base, probability of fronts, seabed sediments, and coastal physiography; 2) areas predicted by the GAM as important habitat for divers were constrained to include only those areas within the typical maximum foraging range from any known breeding site. The foraging range was 10km based on the maximum flight range and the maximum foraging area derived from visual and radio-tracking. Breeding sites were identified based on a 2006 national survey of breeding divers; and 3) for those areas predicted by the constrained GAM as important habitat for divers within foraging range of known breeding sites, the number of pairs breeding within foraging range was calculated based on the 2006 national survey data. This allowed areas to be identified that are potentially used by nationally and internationally important numbers of birds. The areas predicted by the flight range constrained model compare well with independent data on foraging locations obtained from visual and radio-tracking, suggesting a high level of confidence in the model predictions.

The output from the model has yet to be applied to identify definitive areas for possible SPA classification.

7.2.2 Germany

In identifying SPAs in the German EEZ, seabird distribution in the southeastern North Sea and the southwestern Baltic Sea was assessed by transect counts from ships and aircraft. For counts from ships, the methodology has been for the most part standardised internationally, again first described by Tasker *et al.* (1984). Seabirds were counted from aircraft using a transect methodology recently described by Diederichs *et al.* (2002).

Species distribution maps were compiled based on densities, that is, the number of individuals per unit area. Species, distributions were analysed using grid maps with grid cells measuring either 3′ latitude x 5′ longitude (grid cell size: *c*. 30 km²) or 6′ latitude x 10′ longitude (grid cell size: *c*. 120 km²). Species with wide-ranging distributions were visualised by the larger grid cells, and species with a more restricted, concentrated distribution by the smaller grid cells. For each grid cell, overall bird density was calculated, being obtained from the sum of all birds recorded in transect divided by the total area mapped. This way, the data were corrected for effort.

Species that occurred in concentrations gathered in numbers that were far too large to allow total counts of all the birds. For these species, therefore, a spatial interpolation procedure based on ordinary kriging (Kitanidis 1997) was applied in order to compile a surface of estimated bird density (Garthe 2003, Garthe and Skov 2006). Thus, distributional data were interpolated and smoothed between survey lines on the basis of the species-specific spatial abundances structure (which was measured by the software used).

Boundaries of concentration areas were determined by an analysis investigating the gradient of density change over space. In order to do that, the modelled distributional data were projected into a two-dimensional map. In each of such cases, the modelled isoline of bird density (i.e., the line drawn through the same level of bird density) located just outside the strongest gradient in spatial density was chosen as the border of a concentration. In this way, the major part of the concentration was included in the selected area. The density value of the borderline was noted and used as the species- and season-specific minimum density defining a seabird concentration. This value was then taken for plotting the contour line showing the spatial extent of the respective concentration.

For each of the species of interest derived from the list of Annex I and migratory bird species, concentration areas were retained for analysis. These respective areas and contour lines were then overlaid so that a set of areas for potential conservation was identified. From this map, potential SPAs were derived.

7.2.3 Portugal

Three types of data were collected on seabird distributions in Portuguese waters in support of IBA identification. At-sea observations were taken from ship cruises covering 65 000 km of trackline (20 000 km^2); these data were complemented by aerial surveys that are more efficient at collecting data close (<3 nm) to the shore. Reliable data on the movements of Cory's shearwaters were obtained from fitting the birds (N=272) with data loggers (either GPS or compass-loggers); attempts at radio-tracking other species such as Madeiran storm-petrel and roseate tern met with limited success and contributed little to the delineation of IBAs.

The preferred sea areas used by seabirds were modelled using ship-based bird survey data and various environmental variables in Generalised Linear Models. Models were built for the distributions of species near their breeding sites during the breeding season (to inform possible extensions), for species away from their colonies during the breeding season (to identify mainly feeding and resting areas in the high seas), and for seabird distributions outside the breeding season (to identify wintering and/or migration areas).

Aerial survey (raw) data for certain species only (Cory's shearwater, Balearic shearwater, northern gannet, and common scoter) were used to complement ship-based modelled data for the purposes of defining IBA boundaries.

Tracking (and other) data for individual seabirds were analysed using kernel density estimation (Georges *et al*. 1997, Wood *et al*. 2000). Various % kernels were applied in the setting of boundaries of IBAs depending on species, length of trip, and other information.

7.2.4 Spain

Three broad methods of bird data collection were used to identify IBAs: boat-based surveys applying standardised strip transect methods were conducted; more than 30 000 km of trackline was covered throughout all Spanish waters; individual birds were tracked by fitting devices to individual seabirds that store or transmit data that can be used to determine their locations at sea at varying time intervals; and land-based counts were made where necessary of breeding birds at colonies (to inform colony extensions), and also of birds at sea (to inform migration corridors). Where available, other data sources were also used to complement these sources in compiling an IBA inventory.

In addition to the direct bird information collected, habitat data were also compiled to inform the building of models aimed at identifying the most important bird areas. The bird and habitat data were combined in modelling procedures (see below). Several habitat variables were used, both static (bathymetry, distance to the coast, to the shelf-break and to the breeding colonies), and dynamic (sea surface temperature, chlorophyll concentration, and derived information, e.g. oceanographic fronts).

7.2.4.1 Coastal and offshore areas at sea

Data from the boat-based surveys, bird tracking and habitat modelling were overlaid in a Geographical Information System (GIS).

Information from boat surveys was allocated to count-units that correspond to 10 minutes of transect censuses, for which a density value was estimated. The main approach guiding the identification of hotspots was to highlight those count units with the highest 5% density values (excluding zero counts), using counts > 50% as supporting data.

Tracking data are usually resolved into kernels, which highlight the areas where most readings were recorded (Arcos *et al*. 2009). Areas within the 50% kernel, i.e. those containing half of the locations from each track from a given colony for each breeding stage and year, were combined to produce a single GIS layer; information from different colonies, breeding stages and/or years was treated independently.

Habitat-based models indicating the most suitable areas for birds were based on presence-only data using the Maximum Entropy approach (MAXENT; Phillips *et al*. 2006). Model output here is qualitative and was referred to a grid of 2.5' of latitude x 2.5' of longitude (*c*. 4.5 x 4.5 km); each output cell had a value of 'habitat quality' which ranged from 0 (low) to 1 (high). Models were run differentiating four biogeographical regions, and separately for each species, season and year. The best areas were then averaged between years (for the same species, season and region), only taking into account those models that were considered as significant. This way, those areas that were suitable across years (i.e. 'stable') were identified.

The best areas were clearly highlighted as layers in GIS. Again, data were considered independently for each species, as well as for each season if appropriate. Layers were treated as either primary or complementary depending on their quality. Once all available layers had been arranged, hotspots for each seabird species were identified by overlapping them and picking out the best locations as highlighted by two or more layers. Priority was given to primary layers.

7.2.4.2 Seaward extensions to breeding colonies

The extent of this type of marine IBAs was defined by a radius around the most relevant breeding colonies. Tracking data and specifically designed surveys around colonies were used to set the appropriate radii for each species (and site); complementary information from other sources was also used where appropriate. The area captured aimed to provide for rafting or foraging concentrations of birds, could be adjusted to suit the particular habitat attributes of a site, or could even be precautionary. Species-specific radii range from 1 km for storm-petrels, for example, to 10 km for Audouin's gull.

7.2.4.3 Migration corridors

Overall, migration hotspots were identified following the same procedure as coastal and offshore areas - by overlapping different GIS layers. However, in this case it was

necessary to use data from land-based counts of total numbers of seabirds migrating through the hotspots.

7.2.4.4 Defining the IBAs

Once all hotspots for the different seabird species and seasons had been identified and validated in a given region, the final delimitation of marine IBAs took place. If different hotspots partly overlapped or were very close together, they were combined to form a single IBA, provided that it made both biological and management sense. The final limits of marine IBAs were adjusted to simple polygons based on straight lines.

7.2.5 Netherlands

7.2.5.1 Existing SPAs

Birds in the Voordelta and Wadden Coast SACs/SPAs were monitored at sea between 1995 and 2005 by both aircraft and ship, the data being stored in the ESAS database. Bird densities were estimated from the raw survey samples in 5x5 km cells for each 2 month period for both data-sets, and an assessment made of the likely total numbers of birds occurring regularly in each area. This allowed application of Ramsar criteria to determine importance of the bird concentrations and whether they would qualify as SPAs. An assessment was also made of the total "bird value" of each 5x5 km cell. This metric depicted the occurrence of all species combined (appropriately weighted) and allowed the importance of the areas to seabirds to be determined in a more general way.

7.2.5.2 Application of IBA criteria to existing and proposed MPAs

The marine IBA criteria (Ramirez *et al*. 2008) have been applied to all 12 of Lindeboom's *et al*. (2005) proposed MPAs (i.e. not only the proposed SPAs but the SACs also). The general approach is that adopted in Spain and Portugal for the identification of IBAs in those countries (see above). Three different (existing) data sources on seabird numbers/distribution were used:

Primary data Since 1991, the Dutch sector of the North Sea has been surveyed for birds over 3 days every 2 months (Baptist and Wolf 1993, Berrevoets and Arts 2001, 2002, 2003). Data from the optimal spatial coverage achieved here since 1999 (Berrevoets and Arts 2001) were used to assess bird numbers using the 12 proposed MPAs.

Secondary data Various ship-based survey data were also used to assess the bird interest in the 12 areas. These data are very patchy and coverage between 1999/2000–2007/2008 is rather poor. Most year-round information for this period comes from bespoke surveys at two offshore windfarms (Leopold *et al.* 2004; also unpublished data.). The ship-based data were used to calibrate bird densities recorded during the aerial surveys and to estimate the species composition for some species groups (divers, alcids, commic terns); this was done for the complete period of available aerial data, 1991/1992–2007/2008.

Complementary secondary data Additional data from diverse sources including the ornithological literature and unpublished tracking data of ongoing studies were also used in the assessment of the importance of the 12 areas to birds.

The results of the application of marine IBA criteria to the assessment of the bird interest in the 12 proposed MPAs are not yet available (M. Poot, unpublished report).

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8   Potential contribution by WGSE to the high priority topics of the ICES Science Plan

WGSE was asked to complete a questionnaire to indicate the potential contributions that it could make to the various research topics of the ICES Science Plan based on an evaluation of the current expertise of the group   Potential contributions were ranked as high (H), medium (M) or low (L) and are indicated in the tables below.

ICES Science Plan High Priority Research Topic 1 : Understanding Ecosystem Functioning

11. Climate change processes and predictions of impacts

- 111 ICES niche: ecosystem responses to selected physical oceanographic scenarios
- 112 Define responses at the individual and population level to changes
- 113 Changes in distributional patterns at the species and community levels
- 114 Prediction of responses to selected climate change future scenarios (IPCC)
- 115 Responses based on physical-biological interactions and using long-term ICES data

	111	112	113	114	115
Rank	L	H	H	H	H

12. Biodiversity and the health of marine ecosystems

- 121 Biodiversity and scale in ecosystems: genetic, population, species, community levels
- 122 Relate biodiversity to resilience and plasticity of ecosystems
- 123 Define indicators of ecosystem health: attributes of ecosystems, conditions of change, external pressures
- 124 Comparative analyses to study of resilience of shelf seas exploited ecosystems

	121	122	123	124
Rank	M	H	H	M

13. The role of coastal zone habitat in population dynamics of exploited species

- 131 Coastal zone: essential nursery grounds and home of invertebrates, critical to mariculture. These habitats are threatened by human activities.

- 132 Focus on processes linking habitat to spatial patterns at the population and community levels.
- 133 Ecosystem-based marine spatial planning
- 134 Sustaining ecosystem goods and services

	131	132	133	134
Rank	L	L	M	L

14. Fish life history information in support of EAM

- 141 Relate population variability, vulnerability, viability to external and ecosystem drivers.
- 142 Make use of spatial contexts and in particular operational oceano-graphic products
- 143 Monitor the status of populations and ecosystems with indicators
- 144 Predict population distributions, connectivities, and recruitment
- 145 Relate growth, reproduction, and feeding to the quality of habitats
- 146 Increase knowledge on fish physiology and behaviour, and their ge-netic basis
- 147 Processes underlying connectivity between populations: larval trans-port, fish movements

	141	142	143	144	145	146	147
Rank	L	L	M	M	L	L	L

15. Sensitive ecosystems (deep-sea, seamounts, arctic) and data-poor species

- 151 Map habitats for conservation and management: develop habitat clas-sification systems and mapping tools
- 152 Basic studies on the biology and ecology of these species and ecosys-tems in relation to water circulation, productivity, and climate change
- 153 Vulnerability to fishing: unfished deep-sea habitats, long-lived slow growing species
- 154 Rare species: genuinely rare, apparently rare to sampling
- 155 New species that are as yet unknown to science in these special envi-ronments

	151	152	153	154	155
Rank	L	M	M	M	L

16. Integration of surveys and observational technologies into operational ecosystem surveys

- 161 Develop an ecosystem monitoring programme with: existing time-series, emerging survey methodologies, enhanced coordination (plankton nets, acoustics, optics, trawling) and a network of fixed stations.
- 162 Aim of providing indicators in support of advisory needs of inte-grated management and ecosystem status reporting

	161	162

Rank	H	H

17. Role of top predators (mammals, birds, and large pelagics) in marine ecosystems

- 171 Role in the functioning of marine ecosystems: "top-down" controlled systems
- 172 Anthropogenic impact: removal of larger fish and increase top predators
- 173 Comparative analyses of ecosystem dynamics in response to changes in abundance and relative composition of top predators

	171	172	173
Rank	H	H	H

ICES Science Plan High Priority Research Topic 2 : Understanding of Interactions of Human Activities with Ecosystems

21. Impacts of fishing on marine ecosystems

- 211. Understand the impacts of fishing on all components of the ecosystem.
- 212. Gather information on biota of all types (landings, discards at sea, subject to increased mortality through unobserved interaction with fishing gear) and on habitat.
- 213. Focus on technical challenges associated with collecting and interpreting the data required to assess fishing impacts
- 214. Modify, develop, and implement fishing gears designed to minimize fishing impacts.
- 215. Strategies to reduce the costs of fishing.

	211	212	213	214	215
Rank	H	L	H	H	M*

*215 = H if "costs" are ecological rather than economical

22. Carrying capacity and ecosystem interactions associated with mariculture

- 221. Define carrying capacity for cultured species within diverse coastal environments where there is an increasing competition for space.
- 222. Mitigation of the impacts of aquaculture through the development of multi-trophic aquaculture systems (e.g. kelp, salmon and mussel).
- 223. Interactions between wild and "farmed" species, contaminants associated with disease control and feeds, and escapement impacts.

	221	222	223	224	225
Rank	L	L	L		

23. Influence of development of renewable energy resources (e.g. wind, hydropower, tidal and waves) on marine habitat and biota

- 231 Impacts on ecosystem structure and function: structural habitat features, influence on ocean circulation and mixing

- 232 Evaluate risk of potential impacts, identify mitigation options

- 233 Coordinate multi-disciplinary research to augment existing knowledge base

	231	232	233
Rank	M	H	H

24. Population and community level impacts of contaminants, eutrophication, and habitat changes in the coastal zone

- 241 Understanding the impacts of contaminants at the individual, population and community levels.

- 242 Estimating the cumulative impacts of contaminants, eutrophication, and changes in habitat substrate.

- 243 Synthesize knowledge on the impacts of diverse land-based and marine activities

- 244 Characterize the status of regional coastal zone ecosystems and causal relationships

- 245 Synthesize ecological understanding, identify gaps in knowledge and monitoring needs, based on the rich data sets for the coastal zone

	241	242	243	244	245
Rank	H	M	H	L	L

25. Introduced and invasive species, their impacts on ecosystems and interactions with climate change processes

- 251 Processes that facilitate intentional and accidental introductions of species in the North Atlantic and their drivers (e.g., role of climate change).

- 252 Impact on the distribution and abundance of native biota through niche displacement, ecosystem structure (e.g. biodiversity) and function (e.g. food chain processes).

- 253 Risk assessment modelling for evaluation of management options

- 254 Support the development of regulatory frameworks and implementation of management measures through member countries and IMO, OSPAR, and HELCOM.

	251	252	253	254
Rank	L	L	L	L

ICES Science Plan High Priority Research Topic 3 : Development of Options for Sustainable Use of Ecosystems

31. Marine living resource management tools

- 311 Development of indicator-based evaluations of species and habitats at different spatial scales, with reference points.

- 312 Exploration of management options under the "ecosystem approach"
- 313 Address issues associated with integrated management and conservation objectives.
- 314 Operating needs of the EAM: spatial extent of management areas, strategies to meet conservation objectives and report on ecosystem characteristics.

	311	312	313	314
Rank	H	M	M	L

32. Operational modelling combining oceanography, ecosystem and population processes

- 321 Facilitate the availability and dissemination of long-term data
- 322 Give a reliable description of the actual marine conditions including physical and ecosystem variables, using analyses, forecasts, and model-based products
- 323 Evaluate the accuracy of the predictions as well as limits to forecasting.
- 334 Operational models to support the specific needs for the advisory process.
- 335 Forecasting of trends in recruitment as a function of oceanographic variables
- 336 Prediction of spatial pattern in populations and community properties due to changes in the environment.
- 337 Operational models to predict the development and spreading of harmful algal blooms, and environmental effects in the event of oil spills in the sea.

	321	322	323	324	325	326	327
Rank	H	L	L	L	H	M	L

33. Marine spatial planning, effectiveness of management practices (e.g. MPAs), and its role in the conservation of biodiversity

- 331 Develop and evaluate integrated management procedures of the multiple uses of the oceans, in particular spatial planning tools.
- 332 Predict benthic habitat spatial patterns based on a combination of geomorphological and oceanographic properties.
- 333 Utility of MPAs (with a range of sizes and spatial patterns) for diverse conservation objectives under Integrated Management.
- 334 Sensitivity of benthic habitats to disturbance and reference points on the limits to disturbance for a range of anthropogenic impacts.
- 335 Evaluate GIS methods with respect to the specific needs of marine spatial planning.

	331	332	333	334	335
Rank	L	L	H	L	M

34 Contributions to socio-economic understanding of ecosystem goods and services, and forecasting of the impact of human activities

- 341 Behavioural responses/strategies of the users of ocean ecosystems.
- 342 Social and economic motivations of ocean industries
- 343 How ecosystem goods and services are turned into socio-economic values.
- 344 Forecast the impact of human activities and evaluate mitigation options
- 345 Assessment of the resilience properties of marine ecosystems
- 346 Role of biodiversity at the species and genetic levels in ecosystem functioning.

	341	342	343	344	345	346
Rank	L	L	L	L	M	H

9 Planned contribution for the 2010 SSGEF session during the ICES Annual Science Conference

For its 2010 meeting WGSE was given the following ToR:

- Prepare contributions for the 2010 SSGEF session during the ASC on the topic areas of the Science Plan which cover: individual, population and community level growth, feeding and reproduction; the quality of habitats and the threats to them; indicators of ecosystem health.

WGSE would aim to report on the EcoQO work it has developed in recent years on seabird populations, updated in Chapter 2 of this report. The EcoQO has been applied to seabird population data most comprehensively in OSPAR Region III. The planned contribution to the ASC will report on this metric of ecosystem health. It is an indicator that is applied not simply to single species' populations but to a large suite of different species and as such represents a good indicator of the general health of the seas in OSPAR III, not one which pertains only to a single habitat or niche.

Proposed title: Seabird population trends as an indicator of ecosystem health.

Annex 1: List of participants

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Annex 2: English and scientific names of birds mentioned in this report

Red-throated diver	*Gavia stellata*
Black-throated diver	*Gavia arctica*
Southern royal albatross	*Diomedea epomophora*
Black-footed albatross	*Phoebastria nigripes*
Black-browed albatross	*Thalassarche melanophrys*
Northern fulmar	*Fulmarus glacialis*
Bermuda petrel (Cahow)	*Pterodroma cahow*
Bulwer's petrel	*Bulweria bulwerii*
White-chinned petrel	*Procellaria aequinoctialis*
Parkinson's petrel	*Procellaria parkinsoni*
Cory's shearwater	*Calonectris diomedeas*
Greater shearwater	*Puffinus gravis*
Wedge-tailed shearwater	*Puffinus pacificus*
Sooty shearwater	*Puffinus griseus*
Short-tailed shearwater	*Puffinus tenuirostris*
Manx shearwater	*Puffinus puffinus*
Yelkouan shearwater	*Puffinus yelkouan*
Balearic shearwater	*Puffinus mauretanicus*
Madeiran (band-rumped) storm-petrel	*Oceanodroma castro*
Leach's storm-petrel	*Oceanodroma leucorhoa*
Northern gannet	*Morus bassanus*
Masked booby	*Sula dactylatra*
Red-footed booby	*Sula sula*
Double-crested cormorant	*Phalacrocorax auritus*
Great cormorant	*Phalacrocorax carbo*
European shag	*Phalacrocorax aristotelis*
Common pochard	*Aythya ferina*
Tufted duck	*Aythya fuligula*
Greater scaup	*Aythya marila*
Common eider	*Somateria mollissima*
Steller's eider	*Polysticta stelleri*
Long-tailed duck	*Clangula hyemalis*
Common scoter	*Melanitta nigra*
Velvet scoter	*Melanitta fusca*
Common goldeneye	*Bucephala clangula*
Smew	*Mergellus albellus*
Red-breasted merganser	*Mergus serrator*
Goosander	*Mergus merganser*
Great skua	*Stercorarius skua*
Arctic skua	*Stercorarius parasiticus*
Audouin's gull	*Larus audouinii*
Kelp gull	*Larus dominicanus*
Great black-backed gull	*Larus marinus*

Herring gull	*Larus argentatus*
Ivory gull	*Pagophila eburnea*
Black-legged kittiwake	*Rissa tridactyla*
Sandwich tern	*Sterna sandvicensis*
Roseate tern	*Sterna dougallii*
Common tern	*Sterna hirundo*
Arctic tern	*Sterna paradisaea*
Little tern	*Sternula albifrons*
Sooty tern	*Onychoprion fuscatus*
Black noddy	*Anous minutus*
Little auk	*Alle alle*
Common guillemot	*Uria aalge*
Brunnich's guillemot	*Uria lomvia*
Razorbill	*Alca torda*
Black guillemot	*Cepphus grylle*
Marbled murrelet	*Brachyramphus marmoratus*
Ancient murrelet	*Synthiliboramphus antiquus*
Japanese murrelet	*Synthiliboramphus wumizusume*
Rhinoceros auklet	*Cerorhinca monocerata*
Atlantic puffin	*Fratercula arctica*

Annex 3: WGSE Draft Terms of Reference for the second meeting in 2010

The **Working Group on Seabird Ecology** [WGSE], chaired by Jim Reid, UK, will meet in Montpellier, France or the Azores, Portugal in late autumn 2010 (to be confirmed) to:

a) Explore the use of long-term seabird data-sets as indicators of recruitment in small pelagic schooling fish;

b) Review the methods used in assessing the effects of windfarms on birds;

c) Review the methods used in assessing the effects of wet renewable energy developments on birds;

d) Review progress with further development of the OSPAR ecological quality objective (EcoQO) for seabird populations in OSPAR regions II and IV;

e) Update and extend the review of studies of the distribution and habitat associations of seabirds based on remote tracking of individual birds;

f) Explore the use of demographic and behavioural data as early warning systems of population change in seabirds;

g) Review progress towards a Community Plan of Action to reduce seabird bycatch in EU waters, and report any new data on fishing effort and seabird bycatch in these waters.

WGSE will report by 17 December 2010 (via SSGEF) for the attention of SCICOM.

Supporting Information

Priority:	This is the only forum for work being carried out by ICES in relation to marine birds. If ICES wishes to maintain its profile in this area of work, then the activities of WGSE must be regarded as of high priority.
Scientific justification	All proposed Terms of Reference pertain directly to one or more of the high priority research topics contained in the three thematic areas of the ICES Science Plan. Term of Reference a) Recruitment to small pelagic fish populations such as gadoids and sandeels is notoriously difficult to study directly; it is both difficult to sample these fish in the field and also to model this key demographic parameter. It has proved possible to use certain seabird demographic data as a proxy for recruitment to some fish populations, for example Atlantic puffin breeding success as an indicator of recruitment in Ammodytes. A further exploration of this in more species of seabirds and fish species would be a worthwhile and cost-effective exercise. It could also prove a fertile collaboration between WGSE and relevant EGs working on small fish populations. Term of Reference b) The establishment of windfarms at sea presents a potential threat to seabird and other waterbird populations. The possible effects range from collision risk to disturbance and habitat loss. Many studies are in progress studying such effects and many more are planned given Europe-wide governmental policies to derive ever-increasing proportions of domestic energy requirements from renewable sources. WGSE therefore considers it timely to review the methods used in assessing the effects of windfarms on birds. Term of Reference c) The drive to meet energy requirements increasingly from renewable sources is now seeing the deployment of devices aimed to harness wave and tidal power. The potential effects of these on birds at sea is not known so again WGSE

considers it worthwhile to review the efficacy of methods now being proposed to assess the possible effects on bird ecology at sea.

Term of Reference d)

Convened in association with WGSE 2008, ICES WKSEQUIN recommended that WGSE review annually the status of selected seabird populations in the context of the EcoQO on seabird populations it has formulated. Development of the EcoQO was in response to a request by OSPAR, and was recommended by WGSE in 2001. WGSE reviewed progress with and updated the EcoQO for OSPAR region III in 2010. There is a need to extend application of the EcoQO to other regions, especially as there may be a use for the EcoQO in EU Marine Strategy Framework Directive reporting. Term of Reference e)

Identification of important seabird habitats is critically important for spatial planning and can help to identify Marine Protected Areas and area of common usage by seabirds and fisheries; tracking of individual birds using satellite tags and other data loggers is one of the most important sources of information available for this purpose. There is a continuing need to review progress in the field given the increasing number of studies made possible by technological advances and falling costs.

Term of Reference f

ICES WKSEQUIN recommended that WGSE review annually the status of selected seabird populations with regard to the EcoQO on seabird populations. Typically, there is a lag between environmental change and population change, so WGSE consider it useful to review intrinsic early warning systems of population change to provide more rapid assessments of environmental impacts.

Term of Reference g)

The EC is committed to prducing a Community Plan of Action to reduce the incidental bycatch of seabirds in EU waters. Bycatch affects many species of seabird, including some critically endangered populations, but actual bycatch rates are not known with certainty for any species or regions. A crucial part of the Plan is to assess the extent of bycatch in all fishing gears. WGSE reviewed progress with the Plan of Action in 2010, noting in fact that little recent progress appeared to have been made. WGSE 2010 recommends that a workshop be convened to take forward planning for the PoA, but that meantime the issue should remain on the group's agenda.

Resource requirements:	Facilities for WGSE to work at Venue are anticipated to be excellent.
Participants:	Meetings of WGSE are usually attended by ca. 15 nominated and Chair-invited members. Although the Working Group should be able to achieve most of the above objectives, some members may not be able to attend through lack of funding. Funding of these members from Member Countries would be very welcome.
Secretariat facilities:	Routine office and other support usually available from ICES HQ when meeting remotely.
Financial:	
Linkages to advisory committees:	ACOM
Linkages to other committees or groups:	WGSE is keen to continue the process of integration of seabird ecology into ICES.
Linkages to other organizations:	EU, OSPAR, HELCOM

Annex 4: Recommendations

RECOMMENDATION	FOR FOLLOW UP BY:
1. ICES to recommend to OSPAR that the EcoQO on seabird populations be further developed and applied to OSPAR regions II and IV, and that provision should be made for the supply of seabird population data from OSPAR states to WGSE annually.	ACOM
2. ICES notes that many important steps have been taken towards the writing of an EC Plan of Action to reduce seabird bycatch in fisheries. However, ICES understands that the European Commission is short of capacity to undertake further steps needed before a draft can be written. One of these is the further engagement of experts in a variety of fields, such as seabird bycatch mitigation, observer programmes, fisheries technology and the fishing industry. ICES recommends that a potential solution to this would be for it to convene a 4–5 day Workshop on an EC-PoA for Seabirds in October/November 2010 at ICES Headquarters, Denmark. A full justification for this recommendation comprises Annex 5.	ACOM

Annex 5: Proposal to the European Commission on a Joint Workshop contributory to the drafting of an EC-PoA for Seabirds

ICES notes that many important steps have been taken towards the writing of an EC-PoA for Seabirds, for example the Commission's Policy Statement released in November 2009 and advice provided by ICES in 2008. However, ICES understands that the European Commission is short of capacity to undertake further steps needed before a draft can be written. One of these is the further engagement of experts in a variety of fields, such as seabird bycatch mitigation, observer programmes, fisheries technology and the fishing industry. ICES suggests a potential solution to this would be for it to convene a 4–5 day Workshop on an EC-PoA for Seabirds in October/November 2010 at ICES Headquarters, Denmark.

ICES is already convening a joint workshop with NAMMCO on the design of observer programmes for marine mammal and seabird bycatch in late June 2010. The results of this workshop will be relevant to an EC-POA for seabirds.

Proposed Terms of Reference for the workshop:

a) Review and describe the transferability of existing International, Regional and National Plans of Action for Seabirds

b) Recommend best practice for establishing and implementing an EC-PoA for Seabirds

c) Draft text that could contribute to the drafting of an EC-PoA for Seabirds

WKECPoA will report by 15 December 2010 for the attention of the ICES Advisory Committee. A workshop report will be submitted to the Commission by 15 February 2011. It is projected that this time frame accords with the current DGMARE work plan to adopt by April 2011 a Communication on a Community Plan of action for reducing incidental catches of seabirds in fishing gears (2009/MARE/071).

Supporting information

Priority	High. DG MARE outlined the need for an EC-PoA for seabirds in its provisional workplan of 4 March 2010, indicating completion of a Communication on the plan by April 2011. ICES is offering to help address the issue of best practice in designing and implementing such a plan.
Scientific justification	Term of Reference a) 1. To review and describe the transferability of existing models for the formulation of an EC-PoA for Seabirds 2. To provide an assessment of best practices for the development and implementation of an EC-PoA for Seabirds, 3. To exchange information among relevant stakeholders on the current state of seabird bycatch and mitigation in EU fleets. Terms of Reference b) and c) 1. ICES will elaborate a draft framework for an EC-PoA for Seabirds to be agreed in advance with DG MARE. This will form the agenda for the workshop and will be developed to provide a report and advice to DG MARE.
Resource requirements	Resources to allow relevant stakeholders from within EU member states and outside (depending on relevance of expertise) to travel to, and attend, a 4-5 day workshop held at ICES Headquarters in Copenhagen, Denmark.

Participants	20–30 participants expected. Support should be made available for expert participation. Prospective invitees include representatives from DG MARE and DG Environment, FAO, all seven Regional Advisory Councils, European Fisheries Control Agency, relevant NGOs, relevant scientific and technical specialists in the fields of seabird bycatch and mitigation.
Secretariat facilities	The Atlantic Room plus one other breakout room for 4–5 days. Aside from the usual helpful attitude from the Secretariat, few other requirements are foreseen.
Financial	Secretariat to assess.
Linkages to advisory committees	ACOM will consider the final report with a view to providing advice to the Commission.
Linkages to other committees or groups	
Linkages to other organizations	FAO, DG MARE, DG Environment, OSPAR, RACs [Baltic, North Sea, North-west waters, South-west waters, Mediterranean, Pelagic and Long-range], European Fisheries Control Agency, relevant NGOs, consultants and the fishing industry.

Annex 6: Technical minutes

Protected Species and Mammals Review Group (RGPROT/MAM) dealing with OSPAR request on 'EcoQo on Seabirds' and EC requests on 'Impacts of fishing on seabirds, mammals and habitats' and 'Status of small cetaceans in European waters'

Review of:

- Sections 4 and 11 and Annex 9 of ICES Report of the Study Group for By-catch of Protected Species (SGBYC) 2010

- Optional – Chapter 4 of ICES Report of the WGSE 2010

- Section 7.1 of ICES Report of the Working Group on Marine Mammal Ecology (WGMME) 2010

- Section 1.1.1 of ICES Report of the WGMME 2009

- **Chapter 2 of ICES Report of the** Working Group on Seabird Ecology **(WGSE) 2010**

Reviewers: Nicole LeBoeuf (Chair), Henrik Skov, and Paul Thompson

WGs Chairs: SGBYC – Simon Northridge, WGMME – Sinéad Murphy, <u>WGSE – Jim Reid</u>

Secretariat: Mette Bertelsen and Michala Ovens

<u>Audience to write for</u>: These comments are to be provided to the Protected Species and Mammals Advice Drafting Group for consideration at its meeting to be held 17–18 May 2010.

WGSE Review – OSPAR request on 'EcoQo on Seabirds'

Over the past eight years, ICES (WGSE) has been developing an EcoQO for the status of seabirds with the aim of adoption by OSPAR for the entire OSPAR area. The RGPROT/MAM was asked to review Chapter 2 of ICES Report of the WGSE 2010 and was encouraged, should the reviewers wish to, to review Chapter 4 of ICES Report of the WGSE 2010.

Chapter 2: Recent progress with the OSPAR EcoQO for seabird populations

The EcoQO contains only indicators using data from breeding populations, while the value of using data on non-breeding populations has not been assessed by ICES. The development of region-specific EcoQO indicators has been in progress since 2008, but as yet they have only been constructed for OSPAR III. The application of the EcoQO for OSPAR III indicates that it is scientifically sound and performing well according to the main intentions of this EcoQO. The WGSE 2010 report provides an updated evaluation of the EcoQO for OSPAR III. The updated evaluation is based partly on the use of an improved statistical framework, and partly on the addition of population data from three more years (2007–2009) and the addition of four more species. The statistical method for trend estimation allows for improved routines for imputation across years and sites of missing data, as well as an improved integration of counts at various geographical scales. WGSE concludes that the EcoQO for OSPAR III (Changes in breeding seabird abundance should be within target levels for 75% of species monitored in any of the OSPAR regions or their sub-divisions) was not achieved in 1988, 1989, 1990, 1992 and in consecutive years during 2003–2009, irrespective of whether eight or 12 species were included. The number of species not

achieving targets during 2003–2009 increased in consecutive years from four to nine in both 2008 and 2009. In the last 2 years, the abundance of six species had fallen below their respective lower targets, while three species exceeded the upper targets.

The evaluation is based entirely on the mean values, while the confidence intervals are not used. The confidence intervals are very wide (especially the upper bounds). If confidence intervals had been used to assess the EcoQO then only one species (Roseate Tern) would show as not achieving target. This raises the question whether it would be beneficial to compare the statistical framework applied with at least one other statistical method which allows for imputation and integration of data sources with different levels of uncertainty (e.g. Bayesian time series models). Comparative tests would be useful to show the robustness of the trends and associated confidence intervals estimated with the applied method. Further scrutiny of the statistical framework also seems warranted given the general lack of consensus on statistical methods for determination of population trends, and the variability of results produced by different methods.

The success of ICES' work on this EcoQO will be measured by the full adoption by OSPAR. As the WGSE report states this adoption is likely to depend on it being an appropriate indicator in assessing and achieving Good Environmental Status as part of measures to be implemented under the EC Marine Strategy Framework Directive by 2020. In relation to the qualitative descriptors being drawn up for the Directive by ICES the Seabird EcoQO has been recommended as part of the food web indicators. Despite the fact that the evaluations of the Seabird EcoQO suggest that it is scientifically sound and performs well certain limitations with the application of the indicator on the basis of breeding populations alone might be worth further consideration. Since a large proportion of breeding seabirds feed themselves and their chicks on prey taken primarily in coastal waters (e.g. cormorants and shags, gannets, skuas, terns, gulls and auks) the EcoQO based entirely on data from breeding colonies may fail to provide useful information to feed into the general system of food web indicators envisaged by the OSPAR Common Procedures under the MSFD. For species relying on food sources in offshore waters this indicator may be difficult to relate to appropriate spatial areas, since these species (typically Procellariiformes) may feed at considerable distances (hundreds of kms) from their colonies.