North Sea cetacean research since the 1960s: advances and gaps

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In the 1960s, our knowledge of cetaceans in the North Sea depended largely upon strandings schemes that existed in the countries that surround the southern North Sea, particularly the UK (Fraser 1974, Sheldrick 1976, 1989, Sheldrick et al. 1992, 1994), Belgium (De Smet 1974, 1979, 1981, Van Gompel 1991, 1996), and the Netherlands (van Bree 1977, Smeenk 1987, Addink & Smeenk 1999). Scarcely any sightings programmes existed until the 1970s (Verwey 1975, Evans 1976, 1980, Evans et al. 1986). In those years between the 1960s and 1980s, increasing concern was expressed for the status of the harbour porpoise (*Phocoena phocoena*) which appeared to be declining in the North Sea and beyond (Evans 1980, Kayes 1985, Kroger 1986, Kremer 1987, Smeenk 1987). The result was that a small group of scientists, including the late Chris Smeenk to whom this special issue is dedicated, came together to form the European Cetacean Society in 1987, and then issued a statement of concern on behalf of the society (Evans et al. 1987) to the 2nd North Sea Ministerial Conference held in London in 1987. A number of non-governmental organisations (notably WWF-Germany, WWF-Sweden, and Greenpeace) lobbied for conservation action.

With the status of the harbour porpoise in the North Sea and environs very much at the forefront of environmental concern, one of the first regional agreements under Article IV of the Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS or Bonn Convention), which had come into force in 1983, was ASCOBANS, the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas. The Final Act was signed in September 1991, and then opened for signature by Range States, at the UN Headquarters in New York in March 1992.

Two human pressures were highlighted at the time that could be having a negative impact upon porpoises in and around the North Sea. These were prey depletion caused by a combination of overfishing and environmental change (Evans 1990, Reijnders 1992) and fisheries bycatch (Northridge 1988), although the potential impact of bycatch was not fully appreciated until the 1990s (Bjørge et al. 1994, Lowry & Teilmann 1994, Donovan & Bjørge 1995, Kock & Benke 1996, Vinther 1999, Northridge & Hammond 1999). During the 1990s, the potential harmful effects of chemical pollution (Reijnders et al. 1999) and underwater noise (Richardson et al. 1995) on marine mammals also started to get noticed.

The evidence for earlier declines in the harbour porpoise had been based largely upon stranding trends and changes in sightings rates from fairly limited sightings surveys (often shore-based). The first large-scale survey of the North Sea using line transect Distance methodology to derive abundance estimates, was the SCANS survey undertaken

in July 1994 (Hammond et al. 2002). These yielded an abundance estimate of ca. 170,000 porpoises in the central and southern North Sea whilst independent observers aboard a sample of fishing vessels estimated annual mortality from bycatch alone to be ca. 4,450, or 2.6% of the population size (Vinther 1999, Northridge & Hammond 1999, Hammond et al. 2002, Vinther & Larsen 2004). Based upon knowledge of their life history parameters, the regional conservation agreement, ASCOBANS, concluded that annual total mortality exceeding 1.7% of porpoise population size would not be sustainable, and that therefore action was needed urgently by Parties. Out of this concern came a new regulation within the EU Common Fisheries Policy – Reg. 812/2004. This required member states to deploy Acoustic Deterrent Devices (ADDs) known as pingers to be used on fishing vessels of 12 metres length or more using bottom set gillnets or entangling nets. The Regulation also issued a requirement for at sea observer schemes on vessels of 15 metres length or more, and for smaller vessels, to take the necessary steps to collect scientific data on incidental catches by means of appropriate scientific studies or pilot projects. Earlier studies in both US and Danish waters had shown that pingers could be very effective at alerting porpoises to the presence of nets (although there have been concerns about habituation, and, conversely, habitat exclusion when applied over wide areas). The Regulation was generally welcome but, unfortunately, has not been totally successful although pressure from bycatch may not be as great as it was due to an overall reduction in fishing effort.

Following the 1994 SCANS survey, further large-scale surveys were undertaken in July 2005 (SCANS II - Hammond et al. 2013) and July 2016 (SCANS III - Hammond et al. 2017). They showed no significant change in numbers of harbour porpoise in the North Sea, although between 1994 and 2005, there appeared to be a major re-distribution of animals from the concentrations observed in the north-western North Sea in 1994 to the highest abundance in the southernmost North Sea in 2005, which has persisted through to at least 2016. Since the early 1990s, concerns for declines in the Northern Isles of Scotland possibly due to local reductions in sand eel numbers, had been expressed (Evans et al. 1993, Evans & Borges 1995) whilst increases in the southernmost North Sea and eastern part of the Channel had been reported by a number of authors (Camphuysen & Leopold 1993, Camphuysen 1994, Witte et al. 1998, Camphuysen 2004, Haelters & Camphuysen 2009).

Besides the snapshot large-scale SCANS surveys, most cetacean survey effort in the 1980s and 1990s relied upon measures of relative abundance and did not necessarily follow a systematic line transect design (Northridge et al. 1995, Reid et al. 2003, van der Meij & Camphuysen 2006). From the 2000s onwards, there was increasing use of aerial surveys to determine both seasonal and annual trends in abundance (Scheidat et al. 2004, 2012, Siebert et al. 2006, Gilles et al. 2009, 2016). These could make use of brief windows of good weather and cover large areas in a short time. Those surveys were initiated to identify and monitor areas of persistent high density that could then be proposed as Special Areas of Conservation for harbour porpoise as part of the EU Habitats Directive's Natura 2000 network, and to establish the potential impacts of offshore renewable development in the form of wind farms. For the latter, aerial surveys were combined with click detectors (first T-PODs and later, C-PODs) to monitor changes in porpoise presence in the vicinity of pile driving activities during the construction phase of wind turbines (Gilles et al. 2009, Tougaard et al. 2009, Brandt et al. 2011, Scheidat et al. 2011, Dähne et al. 2013, Peschko et al. 2016). Studies in the North Sea and Baltic found different levels of impact at different sites, thought to reflect the context in which the site was used by the species. At Horn Rev, for example, effects were found up to ca. 20 km from the pile driving activity (Brandt et al. 2011) and in the test area

of "*alpha ventus*" more than 25 km (Dähne et al. 2013). However, a review of the effects of the construction of eight offshore wind farms in the German North Sea between 2009 and 2013, could find no long-term population effects (Brandt et al. 2016).

In examining for population level effects of human activities like fisheries and noise, it is important to have a good understanding of population structure. A combination of genetics, morphometrics, life history parameters, stable isotope and contaminant loads, and telemetry studies has been used to establish management units (demographically distinct populations) for various small cetacean species (Evans & Teilmann 2009, ICES WGMME 2014). Within the North Sea, these remain tentative, and there is still debate as to whether North Sea porpoises should be considered a single, two, or even three management units (ASCOBANS 2014).

Research on cetaceans in the North Sea has tended to focus upon the harbour porpoise, probably because it is the commonest and most widespread cetacean species with between 300,000 and 350,000 estimated across the region (Hammond et al. 2017). However, several other cetacean species inhabit the North Sea either year-round (e.g. bottlenose dolphin *Tursiops truncatus*, white-beaked dolphin *Lagenorhynchus albirostris*) or seasonally (e.g. minke whale *Balaenoptera acutorostrata*, fin whale *Balaenoptera physalus*), and some species (e.g. Atlantic white-sided dolphin *Lagenorhynchus acutus*, killer whale *Orcinus orca*, long-finned pilot whale *Globicephala melas*) which normally live further offshore in deeper waters do annually come into the northern North Sea (Evans et al. 2003, Reid et al. 2003, Camphuysen & Peet 2006).

Although bottlenose dolphins were once a regular feature off the Dutch coast (Verwey 1975, Kompanje 2001), nowadays the species occurs mainly in eastern Scotland, particularly the Moray Firth where it has been studied intensively (see, for example, Wilson et al. 1997, 1999, 2004), with a population size of around 200 (Cheney et al. 2012, 2014). Since the 1990s, the species has extended its range southwards from the Moray Firth as far south as Yorkshire, with occasional sightings off Norfolk. Bottlenose dolphins in the North Sea are recorded only occasionally away from the coastal zone (Reid et al. 2003, Cheney et al. 2012).

White-beaked dolphins are widely distributed in the North Sea, with a population size of between 20,000 and 30,000, although numbers appear to be greatest in the central and northern sectors (Northridge et al. 1995, Evans et al. 2003, Reid et al. 2003, Hammond et al. 2002, 2013, 2017). Surprisingly, we have relatively poor information on the biology of the species, although in recent years, there have been new studies on its habitat preferences, life history, diet, and genetics (Kinze et al. 1997, Canning et al. 2008, Banguera-Hinestroza et al. 2010, Jansen et al. 2010, Galatius & Kinze 2016). Camphuysen & Peet (2006) have suggested that the southern North Sea cetacean community changed markedly during the 20th century, from a *Tursiops*/*Delphinus* (bluefin tuna/great shearwater) constellation mid-century towards a white-beaked dolphin 'constellation' by the end of the 20th century.

The minke whale is the most common and widely distributed baleen whale in the North Sea (Northridge et al. 1995, Evans et al. 2003, Reid et al. 2003), with a population size somewhere between 5,000 and 15,000 (Hammond et al. 2002, 2013, 2017). In the north-western North Sea, it suffers incidental entanglement in creel lines and other ropes as well as ghost netting (Northridge et al. 2010). The much rarer humpback whale, which is experiencing something of a resurgence in the region (Evans et al. 2003, Smeenk et al. 2003, Camphuysen 2007, Leopold et al., this volume), is also a victim of entanglement in similar gear, causing additional concern (Ryan et al. 2016).

One cetacean species, not a native of the region, above all others attracts much media attention when it wanders into the North Sea. That is the sperm whale (*Physeter macrorhynchus*). Strandings of several sperm

whales have occurred on a number of occasions in the southernmost North Sea, the most recent notable examples being in March 1996, December 1997, and January-February 2016. Many theories are discussed as possible factors resulting in these strandings, including increasing sperm whale stocks, side effects of migrating animals, solar storms, diseases, chemical pollution, temperature anomalies and anthropogenic noise (Sonntag & Lütkebohle 1998, Wright 2005, Vanselow & Ricklefs 2005, Pierce et al. 2007, Vanselow et al. 2009, 2017), although some believe there is no need to seek elaborate explanations for these "accidents" (Evans 1997, Smeenk 1997). Chris Smeenk took a special interest in documenting the sperm whale strandings that have occurred across the centuries, and studiously corrected a number of records that were misleading or wrong. In this special issue, a catalogue of strandings of this species in the North Sea since the thirteenth century is presented.

In the last two decades, strandings schemes have consolidated in all the countries bordering the North Sea, with increased emphasis upon investigations to determine causes of death (Clausen & Andersen 1988, Baker & Martin 1992, Siebert et al. 2001, Wünschmann et al. 2001, Jepson et al. 2000, 2009, Jauniaux et al. 2002, Jepson 2005, Camphuysen et al. 2008, Haelters & Camphuysen 2009, Kinze et al. 2010, Deaville & Jepson 2011). Post mortem studies have also been extremely valuable for stomach contents analysis for dietary studies (see, for example, Pierce et al. 2004, Canning et al. 2008, Jansen et al. 2010), analyses of contaminants and their effects (Bruhn et al. 1999, Siebert et al. 1999, Das et al. 2004, 2006, Beineke et al. 2006, Law et al. 2010, Jepson et al. 2005, 2016; Murphy et al. 2015), reproductive (Addink & Smeenk 1999, Lockyer 2003, Learmonth et al. 2014), morphometric (Kinze 1985) and genetic studies (Tolley et al. 1999, Andersen et al. 2001, Banguera-Hinestroza et al. 2010).

The North Sea, particularly its southernmost sector, has been experiencing profound changes to its climate (Rayner et al. 2003, Hughes et al. 2017) which in turn has affected plankton (Edwards et al. 2001, 2002, 2013, Beare et al. 2002), cephalopod (van der Kooij et al. 2016), and fish (Perry et al. 2005) communities. The marked expansion of cephalopod numbers in the North Sea may account for a recent increase in occurrence of Risso's dolphin (*Grampus griseus*) in the central and north-western North Sea, and, similarly, the spread of sardine and anchovy may be why common dolphins (*Delphinus delphis*) are now being seen regularly in this same region (Evans & Bjørge 2013). In coming years, we may expect increased frequency of occurrence of species that have their main range in warmer waters to the south, such as striped dolphin (*Stenella coeruleoalba*) and Cuvier's beaked whale (*Ziphius cavirostris*), but a northward shift increasingly out of the area of the more northern species, white-beaked dolphin and Atlantic white-sided dolphin.

In the last half century, our knowledge of the cetacean fauna of the North Sea has increased tremendously. Nevertheless, there are still many gaps. We little understand movements within the North Sea for most species and there remains great uncertainty over their population structure and demographies. Much of the focus for study has been upon the harbour porpoise (and, in Scotland, the bottlenose dolphin); there is scope for increased research effort on white-beaked dolphin and minke whale, not to mention some of the other species that may become a regular component of the North Sea cetacean fauna. This special issue of Lutra commemorates the life of Chris Smeenk who over the period under review here has made so many significant contributions to cetacean research in the North Sea.

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