Europa-kommissionens handingsplan for reduktion af utilsigtet fangst af hav-fugle i fiskeredskaber

Notat fra DCE - Nationalt Center for Miljø og Energi

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Indhold

Problem definition

I den engelsksprogede "Action Plan for reducing incidental catches of seabirds in fishing gears" angives tre kategorier af direkte mortalitet blandt vandfugle i fiskeredskaber, nemlig i) langliner, ii) nedgarn og iii) andre redskaber.

I Kapitel 2.1 indledningen beskrives det at interaktioner imellem fiskeri og fugleforekomster kan kategoriseres i tre klasser, nemlig i) direkte mortalitet ved bifangst af fugle i fiskeredskaber, ii) forbedrede levevilkår for visse fuglearter pga. discard af fangne fisk eller iii) påvirkninger af fugleforekomsters trivsel som følge af ændringer i fiske- eller andre marine arters tilgængelighed som følge af fiskeriaktiviteter

Denne gennemgang relaterer sig udelukkende til den direkte mortalitet som følge af bifangster af fugle i nedgarn, og skal ses som en vurdering af den fremlagte handlingsplans potentielle indvirkning på danske forhold.

Omfanget af bifangster af fugle i Danmark

Der foreligger en række informationer om omfanget af bifangster af fugle i fiskeredskaber i Danmark. De fleste af disse har anekdotisk karakter eller informationer om antallet af bifangster fordelt på forskellige fuglearter, men uden information om den fiskeriintensitet der ligger til grund for bifangsterne.

Undersøgelsen af omfanget af bifangster af fugle i nedgarn hos erhvervsfiskere i farvandet omkring Ærø (Degel et al. 2010) tilvejebragte data på såvel antallet af bifangne fugle og den fiskeriintensitet der lå til grund. Det overordnede resultat var at bifangstniveauet var lavt, set i relation til tilsvarende undersøgelser andre steder i Østersøen.

Danske NGOer påpegede at bifangstniveauet givetvis vil være højere i nedgarn hos fritidsfiskere. Naturerhvervsstyrelsen bad derfor DCA – Nationalt Center for Fødevarer og Jordbrug om at forestå en undersøgelse, der skulle belyse dette nærmere, specielt med henblik på bifangstniveauer i udvalgte Fuglebeskyttelsesområder. DCA overdrog efterfølgende opgaven til DCE. Sideløbende administrerer DTU-Aqua en undersøgelse af fritidsfiskeriets fangster af fisk. Dette projekt indsamler desuden informationer om bifangster af fugle. Det undersøges nu hvordan data fra disse projekter kan samkøres.

Endelig forestår DTU-Aqua undersøgelser af omfanget af bifangster af marsvin og fugle vha. video-overvågning på kuttere.

Birdlife workshop om bifangst af fugle i fiskeredskaber

I maj måned 2012 afholdt Birdlife en workshop i Berlin om bifangster af fugle i fiskeredskaber, set i et globalt perspektiv. Både NGOer og myndigheder fra en række lande, fortrinsvis europæiske, deltog. Undertegnede deltog på vegne af Aarhus Universitet, og fremlagde under mødet resultaterne fra rapporten om bifangster af fugle i nedgarn blandt erhvervsfiskere omkring Ærø (Degel et al. 2010).

Workshoppen resulterede i en workshop rapport (Gillnet Seabird Bycatch Workshop Report_FINAL_030712.pdf), som vedlægges i en pdf version. Dette arbejde er siden sammenskrevet til en videnskabelig artikel (Zydelis et al. 2013), der blev offentliggjort i sidste uge. Artiklen vedlægges i et pdf-format (Zydelisetal_2013.pdf). Desuden vedlægges en oversigt over arter af fugle der indgår i bifangst statistikker (Zydelisetal_2013_Overview.* og Zudelisetal_2013_Litterature.*), med angivelse af bl.a. referencer.

Handlingsplanens niveau

Handlingsplanen vil lægge grundlaget for administrative tiltag til reduktion af antallet af bifangster af fugle i fiskeredskaber i de enkelte lande. Der må derfor forventes forskelligartede tiltag i de enkelte medlemslande. Det har vakt opsigt at de tyske myndigheder har foreslået forbud mod nedgarnsfiskeri i meget store marine Fuglebeskyttelsesområder i både Nordsøen og tysk Østersø. Det foreslåede forbud er enten helårigt eller tidsbegrænset til dele af året, fortrinsvis forår, efterår og vinter. Hvis en tilsvarende tilgang bliver aktuel i Danmark kan det få meget vidtgående indflydelse på nedgarnsfiskeriet, som det fremgår af nedenstående afsnit om danske Fuglebeskyttelsesområder.

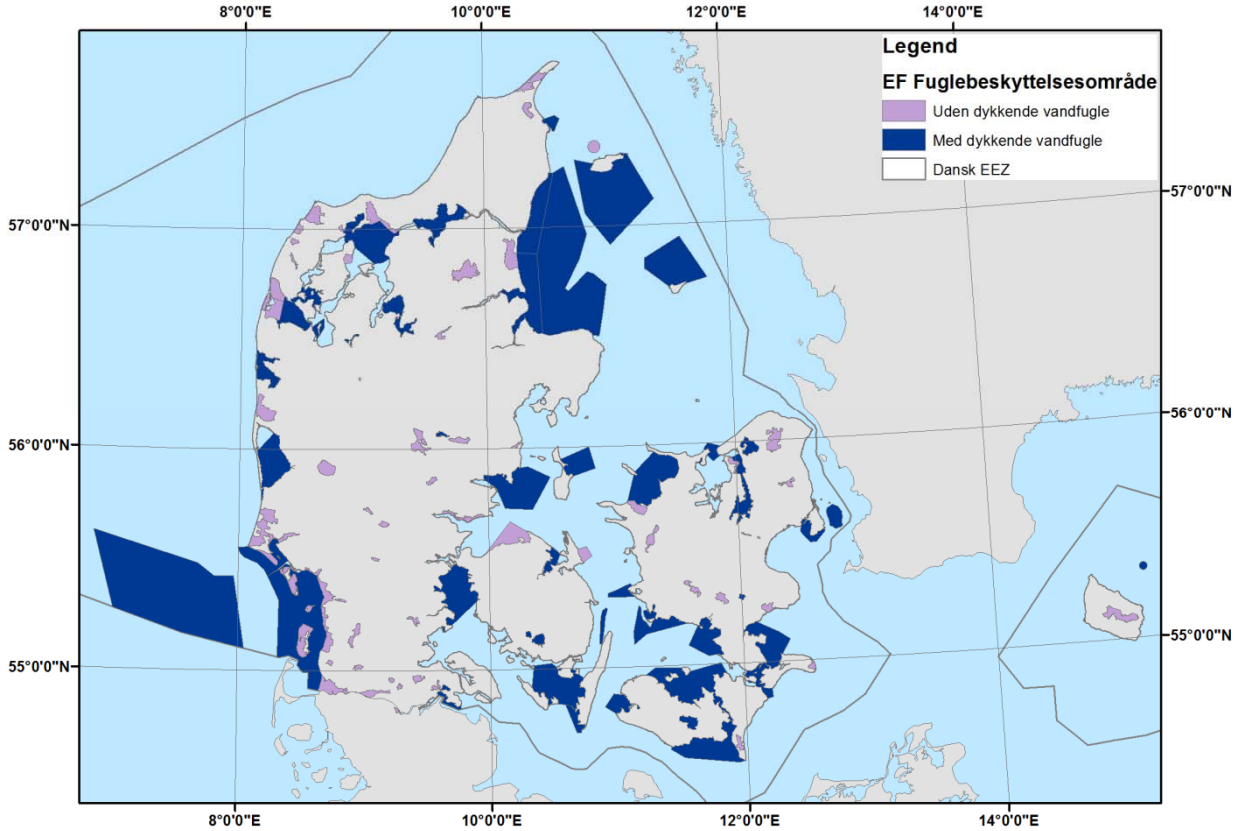
Informationer om omfanget af bifangster af fugle i nedgarn i Danmark, kombineret med informationer om den bagvedliggende fiskeriintensitet, vil være af stor betydning. Data bør være både geografisk og tidsmæssigt fordelte, med samhørende information om fiskeriaktiviteten. Sådanne data ville gøre det muligt at sammenholde dem med de temmeligt fyldestgørende beskrivelser af geografisk og tidsmæssig fordeling af de vigtige vandfuglearter i danske farvande, herunder også informationer om fuglenes biologi som f.eks. deres vanddybde-præference.

Danske Fuglebeskyttelsesområder

En af de betydningsfulde lovgivninger omkring beskyttelse af vandfugle i Danmark er Fuglebeskyttelsesdirektivet. Der er p.t. udpeget i alt 113 danske Fuglebeskyttelsesområder. I 50 Fuglebeskyttelsesområder indgår dykkende vandfugle som er kendte fra statistiker over bifangster af fugle i nedgarn i udpegningsgrundlaget.(Figur 1). Disse arter omfatter arter af lommer og lappedykkere, skarv, dykænder og blishøne.

De nævnte 50 Fuglebeskyttelsesområder som huser arter af vandfugle, der er sårbare overfor bifangster i fiskeredskaber udgør et samlet areal på knap 13.000 km^2.

Set i lyset af restriktioner af nedgarnsfiskeriet i tyske Fuglebeskyttelsesområder som følge af risiko for bifangster af vandfugle på udpegningsgrundlaget, vil det være formålstjeneligt for Naturerhvervsstyrelsen at få belyst hvordan EU Kommissionen ser på ønsket om reduktion i omfanget af bifangster af vandfugle i fiskeriredskaber indenfor netop disse udpegede områder. Det vil være af betydning at få belyst hvilke påvirkningsniveauer der er acceptable, både inden for og uden for Fuglebeskyttelsesområderne.



Figur 1. En oversigt over Fuglebeskyttelsesområder i Danmark, med indikation af områder der ikke huser arter af vandfugle der er sårbare overfor bifangst i fiskeredskaber (rosa områder) og de områder hvor arter, der er sårbare overfor bifangst i fiskeredskaber (blå områder) forekommer.

Afværgeforanstaltninger

Afværgeforanstaltninger i forhold til bifangster af fugle i nedgarn har typisk haft karakter af geografiske og/eller tidsmæssige forbud eller begrænsninger i nedgarnsfiskeriet (van Eerden et al. 1999). Til reduktion af bifangster af marsvin er der anvendt pinger, der frembringer en lyd, der skræmmer marsvinene væk. En lignende løsning forekommer ikke anvendelig til fugle.

Hvis omfanget af bifangster af vandfugle skal reduceres for nedgarnsfiskeriet vil det være af stor betydning af have indgående kendskab til det faktiske omfang af bifangster. Desuden skal fuglenes geografiske og tidsmæssige tilstedeværelse i områderne være kendt.

Med kendskab til de enkelte arters vanddybdepræferencer vil der desuden være mulighed for at indføre vanddybderelaterede reguleringer af nedgarnsfiskeriet.

Vurderinger af betydningen af bifangsters omfang ved hjælp af Population Viability Analysis (PVA-analyser) anvendes i en række tilfælde. Metoden har dog en række begrænsninger. En langt mere fleksibel metode kunne være anvendelse af geografisk eksplicitte individbaserede modeller. Sådanne modeller er langt mere teknisk komplicerede at etablere, men har til gengæld den styrke at de kan anvendes til at lave vidensbaserede sammenligninger af effekterne af forskellige scenarier for afværgeforanstaltninger.

Litteratur

I den nyligt offentliggjorte artikel i Zydelis et al. (2013) findes en omfattende og opdateret litteraturliste, som vedlægges i et Word-format.

I denne litteraturliste angives udelukkende arbejder, der refereres til i notatets tekst.

Degel, H., Petersen, I.K., Holm, T.E. and Kahlert, J. 2010. Fugle som bifangst i garnfiskeriet. Estimat af utilsigtet bifangst af havfugle i garnfiskeriet i området omkring Ærø. DTU Aqua-rapport nr. 227-2010.

van Eerden, M.R., Dubbeldam, W., Muller, J., 1999. Sterfte van watervogels door visserij met staande netten in het IJsselmeer en Markermeer. RIZA rapport nr. 99.060, Lelystad, The Netherlands.

Zydelis, R., Small, C. and French, G. 2013. The incidental catch of seabirds in gillnet fisheries: A global review. Biological Conservation, 162, 76-88.

Bilag

Workshop rapporten: Seabird Bycatch in Gillnet Fisheries.

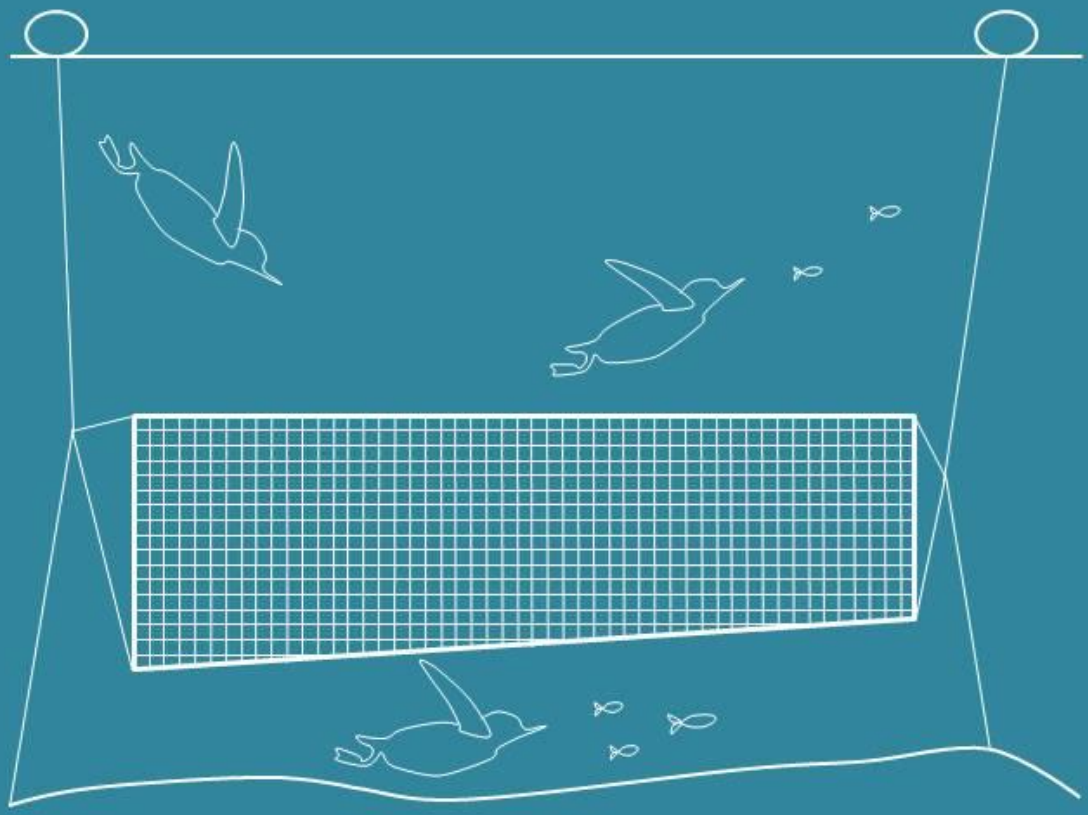
Zydelis, R., Small, C. & French, G. 2013. The incidental catch of seabirds in gillnet fisheries: A global review. Biological Conservation 162 (2013) 76-88.

Oversigt over arter af fugle, der indgår i bifangst statistikker fra Zydeles et al 2013.

Oversigt over referencer fra Zydelis et al 2013.

Seabird Bycatch in Gillnet Fisheries

BirdLife International Workshop
3-4 May 2012 Berlin, Germany



NABU

BirdLife INTERNATIONAL

RSPB

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BIRDLIFE INTERNATIONAL WORKSHOP

ON SEABIRD BYCATCH IN GILLNET FISHERIES

(NABU, Berlin, Germany – 3-4th May 2012)

1. Introduction

Bycatch in fisheries is one of the principal threats to seabirds around the world[1]. Since 2000, BirdLife International Global Seabird Programme (GSP) has worked to reduce seabird bycatch in longline and trawl fisheries. The programme initially began work with these types of fisheries in the Southern hemisphere because of the urgent threat to albatrosses and petrels (17 out of 22 albatross species are currently threatened with extinction).

More recently, the scale of the threat posed by gillnet fisheries to diving and pursuit-foraging species has become more apparent. Several studies in the Baltic have estimated gillnets kill 8-17% of the local wintering population of birds each year[2]. Gillnet fisheries are common to most regions of the world's oceans, however the greatest incidences of gillnet bycatch appear to occur in higher latitudes, where the species most often affected typically occur.

Consequently, the GSP instigated a workshop to bring together leading experts from around the world to discuss how to tackle this latest threat to the world's seabirds. The workshop focused on gillnet bycatch in European, Baltic and Nordic waters, as bycatch is known to be a particular problem in these areas and the region has several cross-boundary initiatives and governance structures around which a conservation initiative may be formed to begin tackling these problems on a regional scale.

2. Objectives of workshop and structure of report

The two-day workshop was hosted at Nature and Biodiversity Conservation Union (NABU) in Berlin, Germany on 3-4th May 2012. The workshop was attended by 27 participants from 16 countries, mainly from Europe, but also including Canada, Japan and Chile. The objectives of the meeting were to: (1) review the extent of the problem, especially in Europe, with a particular focus on Nordic and Baltic regions; (2) identify best practice and current blocks to progress; and (3) identify priority actions and what BirdLife, and other stakeholders, can effectively contribute to the issue.

The Agenda and List of Participants are in **Appendices 1 and 2, respectively**. The body of this report gives a brief summary of each presentation followed by the discussions arising in each session. The full abstracts for the presentations at the workshop are given in **Appendix 3**.

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[1] Croxall *et al.* (2012) Seabird conservation status, threats and priority actions: a global assessment. *Bird Conservation International* 22: 1–34.

[2] Zydelis *et al.* (2009) Bycatch in gillnet fisheries – An overlooked threat to water bird populations. *Biological Conservation* 142: 1269-1281.

3. Participants' expectations

At the start of the workshop, a round table was conducted to gauge participants' expectations and 'wish list' outcomes from the meeting. These included: (1) gaining contacts and building a network of experts in seabird bycatch in gillnet fisheries; (2) identifying next steps; (3) agreement on best practice for data collection; (4) an understanding of technical mitigation solutions; (5) ways to work jointly with fishermen; (6) initiate action with government support; and (7) develop action plans for the most threatened species.

4. BirdLife European Marine Task Force – providing workshop context

Ivan Ramirez (BirdLife's European Marine Coordinator) provided a summary of BirdLife Europe's organisational structure and the role of its Marine Task Force. Key points were highlighted from BirdLife's European Marine Strategy and Action Plan. He highlighted the great opportunity presented by IBAs and SPAs and their future management. Gillnets are usually used by local and artisanal fleets, providing an ideal scenario for ground-based NGO-fishermen collaborative projects. Ivan also noted that EU and non-EU funders favoured international consortiums, when considering suitable conservation initiatives to fund, such as that likely to result from the gillnet workshop.

Discussion: In response to the highlighting of data gaps, it was noted that the ICES Bycatch WG welcomed further input on bird bycatch (mostly have marine mammal data to date) and that it would be useful for the relevant ICES working groups (Bycatch and Seabird Ecology) to coordinate further on this.

5. SESSION 1: International gillnet bycatch

5.1 Global review of seabird bycatch in gillnet fisheries

Ramūnas Žydelis (DHI) presented results from a global review of bycatch in gillnet fisheries, commissioned by BirdLife Global Seabird Programme. At least 400,000 birds are thought to be killed annually, with temperate and polar regions more at risk due to high numbers and diversity of susceptible species. Highest reported bycatch was in the northwest Pacific, Iceland and the Baltic. The presentation also reflected the relatively high scale of gillnet bycatch in European waters, lending support to the choice of a European focus and location for the workshop. As some areas are very data deficient, further monitoring and population modelling work are considered a priority.

Discussion: The group was asked to forward any known discrepancies or new data to Ramūnas for incorporation in the review.

5.2 Potential seabird bycatch mitigation in gillnet fisheries

Orea Anderson (RSPB, BirdLife) presented a summary of existing research into mitigation measures to reduce seabird bycatch in gillnet fisheries. These can be divided into: (1) technical measures, involving gear modifications; and (2) operational measures, involving changes to overall fishing activity. Acoustic and visual alerts show promise, but require further testing to demonstrate their efficacy, improve design efficiency, and understand the extent to which they are effective on different species/groups of birds. The replacement of gillnets by alternative gears including fish traps is thought to have potential as an

operational measure, but further cost-benefit analyses for specific fisheries are required before it can be recommended. The potential to use time/area closures to reduce bycatch levels was also discussed.

Discussion: The group noted that technical measures will need to take into account regional differences in seabird assemblages and foraging patterns. Measures may need to be refined for particular locations in order to maximise effectiveness.

5.3 Potential applications from marine mammal bycatch mitigation

Finn Larsen (Technical University of Denmark) presented a summary of potential applications, currently used to reduce marine mammal bycatch in gillnet fisheries, which may be of use in reducing the bycatch of seabirds. Methods which may have potential cross-over applications include; acoustic pingers, net profiles, and ease of entanglement. Single factor experiments are required when testing for seabird bycatch reduction efficiency, due to the potential for confounding variables produced by different net types. Protected areas and seasonal/temporal closures may be the most effective measures for reducing bycatch of seabirds, provided effort displacement is appropriately considered.

Discussion: Pingers suffer a drawback in that they can transmit noise up to 4km away, thus reducing feeding habitat of birds/marine mammals. Comprehensive studies into the hearing sensitivities of different types of seabirds are needed. A comment was made that some fishermen try to stake their claim to an area, by often setting their nets 2-4 weeks in advance of the season starting – thus significantly increasing the likelihood of bycatch incidences, through unattended nets.

5.4 Seabird bycatch in gillnet fisheries in Russia

Mayumi Sato (BirdLife Asia), presenting work on behalf of Yuri Artukhin, described the extent of bycatch in the Russian and Japanese salmon driftnet fishery operating in the Russian Exclusive Economic Zone (EEZ). From the early 1990s to 2008, Japanese vessels killed 1.6 million birds, while the Russian vessels killed 645,000 birds over the same period. This equates to a total bycatch of 140,000 birds/year in the Russian EEZ as a whole, demonstrating this area as a priority for future bycatch mitigation efforts.

5.5 Trialling seabird bycatch mitigation measures in Japan for Tufted Puffin conservation

Mayumi Sato, presenting work on behalf of Koji Ono, highlighted the drastic declines in tufted puffin colonies in western Hokkaido since the 1970s. Currently there are only c. ten pairs on two small islands in eastern Hokkaido. Declines are linked to a nearshore gillnet fishery operating near the breeding colonies. In 2008, the Ministry of Environment held a competition on ideas to mitigate the potential bycatch. Current trials involve using visual alerts, such as CDs on nets and plastic eagles on buoys.

5.6 Seabird bycatch in eastern Canada gillnet fisheries

April Hedd (Memorial University of Newfoundland) presented fisheries observer data from 1998-2011 in the Newfoundland and Labrador regions, during which 3,291 birds were caught, with >37,000 sets observed. Bycatch events were concentrated in the summer and fall, with 83% bycatch observed in the traditional offshore fishery (turbot, hake, skate) and inshore fisheries accounting for the remaining 17%.

Over 95% of offshore bycatch events involved shearwaters, with murres *Uria* spp. predominating in the inshore Atlantic cod fishery in summer months close to the breeding colonies. A risk analysis is planned, involving spatio-temporal overlap of species vulnerable to bycatch combined with effort data from fisheries known to have bycatch.

Discussion: There is a need for consistent use of bycatch measurements, both in terms of effort and CPUE. ICES bycatch WG have already recommended the standard use of birds/metre/hour of soak time.

5.7 Impact assessment of historic seabird bycatch in Canada cod fishery

Bill Montivecchi (Memorial University of Newfoundland) highlighted the potential to use the 1992 northern cod moratorium as a unique example of an ocean basin gillnet-removal experiment. He linked the cessation of incidental bycatch among breeding seabird populations in eastern Canada (a by-product of the moratorium) with increases in nearby colonies. Breeding populations of divers, which are susceptible to bycatch, have increased. Meanwhile, scavenging surface-feeders, which are not susceptible to bycatch but to elimination of fisheries discards, have decreased. Data reflect a positive breeding response of common murres (*Uria aalge*) to reduced gillnet effort within their foraging range, supporting a causal link between fisheries bycatch and seabird population trajectories, in this instance. However, at such a broad scale, it is very difficult to prove a population level impact directly resulted from a cessation of bycatch mortality.

Discussion: The benefits of including data on discards, in order to better support the causal decrease in surface-feeders during the period, was highlighted.

5.8 Plenary discussion on Session 1 - International

The group commented on the need for more data on which life stages were most impacted and the origin of birds caught. Generalisations about colony of origin were thought possible, with more tracking studies and other techniques. The potential for expanding BirdLife's Tracking Ocean Wanderers (TOW) database to capture species caught in gillnets, was suggested. The point was made that bycatch often involves migrating birds so the problem can only really be identified at the flyway scale. To demonstrate a population effect would require a flyway scale estimate of bycatch mortality and this is difficult to achieve. It is possible to model population effects, but not without good quality flyway scale bycatch data.

The question was raised as to which bycatch threats to prioritise - fisheries with the greatest numbers of birds caught, or those with more threatened species caught, i.e. should it be conservation or moral imperatives that drive priority-setting. The group reflected that data on population level impacts from oil spills was also lacking, but action had still been taken based on the moral imperative, hence further work was needed to highlight bycatch to a global audience in order to drive action.

The group highlighted the importance of fisheries certification and MPA networks as potential means of achieving bycatch reductions. Further research on mitigation, improved data collection and identifying incentives for fishermen, were considered priorities. The group highlighted that important areas for birds

and for fishermen typically co-occurred in the case of gillnet fisheries, and that novel solutions would have to be identified to circumvent this problem. Further understanding of physiological characteristics of affected species was also deemed important to inform mitigation design, e.g. the ability of birds to detect nets underwater, diving behaviour etc.

6. European policy context for gillnet bycatch mitigation

Euan Dunn (RSPB) gave an overview of the policy context for mitigating bycatch in fisheries, especially gillnets, focussing on EU and national EU initiatives. Despite committing to take action under the FAO IPOA-Seabirds in 2001, the EU has failed to produce an EU Seabird Plan of Action (PoA) so far. While the Commission is expected to propose a PoA this year, it will remain voluntary, so requires legislation to underpin it via the CFP basic regulation, the Data Collection Framework (needs an obligation to collect and report data on seabird bycatch), and Technical Measures Framework (to deliver mitigation measures), in turn supported by the forthcoming EU Maritime and Fisheries Fund (EMFF). BirdLife is focused on achieving a strong PoA, necessary CFP–related measures, consideration of joint funding bids with fishermen for projects under future EMFF, and strong representation at the Regional Advisory Councils (RACs).

There is special focus now on developing and agreeing 'seabird-friendly' fisheries management measures for Natura 2000 sites. The policy challenge across European waters also needs to include the potential of wind farm development to lead to an increase in static gears at the expense of mobile gears (trawls).

Discussion: A question was raised on whether voluntary approaches to seabird bycatch mitigation were effective. The group reflected that providing incentives for fishermen to reduce bycatch was important. However experience worldwide has suggested that effective bycatch reduction requires a combination of incentives together with regulation.

7. SESSION 2: Nordic Gillnet Bycatch

7.1 Seabird bycatch in Icelandic gillnet fisheries

Aevar Petersen (Iceland Institute of Natural History) presented data available on seabird bycatch in Iceland. The main fisheries implicated were cod, haddock, and pollock fisheries for common guillemot; lumpsucker for eider, black guillemot, cormorant and shag; and trout and char fisheries for red-throated diver, great northern diver and various ducks. The main species impacted was black guillemot, which has been in decline for many years. In 2000 c. 120,000 birds were estimated killed in bycatch, but despite such high levels, common guillemot, razorbill and fulmar populations were increasing until 2000-2005. Population declines are thought to result from stock depletion of sand eels and reductions in discards, but bycatch may exacerbate this.

Discussion: 10-year-old data suggest 100,000-200,000 birds are caught annually, but this was not seen as a problem by the authorities as bird populations increased during the period. However, this is no longer the case, since the sand-eel crash. There is a great challenge in collecting data on bycatch in freshwater gillnet fisheries. A question was posed regarding whether Icelandic authorities are engaging with MSC.

Aevar felt this is beginning to happen, although 'home-grown' labels are preferred. A question was raised whether there is any insight on sensitive areas, notwithstanding the paucity of information on spatial distribution. Aevar answered that his map is a conglomerate of 23 species so much is masked. But the biggest risk is just before summer when birds are moving towards the breeding cliffs. Also, the provenance of birds is unknown, e.g. Icelandic thick-billed murres move to Greenland and Newfoundland in winter and are replaced by birds from Norway and Russia – which are being killed in nets. Consequently there is a real need to model all of this.

7.2 Seabird bycatch in Norwegian coastal gillnet fisheries

Kirsten Fangel (NINA) presented data from a 3 year study involving fisher interviews from various fisheries. Estimates of bycatch were c. 8,000-10,000 birds per year across all fisheries (cod longline and gillnet, lumpsucker gillnet, Greenland halibut longline and gillnet fisheries), plus 2,000 birds/yr in salmon nets. Fulmars, cormorants, black guillemot, puffins and razorbills are the species most often caught. There are also episodically large bycatch events of common guillemots in lumpsucker gillnets, not accounted for in the estimates above. There are plans for more detailed studies of the lumpsucker gillnet fishery.

Discussion: A question was asked if the longline sample is representative. Kirsten said it wasn't but they still want to collect such data, even though it isn't the focus of their study. The fleet doesn't carry observers but vessels are paid to report back and the Fisheries Directorate has inspectors. Vessel feedback on bycatch has improved with the growing contact. There is an obligation in Norway to report bycatch but it's very difficult with so many target fisheries and areas.

7.3 Seabird bycatch in Greenlandic gillnet fisheries

Flemming Merkel (DMU) presented bycatch data from Greenland, which affects common guillemots and to a lesser extent king eiders, and is largely limited to southwest Greenland. Most bycatch occurs in the lumpsucker fishery from Mar-May. In 2008, bycatch was thought to be c. 6,000 eiders/yr. Alternative estimates, based on crude bycatch rates in the Nuuk area, and extrapolated to a national scale, indicate bycatch may be in the order of 20,000 eiders/yr. This higher estimate would bring it close to the hunting quota of 25,000 birds/yr. Potential management includes limiting the lumpsucker fishery to abundance-based fishery opening, i.e. postponing the season until May. As a first stage this could be implemented in areas with the highest bycatch risk, but more data on bycatch distribution is required before these areas can be defined.

Discussion: A question was asked, if the birds caught in April are of Greenlandic or Canadian origin. The answer was 'both'. A question was asked, if fishermen would use a mitigation measure that worked. The answer was 'yes' if it wasn't too costly, as they don't like disentangling birds. Bycatch reporting is compulsory.

7.4 Plenary discussion on Session 2 - Nordic

The group noted the difficulty of separating the impacts of hunting versus bycatch in this region, as both activities may contribute significantly to the conservation status of seabird species. This also applies with respect to potential management measures, as bycatch may be offset against hunting quotas, if reducing bycatch is not easily achievable. Likewise bycatch reductions may be a means of maintaining sustainable hunting quotas, in the face of mounting pressures on Nordic seabird populations. The group noted that directed take may remove more birds than bycatch in some regions, but that different age/groups of birds may be affected. It was also noted that weak implementation of hunting limits posed a problem, with fishermen feeling that not selling dead bycaught birds was a waste of resources, particularly in the face of badly managed hunting regulations. Finally, while many countries had regulations on reporting of bycatch data, it was felt most were not sufficiently enforced or adhered to consistently.

8. SESSION 3: Baltic Gillnet Bycatch

8.1 Seabird bycatch in German Baltic gillnet fisheries

Jochen Bellebaum (Institute for Applied Ecology/NABU) highlighted that bycatch may have declined in parallel with decreases in common eiders in German Baltic waters since a historic 30 year old estimate of 15,800 birds; however bycatch is likely to remain a big issue. Tufted duck and pochard are known to be impacted. Bycatch is highest in winter due to overlap with wintering areas for sea ducks, with rates dependent on direct abundance or predictors of abundance (e.g. water depth and location). Specific measures were recommended to reduce bycatch, e.g. using targeted effort reductions and replacement of set nets with alternative gear. The need for closer cooperation of German federal and state level management was noted.

Discussion: The group highlighted that effective management of the impacts of gillnets on seabirds might be achieved through SPAs and EU-PoA. Gear replacement held potentially attractive funding opportunities through such funds as the EMFF. Important priorities would be R&D to improve alternative gears and further monitoring.

8.2 Seabird bycatch in Danish commercial gillnet fisheries

Ib Krag Petersen (DMU) presented data from a study on a selected area in the western Baltic, around the islands of Ærø and Langeland. From Dec 2002-Apr 2003, 12 vessels reported details information on effort distribution and bycatch. 42,000 net sets were observed, with 426 birds being reported, equating to 0.39 birds/1000 net metre days (NMD). Common eider was the most commonly caught species, followed by common scoter, cormorant and long-tailed duck. The study resulted in a bycatch estimate of 800 birds for the study area per winter season. The project also recorded that fishermen identified high incidences of bycatch with the presence of heavy fog – a co-occurrence that had not previously been identified, and may be worth bearing in mind in future studies.

Discussion: The group noted it was critical to account for recreational effort when estimating gillnet impacts on seabirds. In Demark there are 6,000 professional and 35,000 recreational fishermen, the latter

equating to 1 million fishing days per year, mostly close to the coast. This was recognised as a potentially significant problem for SPA management (i.e. it is hard to curtail activities like yachting, if bycatch is allowed to continue unregulated). In Spain, similarly, there are around 70,000 recreational fishermen, compared to 12,000 professional fishermen. As to why more eiders are caught in fog, this may be because the birds are more dispersed and disorientated, but the spring peak may also be accounted for by immigrant eiders unfamiliar with the location of nets. It was noted that there was a need for data from other areas in Danish waters.

8.3 Seabird bycatch in Lithuanian gillnet fisheries

Mindaugas Dagys (Vilnius University) reported on two distinct fisheries operating in Lithuania – inshore and offshore gillnetting. Little is known about the 5 offshore vessels. Inshore, there are c. 100 small boats (<10m) currently registered in the area, operating from the coast rather than from harbours so hard to monitor. Most fishing effort occurs from Sept-May, which coincides with aggregations of wintering and migrating seabirds. Previous research into gillnet fishery impacts suggested up to 10–15% of all birds wintering in Lithuanian waters were killed in nets. The most common bycatch victims were long-tailed duck (51%), velvet scoter (15%), goosander (13%) and red-throated diver (5%). Surface set salmon nets of large mesh size proved to most dangerous, with entanglement rates c. 6 times higher than in small mesh size herring and smelt gillnets. Ten years ago, attempts were made to increase visibility of gillnets, but this proved difficult to operate. From this, restrictions on the gillnet fishery were proposed in the marine SPAs, including a ban on mesh sizes >50 mm during the wintering period in waters up to 15 m in depth. However, there is still a lack of compliance with these restrictions.

8.4 Seabird bycatch in Latvian gillnet fisheries

Antra Stipniece (LOB) presented data on bycatch from a coastal gillnet fishery that typically operates in <20m depth. In recent years, effort has decreased due to EU scrapping activities and reduced fishing quota. Two projects in 2000-2001 and 2005-2008 asked fishermen to report effort and bycatch (reported rates c. 0.28 birds/100m net day), with severity and species composition differing by location. Long-tailed duck was the most frequently caught species, with peak bycatch occurring during migration season in Mar-Apr. There is no obligation in Latvia for reporting gillnet fishing effort or bycatch, only target catch.

<u>Discussion:</u> Unlike the finding in this study, (i.e. that smaller mesh sizes were less harmful) Jochen Bellebaum noted that he didn't find any such effect in Germany. It needs to be tested whether this apparent causal effect is an artefact of something else, e.g. spatial. It would be desirable to see the result of the three Baltic studies analysed together.

8.5 Plenary discussion on Session 3 - Baltic

The group discussed the pros and cons of payment/incentives for fishermen to collect bycatch data, noting conservation gains to be had from instilling ownership and responsibility for seabirds. Experience from the Baltic indicated that data gleaned from fisher interviews or log books may suffer from full disclosure issues, with fishermen wishing to avoid further regulation. In all cases, effective data collection through fishermen required regular interaction with them, including phone calls and port visits.

Electronic monitoring is being tested in Portugal and in the Baltic, and has been tested in Denmark: the Baltic test found that 3 cameras didn't work well, however in Denmark it has had some acceptance from fishermen (see 9.2).

It was noted that EU fisheries had been subject to greater government interference and management control than developing countries, and consequently may be more resistant to grass-roots efforts to engage on a new issue and potentially new regulations. The group noted that, in certain areas of the Baltic, antagonism had resulted from past engagement on cetacean bycatch issues, and that overcoming this may be necessary before engagement on seabird bycatch could fully commence. It was also felt important to streamline multi-taxa mitigation efforts, to minimise impacts on fishermen. There is a need to consider incentives for fishermen. Possible incentives include increased quotas for transparent monitoring. The group highlighted the potential benefits of demonstration projects (e.g. small-scale trials of alternative gears and electronic monitoring) and the need for creative use of the EMFF (EU fisheries fund). The group also noted misinformation on the impacts of mesh size on bycatch rates, with mixed results from the existing literature and no clear trend as to whether larger mesh sizes were more or less harmful. There is a clear need for further research on this topic.

9. SESSION 4: Monitoring and experiences from other fisheries

9.1 Experiences from the Albatross Task Force

Oli Yates described the way that the Albatross Task Force (ATF) works with fishermen to reduce seabird bycatch in 8 countries in South Africa and South America, highlighting aspects that could be relevant to engagement with gillnet fishermen. The ATF works predominantly with trawl and longline fleets, but is also starting to work with gillnet fisheries. The ATF works on land and sea, liaising with fisheries managers, fishery observers and industry through workshops, and going out with fishermen on vessels collecting baseline bycatch data, demonstrating best practice mitigation, conducting mitigation research, and raising awareness of bycatch problems and solutions. Bycatch reductions of over 85% have been achieved in some fisheries. Success has been delivered through the combination of direct engagement with fishermen plus advocacy with government for appropriate regulation. Building of trust with fishermen, sometimes taking 2 or more years, is essential.

Discussion: A question was raised on how the ATF will ensure long term impact once initial bycatch reductions have been achieved. It is important to make sure bycatch mitigation becomes part of a fisherman's daily routine. Capacity will also have been built within government and national observer programs, allowing the need for only low levels of ATF input. The group also noted the importance of fisher ownership of the issue, and the potential incentives through fishery certification. In some countries, engagement with fishery unions can be important (e.g. in the co-sponsorship of a fishermen/BirdLife workshop in the future). BirdLife is planning to use an ATF approach in 3 trial fisheries in Europe and this workshop could inform how to best take that forward. Causation of trawl and longline bycatch is fully understood but this is not the case with gillnets. Research is needed to better understand the mechanism by which birds are caught and what are the drivers of behaviour to place them at risk (i.e.

depth, fish type, turbidity, etc.). Underwater video was postulated as a potential future avenue for research to answer these questions.

A further point was made that it is important to distinguish between commercial and 'spare time' fishermen and to develop some education and guidance for the latter, e.g. how to set gillnets and manage them, and not to set nets when the water is icing over, as birds are attracted to the ice edge and nets may be stranded in ice or may move when the ice moves. Recreational fishermen should not be allowed to adhere to lower standards (of best practice) than commercial fishermen. We also have to take into account the issue of lowered fishing efficiency if we promote alternative gears.

The point was raised whether there are any examples of fishing regulations related to highly endangered species, e.g. short-tailed albatross. Some examples were given. Under the Birds Directive it is illegal to catch sea duck but monitoring and enforcement are key. In South Africa there is a bycatch limit of 25 birds for the pelagic distant water fleet, which has acted as an incentive for Japanese vessels to use line weighting.

9.2 Potential applications of camera monitoring for seabird bycatch assessment

Finn Larsen presented results of a trial with Remote Electronic Monitoring (REM) on board 6 Danish gillnet vessels. Over 811 trips, 68 birds were observed killed, 64 of which were identifiable to species level. Observing seabird bycatch on the videos requires a slower review process than for target catch or marine mammals, which has cost implications. Installation costs for this project were c. 9,000 EUR per vessel and running costs, including video reviewing, were 220 EUR per day at sea. This compares to the cost of an onboard observer in Denmark of approx. 667 EUR per day at sea.

Discussion: Testing of REM against logbooks suggests that logbooks often under-report bycatch. An automated reviewing process should be possible, but is not yet available. The question of whether fishermen prefer REM or observers on board was raised. It was felt that initially fishermen in Denmark were strongly opposed to the use of REM, but with incentives, such as preferential quotas and other perks, they were now more favorable to its use. The group noted with interest the success of this project in gaining EMFF funds for monitoring and fisheries mitigation in a European gillnet fishery.

9.3 Potential applications of SaveWave Technology to reduce seabird bycatch

SaveWave have experience designing technology such as the Dolphin Saver and Orca Saver to reduce bycatch of cetaceans in gillnets. The Seabird Saver technology, currently in R&D, aims to use visual and acoustic signals to scare away birds from being caught by longline vessels. There is the potential for such a device to be modified for use in gillnets. The project is funded by EuroStar, and plans to examine seabird acoustic and visual capabilities underwater, a data gap that was highlighted earlier in the workshop.

Discussion: The group noted that this potential line of research, on seabird underwater acoustic and visual capabilities, would be of great benefit to the wider work to reduce seabird bycatch in gillnet

fisheries. As without the answers to some of these behavioural and ecological questions, further developments on mitigation may be hindered.

10. Breakout Group 1 - mitigation measures, fishermen engagement

Breakout Group 1 was tasked with brain-storming ideas for future mitigation research and development, as well as best practice techniques to engage with artisanal/local fishermen. A primary objective was to identify new mitigation techniques to reduce seabird bycatch in gillnets, which were either already in development or required further testing and which were likely to prove both practical and cost-effective. A secondary objective was to identify best practice means of engagement with gillnet fishermen, as these fisheries are typically more local/artisanal in set-up, compared with the large-scale industrial trawl or longline fisheries we have historically engaged with.

10.1 Mitigation measures

The group felt that mitigation options fell into three categories: (1) measures that reduced fishing effort; (2) measures that separated effort from bird distribution (space/time) (e.g. promoting use of MPAs); and (3) measures that resulted in 'bird-friendly' gear (i.e. modified gillnets or alternative gear). However, it was also agreed that not all three options were equally acceptable to industry. Options 1 and 2 could be economically and logistically challenging, and be more or less applicable depending on local conditions (e.g. whether an MPA exists on fishing grounds). Option 3 is technologically challenging and may require significant R&D. It was felt that a switch to longlines or fish traps could be part of the solution in the Baltic, subject to further testing of cost-effectiveness, potential impacts on non-target species, etc.

10.2 Alternative gear types for potential research

The group identified two possible alternatives for typical static gillnet gear, but more may be identified with further research. Fish traps can sometimes be species-specific, and may produce better quality, more profitable fish. Bycatch of cormorants in fish traps is known in some cases, but modifications exist (e.g. Sweden). Longlines provide a possible alternative to prevent benthic feeder bycatch, but may not reduce pursuit-diver bycatch (e.g. shearwaters), which often take baited hooks. Further studies are required to determine the effect across all seabirds and other taxa, and its suitability as an alternative gear may be region/fishery specific. The group further noted that the appropriateness of radical changes in gear was also dependent on how much previous fisher engagement had occurred (e.g. alternatives already possible in the Baltic, but may not suitable for Atlantic and Mediterranean industrial fisheries, and could even be counter-productive).

10.3 Aspects of gillnet design

The group identified a number of aspects of gillnet design that warranted further investigation with respect to reducing seabird bycatch, including; alternative materials and dimensions, acoustic and visual deterrents (e.g. LEDs, pingers, etc.), others (e.g. decoy sea eagles mounted on buoys).

The group commented that any reduction in mesh size (if deemed a suitable bycatch mitigation option) could put pressure on fish stocks, through capture of smaller sized fish, so would have to be carefully considered. There is a need to take into account foraging methods of bird species at risk, especially benthic feeders (foraging in turbid waters and also nocturnally) versus pursuit feeders (highly visual hunters) when considering visual alert gear modifications. Finally, experimental trials must be aware of the challenge of decoupling design features of gillnets (e.g. mesh size and filament thickness are linked).

10.4 Engagement with fishermen

The group discussed means of effectively engaging with fishers, highlighting the need for respect and transparency in any communications, and engagement with industry from the outset. Engagement with younger fishermen coming in, through their training programs, can be effective. The group noted the need for a stepwise approach ((e.g. data collection may be a prerequisite for discussing solutions), that different fisheries will be at different stages, and that the FAO International Action Plan-Seabirds (FAO IPOA-Seabirds) gives a good overview of the steps necessary for effective bycatch reduction. It was also felt that early acknowledgement of the need to take account of catch rate of target species was critical to successful engagement. Terminology may also be important, with language such as 'sector' preferable to 'industry' from the perspective of small-scale fishers. Salmon fisheries were highlighted as a priority for engagement.

10.5 Ideas for EMFF supported projects

The European Maritime and Fisheries Fund (EMFF) is currently being revised and will offer the opportunity to fund fisher-led projects to trial gear modifications and alternative methods to mitigate the impacts of their activities on the wider marine ecosystem. When selecting appropriate trials the group noted it was important that any alternative gear testing be done on the same grounds where gillnets normally operate. Other ideas included the use of EMFF to develop direct selling to consumers, as a value-added incentive for using more sustainable gear (e.g. fish pots/traps). Certification may act as another incentive but assessment is expensive, especially for small-scale fisheries. EMFF could also be used to fund a comparative study of gillnet visibility in relation to sensory abilities of different at-risk seabirds (benthic and pursuit feeders), as well as trials of underwater video monitoring to better understand the characteristics of capture events. The group also noted the benefit of establishing a data network – working with fishers to provide data and answers, thus empowering them and facilitating buy-in to solutions.

10.6 Plenary discussion of Breakout Group 1

The group highlighted the need to develop standard advice for recreational fishermen (e.g. where not to set, check nets frequently, don't leave them overnight, don't set when temperature expected below freezing point, etc.). It was stressed that this group should not be allowed to work at a lower level of regulation than commercial fishermen. The opportunity to amend the EU-PoA Seabirds when it comes to the European Parliament was also noted, thus drawing attention to the issue of the extent of recreational gillnet effort and the need to work to the same standards.

Under the EU Birds Directive, it is effectively illegal to kill birds, but this is not enforced in reality. Effective regulation is reliant on monitoring and enforcement. In South Africa, monitoring of trawl vessels and enforced return to port visits if observed without mitigation, demonstrates that major reductions in bycatch can be achieved with suitable regulation and enforcement. Paying fishers to collect data is a solution supported by experience from Lithuania and Canada. Another option, rather than paying fishermen directly, is to cover operational costs (e.g. diesel) or allocate more beneficial quota rights.

11. Breakout Group 2 – data needs (gaps, data collection and monitoring)

Breakout Group 2 was tasked with producing a list of the main obstacles and gaps in current knowledge, which prevent an adequate characterisation of gillnet bycatch within a given fishery. Based on presentations from different regions around Europe, Baltic and Nordic regions, it was clear that data are often collected using different methodologies (i.e. from experimental studies to routine logbook data collection). Principle objectives were to identify means of harmonising data collection methods, best practice techniques for monitoring bycatch, and gap-analysis of seabird and fishery data that would aid in the identification of potential bycatch hotspots (e.g. improved seabird distribution data).

11.1 Data collection protocols

The group agreed it would be useful to have a basic standard questionnaire to cover the main questions asked of fishermen. There is a proposal for a template to be developed by BirdLife through the FAME project, but currently this includes marine mammals. It may require a scaled-down version just focussing on seabirds. The group agreed it was necessary for interviewers to be sufficiently trained to 'warm-up' fishermen to bycatch-related questions. BirdLife agreed to distribute the proposed FAME (Future of the Atlantic Marine Environment) model to participants.

Defining compulsory fields in the questionnaire was identified as a priority; leaving national/local research needs to be added later by the relevant agencies. Compulsory fields were: Date/Time; Effort/Type of vessel/Type of gear/Landings; Weather/Sea conditions; Location and Net depth; target and bycatch species. Advisable fields were: ID guides included in the form; Sex/Age of bycatch species; nil bycatch events; data-protection regulations per country (to avoid potential conflict over personal/sensitive data being recorded); grid map for fishermen to locate preferred fishing areas (voluntary).

11.2 Fishing effort data gaps

The group noted the difficulty in acquiring fishing effort data and suggested direct contacts with fishermen and associations, rather than with regional management organisations and institutions. The need for a standard EU-wide system for gillnet effort data collection and reporting was stressed, with a possible mechanism identified through the EC-PoA Seabirds and Technical Measures Regulations under CFP (which should make reporting and monitoring of bycatch compulsory). There is also a need to establish a standard form for reporting bycatch. Currently it is difficult to access data on gear configurations among EU gillnet fisheries; this also needs to be rectified. The group reiterated the

potentially huge data gap from recreational gillnet fisheries. Potential solutions include gaining access to the number of licenses per country, collating data on the number of sets, location of effort, etc. There is a need for stronger and clearer regulation of these fisheries.

11.3 Seabird ecology data gaps

The group agreed information is available, but currently much dispersed and not readily accessible. There is a clear need for centralised and open access to data from aerial census, boat-based census, and tracking. Little is known about population delineation and how bycatch affects this. Only with phenological data for each species can management proposals be put in place and seasonal closures, considered appropriate by fishermen, be determined rather than large scale precautionary fishing bans in particular areas such as SPAs. The group highlighted the utility of an open access data analysis toolkit, to help researchers and BirdLife partners model seabird population fluctuations and bycatch impacts.

11.4 Fisheries research

The group noted the need to understand mechanisms of gillnet bycatch and gear specifications (e.g. net size), to assist with future management proposals. Experimental trials using underwater video were deemed a priority, as well as using fisher knowledge to increase understanding. Further mitigation testing on devices such as pingers and other new technology are required.

11.5 Plenary discussion of Breakout Group 2

Priorities agreed included: an assessment of the extent to which bycatch is sufficiently covered under MSC certification process; future collaboration with marine mammal mitigation experts; greater implementation of existing reporting requirements (e.g. Iceland, Norway, Greenland compulsory to report bycatch but not enforced); compile a list of fishing association contacts to make links with BirdLife and EMFF; awareness raising (using communication materials and direct involvement with fishers and unions in parallel); and better data collection, in Iceland particularly.

12. Priorities, opportunities and next steps

In the final session of the workshop, participants reflected on the issues presented and discussed during Day 1 and Day 2, in order to identify priority actions for making progress in reduction of seabird bycatch in gillnet fisheries. These priorities were divided into research and monitoring, policy and management, and fishermen engagement.

12.1 Research and monitoring priorities

1. Systematic monitoring/reporting of gillnet bycatch
2. Common data collection forms/protocols
3. Standardised reporting of CPUE and effort
4. Broader access to existing data
5. Representative and wider application of observer programmes

6. Improved at-sea distribution data on most commonly caught species and a centralised open access database to analyse overlap with fisheries effort distribution
7. Population modelling and impact assessments (including other threats) for priority species

12.2 Policy and management priorities

1. Closer cooperation of federal and state level efforts to address gillnet bycatch
2. Drafting of mitigation plans, with clear reporting and published targets
3. Ensuring certification bodies adequately address bycatch issues under their assessment criteria
4. Lobby EU and non-EU institutions for compulsory data collection and reporting
5. The creation of management plans under the Birds Directive (through SPAs) and EC-PoA
6. Enforcement of existing fishery regulations and data collection
7. Stronger regulation, monitoring and enforcement of recreational fisheries
8. Weighting bycatch against hunting of seabirds in relevant regions/countries (i.e. bycatch wasteful, need to improve implementation of hunting bans/quotas)

12.3 Fishermen engagement priorities

1. Need to raise awareness with fishers and form effective trial/research collaborations (longevity and consistency important)
2. Use fisher contacts and experience to develop combined funding proposals (e.g. EMFF)
3. Gear replacement has attractive possibilities for funding where applicable (e.g. fish traps in Baltic)
4. Investigate means of incentivising data collection, reporting and uptake of measures (direct or indirect)
5. Engage with recreational as well as commercial gillnet fisheries
6. Stepwise approach (e.g. IPOA-Seabirds) depending on where in the process a fishery is (e.g. data collection may be a prerequisite for discussing solutions)
7. Research on effective mitigation techniques (trials must take account of target catch impacts, ease of use, etc.)

13. Agreed actions arising from workshop

13.1 Research monitoring

1. Table seabird bycatch reporting protocols as Term of Reference (ToR) for ICES Working Group on Seabird Ecology and Bycatch Working Group **(BM / FL)**
2. Circulate existing fisher questionnaires to participants **(IR)**
3. Create a gillnet document/ materials database for open access **(Birdlife Europe)**
4. Create a glossy EU policy document– include paragraph on recreational fisheries **(GSP)**

13.2 Policy / management

1. Review certification bodies (e.g. MSC) on efficiency of bycatch assessment **(ED)**
2. Increase BirdLife engagement with certification process early on **(BirdLife partners)**
3. Lobby governments directly for compulsory data collection **(all participants)**

4. Distribute management plan guidelines on SPAs **(IR)**
5. Feed bycatch priorities into forthcoming related Species Action Plans (eg long-tailed duck) **(all participants)**

13.3 Fisher engagement

1. Make lists of key contacts / organisations in fishing communities to target future collaborations and funding bids **(IR)**
2. Meta-analysis on impact of mesh size on bycatch **(JB?)**
3. Summary sheet on mitigation measures research and alternative gears or fishing ID guide **(OA)**
4. Future workshop to start with presentation on gear types and alternatives

Initials: IR=Ivan Ramirez, BM=Bill Montevecchi, ED=Euan Dunn, OA=Orea Anderson, FL=Finn Larsen, JB=Jochen Bellebaum, GSP=BirdLife Global Seabird Programme

Appendix 1

AGENDA

Day One **BirdLife Gillnet Seabird Bycatch Workshop (08.45-17.00 GMT+1)**

Time	Item	Section	Lead
08.45-09.00	Welcome, Introduction, Housekeeping	Jöerg Andreas Krueger (NABU) Cleo Small Kim Detloff	JK,CS, KD
09.00-09.15	Round table introductions		CS
09.15-09.30	BirdLife Marine Task Force	Context for workshop	IR
09.30-11.00	**International gillnet bycatch session & research on mitigation measures**		**CS**
09.30-09.50		Global overview of seabird bycatch in gillnet fisheries	RZ
09.50-10.10		Developments in gillnet mitigation	OA, FL
10.10-10.25		Russia and Japan	MS
10.25-10.45		Canada	BM, AH
10.45-11.00		Reflections/discussion from session	
11.00-11.30	*Coffee break*		
11.30-11.45	**European policy context for gillnet bycatch reductions**		ED
11.45-13.00	**Nordic gillnet bycatch**		**OA**
11.45-12.00		Iceland	AP
12.00-12.15		Norway	KF
12.15-12.30		Greenland	FM
12.30-13.00		Reflections/discussion from session	Panel
13.00-14.00	*Lunch*		
14.00-15.30	**Baltic gillnet bycatch**		**KD**
14.00-14.15		Germany	JB
14.15-14.30		Denmark	IP
14.30-14.45		Lithuania	MD
14.45-15.00		Latvia	AS
15.00-15.30		Reflections/discussion from session	Panel
15.30-16.00	*Coffee break*		
16.00-17.00	**Breakout group sessions:** identify priorities, blocks to progress, best practice, and role of BirdLife and this group	(a) gillnet mitigation measures & stakeholder/fisher engagement (b) data needs (gaps, data collection & monitoring)	Panel (**ED**)

Day Two BirdLife Gillnet Seabird Bycatch Workshop (09.00-16.30 GMT+1)

Time	Item	Section	Lead
09.00-09.10	Welcome to Day 2		KD/ED
09.10-09.40	**Albatross Task Force**	Experience from ATF longline and trawl fisheries	OY
09.40-09.50	Camera monitoring		FL
09.50-10.00	SaveWave Technology		DV
10.00-10.30	*Coffee break*	*Chance to finalise breakout group outcomes*	
10.30-11.00	**Data Collection**	Feedback from breakout group and discussion	Panel (**ED**)
11.00-12.00	**Mitigation research and stakeholder/fisher engagement**	Feedback from breakout group and discussion	Panel (**ED**)
12:30-13:30	*Lunch*		
13:30-15:00	**Priorities, opportunities and next steps**		IR
15:00-15:30	*Coffee break*		
15:30-16:30	**Conclusions**	Workshop close	IR

Initials: JK= Jöerg Krueger, IR=Ivan Ramirez, CS=Cleo Small, RZ=Ramunas Zydelis, MS=Mayumi Sato, BM=Bill Montevecchi, AH=April Hedd, ED=Euan Dunn, OA=Orea Anderson, FL=Finn Larsen, DV=Dimitri Vernicos, AP=Aevar Petersen, KF=Kirstin Fangel, FM=Flemming Merkel, KD=Kim Dietloff, JB=Jochen Bellebaum, IP=Ib Petersen, MD=Mindaugas Dagyis, AS=Antra Stipniece, OY=Oli Yates

Appendix 2

LIST OF PARTICIPANTS

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Appendix 3

ABSTRACTS OF PRESENTATIONS

BirdLife International and the Global Seabird Programme

Ivan Ramirez[1]

[1]European Marine Coordinator, BirdLife European Secretariat, Brussels, Belgium

The BirdLife European and Central Asian Partnership consists of 45 conservation organisations with almost 3,000 staff, 1.9 million members and more than 6,000 reserves covering over 300,000 hectares. In 2010, BirdLife Europe created the European Marine Coordinator position with direct support from BirdLife International Global Seabird Programme (GSP).

The GSP aims to support partners to: a) Promote collaborative international action b) Advocate the conservation of seabirds c) Work directly with fishermen and other main stakeholders. In Europe, the GSP has focused mainly on the definition of the Marine IBA toolkit, supporting European partners to complete their marine IBA networks, and on alien species eradication programmes.

In 2011, following the creation of the European Marine Task Force, the European Partners actively participated in the drafting of an European Marine Strategy (approved officially in November 2011) that is now ready to implement. In order to prioritise our limited capacity, EU partners were asked to vote on their top two preferred actions. The result of this exercise showed that marine IBA/MPA management and seabird bycatch are the most important priorities for the partnership.

Global overview of seabird bycatch in gillnet fisheries

Ramūnas Žydelis[1], Gemma French[2], Cleo Small[2]

[1]Ecology and Environment Department, Danish Hydraulic Institute, Denmark

[2]The Royal Society for the Protection of Birds, Sandy, UK

Based on bird feeding ecology we identified 148 seabird species as susceptible to bycatch in gillnets. The susceptible species represent all major taxonomic seabird groups and highest species diversity occurs in temperate and polar regions of both hemispheres. Similarly, gillnet fisheries are wide spread and are particularly prevalent in coastal areas and are mostly operated by artisanal fishermen. A review of reported bycatch estimates suggests that at least 400,000 seabirds die in fishing nets annually. The highest bycatch has been reported in the Northwest Pacific, Iceland and the Baltic Sea. Species that may be suffering significant impact include long-tailed duck, common guillemot, thick-billed guillemot, red-throated diver, Humboldt penguin, Magellanic penguin, yellow-eyed penguin and little penguin.

Overall knowledge on the details and magnitude of this phenomenon is poor for all regions. Furthermore, there are very few analyses on factors causing bycatch events. Population modelling to assess effects of bycatch mortality on seabird populations is also very limited to date.

Potential mitigation measures to reduce seabird bycatch in gillnet fisheries

Orea Anderson[1]

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Seabird bycatch mitigation measures for longline and trawl fisheries have been extensively developed in recent years. However, the development of means to reduce seabird bycatch among gillnet fisheries has been largely unexamined. Here we examine what research has been done to-date, and identify two principle avenues for future research; (1) technical measures, which involve specific alternations and changes to gear configurations, and (2) operational measures, which involve changes to the way in which the fishery itself currently operates. Examples of the latter include measures such as temporal and spatial closures, or widespread replacement of the principle fishing method for a particular fishery.

Technical fixes can involve both acoustic and visual deterrents being place in or around the gillnets themselves. Acoustic pingers have been demonstrated to be effective in some instances but were also shown to be species-specific in their efficacy. Visual deterrents, such as replacement of sections of the net with high visibility netting, have also demonstrated variable results. These results have also shown variable impacts on target as well as non-target catch. There appears to be no 'one-stop shop' on the technical side of gillnet mitigation.

Temporal or seasonal closures are likely to be the most effective means of reducing gillnet bycatch, from an operation stand point. However, such measures are likely to be met with widespread resistance among the fishing communities where they could be trialled. A final option, with considerable expense attached, may be the use of alternative gear as a means of reducing seabird bycatch. In the Baltic Sea, fish traps have been tested on a small scale as a replacement for existing cod fisheries in Sweden and Germany, where considerable bycatch currently occurs. Initial tests would seem to indicate a marked reduction in bycatch relative to gillnets, although some bycatch of cormorants and cormorant-like species has been reported among Fyke nets, which are similarly configured. The true impact of such a major gear modifications is hard to predict, but it is likely that it would not be appropriate for all gillnet fisheries currently operating in European waters. Further work is required across different fisheries and regions, to examine the cost-effectiveness of replacing gillnets with new gear such as fish traps. Equally, fish traps may not be appropriate for schooling salmonids during periods in their life cycle when they are not feeding, for example, as they would have no reason to enter a baited fish trap.

Developments in marine mammal mitigation with potential applications for seabird bycatch

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Finn Larsen gave a presentation on potential cross-over techniques from marine mammal bycatch mitigation. With respect to pingers, experience has shown that small cetacean species can react differently to the same signals, there are even suggestions of population differences within the same species. So it is important to tailor the frequency level and signal type to each species' sensitivities. There have been a number of technical problems with pingers, including low manufacturing quality and interference with normal fishing operations. Pingers can also be quite expensive compared to other costs of gillnet fishing. Pingers have a number of other disadvantages such as potential habituation and environmental issues like habitat exclusion and noise pollution. A further challenge of pinger use is that enforcement is not straightforward.

With respect to gear modifications, small cetacean bycatch research has focused on net properties like net profile (as determined by number of meshes, mesh size, head rope buoyancy, tie downs, floats) and ease of entanglement (as determined by bar length, twine type, twine size, twine material). In commercial fisheries several of these determining factors are confounded and also with target species, area and season, making it difficult to assess the effects of any of them on their own. The only way to do this is therefore by conducting single-factor experiments. Regarding operational measures like protected areas and seasonal/temporal closures these are most effective in situation where bycatch rates are markedly higher in certain areas and/or seasons in order to avoid merely displacing effort and thus not achieve a reduction in bycatch.

Accidental By-catch of Seabirds in the Salmon Gillnet Fishery in the Russian EEZ

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In the early 1990s, under bilateral Russian-Japanese agreements, Russia allowed Japanese fishing companies to catch salmon in the Russian Far East Exclusive Economic Zone (EEZ). Because of increasing concerns of the potential impact of driftnets on seabirds and mammals, monitoring of seabirds and mammals caught by driftnet fisheries was conducted by the Kamchatka Federal Department for Protection and Reproduction of Fish Resources and Fisheries Regulation between 1992 and 2001.

Japanese fishermen were monitored from 1992-2001, during which 183,646 seabirds were caught, with 31 different species identified (mostly alcids and shearwaters). Shearwaters (predominantly short-tailed) accounted for 32.1%, 28.3% murres (mainly thick-billed murrlets), 19.3% tufted puffins, 11.4% crested auklets, 5.7% fulmars and 1.2% horned puffins. The frequency of bycatch in Japanese driftnets varied from 0-89.6 birds/km of net.

In addition to the Japanese, Russia conducted its own (scientific) driftnet fishery to research Pacific salmon. Monitoring of this fishery occurred between 1996-2005, during which 18,689 birds were caught with 20 species identified (mostly alcids and shearwaters). Shearwaters (predominantly short-tailed), accounted for 34.8%, 28.7% tufted puffins, 18.3% Murres Uria species, 6.9% crested auklets and 5.2% fulmars. The frequency of bycatch varied from 0-20.2 birds/km of net. Overall, Japanese driftnet fishing for salmon between 1992-2008, accounted for over 1,600,000 seabirds, averaging 94,330 birds per year. The total for the Russian driftnet fishery between 1995-2008 was 645,000, averaging 46,099 birds per year.

Considering the world abundance of short-tailed shearwater, fulmar and crested auklet, it is likely that bycatch from the Russian and Japanese driftnet fisheries does not impact these species at the population level. However, they do present real danger to the colonies of thick-billed murres in the south-western Bering Sea and the adjacent Pacific coast of south-western Kamchatka. Tufted puffin colonies in the region are likely to be similarly affected. Additionally, rare and endangered species such as the yellow-billed loon, short-tailed albatross, sooty shearwater, red-legged kittiwake, and long-billed and Kittlitz's murrelets all listed in the IUCN Red List – also get caught in the driftnets of ocean salmon fisheries.

Driftnet fisheries present a real danger to some species, including several rare and endangered species. This issue is poorly researched in Russia, and so far, Russian government agencies ignore the bycatch of rare species in such gillnets. It is impossible to completely avoid bycatch during driftnet fishing, but a good monitoring system, combined with efficient use of resulting data, would reduce the severity of impact by introducing restrictive measures such as changing the fisheries boundaries or fishing seasons, reducing the size of fishing fleets and fishing quotas, limiting driftnet length and the length of driftnet set cycles as well as developing alternative salmon fishing methods and effective mitigation measures. The driftnet fishing in Russian waters now needs serious attention and management.

Tufted Puffin Conservation in Japan: Trials on Gillnet Mitigation Measures

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Japan is spread across many islands to the north and the south, surrounded by ocean and has more than 100 species of seabirds annually between subarctic and subtropical regions. Tufted Puffins are found in subarctic region of North Pacific and, in Japan, they used to breed on the islands of western Hokkaido. The local population decreased drastically in 1970s, and currently only about ten pairs breed on two small islands in eastern Hokkaido. Various causes may have led to their decline, although, a near-shore gillnet fishery is likely to be a principle factor. In Hamanaka, where Tufted Puffin is a mascot, conservation actions have been taken, including the instalment of decoys to attract Tufted Puffins, building a locally managed marine protected area, introducing a ban on gillnets during the breeding season and monitoring of gillnets and fishing boats.

Because there are no effective mitigation measures to avoid gillnet bycatch, Kushiro Branch of Ministry of Environment held an ideas competition in Hamanaka Town in 2008 to come up with mitigation measures. Although not many ideas were sent to us, the purpose was also to raise awareness about bycatch nationwide. An idea sent by a local middle-school student involved placing buoys with large eyes on them on top of the net (to scare the birds away). Another involved tying Ds to the net (again to scare birds away). The following year, we tested whether nets with CDs have any effect on reducing seabird bycatch.

The preliminary results showed that nets with CDs had no bycatch and had more fish catch. However, fishermen were reluctant to use the measure mainly because of some difficulties associated with handling the nets with CDs. Fishermen would not use the measure unless there is some significant benefit. This year, buoys with eagle decoys will be tried.

To promote the conservation of the Tufted Puffin, it is crucial to have cooperation from local fishing groups and individual fishermen and to get all involved in the process and continue the efforts. Our wish is to restore oceans with abundant marine life including seabirds. We can only work on a few programmes, but prevention of gillnet bycatch is a common issue for many diving seabirds.

Seabird bycatch in Eastern Canadian gillnet fisheries: An assessment using data collected by on-board observers, 1998-2011

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Large-scale fisheries employing gears known to incidentally catch seabirds operate off the east coast of Canada (Northwest Atlantic Fisheries Organization [NAFO] subareas 0, 2, 3, 4 and 5). Yet, information on seabird bycatch is very limited. Observation of > 37,000 gillnet sets (Department of Fisheries and Oceans [DFO], Canada) between 1998-2011 recorded the catch of ~3,300 seabirds. Bycatch within gillnet fisheries is widespread with the bulk of mortality occurring during summer and fall (1 May – 30 November). While there were substantial differences between regions in the fishery target and the seabird species involved, we highlight some areas of increased risk. Within Davis Strait, for example, summer and fall gillnet fisheries for Greenland halibut *Reinhardtius hippoglossoides* catch Northern Fulmars *Fulmarus glacialis* and Gulls *Larus* spp. Relatively high bycatch rates were observed off southeast Baffin Island near Cape Searle, the site of Canada's largest fulmar breeding colony. During summer off Newfoundland and Labrador, the offshore gillnet fisheries for Greenland halibut and monkfish *Lophius americanus* were responsible for most of the observed seabird bycatch, with southern hemisphere migrant Shearwaters *Puffinus* spp. frequently taken along the northern and south-western slopes of the Grand Bank. Seabird bycatch also occurs within the inshore Atlantic cod *Gadus morhua* fishery in summer. Murres *Uria* spp. are the most common victims with locally high bycatch rates again observed in the vicinity of breeding colonies. In the Gulf of St. Lawrence, gillnet bycatch occurs largely in summer in fisheries for Atlantic cod and Greenland halibut. Murres and other Alcids are most commonly taken. While relatively little gillnet bycatch occurs within the Maritimes region overall, Common Eiders *Somateria mollissima* and to a lesser extent, cormorants *Phalacrocorax* spp., are taken off southern Nova Scotia in the summer and spring winter flounder *Pseudopleuronectes americanus* fishery. Analysis of the observer data has improved our understanding of areas of conflict between seabirds and fisheries, however, as the program covers a relatively small portion of the fishing fleet, our understanding of the issue is incomplete. Next steps will involve a risk assessment approach, examining spatio-temporal overlap of seabird species vulnerable to bycatch and effort data for the fisheries that are likely to catch them. This will allow identification of other potential conflict areas and improve understanding of the magnitude of the problem. Information for the inshore portion of the gillnet fleet, not currently covered by DFO's Fishery Observer program, will be critical here as it could be expected to represent a significant source of mortality due to the presence of high densities of diving and vessel-attracted seabirds year-round.

Canadian cod fishery closure provides an ocean-basin test of gillnet bycatch on seabird populations

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Bycatch mortality associated with global fisheries imposes well documented negative consequences for large marine animals. Yet data deficiencies associated with both bycatch and population estimates have precluded demonstration of causal linkages to population level effects, with most population implications being related to species at risk. Here we analyze the influences of the ocean-basin gillnet removals associated with the 1992 northern cod fishery closure[7] to assess the consequences of bycatch mortality on breeding seabird populations in eastern Canada. Consistent with predictions, we show that the breeding populations of divers (susceptible to bycatch in gillnets) have increased, while the populations of scavenging surface-feeders (not susceptible to gillnet bycatch but to elimination of fisheries discards) have decreased following the fishery closure. Using the best available series of seabird censuses of the most vulnerable species at their second largest colony in eastern Canada, we demonstrate positive breeding population responses of Common Murres (*Uria aalge*) to reductions in gillnet fishing activity within their foraging range. This finding supports the contention that fisheries bycatch influences populations of non-target large vertebrates.

European policy context for gillnet bycatch reduction

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With insufficient knowledge of Europe beyond the EU, this presentation deals with the EU only, addressing policy responses at 3 different levels: international (Brussels), national (Member States) and BirdLife, respectively.

International response

For over 10 years, and despite persistent inputs and lobbying from BirdLife, the Commission has failed to develop the crude draft EU Seabird Plan of Action (PoA - addressing longline bycatch only), it presented to FAO-COFI in 2001. However, we have good reason to expect a final proposal in the coming months, that it will comply with the FAO Best Practice Technical Guidelines (addressing all fishing gears in EU and external waters), and hopefully will include *inter alia* an objective to minimize bycatch, monitoring , assessing mitigation measures, prioritising static gears for action, and raising awareness.

However, the PoA is essentially voluntary, so needs to be underpinned by legislation via the CFP basic regulation (currently being reformed), the related Data Collection Framework (needs an obligation to collect seabird data, currently missing) and Technical Measures Framework, in turn supported by the forthcoming EU Maritime and Fisheries Fund (EMFF).

National response

There is special focus now on developing and agreeing 'seabird-friendly' fisheries management measures for Natura 2000 sites. The Dutch FIMPAS (Fisheries Measures in MPAs) process is described as a case study, focussing on the proposal for a seasonal gill-netting ban (and some other measures) on the Frisian Front SPA to protect Common Guillemot. The policy challenge across European waters also needs to include the potential of wind farm development to lead to an increase in static gears at the expense of mobile gears (trawls).

BirdLife response

This should include lobbying for a strong PoA (the Commission's communication will be subject to Council conclusions), lobbying for the necessary CFP-related measures, consideration of joint funding bids with fishermen for projects under the future EMFF, and strong representation in the RACs.

Seabird gillnet bycatch issues in Iceland

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Fishery management system states that all catch recorded in digital log book and database, and all catch brought ashore and weighted. Problems includes no species identification and in Lumpsucker fishery for 2012 is first season that total catch is brought ashore (earlier only the roes).

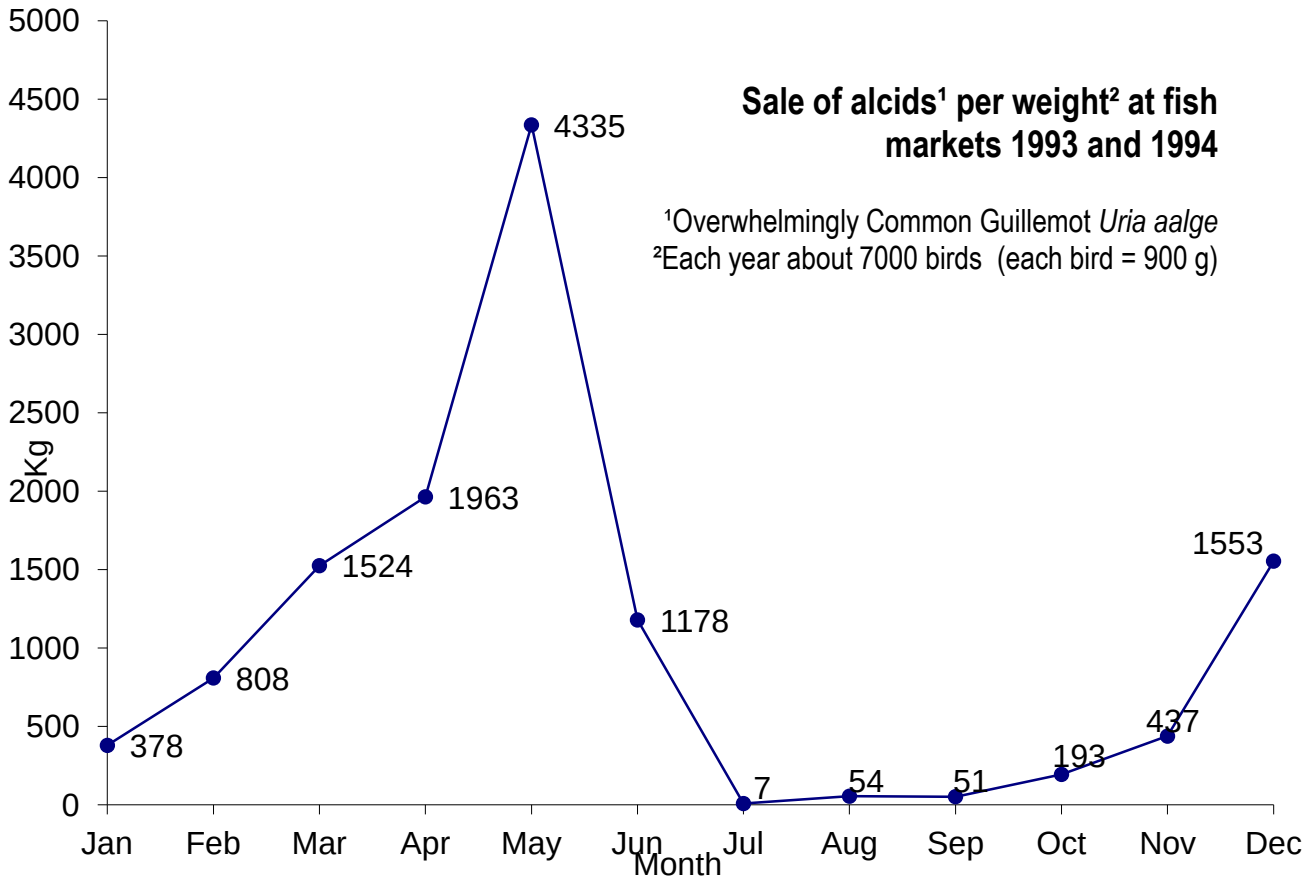
Main fisheries relating to bycatch are Cod, Haddock, and Pollock for Common Guillemot; Lumpsucker for Eider, Black Guillemot, Cormorant and Shag; Trout and Char for Red-throated Diver, Great Northern Diver, and various ducks.

Estimated numbers bycaught (around 2000):

- Common Guillemot 70 000
- Razorbill 10 000
- Fulmar 30 000
- Eider 2 000
- Black Guillemot 1 000
- Cormorant & Shag 3 000
- Others 5 000
    - Total 121 000

Despite large bycatch Common Guillemot, Razorbill, and Fulmar populations were increasing until 2000-2005 when declines started presumably due to sand-eel deficiency and lessened discards. Main species impacted are Black Guillemot, which population has been declining for a long time, while the populations of Red-throated Diver, Great Northern Diver (Redlist species), and Cormorant are rather small.

Temporal changes in bycatch, as shown in the fish market sales (primarily Common Guillemot), indicated that alcids are killed in largest numbers in spring, see figure.



Spatial and temporal at-sea distribution is poorly known. Targeted fish species and birds, such as Common Guillemots, concentrate in same areas, e.g. when Cod follows Capelin runs. Temporal ocean closures only focused on fish. No allowance is for bird protection in fishery management decisions, and MPAs do not exist.

Bycatch in freshwater is presently little known but main problem species are Red-throated Diver, Great Northern Diver, and various diving ducks.

No formal mitigation measures take place although encouraged by authorities. No engagement with fishermen. One study has been undertaken on influencing ducks from char nets.

The present situation is such, that hardly any studies or other work is underway on the bycatch issues, nor planned. A recent ministerial report (autumn 2011) made a recommendation for improved registration of bycatch through statistics system (species, gear type, temporal aspect, numbers caught), and for seeking mitigation methods. Besides improving the knowledge database both in marine & freshwater environment, research should be carried out into targeted species, identify source populations and analyze effects, and lastly improve information on at-sea distribution.

Seabird by-catch study in the Norwegian coastal fisheries (2008-2011)

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Our study's aim was to improve knowledge of seabird bycatch in Norwegian coastal gillnet and longline fisheries. The results are used to rank fisheries and identify those recommended for further studies. One objective within this project was to try out different methods for collecting data on current levels of seabird bycatch in Norwegian fisheries. We did an *in situ* survey with personal interviews with fishermen. Additionally, we analyzed data on seabirds taken as bycatch from 2006 to 2009 in the coastal reference fleet program. From May 2009 to May 2010, we conducted 133 interviews with fishermen who mainly carried out a coastal fishery from boats less than 15 m long. We also interviewed seventeen fishermen using salmon nets. Ninety percent of the interviews were conducted in northern Norway. For each fishery, we calculated a bycatch coefficient (seabird bycatch per metric ton landed target fish) based on data from the survey and data from the reference fleet. The coefficient was used to estimate the total yearly bycatch of seabirds within the fishery, based on publicly available statistics for the yearly total catch of target fish (tonnes landed) within the fishery in question. Public statistics on fishing effort are not presently available, which is why we used fish catch for this extrapolation.

The lumpsucker fishery is one of two fisheries where the bycatch coefficient was relatively high (0.693 seabirds/ton lumpsucker), and ten times higher than in other gillnet fisheries in our study (0.86 for gillnet cod fishery and 0.072 for gillnet Greenland halibut). The bycatch coefficient for the longline fishery for Greenland halibut was 0.279 seabirds/1000 hooks or 0.759 seabirds/ton halibut. The number of respondents was limited for both lumpsucker and Greenland halibut fisheries, and our estimates should therefore be considered with some caution. The estimate is also somewhat higher than those reported in other studies of seabird bycatch in longline halibut fisheries.

Our estimates suggest that a total of 8,000 - 10,000 seabirds died in the study fisheries each year in 2009 and 2010 (cod gillnet and longline fisheries, gillnet lumpsucker fishery, Greenland halibut longline and gillnet fisheries). In addition we estimated seabird by-catch in salmon nets to be 2,000 yearly. If we use the bycatch coefficients based on data from the reference fleet alone, the estimates are somewhat lower. Our study indicates northern fulmars, cormorants (*Phalacrocorax* spp.), black guillemots, Atlantic puffins and razorbills are the bird species that most often drown in fishing gear in Norway. It should however be noted that in an episodic bycatch event, 200 common guillemots were recorded drowned in gillnets set for lumpsucker. These data were not included in our bycatch estimates because we did not have any measure on the frequency of such events.

We will start more detailed studies of seabird bycatch in Norway's lumpsucker and Greenland halibut longline fisheries to provide more accurate data on bycatch. Additionally, we start a more detailed data collection on bycatch of seabirds through existing sampling systems as the reference fleet programs managed by Norwegian Institute of Marine Research and the Norwegian Directorate of Fisheries' Monitoring Service.

Seabird bycatch in gillnets in Greenland

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Bycatch of seabirds in Greenland is largely limited to Southwest Greenland and concerns almost exclusively the common eider and to a smaller extent the king eider. Information is available from the national harvest statistics, to which it became mandatory to report seabird bycatch in 2002. Previous information came from surveys of the local market in Nuuk, but since 2004 there has been a ban on selling seabird bycatch in Greenland.

The bycatch in Southwest Greenland is to a large extent is caused by the gillnetting of lumpsucker in March, April and May, and especially the regions of Nuuk and Maniitsoq appear to be high-risk areas for eider bycatch. To a smaller extent cod gillnets and seal gillnets also contribute to the bycatch.

The annual landings of lumpsucker have increased rapidly over the past 15 years in Greenland and may give reason to concern for the bycatch. The reported bycatch has also increased, but the quantity is clearly underreported. The largest number of eiders reported so far is app. 6000 eiders for all Greenland in 2008. Alternative estimates based on crude bycatch rates in the Nuuk area and extrapolation to a national scale, indicate that the magnitude of the bycatch might be in the order of 20,000 eiders.

For Greenland an effective solution to reduce the bycatch of eiders could be to manage the lumpsucker fishery according to abundance- based fishery openings, which would imply a postponement of the lumpsucker fishery until May. Realistically, this could perhaps be implemented in the fishing areas with the highest bycatch risk. However, this requires more detailed information about the exact locations of the bycatch and the circumstances and this is considered high priority for Greenland. Another top priority is to link catch efficiency of the target fishery with the bycatch frequency, to be able to achieve the best compromise of which fishing areas to avoid.

Bycatch of Seabirds in Gillnet Fisheries along the German Baltic coast

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In the German Baltic, seabird bycatch in coastal set net fisheries was recognised as a conservation issue by the study of Kirchhoff 1982, who estimated an annual bycatch of 15,800 birds (mainly Common Eider) in the Western part of the German Baltic coast (Schleswig-Holstein). There is no recent update of this estimate, and total numbers may have decreased along with Common Eider numbers, but bycatch most likely remains to be an issue.

In 2006-2009, magnitude and temporal trends were studied in the eastern part (Mecklenburg-Vorpommern) based on (i) a survey of c. 4 % of the total fishery in the period 2006-2009 and (ii) results from bycatch monitoring in a part of this region covering a period of 20 years. We collected bird carcasses and information on fishing effort from fishermen using interviews and on-board observations on selected trips.

Bycatch of seabirds occurred in all types of fishing gear and métiers studied with highest bycatch rates in coastal lagoons. The minimum estimate of total bycatch by 440 commercial fishermen to be 17,551 (range 14,905 – 20,533) birds annually between November and May.

We found bycatch rates to depend either directly on bird abundance as shown for the Long-tailed Duck or on predictors of abundance such as water depth and location.

Bycatch in the Pomeranian Bay has decreased over 20 years due to the severe decline of seaducks, particularly of Long-tailed Ducks which were most frequently bycaught. The estimated individual bycatch risk also decreased in Long-tailed Ducks but the current monthly losses of 0.81 % may still indicate a potential threat for this species.

Carcass collections and interviews proved to be feasible to monitor bycatch over a 20-year period in spite of some underreporting. Based on the results we recommend specific measures to reduce bycatch risk in the German coastal fisheries using targeted effort reductions and replacement of set nets with alternative gear.

A report is of the 2006-2009 survey available at:

http://meeting.helcom.fi/c/document_library/get_file?p_l_id=79305&folderId=1480129&name=DLFE-45901.pdf

Investigations of bird by-catch in commercial gill net fishery in Denmark

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In 2002, the Ministry of the Environment and the Ministry of Food, Agriculture and Fishery requested a survey of the amount of bird by-catch in gill nets with Danish commercial fishers. The work was carried out as collaboration between DTU Aqua and Aarhus University. A survey area in the western Baltic, around the islands of Ærø and Langeland was chosen. Information about by-catch amounts was achieved in collaboration with the commercial Fishery Association in that area. 12 vessels participated in the project, starting in December 2002 and extending into April 2003. The vessels recorded spatial and temporal explicit information on all net sets during that period, along with information on by-catch events.

Information from more than 42,000 nets was covered by the survey, revealing a total of 426 caught birds. This equals 0.39 birds/1000 NMD (net meter days). The most numerously by-caught bird species was Common Eider *Somateria mollissima*, with 0.27 birds/1000 NMD. Common Scoters *Melanitta nigra* (0.03 birds/1000 NMD), Cormorant *Phalacrocorax carbo* (0.04 birds/1000 NMD) and Long-tailed Duck *Clangula hyemalis* (0.03 birds/1000 NMD) also frequently appeared in the by-catch statistics. This leads to an estimated 800 by-caught birds per winter season.

During the study a total of 8 aerial surveys of birds were conducted. Up to 140,000 Common Eiders were estimated to be present in the study area at peak presence. The average spatial distribution of these birds was modeled.

The gill net fishery was concentrated in water depths of between 4 and 18 meters, which coincide with the preferred water depth of most diving ducks. A close relation between bird density and fishing intensity could be demonstrated.

Based on this survey a continued programme has recently been initiated. As a request from the Danish Agrifish Agency, Aarhus University will do a two year survey on by-catch in the non-commercial fishery. This work is specifically focused on the NATURA2000 areas under the Habitats Directive.

Seabird bycatch in Lithuanian gillnet fisheries

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Most documented seabird bycatch in Lithuania occurs in the costal waters (marine waters up to 20 m depth) along the *ca*. 100 km long Lithuanian Baltic Sea coast. The coastal gillnet fishery in its present form started here in 1992 after restrictions, formerly imposed by the USSR outer border status, were lifted. Fishing effort and catches increased rapidly during the first decade, but stabilised around 2000 and have even decreased slightly over recent years. At present, up to 100 small boats (mostly up to 10 m in length), operated from the coastline, are involved in the coastal gillnet fishery, with the main target species being cod, herring, smelt and salmon. Most fishing effort occurs from September to May, which coincides with aggregations of wintering and migrating seabirds in Lithuanian waters. Previous research into gillnet fishery impact on wintering seabirds in Lithuanian waters suggested that up to 10–15% of all the birds wintering in Lithuanian waters were killed in fishing nets. The most common bycatch victims were Long-tailed Duck (51%), Velvet Scoter (15%), Goosander (13%) and Red-throated Diver (5%). Surface set salmon nets of large mesh size proved to be the most dangerous to seabirds – bird entanglement rate in these nets was *ca*. 6 times higher than in small mesh size herring and smelt gillnets. As a result of this research, restrictions on gillnet fishery were proposed in the marine SPAs, established for the protection of wintering seabirds. These restrictions include a ban on the most dangerous gillnets (mesh size 50 mm and larger) during the seabird wintering period in waters up to 15 m in depth. However, there is still a lack of compliance with these restrictions.

Pilot studies have also been carried out in Lithuania to assess the feasibility of using alternative fishing gear, less dangerous to birds. The alternatives included long-lines for cod and herring traps. Long-lines seem to be a particularly viable solution, since in Lithuanian waters they produce almost no bird bycatch and are as effective at catching cod as gillnets.

Main problems in eliminating bycatch in Lithuania include the lack of visibility of the problem – despite that the problem has been identified more than 10 years ago, public is not aware of its extent, ministries, responsible for the protection of environment and for fisheries, are reluctant to solve the problem. There is still no legal obligation to report the bycatch, despite that fishing nets also kill numerous rare birds – included in the Annex 1 of the EU Birds Directive and the Lithuanian Red Data Book.

Priorities, related to seabird bycatch in Lithuania, include establishment of the systematic monitoring and reporting of seabird bycatch, enforcement of the already existing bycatch mitigation measures and development and promotion of alternative fishing techniques.

Seabird bycatch information from gillnet fisheries in Latvia

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In Latvia gillnets are used in coastal fishety (<20m depth), beyond 20m isobath and in inland waters. None of the users has to report fishing effort or bycaught birds. In recent years fishing effort has decreased due to ship scrapping activities and reduced fishing quotas. Knowledge about bycatch extent and composition so far refers to coastal fishery (20m depth) and has come from Fisheries research institute contact fishermen (Urtāns, Priednieks 1999) and 2 special projects in 2000/2001, 2005-2008, when fishermen were contracted and asked to register fishing effort and to provide bycaught birds for species identification. Bycatch severity (in 2005-2008 0-0.83,average 0.28 birds/100 net day) and species composition differs site by site, Long tailed duck *Clangula hyemalis* being the most common victim. Bycatch peaks coincide with migration season in March-April and autumn.

Experiences from the Albatross Task Force

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Confronted by alarming declines in albatross and petrel populations, especially in the Southern Hemisphere, BirdLife International and the Royal Society for the Protection of Birds recognised the urgent need to directly combat the primary impact on seabird survival; mortality in longline and trawl fisheries. The Albatross Task Force (ATF) was established to tackle the problem at the source, on board vessels and in ports shoulder to shoulder with the captains and crew.

Significant advances in mitigation measure design have been achieved since seabird bycatch was first recognised in longline and trawl fisheries. The ATF has demonstrated how locally employed experts can demonstrate, develop and improve existing measures in collaboration with industry to facilitate and encourage implementation on board vessels.

Over the past years the ATF has managed to achieve significant reductions of >80% in seabird mortality in several of the target fisheries through the implementation of measures and the adoption of regulations. An important aspect of industry acceptance has been due to experimental testing of mitigation at-sea in commercial conditions, which has allowed industry to be closely involved with the process from the beginning.

Mitigation measures to prevent seabird mortality in trawl and longline fisheries started off as a set of concept ideas. The ATF model of working directly with industry to experiment and improve measures and develop best practice standards for mitigation designs is a clear example of how concept ideas can be developed into an effective measure to combat seabird mortality.

While no measures currently exist for gillnet fisheries, there are many concept ideas that should be developed in collaboration with industry. One, or several, of these may become the next conservation success story for seabirds.

Potential applications of camera monitoring for seabird bycatch assessment

Finn Larsen[1]

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Finn Larsen presented the results of a trial with Remote Electronic Monitoring (REM) conducted by the Danish National Institute of Aquatic Resources (DTU Aqua) on board 6 Danish gillnet vessels. The main aim was to test if a fully documented fishery using REM was possible on vessels smaller than 15 m l.o.a. A secondary aim was to test if REM could be employed to reliably document bycatch of marine mammals and seabirds. The REM system used was manufactured by Archipelago Ltd. and consisted of 3 CCTV cameras, a GPS receiver and a hydraulic pressure sensor, all connected to a control box with a replaceable hard disk and a user interface. The cameras were positioned to provide a view of the net as it came out of the water, a view of the table where the catch was removed from the nets and an overview of the deck, respectively. Two of the vessels fished in northern Øresund (ICES sub-area IIIb), four vessels fished in Skagerrak and two of these four also fished in the North Sea. The trial covered a total of 811 trips with 5,096 hauls from May 2010 to May 2011. Observing seabird bycatch on the videos was not possible at speeds higher than normal speed, so for 5 of the vessels only every 10th trip was reviewed. For the 6th vessel all trips were reviewed. A total of 68 seabirds were observed, of which 64 could be identified to species, and were 31 guillemots, 16 cormorants, 12 eiders and 5 gulls. The gulls were all alive and subsequently released. The installation costs were c. 9,000 EUR pr. vessel and running costs including video reviewing were 220 EUR pr. day at sea. DTU Aqua is starting a new REM project in May 2012, which will cover up to 16 gillnet vessels in ICES sub-areas 22-23, and continue for about one year. The main aim is monitoring harbour porpoise bycatch, and there is at present no funding to extract seabird bycatch information. However, the video recordings will be stored for later review if funding for extracting seabird bycatch data should become available.

Potential applications of Save Wave Technology to reduce seabird bycatch

Dimitri Vernicos[1]

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Dimitri Vernicos presented the activities of the company SaveWave BV in the field of by-catch, he has been involved in the field of by-catch since his thesis 10 years ago which aim was to assess *Tursiops truncatus* interaction with the Greek traditional trammel net fishery as well as assessing the efficiency of Acoustic Deterrent Devices to offer a solution to the interaction.

SaveWave BV is a small and dynamic Dutch company specialized in the development of ecologically sustainable solutions to problems in the world's oceans. Its goal is to save sea mammals and seabirds, who die as a result of by-catch, with solutions that are economically sustainable for fishermen. It has developed various products such as the Dolphin Saver, Orca Saver and is now developing two new products the Aquaculture Shield and the Seabird Saver.

The Seabird Saver is a project in the early stages of Design and Development and will be funded for two years by the European Subsidy called Eurostar under the acronym Bird Saver. It will emit simultaneously both visual and acoustical signals specially designed to warn seabirds of the danger zone at the stern of the fishing vessel as the longlines are set. The Acoustic and Visual signals will trigger a flee response in seabirds and in the long term will lead to an increase in sensitization and thus avoidance of fishing vessels. The Seabird Saver is being developed to solve mainly seabird by-catch in the longline industry with possible spin offs in other areas where unwanted mortality of seabirds occur.

At the end of the presentation it was underlined that there is lack of knowledge on two topics, respectively on the seabirds aerial and aquatic acoustic and visual abilities, and that further knowledge and research on these topics in relation to by-catch was necessary in order to develop effective solutions and mitigation measures that would efficiently reduce seabird by-catch.

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Review

The incidental catch of seabirds in gillnet fisheries: A global review

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ABSTRACT

Based on bird feeding ecology we identified 148 seabird species as susceptible to bycatch in gillnets, of which 81 have been recorded caught. The highest densities of susceptible species occur in temperate and sub-polar regions of both hemispheres, with lower densities in tropical regions. Gillnet fisheries are widespread and particularly prevalent in coastal areas. A review of reported bycatch estimates suggests that at least 400,000 birds die in gillnets each year. The highest bycatch has been reported in the Northwest Pacific, Iceland and the Baltic Sea. Species suffering potentially significant impacts of gillnet mortality include common guillemot (*Uria aalge*), thick-billed guillemot (*Uria lomvia*), red-throated loon (*Gavia stellata*), Humboldt penguin (*Spheniscus humboldti*), Magellanic penguin (*Spheniscus magellanicus*), yellow-eyed penguin (*Megadyptes antipodes*), little penguin (*Eudyptula minor*), greater scaup (*Aythya marila*) and long-tailed duck (*Clangula hyemalis*). Although reports of seabird bycatch in gillnets are relatively numerous, the magnitude of this phenomenon is poorly known for all regions. Further, population modelling to assess effects of gillnet bycatch mortality on seabird populations has rarely been feasible and there is a need for further data to advance development of bycatch mitigation measures.

Contents

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1. Introduction

The status of seabird populations is deteriorating faster compared to other bird groups, and bycatch in fisheries is identified as one of the principle causes of declines (Croxall et al., 2012). The problem of seabird bycatch in gillnet fisheries has long been known in the Pacific, Atlantic oceans and Baltic Sea (Tull et al., 1972; Ainley et al., 1981; Piatt and Nettleship, 1987; Stempniewicz, 1994), and gillnets have been the cause of some of the highest recorded mortalities of seabirds worldwide. In the North Pacific, drifting gillnets were estimated to be killing c. 500,000 birds per year, prior to a UN moratorium in 1992 (DeGange et al., 1993; Uhlmann et al., 2005). A review by Robins (1991) found 60 species of seabirds had been reported caught in gillnets worldwide, and that net mortality was a major contributor to declines of auk populations in California, Newfoundland, the Canadian Arctic, west Greenland and northern Norway. A regional review revealed that between 100,000 and 200,000 seabirds could be being killed annually in gillnets in the Baltic and North Sea region alone (Žydelis et al., 2009).

Surprisingly, the global magnitude and significance of seabird bycatch in gillnet fisheries remain largely unknown (Robins, 1991; Žydelis et al., 2009). Assessment is hampered by large and diverse artisanal fisheries (i.e. small-scale fisheries for subsistence or local markets, typically using traditional fishing gears and small boats), and data on fishing effort and catch of target and non-target species are very sparse.

The objectives of this review were to:

- identify seabird species susceptible to and impacted by gillnet fishing;
- summarise seabird bycatch in gillnet fisheries globally by region and identify likely data gaps;
- assess factors determining bird captures in gillnets;
- review bycatch mitigation measures in use or under development;
- identify areas where conservation actions are most needed.

2. Materials and methods

2.1. Literature search

We reviewed a broad array of scientific publications, published and unpublished reports to collate available data on seabird bycatch in gillnet fisheries worldwide. We identified literature sources by querying the Internet and academic databases (e.g., ISI Web of Knowledge and Zoological Record (TM)), and examining reports otherwise known to authors of this review. Our focus was on existing fisheries, although where useful we mention fisheries that are no longer active.

Due to the high variability in metrics used when assessing and reporting seabird bycatch in gillnet fisheries (Žydelis et al., 2009), it was not possible to summarise the studies in a standardised way. We therefore summarised results by pooling the reported bycatch estimates from non-overlapping regions. We included all information available, including some based on small sample sizes, on the assumption that they represent the best available knowledge to date.

We focused this review on seabird bycatch in marine waters only and considered only seabird species listed in Croxall et al. (2012). We summarised the results by ocean regions using the FAO fishing area boundaries (http://www.fao.org/fishery/area/search/en), some of which were grouped (Fig. 1).

2.2. Gillnet fishing methods

Gillnets are a non-mobile fishing gear with a mesh that traps fish and other organisms. Mesh sizes vary according to target species, ranging from 15 mm to over 250 mm. The net acts as a wall that is weighted or anchored at the bottom and buoyed at the top (the "float" or "cork" line) to keep it vertical in the water column. This blocks the pathway of larger organisms, creating a risk of entanglement for non-target species such as seabirds, turtles, sharks and marine mammals. The gillnet is known as a "fixed gillnet" or "set-net" if it is attached to the seabed by a weighted anchor at each end. The gillnet is a "driftnet" if it is suspended in the water column (one end is buoyed and the other is attached to the stern of a fishing vessel or buoy). Traditionally, nets were made from hemp, cotton or multifilament nylon, which were usually highly visible to seabirds. In recent decades, monofilament has been increasingly used, being cheaper, longer lasting and easier to handle, but also less visible to seabirds and other non-target taxa, increasing the potential for bycatch. In 1992, the United Nations imposed a moratorium on the use of large-scale (>2.5 km long) driftnets on the high seas (U.N. Resolution 46/215), but small-scale driftnetting continues and driftnets, set-nets and other types of gillnets (e.g., trammel nets) persist within many EEZs. Analysis of gillnet fishing effort revealed that this type of fishing takes place in nearshore waters of all continents except Antarctica, and is the most intensive along coasts of SE Asia and in the NW Pacific (Waugh et al., 2011; Sea Around Us Project, 2013). In this review we considered reported bird bycatch in all types of gillnets.

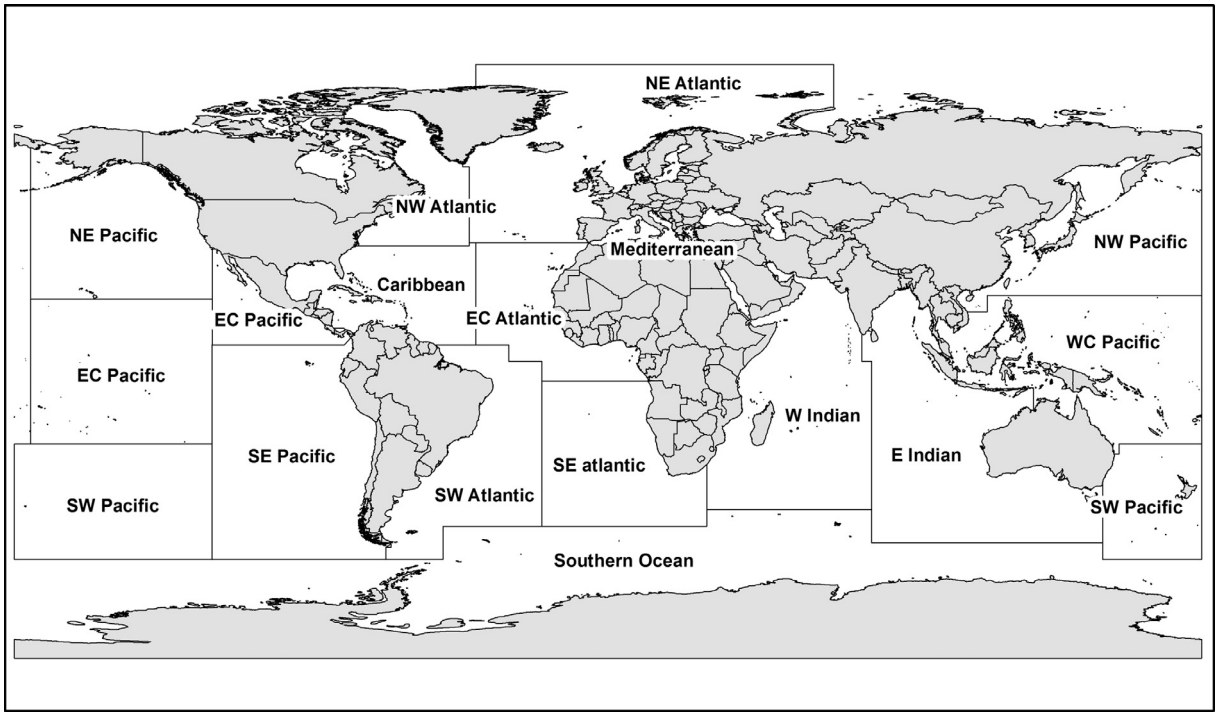

Fig. 1. Ocean regions used for reviewing seabird bycatch in gillnet fisheries. Region boundaries are roughly based on FAO fishing area boundaries.

2.3. Seabird susceptibility to bycatch in gillnet fisheries

The bird species most susceptible to entanglement in gillnets are those that forage by diving for fish or benthic fauna. Susceptibility we define as characteristic that is irrespective of population size and indicates higher probability of being caught in the nets compared to non-susceptible species. The species and number of individuals caught by gillnets are also affected by factors such as mesh size, setting depth, time of day, the length of time that the net is left to soak, water transparency, weather conditions and setting location in relation to seabird abundance.

By reviewing 343 world seabird species (as listed by Croxall et al., 2012) we identified 148 species that are potentially susceptible to entangling in gillnets due to their foraging behaviour, of which 81 have been recorded caught in fishing nets (Appendix). Additionally, 23 surface foraging species were recorded caught in the nets, which we did not identify as susceptible (Appendix, Table 1), however these species never dominated the composition of bycatch. In principle, a gillnet might entangle any bird that comes into contact under different circumstances, and there are records of gillnets trapping dabbling ducks (R. Žydelis personal observations), shorebirds (Manly, 2009) and even a barn owl (*Tyto alba*, Norman, 2000). Marine birds that have been recorded caught in gillnets, but are not listed as susceptible in Appendix, include species which likely entangled during the net hauling or setting (e.g., storm-petrels, gulls; Soczek, 2006) or were trapped when scavenging a net drifting at the surface (e.g., gulls, kittiwakes, storm-petrels; DeGange et al., 1993; Artukhin et al., 2010).

The taxonomic groups with most susceptible species were cormorants, auks, shearwaters, penguins and seaducks (Table 1). Considered together, seabirds susceptible to bycatch in gillnets occur across all oceans, but species diversity is highest in temperate and sub-polar regions (Fig. 2). The list of susceptible species includes 5 Critically Endangered, 14 Endangered, 29 Vulnerable, and 15 Near Threatened species on the IUCN Red List (IUCN, 2012), with the remainder (85 species) being classified as Least Concern (Appendix).

Table 1
Taxonomic groups and numbers of seabird species that were identified as susceptible to fisheries bycatch based on their foraging technique, and actual records of species caught (see Appendix).

Taxonomic group	Total number of species	Number of species identified as susceptible	Number of species reported as bycatch
Steamerducks	4	4	0
Diving ducks	1	1	1
Seaducks	13	13	11
Penguins	18	18	5
Loons	5	5	5
Albatrosses	22	3	8
Giant-petrels	2	0	2
Fulmars	2	2	2
Petrels	54	10	4
Shearwaters	22	22	13
Storm-petrels	23	0	3
Diving petrels	4	4	0
Grebes	4	4	4
Tropicbirds	3	0	0
Frigatebirds	5	0	0
Pelicans	3	0	1
Gannets & boobies	10	10	3
Cormorants	29	29	12
Phalaropes	2	0	0
Gulls, terns, skuas, jaegers, kittiwakes	94	0	11
Auks	23	23	19
TOTAL	343	148	104

3. Results – seabird bycatch by ocean regions

3.1. Northeast Atlantic

This region encompasses the northeast Atlantic bounded by longitude 42 W and latitude 36 N (Fig. 1). The area is home to millions of auks breeding on islands and rocky costs; seaducks are especially numerous in the Baltic Sea; pelagic areas are frequented

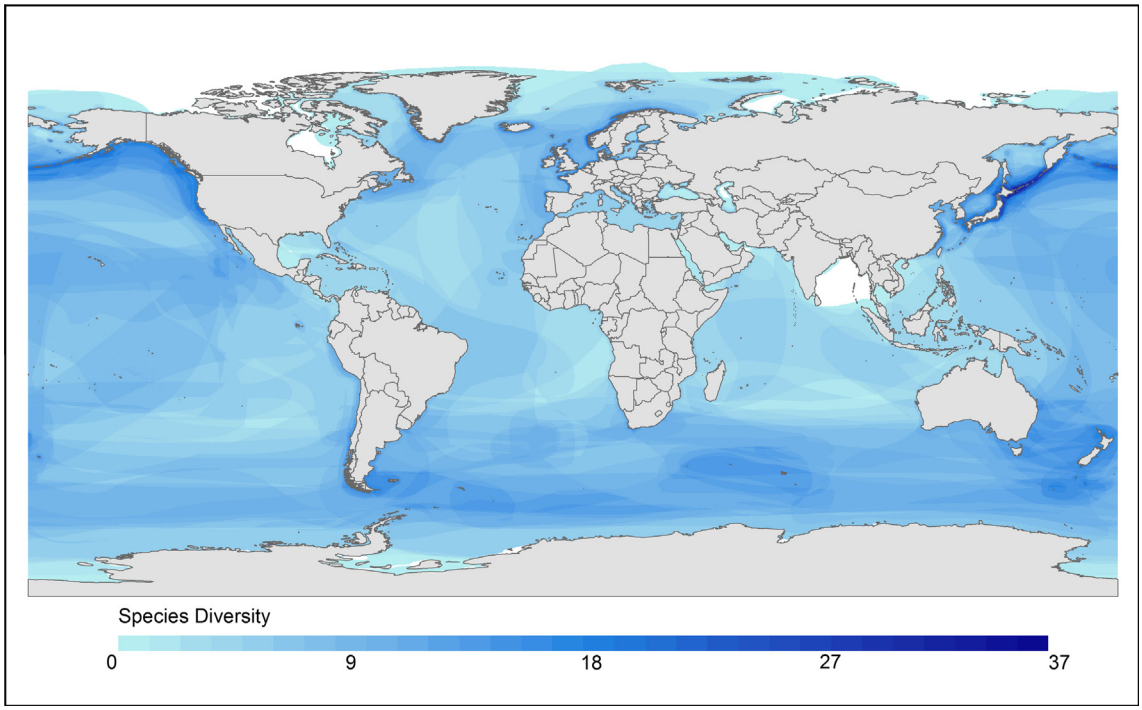

Fig. 2. Global distribution of seabird species susceptible to bycatch in fishing gillnets. The map was created by overlaying species range maps (BirdLife International and NatureServe, 2012). Dark areas represent areas where many susceptible species are located.

by northern fulmars (*Fulmarus glacialis*) and northern gannets (*Morus bassanus*). This region also supports intensive gillnet fisheries, and substantial data exist on interactions with seabird species, compared to other areas.

3.1.1. Baltic Sea

Seabird bycatch in gillnets has been documented in the Baltic since the early 1980s. Žydelis et al. (2009) reviewed 30 studies, mostly based on data from cooperating fishermen, and estimated that at least 76,000 birds were being killed in the Baltic Sea each year. This mortality is thought to have decreased in recent years, driven by the severe decline in seaduck populations (Skov et al., 2011). Bellebaum et al. (2013) estimated an annual bycatch of 17,550 birds along the eastern part of the German Baltic coast, and suggested that annual bycatch had at least halved since the early 1990s, most likely due to population declines. It is also possible that gillnet fishing effort declined during this period, however there are insufficient data to support this (Sonntag et al., 2012; Bellebaum et al., 2013).

Žydelis et al. (2009) found that bycatch species composition in the Baltic Sea generally reflects species distribution, with seaducks predominating in the east, seaducks and diving ducks in the south, and auks in the west. However, taking species abundance into account, pursuit-diving birds, such as loons, grebes, auks and cormorants were found to be more susceptible to bycatch than benthivorous ducks; an earlier study indicated that loons were about ten times more likely to be caught in nets than long-tailed ducks (*Clangula hyemalis*) (Dagys and Žydelis, 2002).

A recent Danish study, unavailable for the review by Žydelis et al. (2009), estimated 841 birds caught in gillnets around the island of Ærø in 2001–2003, mostly common eiders (*Somateria mollissima*), the most common waterbird species in the area (Degel et al., 2010). This study covered only a small part of Danish waters, which is home to hundreds of thousands of wintering waterbirds (Petersen and Nielsen, 2011).

Žydelis et al. (2009) assessed the impacts on three species using a potential biological removal approach, and concluded that gillnet bycatch could be a threat to greater scaup (*Aythya marila*), common guillemot (*Uria aalge)* and long-tailed duck. (Potential biological removal or PBR method allows the assessment of additive mortality on a population with minimum demographic information (Dillingham and Fletcher, 2011 and references therein).) Bellebaum et al. (2013) reached similar conclusion about the long-tailed duck. Further, Steller's eiders (*Polysticta stelleri*), classified as Vulnerable by IUCN (2012), were regularly caught in gillnets on the coast of Lithuania while this species was still wintering there (until 2009, M. Dagys pers. com.), and up to 50 birds of this species die annually in gillnets in Estonia (Žydelis et al., 2006).

While the number of birds being killed per year in some areas is likely to have decreased as a result of population declines, information on bycatch occurring in previously unreported areas suggests that the Žydelis et al. (2009) estimate of 76,000 birds killed per year in the Baltic Sea is probably still a realistic estimate.

3.1.2. Norwegian Sea

In the 1980s, very high bycatch was recorded in salmon and cod gillnet fisheries along the Norwegian coast. Strann et al. (1991) estimated over 100,000 birds killed per year, primarily auks. Since then, there has been a reduction in fishing effort as well as bird populations (Fangel et al., 2011). An interview-based study in 2009–10 estimated 7–8000 birds caught annually in nets set for salmon, cod and lumpsucker (*Cyclopterus lumpus*) in northern Norway (Fangel et al., 2011). It should be noted, however, that episodic incidents of high catches of birds (e.g. 200 common guillemots caught at once) were excluded from these calculations due to their unknown frequency, and further work is planned to improve estimates. In addition, no data were available from several other fisheries. Northern fulmar and black guillemot (*Cepphus grylle*) were most often caught (Fangel et al., 2011).

3.1.3. North Sea and Atlantic Iberia

Data on seabird bycatch in this area are relatively sparse. There are no systematic studies on bird bycatch on the eastern coast of the North Sea. However, occasional bycatch incidents have been

reported: 340 common and velvet scoters (*Melanitta nigra* and *M. fusca*) drowned at one location of the Danish sector of the North Sea in one night in March 1987 (Durinck et al., 1993).

On the Atlantic coast of the Iberian Peninsula, Munilla et al. (2007) linked the collapse of common guillemot population to bycatch in gillnet fisheries after the introduction of synthetic netting material. Similarly, Velando and Freire (2002) analysed the decline of European shag (*Phalacrocorax aristotelis*) on the Galician coast of Spain, and concluded that bycatch in gillnets was responsible for reduced adult survival. The same study also found that bycatch had increased as a proportion of the reported causes of mortality of auks from less than 10% before 1970 to nearly 60% in the late 1990s. Based on fishermen interviews, Arcos et al. (unpublished data, 1996) estimated more than 3000 shags and cormorants and over 2000 auks caught in gillnets in Galicia each year.

In Portugal, the gillnet fleet consists of over 8000 registered vessels, 95% of them being less than 10 m long. A questionnaire survey of captains in 2010–2012 found that, of 80 respondents, 64% reported at least one annual bycatch event of seabirds. Northern gannet was identified as the most frequently caught species, followed by auks, gulls, shags, common scoters, shearwaters, storm-petrels and terns (SPEA and University of Minho unpublished data, 2012). The study highlighted the need for further detailed investigations.

In the UK, Murray et al. (1994) estimated that about 2400 auks (1700 guillemots and 700 razorbills *Alca torda*) drowned in salmon nets in NE Scotland in 1992, however most of this fishery has since been bought out and discontinued. There have been no comprehensive UK studies since then, but there are occasional reports of bycatch events, such as the 200 guillemots and razorbills caught near St Ives in one night in January 2012 (RSPB, 2012a) and seabird bycatch recorded in Filey Bay (RSPB, 2012b). Although there may be some local colony impacts, it is generally assumed that bycatch in gillnet fisheries in the UK is not a significant threat to birds at a regional scale and UK colonies of auks have been growing (BirdLife International, 2004).

In SW Ireland, Rogan and Mackey (2007) analysed data collected by observers in offshore driftnet fisheries for albacore tuna (*Thunnus alalunga*). Although these fisheries were highly detrimental to sharks and cetaceans, bycatch of seabirds was relatively modest: 25 seabirds were estimated caught in 1996, and 137 (all Manx shearwaters *Puffinus puffinus*) in 1998. These fisheries are no longer active following the total ban of driftnets for EU fleets by the Council of the European Union (1998), although there have been calls to re-open them.

Although available information from this sub-region suggests that bird bycatch in gillnets may be at a smaller scale compared to other regions, bycatch on the Atlantic coasts of Portugal and Spain is likely to be influencing population declines. Elsewhere, numbers and impacts may be lower, but data remain sparse.

3.1.4. Iceland

Some of the largest seabird colonies in the world are found in Iceland and these include millions of diving birds (BirdLife International, 2004). At the same time, fisheries are an important industry and use a variety of fishing gears including gillnets.

Petersen (2002) reviewed information from ringing recoveries, sales of bycaught birds and studies in the lumpsucker fishery in the 1980s and 1990s. As many as 70,000 guillemots, the majority being common guillemots, were estimated killed in gillnets in 1997, with an overall estimate of 100–200,000 seabirds killed per year in Icelandic gillnet and longline fisheries (Petersen, 2002). Ringing data indicate 20 species of seabirds caught as bycatch, with the lumpsucker fishery reporting the highest number of ringed birds (Petersen, 2002). Black guillemot and red-throated loon (*Gavia stellata*) may be the most susceptible species in proportion to their populations. However, of four studies of common eider and black guillemot bycatch in the lumpsucker fishery, none identified significant impacts on populations (Frederiksen and Petersen, 1999; Petersen, 2002).

In the absence of more recent data, the estimate of 100–200,000 birds killed per year (Petersen, 2002) represents the only available figure, but is considered likely to still stand (A. Petersen, pers. comm.).

3.1.5. Faroe Islands

In the Faroe Islands, the gillnet fishery is small and takes place in deep waters, and is therefore believed to catch few birds. However, no formal investigation has been conducted (ICES, 2010).

3.2. Mediterranean Sea

Compared to other regions, the number of seabird species susceptible to bycatch in gillnets is low, but includes two of the most threatened seabirds in Europe: Balearic shearwater (*Puffinus mauretanicus*) and yelkouan shearwater (*P. yelkouan*). Despite several international and regionals bans on gillnet fishing, fishers from various countries continue to use driftnets within Mediterranean waters (e.g. Tudela et al., 2005). However, data on seabird bycatch in gillnets are scarce.

Louzao and Oro (2004) showed that Mediterranean shag (*Phalacrocorax aristotelis desmarestii*, a subspecies of the European shag) is caught in gillnets in the Balearic Islands, and it is thought that gillnetting could pose a significant threat to this subspecies (De Juana, 1984; Muntaner, 2004). Regular bycatch of shags was also reported for the Iberian coast, as well as bycatch of razorbills, red-breasted mergansers and great cormorants (*Phalacrocorax carbo*) (SEO/BirdLife, unpublished data). There are no recent reports of shearwater bycatch in gillnets in Spain, although this was reported in the past (Besson, 1973). The Hellenic Society for the Study and Protection of the Monk Seal reported that up to 500 yelkouan shearwaters had been caught in a single drift net in Greece (ICES, 2008). In contrast, Tudela et al. (2005) found no evidence of seabird bycatch in the large scale Moroccan driftnet fleet.

Fragmented knowledge from the Mediterranean Sea (cited above) indicates that seabird bycatch in gillnets may be occurring at lower levels than elsewhere globally, but that impacts may be occurring on one or more species and that more data are needed. We did not find any reports on seabird bycatch from the Aegean Sea and the Black Sea.

3.3. Northwest Atlantic

Like the northeast Atlantic, the coastal waters of the northwest Atlantic have a high concentration of species susceptible to gillnet bycatch, including auks, fulmars, seaducks, loons, gannets and cormorants (BirdLife International, 2004). Migrating and staging shearwaters are also seasonally abundant in nearshore and offshore waters.

3.3.1. West Greenland

Greenland is an important area for cliff nesting seabirds with large populations of auk species. Historically, these birds experienced very high human-caused mortality due to intensive hunting and the commercial gillnet fishery for salmon, the latter killing an estimated 500,000 birds per year in the late 1960s to early 1970s (Tull et al., 1972). This mortality was associated with declines of thick-billed guillemots in Greenland (Evans and Waterstone, 1978). Since 1976, salmon gillnetting has been restricted to Greenland fishermen only and bird bycatch estimates fell to 50–100,000 per year by the early 1980s (Evans, 1984) and subsequently fell further. Based on fishermen interviews, Falk and Durinck (1991)

estimated that less than 3000 guillemots drowned in salmon gillnets in West Greenland in 1988. The commercial salmon fishery has been reduced greatly since the early 2000s allowing only a limited subsistence harvest (Ad Hoc Review Group, 2008), which likely further reduced seabird bycatch.

However, while bycatch in the salmon fishery has declined, birds are also caught in the lumpsucker fishery. Merkel (2004) studied harvested and bycaught eiders sold in Nuuk, Greenland in 2000–2001 and estimated that at least 2024 eiders were being killed per year in the Nuuk area (90% of birds common eiders, 10% king eiders *Somateria spectabilis*). From 2002 it became mandatory to report bird bycatch as part of the annual hunting statistics. Data from 2003–2008 confirm common eiders and king eiders as the most commonly bycaught birds. Other species were reported in low numbers, including common guillemots, great cormorants, little auks (*Alle alle*), black guillemots, common loons and black-legged kittiwakes (*Rissa tridactyla*, Merkel, 2011). While the average annual reported bycatch in 2003–2008 was 3260 eiders caught mostly in lumpsucker fishery, using an alternative estimate Merkel (2011) suggested that the number could be as high as 6000 to 20,000 eiders killed per year in the lumpsucker fishery alone. Merkel (2011) concluded that the impact of bycatch mortality on species other than eiders is negligible.

3.3.2. Atlantic Canada

During the 1970s and 1980s, there was a major gillnet fishery for Atlantic cod (*Gadus morhua*) off the coasts of Newfoundland and Labrador, responsible for approximately 27,500 birds killed per year, 80% of them being common guillemots (Piatt and Nettleship, 1987). In 1992, fisheries for Atlantic cod were closed. However, gillnets have remained in use in other fisheries and, since 2001, near-shore cod fisheries have been intermittently reopened (Benjamins et al., 2008).

Benjamins et al. (2008) estimated that 5000 to 10,000 common guillemots, >2000 shearwaters (mainly great shearwater *Puffinus gravis*), and several hundred loons, gannets, Atlantic puffins (*Fratercula arctica*) and black guillemots were captured in Newfoundland and Labrador each year, mostly in cod and lumpsucker gillnet fisheries. Benjamins et al. (2008) suggested that current levels of bycatch probably do not impair populations of most affected species; however mortalities of guillemots and shearwaters are of potential concern. Davoren (2007) identified a high spatial and temporal overlap between seabirds, mostly common guillemots, and gillnet fisheries for cod off NE Newfoundland. The author estimated that 3053–14,054 guillemots were killed in this hotspot each year, a number which is high compared to estimates for the area as a whole (Davoren, 2007; Benjamins et al., 2008), suggesting that the regional total could be higher. Analysing historic trends of common guillemots breeding in Newfoundland, Regular et al. (2010) demonstrated that gillnet fisheries were among important factors driving changes in population dynamics between 1980–2006.

In the Maritimes region, annual bycatch of 275 birds (range 0–700) was estimated in the winter flounder and pollock fisheries from 2002–2005, great shearwaters being the most common species taken followed by common eider (Ellis et al., in press). In the Gulf of St. Lawrence annual take of 367 birds (range 11–1787) was estimated during 2001–2008 with common guillemots dominating the bycatch composition (Ellis et al., in press).

3.3.3. USA NW Atlantic Coast

Observer data collected by the US Northeast Fisheries Science Center have been analysed by Lanza and Griffin (1997) (1989–1993 data) and Soczek (2006) (1994–2003 data). Shearwaters were the most commonly caught group of birds (81% of birds killed), while other species included gulls, loons, auks, gannets and fulmars (Soczek, 2006). Soczek (2006) estimated 1000–3000 birds caught annually from 1994–1999, dropping to fewer than 500 individuals from 2000–2003 in the Gulf of Maine and southern New England. The decrease in the later period is suggested to reflect lower number of birds foraging in the region due to decreased ocean productivity as a result of the negative phase of the North Atlantic Oscillation (Soczek, 2006).

Further south, using beached bird surveys and counts of coastal gillnets, Forsell (1999) estimated 2387 birds killed on the US Atlantic coast between New Jersey to North Carolina, the most common victims being common loons (*Gavia immer*) and red-throated loons, and warned about potentially unsustainable levels of bycatch.

Warden (2010) assessed overall loon bycatch in the US Atlantic waters and, by analysing gillnet fisheries observer data from 1997 to 2006, estimated that 551 common loons and 897 red-throated loons were killed per year in the area between Maine and North Carolina. By applying a potential biological removal measure the author found that bycatch of red-throated loons is of potential conservation concern (Warden, 2010).

Thus, overall bird bycatch in gillnets does not seem very high in the USA NW Atlantic region, but, as pointed out by Forsell (1999) and Warden (2010), mortality of red-throated loons in coastal gillnets might be unsustainable.

3.4. Southwest Atlantic

This region includes Atlantic waters off the coast of Brazil, Uruguay and Argentina (Fig. 1). Productive waters support a relatively high diversity and abundance of diving seabirds, including shearwaters, petrels, cormorants and penguins.

Data on gillnet bycatch are sparse in the SW Atlantic region. The deep-water gillnet fishery targeting monkfish (*Lophius gastrophysus*) off the coast of southern Brazil was estimated to kill 802 birds in 2001 (Perez and Wahrlich, 2005). While the majority of birds were not identified to species, those identified included white-chinned petrels (*Procellaria aequinoctialis*), great shearwaters and Cape petrels (*Daption capensis*). White-chinned petrels, spectacled petrels (*Procellaria conspicillata*), and southern fulmars (*Fulmarus glacialoides*) have also been recorded caught in gillnets along the Santa Catarina coast of Brazil (Neves et al., 2006).

In addition, Cardoso et al. (2011) reported very high bycatch rates of Magellanic penguins (*Spheniscus magellanicus*) in driftnet and bottom gillnet fisheries off the coast of southern Brazil. The authors reported 68 penguins killed in 17 gillnet sets during eight fishing days, while the entire fleet consists of 280 vessels and the fishing season lasts from July to October (Cardoso et al., 2011). Therefore, overall bycatch may number hundreds or even thousands of penguins killed annually, and Cardoso et al. (2011) suggested that the impact on Magellanic penguin populations is probably significant.

3.5. Northeast Pacific

This region, which includes coastal and offshore waters of the US and Canada (Fig. 1), is renowned for its high diversity and abundance of diving birds, especially in high latitudes. Auks are especially diverse and numerous, and coastal waters are used by non-breeding seaducks, loons and resident cormorants. The region is also visited by millions of migratory shearwaters from the southern hemisphere.

Gillnetting has been present on the Californian coast since at least the 1930s (DeGange et al., 1993). During the 1970s and 1980s, fishing effort increased along with the introduction of monofilament nets, and so did seabird bycatch, particularly of common guillemot. Colonies of this species declined rapidly

(DeGange et al., 1993). Later Julian and Beeson (1998) continued to find substantial bycatch in gillnet fisheries off California. Forney et al. (2001) estimated that common guillemot mortality in 1995–1998 ranged between 5918 and 13,060 birds killed per year in the Californian halibut gillnet fishery alone. During the 1980s, a series of regulations were put in place, and by 2000 a closure to gillnets in depths <60 fathoms was enforced along the entire coast of central California. Following this fishing restriction, only 1 common guillemot and 60 Brandt's cormorants (*Phalacrocorax penicillatus*) were estimated to be killed in the halibut fishery in 2003 (Carretta and Chivers, 2004). Carretta and Chivers (2004) also reported only low bycatch of seabirds in the California drift gillnet fishery for swordfish (*Xiphias gladius*) and thresher shark (*Alopias vulpinus*): in 1996–2002 only 19 birds were estimated killed in that period, 13 of them northern fulmars. Today some gillnetting continues in California, but common guillemot populations have since recovered (McChesney et al., 2009).

Further north, common guillemot remains the species most frequently caught in coastal gillnets in Washington State and British Columbia. Hamel et al. (2009) assessed marine bird strandings in the Salish Sea area and found that common guillemot carcass records were frequently associated with bycatch, and that such mortality added 0.2–2.9% to annual mortality rates. In Puget Sound, 109 birds, mostly common guillemots, were recorded caught in non-tribal salmon fishery in 1993 by monitoring 606 sets or about 1.5% of fishing effort (Pierce et al., 1994). Similarly, Beattie and Lutz (1994) found that common guillemots and rhinoceros auklets (*Cerorhinca monocerata*) frequently entangle in salmon nets of tribal fisheries: 128 birds were recorded in 184 observed sets. Due to declining salmon stocks fishing effort has been decreasing in Washington State in both tribal and non-tribal fisheries – 5 to 10-fold between the 1980s and the late 1990s (McShane et al., 2004). The risk of bycatch of marbled murrelets (*Brachyramphus marmoratus*) prompted introduction of fisheries regulations to reduce bycatch in Puget Sound starting from 1999, but these regulations affected only state-regulated fisheries and were not immediately adopted by tribal fisheries nor fisheries in neighbouring British Columbia (Harrison, 2001). We found no information about levels of compliance since then.

Similarly, in the assessment of seabird bycatch in British Columbia, Smith and Morgan (2005) found that common guillemots were the most frequent victim in salmon gillnet fisheries. The authors estimated that on average 12,085 seabirds were caught annually during 1995–2001, 69% being common guillemots, 23% rhinoceros auklets, and lower numbers of marbled murrelets, sooty shearwaters (*Puffinus griseus*), pelagic cormorants (*Phalacrocorax pelagicus*), pigeon guillemots (*Cepphus columba*), common loons, pacific loons (*Gavia pacifica*), Brandt's cormorants and Cassin's auklets (*Ptychoramphus aleuticus*) (Smith and Morgan, 2005).

The declining marbled murrelet has been extensively studied along the west coast of North America. Due to reduced fishing effort and fisheries restrictions gillnet mortality has decreased recently in California, Oregon and Washington compared to bycatch in the 1980s and 1990s and latest gillnet mortality levels are not considered responsible for the continuing population declines (McShane et al., 2004). Through extensive review of population status and threats Piatt et al. (2007) concluded that annual bycatch mortality or marbled murrelets is "likely in the low thousands per year" in British Columbia and Alaska. Further, authors suggested that bycatch along with oil pollution and competition with fisheries is unlikely to account for the observed population decline alone (Piatt et al., 2007).

In Alaska, bycatch data are sparse, but auks are reported as the most frequently caught species. The Kodiak Island salmon set gillnet fishery was estimated to kill 528 birds in 2002 and 1097 in 2005, the most common species being common guillemot, tufted puffin (*Fratercula cirrhata*), pigeon guillemot, marbled murrelet, red-faced cormorant (*Phalacrocorax urile*), pelagic cormorant and lower numbers of others (Manly, 2007). The Yakutat salmon setnet fishery was estimated to kill 305 birds in 2007 and 137 in 2008, the most common species being marbled murrelet, common guillemot and loons (Manly, 2009). In salmon fisheries in Cook Inlet, 1739 birds were estimated caught in 1999 and 107 in 2000; confidence intervals of these estimates, however, are large (Manly, 2006).

Overall, the bycatch mortality of seabirds along the Pacific coast of US and Canada has declined following enacted fishery regulations and reduced fishing effort (McShane et al., 2004; Piatt et al., 2007), and by summing latest available estimates we are guessing that about 20,000 birds are caught in gillnets per year. However, relatively little information is available from Alaska where seabird diversity and abundance are very high and therefore there is a potential conflict with extensive gillnet fisheries (Piatt et al., 2007). Nitta and Henderson (1993) reviewed interactions between Hawaiian fisheries and protected species, but found no seabirds among bycatch of small-scale coastal gillnet fisheries.

3.6. Northwest Pacific

This region encompasses northwestern waters of the Pacific Ocean bordering China, Russia, Japan and the western half of the Aleutian chain (Fig. 1). The region is distinguished by exceptionally high diversity and abundance of diving birds, including auks, seaducks, loons, grebes, cormorants and shearwaters.

Use of driftnets in the Northwest Pacific was introduced by the Japanese in the 1920s (Artukhin et al., 2010). Monitoring of seabird bycatch was initiated by American and Japanese observers in the 1970s when it was estimated that hundreds of thousands of birds were dying annually in the region (Ainley et al., 1981; Ogi, 1984; DeGange and Day, 1991; Artukhin et al., 2010). Driftnet fisheries in the US EEZ and high seas ceased after 1991, following the UN ban on large-scale driftnet fishing in the high seas.

Since the early 1990s, Russia allowed the Japanese driftnet fleet to fish salmon in the Russian EEZ. Between 1993–2001 fisheries observers collected bycatch data, with results summarised by Spiridonov and Nikolaeva (2004) and updated by Artukhin et al. (2010). Bycatch by the Russian driftnet fleet fishing in the same region was also reported for the period 1996–2005 (Artukhin et al., 2010).

Between 1993–2001, 183,646 birds of 31 species were collected as bycatch in the Japanese fleet, auks constituting over 60% and shearwaters over 30% of all birds, with the thick-billed guillemot and short-tailed shearwater (*Puffinus tenuirostris*) being the main victims in each category. The estimated annual bycatch of seabirds in this fishery was 94,330 (CI 70,183–118,478) (Artukhin et al., 2010).

Additionally, 18,689 birds of 20 species were collected from the Russian fleet between 1996 and 2005. Shearwaters, mostly short-tailed shearwater, were most frequently caught (34.8%), followed by tufted puffins (28.7%), guillemots (18.3%), crested auklets (*Aethia cristatella*, 6.9%) and northern fulmars (5.2%). The estimated average bycatch was 46,099 birds per year (CI 39,254–52,944) (Artukhin et al., 2010).

Despite the very high bycatch of short-tailed shearwater, northern fulmar and crested auklet, Artukhin et al. (2010) concluded that this mortality was not affecting the very large global populations of these species, although it should be noted that little is known about their population trends. However, the authors suggested that bycatch was posing a significant threat to thick-billed guillemot colonies in the southwestern Bering Sea and Pacific coast of southwestern Kamchatka and that local colonies of tufted puffins could be similarly affected (Artukhin et al., 2010). Furthermore, the authors recorded instances of threatened species also

being killed, such as the yellow-billed loon (*Gavia adamsii*), short-tailed albatross (*Phoebastria albatrus*), red-legged kittiwake (*Rissa brevirostris*), and long-billed and Kittlitz's murrelets (*Brachyramphus perdix* and *B. brevirostris*).

In Japan, Ogi (1984) also highlighted tufted puffin as a species of conservation concern due to gillnet fishing. Ogi (2008) linked declines of Japanese murrelet (*Synthliboramphus wumizusume*), common guillemot, tufted puffin and spectacled guillemot (*Cepphus carbo*) to the impact of gillnet fisheries. Of these, the Japanese murrelet is a National monument in Japan (Hasegawa, 1984) and listed as Vulnerable on the IUCN red list. Bycatch of this species had been recorded in high sea driftnet fisheries prior to 1991 (Piatt and Gould, 1994), and it is thought that ongoing gillnet fisheries in the Japanese EEZ continue to catch this species, with the fishery including thousands of small boats (DeGange et al., 1993). However, we did not find any data to give an annual bycatch estimate in the EEZ of Japan, around the Korean Peninsula and eastern China.

3.7. Southwest Pacific

The Southwest Pacific includes waters around New Zealand and southwestern Australia (Fig. 1), and supports a high diversity of seabirds susceptible to bycatch in gillnets, including many species of penguins, cormorants, shearwaters and petrels (Taylor, 2000a,b).

Taylor (2000a,b) identified mortality in inshore commercial and recreational gillnet fisheries as an existing or potential threat to a number of penguin, cormorant and shearwater species in New Zealand, although overall scale of bycatch and impacts on local seabird populations remain generally unknown. Darby and Dawson (2000) studied yellow-eyed penguin (*Megadyptes antipodes*) and concluded that bycatch in gillnets is likely impacting the small population of this species. Ellenberg and Mattern (2012) also concluded that setnet bycatch of yellow-eyed penguin may be substantial, but that there was still insufficient information to assess fisheries impact. In relation to other species, Lalas (1993) investigated bycatch of shags in recreational net fisheries in Otago Harbour, and concluded that impact on local populations of little pied cormorant (*Phalacrocorax melanoleucos*) and Stewart Island shag (*Phalacrocorax chalconotus*) was low, but a potential threat to the local spotted shag (*Phalacrocorax punctatus*) population (Lalas, 1993). More recently, observer data from 2008–2010 recorded yellow-eyed penguin, Fiordland penguin (*Eudyptes pachyrhynchus*), Cape petrel and 3 species of shags killed in New Zealand inshore setnet fisheries, and additional species (including albatrosses and petrels), caught but released alive (Ramm, 2010, 2012). No estimate of total annual bycatch was given.

Similarly, little is known about extent of seabird mortality in gillnet fisheries in Australian waters. Norman (2000) reported results of a mail survey of fishermen in southern Australia, which suggested that little penguins (*Eudyptula minor*) and cormorants die in gillnets, although in low numbers. Stevenson and Woehler (2007) also identified recreational gillnets as one of the causes of little penguin population decline in Tasmania. These authors note that unattended and overnight recreational gillnetting was banned in coastal waters of Tasmania since 2004, which may have reduced numbers being killed.

More recently, Spain reported to the new South Pacific Regional Fisheries Management Organisation that it had two deep water gillnet vessels operating in the Tasman Sea in 2009–2010. No bycatch data were made available (SPRFMO, 2009).

3.8. Southeast Pacific

The Southeast Pacific (Fig. 1) is a very productive region, however the diversity of diving seabirds is relatively low and limited to Magellanic and Humboldt penguins (*Spheniscus humboldti*), cormorants, boobies and shearwaters.

The scale of gillnet fishing in Chile and Peru goes largely unreported due to the extensive involvement of small artisanal vessels. In Chile, Simeone et al. (1999) estimated 120 Humboldt penguins caught each year in the "corvina" gillnet fishery between 1991–1996. Magellanic penguins were also caught, as well as red-legged cormorant (*Phalacrocorax gaimardi*) and guanay cormorant (*P. bougainvillii*). Wallace et al. (1999) reported that 8 out of 19 ring recoveries of Humboldt penguins came from net entanglements in central Chile in the mid-1990s.

In Peru, a study in the 1990s also found Humboldt penguin making up >50% of all seabird bycatch (Majluf et al., 2002). More recently, 49 seabirds were caught in 914 observed sets, including 12 white-chinned petrels, 14 guanay cormorants, 4 Humboldt penguins, 6 sooty shearwaters, 4 pink-footed shearwaters (*Puffinus creatopus*) and low numbers of waved albatross (*Phoebastria irrorata*), black-browed albatrosses (*Thalassarche melanophris*) and grey-headed albatross (*Thalassarche chrysostoma)* (Mangel et al., 2011). Considering the very large Peruvian gillnet fleet, the authors suggested that annual bycatch likely exceeds 10,000 birds (Mangel et al., 2011). Fishermen questionnaires have indicated that Peruvian boobies (*Sula variegata*) also become entangled in gillnets (Ayala, 2008). In addition to incidental bycatch it is thought that Peruvian gillnet fishers may intentionally catch waved albatrosses for food (Awkerman et al., 2006; Ayala, 2008).

No seabird bycatch was recorded when observing 165 sets of driftnet fishery in Ecuador in 2008–2011 (Mangel et al., 2011).

Though information on seabird bycatch in gillnet fisheries is rather limited in this region, reports of consistent bycatch of Humboldt penguins suggest that fisheries induced mortality of this Vulnerable species might be unsustainable. The intentional or unintentional bycatch of the Critically Endangered waved albatrosses is also clearly unacceptable. The magnitude and significance of bycatch of several other threatened species of seabirds remain unknown.

3.9. Southeast Atlantic

The Southeast Atlantic features the productive region of the Benguela Current, which is home to several locally abundant diving seabird populations, including African penguin (*Spheniscus demersus*), Cape gannet (*Morus capensis*), shearwaters and petrels. No information about seabird bycatch in gillnets is available from the region.

3.10. Caribbean

Few diving seabird species inhabit the Caribbean region, and no seabird bycatch in gillnets has been reported.

3.11. Indian Ocean

The diversity and abundance of diving seabirds is low in the region. Reports are numerous of sea turtles and marine mammals caught in gillnets along the coasts of Southeast Asia and Africa, but there are no records of seabird bycatch. It is believed that Socotra cormorants (*Phalacrocorax nigrogularis*) are caught in gillnets (Waugh et al., 2011); however we found no studies documenting that.

3.12. Tropical Pacific

The Tropical Pacific region includes tropical and subtropical regions of the Pacific Ocean, ranging from Mexico to Colombia in the East, and from Taiwan to northeast Australia in the West (Fig. 1).

The few seabird species that are susceptible to bycatch in gillnet fisheries in this region include boobies, cormorants and migrating shearwaters. No information about seabird bycatch in gillnets is available from the Tropical Pacific.

3.13. Southern Ocean

The Southern Ocean is home to very numerous populations of penguins, petrels and shearwaters. No gillnet fishing takes place in this region.

4. Knowledge gaps

In general, knowledge of seabird bycatch in gillnet fisheries is highly fragmented. Even from regions where numerous reports are available, e.g. the Baltic Sea, information often originates from short-term studies and opportunistic observations. Bird bycatch in gillnets is rarely the subject of systematic and continuous monitoring. Better knowledge is needed from every region where seabird bycatch is known or could be anticipated.

However, several regions can be identified as being especially information deficient and where presence of both susceptible species and gillnet fisheries implies potential existence of high seabird bycatch. The Japanese and Korean EEZs in the Northwest Pacific represent two such areas. The Southeast Atlantic is another region, where seabird bycatch must be suspected along coasts of South Africa and Namibia.

There are also regions where existing reports indicate that there could be a substantial bird bycatch, but no reliable estimates are available. Seabird mortality in small-scale fisheries off Chile remains unknown, as does total bycatch in gillnet fleets of Brazil and possibly other countries in the Southwest Atlantic. Also, no bycatch estimates exist for the Mediterranean Sea, New Zealand and Australian waters.

Lastly, almost no information is available on seabird bycatch in gillnets of tropical regions of all oceans. Although it is known that gillnet fisheries are prevalent along coasts of most tropical countries (Waugh et al., 2011), the low occurrence of susceptible seabird species in these areas allows us to presume no or little interaction with fisheries, but verification would be valuable.

5. Mitigation of seabird bycatch in gillnet fisheries

Several methods have been proposed for mitigating seabird bycatch in gillnet fisheries but few of these have been extensively developed or implemented (Bull, 2007).

5.1. Spatiotemporal closures

Many authors have considered spatiotemporal management of fishing effort as one of the most viable solutions for seabird bycatch mitigation in gillnet fisheries, which, when fine-tuned for local conditions, could allow coexistence of gillnet fisheries and seabirds. In Puget Sound, Melvin et al. (1999) showed that restriction of fisheries to the period of peak salmon abundance could reduce seabird bycatch whilst maintaining a good fish catch. Benjamins et al. (2008) highlighted that seasonal closure of the Newfoundland and Labrador lumpsucker fishery during the arrival of birds at their breeding colonies would be a useful mitigation tool.

5.2. Visual alerts

The introduction of monofilament netting has increased seabird bycatch rates as a result of reduced net visibility (DeGange et al., 1993). With experimental testing of modified gillnets for salmon in Puget Sound (USA), Melvin et al. (1999) found that increased visibility of the upper net panel reduced seabird bycatch by up to 45%.

However, increasing net visibility may have little effect for nocturnally diving seabirds, or species which come in contact with fishing gear in poor visibility conditions. It is likely that more visible nets may also reduce catches of target species.

5.3. Acoustic alerts

Acoustic pingers were initially developed to act as a warning device to reduce entanglement of marine mammals in gillnets. Melvin et al. (1999) tested pingers with a frequency within the generic audiogram of birds, and found that common guillemot bycatch was reduced by 50% while there was no effect on bycatch of rhinoceros auklets. In contrast however, higher bird bycatch rates were found in nets when pingers tuned to deterring marine mammals were used in Kodiak Island salmon fisheries (Manly, 2007). Further work is clearly needed to shed light on use of acoustic alerts.

5.4. Restrictions on fishing depth

The majority of diving birds prefer shallow waters and most seabird bycatch occurs in depths of less than 20 m (Stempniewicz, 1994). Bellebaum et al. (2013) also found that the probability of bycatch decreased with increasing water depth. In California, the ban on gillnetting in depths <60 fathoms has nearly eliminated formerly high bycatch of common guillemots (Carretta and Chivers, 2004). It was also found that submerging driftnets at 2 m below the surface significantly reduced seabird bycatch in the northern Pacific (Hayase and Yatsu, 1993). According to these findings, regulating the depths at which gillnetting occurs could substantially reduce bird mortalities. Consideration would need to be given to the impacts that this would have on fish catch rates.

5.5. Change of fishing gear

An alternative approach is to switch from gillnets to other fishing gears. Often there are alternative means to catch target fish species, some of which may also be viable from a practical and economic perspective.

In the German Baltic Sea, replacing gillnets with longlines has been proposed as a means to decrease seaduck bycatch: per tonne of landed cod, bird bycatch was approximately three times lower for longlines compared to gillnets (Mentjes and Gabriel, 1999; Bellebaum et al., 2013). Similarly, in the eastern Baltic it has been suggested that a switch to longlines would nearly eliminate bycatch of birds and offer a viable alternative for cod fishing, and possibly salmon (Vetemaa and Ložys, 2009). Virtually no bird bycatch was recorded during experimental fishing with baited pots for cod in the German sector of the Baltic Sea, while birds were caught in standard gillnets nearby (Bellebaum et al., 2013). Based on the experience of Latvian fishermen, fish traps for herring and other fish were introduced in Lithuania, and proved to be more efficient in catching fish compared to traditionally used gillnets while at the same time having no bycatch of birds (Vetemaa and Ložys, 2009).

However, in some circumstances switching to alternative fishing gear may increase mortalities of other species or have other undesirable effects on marine ecosystems.

6. Discussion

A simple summing of the most recent bycatch estimates from regions around the world suggests that nearly 400,000 seabirds die in gillnet fisheries every year (Table 2). Information about

Table 2
Cumulative most recent estimates of annual bird bycatch in gillnet fisheries in different regions of the world, possibly significantly affected species and responsible fisheries (see references in chapter 3). Bycatch estimates given in parentheses indicate numbers for sub-regions.

Region/sub-regions	Estimated total annual bycatch	Period of study	Significantly affected species	Main fisheries
1. Northeast Atlantic	>194,000			
Baltic Sea	*(76,000)*	1980–2009	Long-tailed duck, Steller's eider, greater scaup	Small-scale nearshore set net and driftnet fisheries
Norwegian Sea	*(8 000)*	2009–2010	–	Small-scale fleet of vessels shorter than 15 m (using gillnets and longlines)
North Sea and Atlantic	*(>10,000)*	1990–2002	Common guillemot (population at the Atlantic coast of Portugal)	Small-scale coastal gillnet fisheries
Iceland	*(100,000)*			Gillnet fisheries for lumpsucker
2. Northwest Atlantic	>30,000			
West Greenland	*(10,000–20,000)*	2003–2008	–	Gillnet fisheries for lumpsucker
Atlantic Canada	*(8000 – 15,000)*	2000–2008	–	Nearshore and offshore gillnet fisheries for cod, lumpsucker, monkfish/skates, flounder and Greenland halibut
USA NW Atlantic coast	*(2000)*	1997–2006	Red-throated loon	Coastal gillnet fisheries
3. Southwest Atlantic	>>1000	2001–2009	Magellanic penguin	Various set net and driftnet fisheries
4. Northeast Pacific	20,000	1993–2002	Local colonies of common guillemot	
5. Northwest Pacific	140,000	1993–2005	Local colonies of thick-billed guillemot and tufted puffin	Gillnet fisheries for salmon
6. Southwest Pacific	Unknown		Yellow-eyed penguin	Various commercial and recreational gillnet fisheries
7. Southeast Pacific	>10,000	2005–2011	Humboldt penguin, waved albatross	Small-scale set net and driftnet fisheries

bycatch which is known as discontinued was not included in this estimate. The approaches used to collect data and estimate total bycatch varied greatly. Information was collected using onboard observers, cooperating fishermen, questionnaires, ring recoveries, stranded bird surveys and opportunistic observations. Estimates of the overall magnitude of the issue were obtained using models, extrapolations or simply best guesses. Metrics used to measure fishing effort and bird bycatch also differed among studies. Therefore, available estimates have varying levels of uncertainty. Nevertheless, these figures represent the best available information. It is also almost certain that the actual number of birds being killed in gillnets is much higher, as bycatch estimates were unavailable for several regions, some data collection methods (e.g. fisherman questionnaires) tend to underestimate mortality (NMFS, 2004), some birds drop out of the net or are scavenged before being accounted for, and finally there is a lot of lost fishing gear in world oceans ("ghost nets"), which continue to kill birds and other animals (Laist, 1997; Good et al., 2009). Thus, 400,000 birds dying in gillnets should be viewed as a minimum annual estimate. The cumulative estimate of bird bycatch in gillnets likely exceeds seabird mortality in longline fisheries, which was estimated to be at least 160,000, and potentially over 320,000, birds per year (Anderson et al., 2011).

When assessing seabird bycatch in gillnet fisheries, many authors suggested that gillnets were a contributing factor to population declines or a main cause decimating local colonies (summarised in Table 2). Most often, impacts were based on correlative comparison of population trends and fisheries bycatch or other factors. However, several studies used a potential biological removal approach (Žydelis et al., 2009; Warden, 2010). Population models have only been used to analyse gillnet impacts on data from the Atlantic Iberian coast (Velando and Freire, 2002; Munilla et al., 2007), and in both cases a significant impact was identified.

Gillnet mortality affects a largely different suite of seabird species compared to bycatch in longline and trawl fisheries: it is primarily pursuit diving and benthic feeding birds that drown in gillnets. However, shearwaters, fulmars and *Procellaria* petrels are regularly recorded as bycatch in all gear types, therefore, cumulative impacts from different fisheries should be considered when assessing fisheries interactions with these species (e.g. Uhlmann, 2003).

Thus far there are no technological solutions known that universally mitigate seabird bycatch in gillnets. This is partly due to the large variety of gillnet configurations, and the high diversity of target fish species and affected seabirds, but it also reflects modest investment in mitigation research to date. Based on existing mitigation trials, it is also apparent that mitigation means may be highly site-specific in some cases. It should also be recognised that worldwide there has been little concerted action to address seabird bycatch in gillnet fisheries so far.

In some regions seabird bycatch in gillnets co-occurs with bycatch of seaturtles and marine mammals (e.g. SE Pacific, SW Atlantic; Read, 2008; Wallace et al., 2010); thus collaborative efforts with specialists investigating other taxa would help monitor fisheries impacts and planning conservation actions and mitigation.

7. Conclusions

By reviewing available data on seabird bycatch in gillnet fisheries we derived an annual minimum mortality estimate of 400,000 birds. Based on foraging behaviour we evaluated that 148 seabird species are potentially susceptible to bycatch in gillnets. Of those, 81 species have been reported caught and additionally 23 surface-foraging species, which we assumed as unsusceptible were recorded caught in fishing nets.

Auks represent the taxonomic group (family *Alcidae*) that is most frequently caught. Significant impacts of gillnet mortality have been identified for local colonies of auks off the Atlantic Iberian coast and islands in the Northwest Pacific. Significant or potentially significant impacts have also been identified for seaducks in the Baltic Sea, loons in the Northwest Atlantic and penguins in the Southeast Pacific, Southwest Atlantic and New Zealand.

Seabird bycatch in gillnets is most prevalent in the temperate to sub-polar regions of both hemispheres, and has been rarely recorded in the tropics. This spatial pattern is largely determined by the distribution of susceptible species.

In addition we identified several regions where seabird bycatch in gillnet fisheries may be occurring, but data are non-existent or very scarce. These included the EEZs of Japan and Koreas, Southwest Pacific, Chilean waters in the Southeast Pacific, Southeast and Southwest Atlantic, and the Mediterranean Sea.

To date, the most feasible way to mitigate bycatch in gillnets has been through spatial and temporal regulation of fishing effort or gear substitution. In comparison to longline and trawl fisheries, research into technical bycatch mitigation measures for seabird

bycatch in gillnet fisheries has been very limited. Existing research has pointed to several potential solutions, such as increasing visibility of nets, but further research is needed.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2013.04.002.

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Appendix 1

By reviewing 343 world seabird species according to a list compiled by Croxall et al. (2012) and excluding 3 extinct species we identified 148 species that are potentially susceptible to entangling in fishing gillnets due to their foraging behaviour, of which 81 have actually been recorded caught in fishing nets. Additionally 23 surface-foraging species, which we assumed as unsusceptible were recorded caught in fishing nets. We assumed that species, which are capable of diving are susceptible to bycatch in gillnets, and non-diving species are not. In addition to diving species we considered 3 surface foraging albatrosses as susceptible, because of their high recorded mortalities in gillnets: Laysan and black-footed albatrosses (*Phoebastria immutabilis* and *P. nigripes*), and waved albatross (*Phoebastria irrorata*) (DeGange et al., 1993; 1991; Awkerman et al., 2006; Artukhin et al., 2010; Mangel et al., 2011).

Table S1. List of seabird species*, their IUCN Red List category, susceptibility to bycatch in gillnet fisheries (diving species ranked as susceptible (Y) and non-diving as unsusceptible (N)), and references that have reported bycatch of a particular species. References for bird species frequently recorded as bycatch are not necessary complete, as we did not seek to list every reference but rather to document species' susceptibility.

Common name	Scientific name	2012 IUCN Red List category	Susceptible to bycatch in gillnets, Y/N	References reporting bycatch in gillnet fisheries
Flightless Steamerduck	*Tachyeres pteneres*	LC	Y	
White-headed Steamerduck	*Tachyeres leucocephalus*	VU	Y	
Falkland Steamerduck	*Tachyeres brachypterus*	LC	Y	
Flying Steamerduck	*Tachyeres patachonicus*	LC	Y	
Greater Scaup	*Aythya marila*	LC	Y	Stempniewicz, 1994; van Eerden et al., 1999; Klinge and Grimm, 2003, 2003; Bellebaum et al., 2012
Steller's Eider	*Polysticta stelleri*	VU	Y	Dagys and Žydelis, 2002; Žydelis et al., 2009
Common Eider	*Somateria mollissima*	LC	Y	Piatt and Nettleship, 1987; Falk and Durinck, 1991; Stempniewicz, 1994; Lanza and Griffin, 1997; van Eerden et al., 1999; Soczek, 2006; Benjamins et al., 2008; Merkel, 2004, 2011; Degel et al., 2010; Bellebaum et al., 2012

Common name	**Scientific name**	**2012 IUCN Red List category**	**Susceptible to bycatch in gillnets, Y/N**	**References reporting bycatch in gillnet fisheries**
King Eider	*Somateria spectabilis*	LC	Y	Merkel, 2004, 2011
Spectacled Eider	*Somateria fischeri*	LC	Y	
Harlequin Duck	*Histrionicus histrionicus*	LC	Y	Manly, 2007
Black Scoter	*Melanitta nigra*	LC	Y	Durinck et al., 1993; Stempniewicz, 1994; van Eerden et al., 1999; Dagys and Žydelis, 2002; Žydelis et al., 2009; Degel et al., 2010; Bellebaum et al., 2012
Surf Scoter	*Melanitta perspicillata*	LC	Y	Ralph et al., 1995
White-winged Scoter	*Melanitta fusca*	EN	Y	Piatt and Nettleship, 1987; Durinck et al., 1993; Stempniewicz, 1994; Lanza and Griffin, 1997; Urtans and Priednieks, 2000; Dagys and Žydelis 2002; Soczek, 2006; Manly, 2007, 2009; Žydelis et al., 2009; Bellebaum et al., 2012
Long-tailed Duck	*Clangula hyemalis*	VU	Y	Stempniewicz, 1994; van Eerden et al., 1999; Urtans and Priednieks, 2000; Dagys and Žydelis, 2002, Žydelis et al., 2009; Degel et al., 2010; Bellebaum et al., 2012
Common Goldeneye	*Bucephala clangula*	LC	Y	Stempniewicz, 1994; van Eerden et al., 1999; Urtans and Priednieks, 2000; Klinge and Grimm, 2003; Žydelis et al., 2009; Bellebaum et al., 2012
Barrow's Goldeneye	*Bucephala islandica*	LC	Y	
Red-breasted Merganser	*Mergus serrator*	LC	Y	Stempniewicz, 1994; van Eerden et al., 1999; Klinge and Grimm, 2003; Žydelis et al., 2009; Bellebaum et al., 2012
Common Merganser	*Mergus merganser*	LC	Y	Stempniewicz, 1994; van Eerden et al., 1999; Klinge and Grimm, 2003; Žydelis et al., 2009; Bellebaum et al., 2012
King Penguin	*Aptenodytes patagonicus*	LC	Y	
Emperor Penguin	*Aptenodytes forsteri*	NT	Y	
Gentoo Penguin	*Pygoscelis papua*	NT	Y	
Adelie Penguin	*Pygoscelis adeliae*	NT	Y	
Chinstrap Penguin	*Pygoscelis antarcticus*	LC	Y	
Southern Rockhopper Penguin	*Eudyptes chrysocome*	VU	Y	
Northern Rockhopper Penguin	*Eudyptes moseleyi*	EN	Y	

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Fiordland Penguin	*Eudyptes pachyrhynchus*	VU	Y	Ramm, 2012
Snares Penguin	*Eudyptes robustus*	VU	Y	
Erect-crested Penguin	*Eudyptes sclateri*	EN	Y	
Macaroni Penguin	*Eudyptes chrysolophus*	VU	Y	
Royal Penguin	*Eudyptes schlegeli*	VU	Y	
Yellow-eyed Penguin	*Megadyptes antipodes*	EN	Y	Darby and Dawson, 2000; Taylor, 2000a; Ramm, 2010, 2012; Abraham and Thompson, 2011; Ellenberg and Mattern, 2012
Little Penguin	*Eudyptula minor*	LC	Y	Darby and Dawson, 2000; Norman, 2000; Taylor, 2000b; Stevenson and Woehler, 2007; Rowe, 2010
African Penguin	*Spheniscus demersus*	EN	Y	
Humboldt Penguin	*Spheniscus humboldti*	VU	Y	Simeone et al., 1999; Majluf et al., 2002; Ayala, 2008; Mangel et al., 2011
Magellanic Penguin	*Spheniscus magellanicus*	NT	Y	Simeone et al., 1999; Cardoso et al., 2011
Galapagos Penguin	*Spheniscus mendiculus*	EN	Y	
Red-throated Loon	*Gavia stellata*	LC	Y	DeGange et al., 1993; Stempniewicz, 1994; Lanza and Griffin, 1997; van Eerden et al., 1999; Forsell, 1999; Urtans and Priednieks, 2000; Dagys and Žydelis, 2002; Petersen, 2002; Manly 2009; Žydelis et al., 2009; Artukhin et al., 2010; Warden, 2010; Bellebaum et al., 2012
Arctic Loon	*Gavia arctica*	LC	Y	Stempniewicz, 1994; Urtans and Priednieks, 2000; Žydelis et al., 2009; Artukhin et al., 2010; Bellebaum et al., 2012
Pacific Loon	*Gavia pacifica*	LC	Y	DeGange et al., 1993; Julian and Beeson, 1998; Smith and Morgan, 2005; Manly, 2009
Common Loon	*Gavia immer*	LC	Y	Piatt and Nettleship, 1987; DeGange et al., 1993; Stempniewicz, 1994; Lanza and Griffin, 1997; Julian and Beeson, 1998; Forsell, 1999; Soczek, 2006; Manly, 2006; Warden, 2010; Merkel, 2011
Yellow-billed Loon	*Gavia adamsii*	NT	Y	Stempniewicz, 1994; Artukhin et al., 2010
Waved Albatross	*Phoebastria irrorata*	CR	Y	Awkerman et al., 2006; Mangel et al., 2011
Short-tailed Albatross	*Phoebastria albatrus*	VU	N	Artukhin et al., 2010

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Black-footed Albatross	*Phoebastria nigripes*	VU	Y	DeGange et al., 1993; Johnson et al., 1993; Gould et al., 1997b; Ogi, 2008
Laysan Albatross	*Phoebastria immutabilis*	NT	Y	Ainley et al., 1981; DeGange and Day, 1991; DeGange et al., 1993; Gould et al., 1997b; Ogi, 2008; Artukhin et al., 2010
Wandering Albatross	*Diomedea exulans*	VU	N	
Antipodean Albatross	*Diomedea antipodensis*	VU	N	
Amsterdam Albatross	*Diomedea amsterdamensis*	CR	N	
Tristan Albatross	*Diomedea dabbenena*	CR	N	
Northern Royal Albatross	*Diomedea sanfordi*	EN	N	
Southern Royal Albatross	*Diomedea epomophora*	VU	N	
Sooty Albatross	*Phoebetria fusca*	EN	N	
Light-mantled Albatross	*Phoebetria palpebrata*	NT	N	
Black-browed Albatross	*Thalassarche melanophrys*	EN	N	Ogi, 2008; Mangel et al., 2011
Campbell Albatross	*Thalassarche impavida*	VU	N	
Shy Albatross	*Thalassarche cauta*	NT	N	
White-capped Albatross	*Thalassarche steadi*	NT	N	Ramm, 2010
Chatham Albatross	*Thalassarche eremita*	VU	N	
Salvin's Albatross	*Thalassarche salvini*	VU	N	
Grey-headed Albatross	*Thalassarche chrysostoma*	VU	N	Mangel et al., 2011
Atlantic Yellow-nosed Albatross	*Thalassarche chlororhynchos*	EN	N	
Indian Yellow-nosed Albatross	*Thalassarche carteri*	EN	N	
Buller's Albatross	*Thalassarche bulleri*	NT	N	Ramm, 2010
Southern Giant-petrel	*Macronectes giganteus*	LC	N	Ramm, 2010
Northern Giant-petrel	*Macronectes halli*	LC	N	Ramm, 2010
Southern Fulmar	*Fulmarus glacialoides*	LC	Y	Neves et al., 2006
Northern Fulmar	*Fulmarus glacialis*	LC	Y	DeGange and Day, 1991; DeGange et al., 1993; Carretta et al., 2004; Soczek, 2006; Rogan and Mackey, 2007; Benjamins et al., 2008; Artukhin et al., 2010; Fangel et al., 2011

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Antarctic Petrel	*Thalassoica antarctica*	LC	Y	
Cape Petrel	*Daption capense*	LC	Y	Perez and Wahrlich, 2005; Rowe, 2010; Ramm, 2010
Snow Petrel	*Pagodroma nivea*	LC	Y	
Blue Petrel	*Halobaena caerulea*	LC	Y	
Broad-billed Prion	*Pachyptila vittata*	LC	N	
Medium-billed Prion	*Pachyptila salvini*	LC	N	
Antarctic Prion	*Pachyptila desolata*	LC	N	
Thin-billed Prion	*Pachyptila belcheri*	LC	N	
Fairy Prion	*Pachyptila turtur*	LC	N	
Fulmar Prion	*Pachyptila crassirostris*	LC	N	
Kerguelen Petrel	*Lugensa brevirostris*	LC	N	
Barau's Petrel	*Pterodroma baraui*	EN	N	
Trindade Petrel	*Pterodroma arminjoniana*	VU	N	
Juan Fernandez Petrel	*Pterodroma externa*	VU	N	
Kermadec Petrel	*Pterodroma neglecta*	LC	N	
Galapagos Petrel	*Pterodroma phaeopygia*	CR	N	
Hawaiian Petrel	*Pterodroma sandwichensis*	VU	N	
Henderson Petrel	*Pterodroma atrata*	EN	N	
Herald Petrel	*Pterodroma heraldica*	LC	N	
Phoenix Petrel	*Pterodroma alba*	EN	N	
Fea's Petrel	*Pterodroma feae*	NT	N	
Zino's Petrel	*Pterodroma madeira*	EN	Y	
Soft-plumaged Petrel	*Pterodroma mollis*	LC	N	
Bermuda Petrel	*Pterodroma cahow*	EN	N	
Black-capped Petrel	*Pterodroma hasitata*	EN	N	
Jamaica Petrel	*Pterodroma caribbaea*	CR	N	
Atlantic Petrel	*Pterodroma incerta*	EN	N	
White-headed Petrel	*Pterodroma lessonii*	LC	N	

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Magenta Petrel	*Pterodroma magentae*	CR	N	
Great-winged Petrel	*Pterodroma macroptera*	LC	N	
Providence Petrel	*Pterodroma solandri*	VU	N	
Murphy's Petrel	*Pterodroma ultima*	NT	N	
Mottled Petrel	*Pterodroma inexpectata*	NT	N	
Pycroft's Petrel	*Pterodroma pycrofti*	VU	N	
Stejneger's Petrel	*Pterodroma longirostris*	VU	N	
Collared Petrel	*Pterodroma brevipes*	VU	N	
Gould's Petrel	*Pterodroma leucoptera*	VU	N	
Cook's Petrel	*Pterodroma cookii*	VU	N	
De Filippi's Petrel	*Pterodroma defilippiana*	VU	N	
Bonin Petrel	*Pterodroma hypoleuca*	LC	N	
White-necked Petrel	*Pterodroma cervicalis*	VU	N	
Black-winged Petrel	*Pterodroma nigripennis*	LC	N	
Chatham Petrel	*Pterodroma axillaris*	EN	N	
Fiji Petrel	*Pseudobulweria macgillivrayi*	CR	N	
Tahiti Petrel	*Pseudobulweria rostrata*	NT	N	
Beck's Petrel	*Pseudobulweria becki*	CR	N	
Mascarene Petrel	*Pseudobulweria aterrima*	CR	N	
White-chinned Petrel	*Procellaria aequinoctialis*	VU	Y	Perez and Wahrlich, 2005; Neves et al., 2006; Mangel et al., 2011; Rowe, 2010; Ramm, 2010, 2012
Spectacled Petrel	*Procellaria conspicillata*	VU	Y	Neves et al., 2006
Westland Petrel	*Procellaria westlandica*	VU	Y	Rowe 2010; Ramm, 2010, 2012
Parkinson's Petrel	*Procellaria parkinsoni*	VU	Y	
Grey Petrel	*Procellaria cinerea*	NT	Y	
Cory's Shearwater	*Calonectris diomedea*	LC	Y	Soczek, 2006; Benjamins et al., 2008;
Cape Verde Shearwater	*Calonectris edwardsii*	NT	Y	
Streaked Shearwater	*Calonectris leucomelas*	LC	Y	

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Wedge-tailed Shearwater	*Puffinus pacificus*	LC	Y	Taylor, 2000b
Buller's Shearwater	*Puffinus bulleri*	VU	Y	DeGange et al., 1993; Ogi, 2008
Flesh-footed Shearwater	*Puffinus carneipes*	LC	Y	DeGange et al., 1993; Gould et al., 1997, Ogi, 2008
Pink-footed Shearwater	*Puffinus creatopus*	VU	Y	Mangel et al., 2011
Great Shearwater	*Puffinus gravis*	LC	Y	Piatt and Nettleship, 1987; Lanza and Griffin, 1997; Perez and Wahrlich, 2005; Soczek, 2006; Benjamins et al., 2008
Sooty Shearwater	*Puffinus griseus*	NT	Y	Ogi, 1984; Piatt and Nettleship, 1987; DeGange et al., 1993; Lanza and Griffin, 1997; Taylor, 2000b; Majluf et al., 2002; Uhlman et al., 2005; Smith and Morgan, 2005; Soczek, 2006; Manly, 2007; Benjamins et al., 2008; Ogi, 2008; Artukhin et al., 2010; Ramm, 2010; Rowe, 2010; Mangel et al., 2011; Abraham and Thompson, 2011
Short-tailed Shearwater	*Puffinus tenuirostris*	LC	Y	Ogi, 1984; DeGange et al., 1993; Uhlman et al., 2005; Ogi, 2008; Artukhin et al., 2010
Christmas Island Shearwater	*Puffinus nativitatis*	LC	Y	
Manx Shearwater	*Puffinus puffinus*	LC	Y	Soczek, 2006; Rogan and Mackey, 2007
Yelkouan Shearwater	*Puffinus yelkouan*	VU	Y	Besson, 1973; ICES, 2008
Balearic Shearwater	*Puffinus mauretanicus*	CR	Y	
Townsend's Shearwater	*Puffinus auricularis*	CR	Y	
Newell's Shearwater	*Puffinus newelli*	EN	Y	Ogi, 2008
Black-vented Shearwater	*Puffinus opisthomelas*	NT	Y	
Fluttering Shearwater	*Puffinus gavia*	LC	Y	Tarburton, 1981; Rowe, 2010; Abraham and Thompson, 2011
Hutton's Shearwater	*Puffinus huttoni*	EN	Y	Tarburton, 1981; Rowe, 2010
Audubon's Shearwater	*Puffinus lherminieri*	LC	Y	
Heinroth's Shearwater	*Puffinus heinrothi*	VU	Y	
Little Shearwater	*Puffinus assimilis*	LC	Y	
Bulwer's Petrel	*Bulweria bulwerii*	LC	N	
Jouanin's Petrel	*Bulweria fallax*	NT	N	
Wilson's Storm-petrel	*Oceanites oceanicus*	LC	N	Lanza and Griffin, 1997; Soczek, 2006

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White-vented Storm-petrel	*Oceanites gracilis*	DD	N	
New Zealand Storm-petrel	*Oceanites maorianus*	CR	N	
Grey-backed Storm-petrel	*Garrodia nereis*	LC	N	
White-faced Storm-petrel	*Pelagodroma marina*	LC	N	
Black-bellied Storm-petrel	*Fregetta tropica*	LC	N	
White-bellied Storm-petrel	*Fregetta grallaria*	LC	N	
White-throated Storm-petrel	*Nesofregetta fuliginosa*	EN	N	
European Storm-petrel	*Hydrobates pelagicus*	LC	N	
Wedge-rumped Storm-petrel	*Oceanodroma tethys*	LC	N	
Madeiran Storm-petrel	*Oceanodroma castro*	LC	N	
Monteiro's Storm-petrel	*Oceanodroma monteiroi*	VU	N	
Swinhoe's Storm-petrel	*Oceanodroma monorhis*	NT	N	
Leach's Storm-petrel	*Oceanodroma leucorhoa*	LC	N	Piatt and Nettleship, 1987; Ogi, 2008; Artukhin et al., 2010
Guadalupe Storm-petrel	*Oceanodroma macrodactyla*	CR	N	
Markham's Storm-petrel	*Oceanodroma markhami*	DD	N	
Tristram's Storm-petrel	*Oceanodroma tristrami*	NT	N	
Black Storm-petrel	*Oceanodroma melania*	LC	N	
Matsudaira's Storm-petrel	*Oceanodroma matsudairae*	DD	N	
Ashy Storm-petrel	*Oceanodroma homochroa*	EN	N	
Ringed Storm-petrel	*Oceanodroma hornbyi*	DD	N	
Fork-tailed Storm-petrel	*Oceanodroma furcata*	LC	N	DeDange and Day, 1991; DeGange et al., 1993; Ogi, 2008; Artukhin et al., 2010
Least Storm-petrel	*Halocyptena microsoma*	LC	N	
Peruvian Diving-petrel	*Pelecanoides garnotii*	EN	Y	
Magellanic Diving-petrel	*Pelecanoides magellani*	LC	Y	
South Georgia Diving-petrel	*Pelecanoides georgicus*	LC	Y	
Common Diving-petrel	*Pelecanoides urinatrix*	LC	Y	
Red-necked Grebe	*Podiceps grisegena*	LC	Y	van Eerden et al., 1999; Žydelis et al., 2009; Bellebaum et al., 2012

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Great Crested Grebe	*Podiceps cristatus*	LC	Y	Stempniewicz, 1994; van Eerden et al., 1999; Klinge and Grimm, 2003; Žydelis et al., 2009; Bellebaum et al., 2012
Horned Grebe	*Podiceps auritus*	LC	Y	Stempniewicz, 1994; van Eerden et al., 1999; Bellebaum et al., 2012
Black-necked Grebe	*Podiceps nigricollis*	LC	Y	van Eerden et al., 1999; Žydelis et al., 2009
Red-billed Tropicbird	*Phaethon aethereus*	LC	N	
Red-tailed Tropicbird	*Phaethon rubricauda*	LC	N	
White-tailed Tropicbird	*Phaethon lepturus*	LC	N	
Magnificent Frigatebird	*Fregata magnificens*	LC	N	
Ascension Frigatebird	*Fregata aquila*	VU	N	
Greater Frigatebird	*Fregata minor*	LC	N	
Lesser Frigatebird	*Fregata ariel*	LC	N	
Christmas Island Frigatebird	*Fregata andrewsi*	CR	N	
Great White Pelican	*Pelecanus onocrotalus*	LC	N	
Peruvian Pelican	*Pelecanus thagus*	NT	N	
Brown Pelican	*Pelecanus occidentalis*	LC	N	DeGange et al., 1993
Northern Gannet	*Morus bassanus*	LC	Y	Piatt and Nettleship, 1987; Lanza and Griffin, 1997; Soczek, 2006; Rogan and Mackey, 2007; Benjamins et al., 2008; Fangel et al., 2011
Cape Gannet	*Morus capensis*	VU	Y	
Australasian Gannet	*Morus serrator*	LC	Y	
Abbott's Booby	*Papasula abbotti*	EN	Y	
Blue-footed Booby	*Sula nebouxii*	LC	Y	Mangel et al., 2011
Peruvian Booby	*Sula variegata*	LC	Y	Ayala, 2008; Mangel et al., 2011
Masked Booby	*Sula dactylatra*	LC	Y	
Nazca Booby	*Sula granti*	LC	Y	
Red-footed Booby	*Sula sula*	LC	Y	
Brown Booby	*Sula leucogaster*	LC	Y	

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Pelagic Cormorant	*Phalacrocorax pelagicus*	LC	Y	DeGange et al., 1993; Julian and Beeson, 1998; Manly, 2007; Smith and Morgan, 2005; Artukhin et al., 2010
Crowned Cormorant	*Phalacrocorax coronatus*	NT	Y	
Little Pied Cormorant	*Phalacrocorax melanoleucos*	LC	Y	Lalas, 1993; Taylor, 2000b
Brandt's Cormorant	*Phalacrocorax penicillatus*	LC	Y	DeGange et al., 1993; Julian and Beeson, 1998; Smith and Morgan, 2005
Flightless Cormorant	*Phalacrocorax harrisi*	VU	Y	
Bank Cormorant	*Phalacrocorax neglectus*	EN	Y	
Black-faced Cormorant	*Phalacrocorax fuscescens*	LC	Y	
Neotropic Cormorant	*Phalacrocorax brasilianus*	LC	Y	
Double-crested Cormorant	*Phalacrocorax auritus*	LC	Y	DeGange et al., 1993; Lanza and Griffin, 1997; Julian and Beeson, 1998; Soczek, 2006; Benjamins et al., 2008; Manly, 2009
Indian Cormorant	*Phalacrocorax fuscicollis*	LC	Y	
Large Pied Cormorant	*Phalacrocorax varius*	LC	Y	Taylor, 2000a; Rowe, 2010, 2012
Great Cormorant	*Phalacrocorax carbo*	LC	Y	Stempniewicz, 1994; Lanza and Griffin, 1997; van Eerden et al., 1999; Taylor, 2000b; Klinge and Grimm, 2003; Žydelis et al., 2009; Degel et al., 2010; Merkel, 2011; Bellebaum et al., 2012
Japanese Cormorant	*Phalacrocorax capillatus*	LC	Y	
Socotra Cormorant	*Phalacrocorax nigrogularis*	VU	Y	
Cape Cormorant	*Phalacrocorax capensis*	NT	Y	
Guanay Cormorant	*Phalacrocorax bougainvillii*	NT	Y	Simeone et al., 1999; Majluf et al., 2002; Mangel et al., 2011
Imperial Shag	*Phalacrocorax atriceps*	LC	Y	
Campbell Island Shag	*Phalacrocorax campbelli*	VU	Y	
New Zealand King Shag	*Phalacrocorax carunculatus*	VU	Y	
Stewart Island Shag	*Phalacrocorax chalconotus*	VU	Y	Lalas, 1993; Ramm, 2012
Chatham Islands Shag	*Phalacrocorax onslowi*	CR	Y	
Auckland Islands Shag	*Phalacrocorax colensoi*	VU	Y	
Bounty Islands Shag	*Phalacrocorax ranfurlyi*	VU	Y	

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Rock Shag	*Phalacrocorax magellanicus*	LC	Y	
Red-faced Cormorant	*Phalacrocorax urile*	LC	Y	Manly, 2007; Artukhin et al., 2010
European Shag	*Phalacrocorax aristotelis*	LC	Y	Velando and Freire, 2002; Louzao and Oro, 2004; Fangel et al., 2011
Red-legged Cormorant	*Phalacrocorax gaimardi*	NT	Y	Simeone et al., 1999; Majluf et al., 2002
Spotted Shag	*Phalacrocorax punctatus*	LC	Y	Lalas, 1993; Darby and Dawson, 2000; Taylor, 2000b; Rowe, 2010; Abraham and Thompson, 2011; Ramm, 2012
Pitt Island Shag	*Phalacrocorax featherstoni*	EN	Y	
Red-necked Phalarope	*Phalaropus lobatus*	LC	N	
Red Phalarope	*Phalaropus fulicarius*	LC	N	
Dolphin Gull	*Leucophaeus scoresbii*	LC	N	
Pacific Gull	*Larus pacificus*	LC	N	
Band-tailed Gull	*Larus belcheri*	LC	N	
Olrog's Gull	*Larus atlanticus*	VU	N	
Black-tailed Gull	*Larus crassirostris*	LC	N	
Grey Gull	*Larus modestus*	LC	N	
Heermann's Gull	*Larus heermanni*	NT	N	
White-eyed Gull	*Larus leucophthalmus*	NT	N	
Sooty Gull	*Larus hemprichii*	LC	N	
Mew Gull	*Larus canus*	LC	N	
Audouin's Gull	*Larus audouinii*	NT	N	
Ring-billed Gull	*Larus delawarensis*	LC	N	
California Gull	*Larus californicus*	LC	N	
Great Black-backed Gull	*Larus marinus*	LC	N	Piatt and Nettleship, 1987; Lanza and Griffin, 1997; Soczek, 2006;
Kelp Gull	*Larus dominicanus*	LC	N	
Glaucous-winged Gull	*Larus glaucescens*	LC	N	Manly, 2009
Western Gull	*Larus occidentalis*	LC	N	
Yellow-footed Gull	*Larus livens*	LC	N	

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Glaucous Gull	*Larus hyperboreus*	LC	N	Artukhin et al., 2010
Iceland Gull	*Larus glaucoides*	LC	N	
Thayer's Gull	*Larus thayeri*	LC	N	
Herring Gull	*Larus argentatus*	LC	N	Piatt and Nettleship, 1987; Lanza and Griffin, 1997; Soczek, 2006; Fangel et al., 2011
Slaty-backed Gull	*Larus schistisagus*	LC	N	Artukhin et al., 2010
Caspian Gull	*Larus cachinnans*	LC	N	
Yellow-legged Gull	*Larus michahellis*	LC	N	
Lesser Black-backed Gull	*Larus fuscus*	LC	N	Soczek, 2006;
Pallas's Gull	*Larus ichthyaetus*	LC	N	
Brown-headed Gull	*Larus brunnicephalus*	LC	N	
Grey-headed Gull	*Larus cirrocephalus*	LC	N	
King Gull	*Larus hartlaubii*	LC	N	
Silver Gull	*Larus novaehollandiae*	LC	N	
Red-billed Gull	*Larus scopulinus*	LC	N	
Brown-hooded Gull	*Larus maculipennis*	LC	N	
Black-headed Gull	*Larus ridibundus*	LC	N	
Slender-billed Gull	*Larus genei*	LC	N	
Bonaparte's Gull	*Larus philadelphia*	LC	N	
Saunders's Gull	*Larus saundersi*	VU	N	
Mediterranean Gull	*Larus melanocephalus*	LC	N	
Lava Gull	*Larus fuliginosus*	VU	N	
Laughing Gull	*Larus atricilla*	LC	N	
Franklin's Gull	*Larus pipixcan*	LC	N	
Little Gull	*Larus minutus*	LC	N	
Ivory Gull	*Pagophila eburnea*	NT	N	
Ross's Gull	*Rhodostethia rosea*	LC	N	
Sabine's Gull	*Xema sabini*	LC	N	

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Swallow-tailed Gull	*Creagrus furcatus*	LC	N	
Black-legged Kittiwake	*Rissa tridactyla*	LC	N	Piatt and Nettleship, 1987; Lanza and Griffin, 1997; Soczek, 2006; Artukhin et al., 2010; Fangel et al., 2011; Merkel, 2011
Red-legged Kittiwake	*Rissa brevirostris*	VU	N	Artukhin et al., 2010
Gull-billed Tern	*Sterna nilotica*	LC	N	
Caspian Tern	*Sterna caspia*	LC	N	
Royal Tern	*Sterna maxima*	LC	N	
Elegant Tern	*Sterna elegans*	NT	N	
Lesser Crested Tern	*Sterna bengalensis*	LC	N	
Great Crested Tern	*Sterna bergii*	LC	N	
Chinese Crested Tern	*Sterna bernsteini*	CR	N	
Sandwich Tern	*Sterna sandvicensis*	LC	N	
Roseate Tern	*Sterna dougallii*	LC	N	
White-fronted Tern	*Sterna striata*	LC	N	
Black-naped Tern	*Sterna sumatrana*	LC	N	
South American Tern	*Sterna hirundinacea*	LC	N	
Common Tern	*Sterna hirundo*	LC	N	
Arctic Tern	*Sterna paradisaea*	LC	N	
Antarctic Tern	*Sterna vittata*	LC	N	
Kerguelen Tern	*Sterna virgata*	NT	N	
Forster's Tern	*Sterna forsteri*	LC	N	
Snowy-crowned Tern	*Sterna trudeaui*	LC	N	
Little Tern	*Sterna albifrons*	LC	N	
Saunders's Tern	*Sterna saundersi*	LC	N	
Least Tern	*Sterna antillarum*	LC	N	
Peruvian Tern	*Sterna lorata*	EN	N	
Fairy Tern	*Sterna nereis*	VU	N	
Damara Tern	*Sterna balaenarum*	NT	N	

Common name	Scientific name	2012 IUCN Red List category	Susceptible to bycatch in gillnets, Y/N	References reporting bycatch in gillnet fisheries
White-cheeked Tern	*Sterna repressa*	LC	N	
Aleutian Tern	*Sterna aleutica*	LC	N	
Grey-backed Tern	*Sterna lunata*	LC	N	
Bridled Tern	*Sterna anaethetus*	LC	N	
Sooty Tern	*Sterna fuscata*	LC	N	
Black-fronted Tern	*Sterna albostriata*	EN	N	
Black Tern	*Chlidonias niger*	LC	N	
Brown Noddy	*Anous stolidus*	LC	N	
Black Noddy	*Anous minutus*	LC	N	
Lesser Noddy	*Anous tenuirostris*	LC	N	
Blue Noddy	*Procelsterna cerulea*	LC	N	
Common White Tern	*Gygis alba*	LC	N	
Little White Tern	*Gygis microrhyncha*	LC	N	
Inca Tern	*Larosterna inca*	NT	N	Mangel et al., 2011
Great Skua	*Catharacta skua*	LC	N	
Southern Skua	*Catharacta antarctica*	LC	N	
Brown Skua	*Catharacta lonnbergi*	LC	N	
Chilean Skua	*Catharacta chilensis*	LC	N	
South Polar Skua	*Catharacta maccormicki*	LC	N	
Pomarine Jaeger	*Stercorarius pomarinus*	LC	N	Artukhin et al., 2010
Parasitic Jaeger	*Stercorarius parasiticus*	LC	N	
Long-tailed Jaeger	*Stercorarius longicaudus*	LC	N	Artukhin et al., 2010
Little Auk	*Alle alle*	LC	Y	Tull et al., 1972; Stempniewicz, 1994; Benjamins et al., 2008; Artukhin et al., 2010; Merkel, 2011
Common Guillemot	*Uria aalge*	LC	Y	Tull et al., 1972; Ogi, 1984; Piatt and Nettleship, 1987; Falk and Durinck, 1991; Strann et al., 1991; DeGange et al., 1993; Murray et al., 1994; Stempniewicz, 1994; Lanza and Griffin, 1997; Julian and Beeson, 1998; Thompson et al., 1998; Melvin et al., 1999; Manly

Common name	Scientific name	2012 IUCN Red List category	Susceptible to bycatch in gillnets, Y/N	References reporting bycatch in gillnet fisheries
				et al., 2003, Smith and Morgan, 2005; Soczek, 2006; Munilla et al., 2007; Benjamins et al., 2008; Manly, 2007, 2009; Artukhin et al., 2010; Fangel et al., 2011; Merkel, 2011; Bellebaum et al., 2012
Thick-billed Guillemot	*Uria lomvia*	LC	Y	Tull et al., 1972; Ogi, 1984; Piatt and Nettleship, 1987; Falk and Durinck, 1991; Strann et al., 1991; DeGange et al., 1993; Manly et al., 2003; Soczek, 2006; Manly, 2007; Benjamins et al., 2008; Artukhin et al., 2010; Fangel et al., 2011;
Razorbill	*Alca torda*	LC	Y	Strann et al., 1991; Murray et al., 1994; Stempniewicz, 1994; Fangel et al., 2011; Bellebaum et al., 2012
Black Guillemot	*Cepphus grylle*	LC	Y	Tull et al., 1972; Piatt and Nettleship, 1987; Falk and Durinck, 1991; Stempniewicz, 1994; Lanza and Griffin, 1997; Petersen, 2002; Benjamins et al., 2008; Žydelis et al., 2009; Fangel et al., 2011; Merkel, 2011; Bellebaum et al., 2012
Pigeon Guillemot	*Cepphus columba*	LC	Y	DeGange et al., 1993; Melvin et al., 1999; Smith and Morgan, 2005, Manly, 2007, 2009; Artukhin et al., 2010
Spectacled Guillemot	*Cepphus carbo*	LC	Y	
Marbled Murrelet	*Brachyramphus marmoratus*	EN	Y	DeGange et al., 1993; Ralph et al., 1995; Melvin et al., 1999; Manly et al., 2003, Smith and Morgan, 2005, Manly, 2007, 2009
Long-billed Murrelet	*Brachyramphus perdix*	NT	Y	Artukhin et al., 2010
Kittlitz's Murrelet	*Brachyramphus brevirostris*	CR	Y	DeGange et al., 1993; Manly, 2007; Artukhin et al., 2010
Xantus's Murrelet	*Synthliboramphus hypoleucus*	VU	Y	
Craveri's Murrelet	*Synthliboramphus craveri*	VU	Y	
Ancient Murrelet	*Synthliboramphus antiquus*	LC	Y	DeGange et al., 1993; Artukhin et al., 2010
Japanese Murrelet	*Synthliboramphus wumizusume*	VU	Y	DeGange et al., 1993
Cassin's Auklet	*Ptychoramphus aleuticus*	LC	Y	DeGange et al., 1993; Smith and Morgan, 2005; Artukhin et al., 2010
Parakeet Auklet	*Aethia psittacula*	LC	Y	Artukhin et al., 2010
Crested Auklet	*Aethia cristatella*	LC	Y	DeGange et al., 1993; Artukhin et al., 2010
Whiskered Auklet	*Aethia pygmaea*	LC	Y	

Common name	Scientific name	2012 IUCN Red List category	Susceptible to bycatch in gillnets, Y/N	References reporting bycatch in gillnet fisheries
Least Auklet	*Aethia pusilla*	LC	Y	DeGange et al., 1993; Manly, 2007; Smith and Morgan, 2005; Artukhin et al., 2010
Rhinoceros Auklet	*Cerorhinca monocerata*	LC	Y	Thompson et al., 1998; Melvin et al., 1999; Smith and Morgan, 2005; Artukhin et al., 2010
Atlantic Puffin	*Fratercula arctica*	LC	Y	Piatt and Nettleship, 1987; Strann et al., 1991; Rogan and Mackey, 2007; Benjamins et al., 2008; Fangel et al., 2011
Horned Puffin	*Fratercula corniculata*	LC	Y	DeGange et al., 1993; Manly, 2007; Ogi, 2008, Artukhin et al., 2010
Tufted Puffin	*Fratercula cirrhata*	LC	Y	Ogi, 1984, 2008; DeGange et al., 1993; Manly, 2007; Artukhin et al., 2010

** The species list has been adapted from Croxall et al. (2012). Extinct species have been removed from the list.*

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