Mission accomplished: chronic North Sea oil pollution now at acceptable levels, with Common Guillemots *Uria aalge* as sentinels

In memory of Peter Hope Jones

Kees (C. J.) Camphuysen[1*]

** Correspondence author: kees.camphuysen@nioz.nl*

[1] *Royal Netherlands Institute for Sea Research (NIOZ), P.O. Box 59, 1790 AB Den Burg, Texel; Nederlandse Zeevogelgroep (NZG), Den Helder, The Netherlands.*

Abstract

Marine oil pollution has been an issue of concern for at least a century. The earliest reports contained outrage over oil-contaminated dead seabirds found ashore. This paper reports on observed trends in strandings and oil rates of Common Guillemots *Uria aalge* to illustrate the history of oil pollution and its effects in the North Sea. This paper is also a tribute to Peter Hope Jones, who brought systematic beached bird surveys and oil-spill impact assessments to a higher level, by implementing detailed research on affected wildlife. In recent decades, unexpectedly, the oil problem has disappeared almost completely from the North Sea. Given the global nature of current environmental issues, including the climate and biodiversity crises, it may be instructive to examine the background to this stunning success. A short history of major oil events is presented, including the measures taken to reduce the oil problem. It required a succession of major oil incidents to push the community into action. The process of international conventions was notoriously slow, and the implementation of concrete measures even slower, as economic arguments prevailed to prevent or delay immediate action.

Introduction

Marine oil pollution has been an issue of concern for at least a century. One of the most dramatic and visible effects of oil pollution is the contamination and associated mass mortality of seabirds at sea (Bourne 1976; Croxall 1977; Reineking & Vauk 1982; Clark 1984; Dunnet 1987; Camphuysen 1989a; Danielsen *et al*. 1990). For decades, it seemed a tough nut to crack. Yet, miraculously, and in the course of only a decade or two, the problem has now disappeared almost completely from the North Sea, and in fact from most other areas worldwide. Give or take a few oil incidents, chronic oil pollution is now, quite suddenly, something from the (recent) past. Now that many people get depressed and feel frustrated by the global nature of current environmental issues, such as the climate and biodiversity crises, the effects of agriculture or fisheries, plastic pollution, or 'just' the human population increase, it may be worthwhile to document this stunning success. How did it come about, how did it develop and escalate, and, most of all, how could it end?

Plate 1. Oiled Common Guillemot *Uria aalge*, Texel, 10 April 2007. © *Jan van Franeker*

Oil pollution (petroleum hydrocarbons, PHCs) enters the marine environment from a variety of sources, including transport (e.g. deliberate discharges or accidental leakages of bilge and fuel oil), tanker operations or shipping accidents, atmospheric emissions, releases or leakages from coastal refineries, offshore production installations or marine terminals, from urban or river run-off (e.g. municipal or industrial waste), together with natural inputs (Wardley-Smith 1976; NRC 1985; Wolfe 1985; Clark 2001). Here I will focus on the situation in the North Sea, where the prime sources for most of the easily *visible* chronic marine oil pollution were (and in a way still are) transport, releases or leakages from offshore installations, and shipping incidents (e.g. Dunnet 1987; Dahlmann *et al*. 1994; Camphuysen 2007a).

The first written reports of marine oil pollution expressed outrage over oil-contaminated dead seabirds found on beaches (Anon. 1910; Dawson 1911; Verwey 1915). Even then it was clear that divers (loons), grebes, sea ducks and auks were the groups most severely affected by oil. This northern-hemisphere perspective was subsequently extended to include penguins and cormorants, and it was confirmed that species that spent the majority of their time swimming had a higher sensitivity to oil pollution than more aerial groups such as tubenoses, skuas, gulls and terns (King & Sanger 1979; Gandini *et al*. 1994; Camphuysen 2007a). Since the earliest accounts, the publication record on oil-related seabird mortality and oil incidents is massive.

Common Guillemots *Uria aalge* (hereafter 'Guillemots') have been over-represented in published reports of oiled birds in the North Sea. Abundant and highly vulnerable seabirds as they are, they commonly washed ashore and are still often found on beaches today. It was not until the early twenty-first century that the EU Marine Strategy Framework Directive insisted on the implementation of an independent indicator to evaluate the effectiveness of measures to reduce chronic oil pollution (OSPAR 2010). The so-called 'oiled-Guillemot-EcoQO' was adopted, an Ecological Quality Objective (EcoQO) to assess fluctuations, patterns and trends in chronic marine oil pollution, and beached bird surveys officially became that independent monitoring instrument. The oil rate in Guillemots was selected because the species was abundant enough to be useful as a 'Canary in the coalmine' in all North Sea countries (OSPAR Commission 2009).

The oiled-Guillemot-EcoQO came late, and was just a measuring instrument. At least 100 years had already been spent on attempts to *reduce* the oil problem, but initially with little effect. To refresh our collective memory, it seems timely to present a short history and a timeline of both the worrying signals, as published since the early twentieth century, and the measures taken to reduce the oil problem.

This paper reports on observed trends in strandings and oil rates (% oiled) of Guillemots to document the history of oil pollution and its effects in the North Sea. It uses data collected from birds that washed ashore along the Dutch coast over the past 120 years (1900–2020), or throughout the entire twentieth and early twenty-first centuries. But not only that. It was the late Peter Hope Jones who, in the late 1970s, brought both systematic beached bird surveys and incidental oil-spill impact assessments to a higher level, by implementing more detailed research on affected wildlife. He saw the ecological importance as well as the relevance for seabird conservation of collecting as much information as possible from animals that were otherwise largely out of reach, far out at sea. An important step was to collect and study carcasses such that, for example, age composition and the (likely) colonies of origin could be assessed. As a tribute to his legacy, I will therefore present and discuss results obtained by using his initial protocols (Hope Jones *et al*. 1978, 1982, 1984, 1985, 1988; Hope Jones & Morgan 1979), partly updated in later years (Kuschert *et al*. 1981; Camphuysen 1983, 1995a, 2007b; Maas 1983; Sandee 1983; Franeker 1983; Harris 2014). As a result of these 'extra' observations, regular beached bird surveys became more than just a demonstration of an existing environmental problem. We were able to learn things from birds that were otherwise notoriously hard to study. The results are valuable pieces of the jigsaw puzzle, especially when combined with results from studies on breeding grounds, at-sea surveys, seawatching, ringing studies, dietary studies using proxies such as eDNA, stable isotopes or fatty acids, and novel tracking studies.

Materials and methods

Underlying the historical review are scientific publications as well as – and in this case perhaps even *primarily* – numerous unpublished or 'grey' reports and papers that have documented oil pollution and its effect on seabirds. An overview and a timeline of events is provided, covering reports of strandings, major spills, international agreements and associated legislation to minimise or prevent oil pollution, and the development of oil and gas exploration within the North Sea basin (Table 1).

Table 1. Timeline of major events, oil spills, and steps to reduce marine oil pollution, and the effects on seabirds.

Year(s)	Events and actions	Effects and impacts
1861	*Elisabeth Watts*, a sailing vessel, was the first ship to carry a full cargo of oil across the Atlantic	
1910s		Early reports of oiled seabirds and oil pollution, USA and Europe
1914–18	First World War	Numerous oiled seabirds related to war activities at sea
1920s		Reports of oiled birds on beaches with increasing frequency
1920s	Regional or local measures to reduce pollution in harbour (risk of fire, damage to campshot and other woodwork)	
1930	'Progress made in combatting oil discharges at sea': the installation of oil separators in ships 'deemed necessary' (Barclay-Smith 1930)	
1930s		Reports of oiled birds on beaches continue with high frequency (Bootsgezel 1933; Anon. 1934; Westhoff 1936; Jongens 1937)
1939–45	Second World War	7,800 sunken vessels (including 860 oil tankers) worldwide
1947–50	Early beached bird surveys in The Netherlands (Brada 1950; Mörzer Bruijns 1959)	
1950s	Ship-owner organisations enforce restrictions on crews	
1950–55	Early beached bird surveys in Belgium (Hautekiet 1955)	
1954	IUCN calls for systematic beached bird surveys to be organised	
1954	International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL) signed in London	
1956–58	United Nations conferences on the topic of the law of the sea in Geneva (Switzerland)	
1957–59	Early beached bird surveys in Germany (Drost 1959)	
1958	OILPOL enforced following ratification by 11 countries worldwide	
1959		Further complaints about wildlife damage resulting from oil
1959	International Conference on Oil Pollution, Copenhagen, 3–4 July 1959	
1959	OILPOL administered and promoted by International Maritime Organization (IMO), London	
1959	Discovery of huge gas fields in Lower	

	Permian sandstones under the southern North Sea (Larminie *et al*. 1987)	
1960s	Early beached bird surveys in the UK (Parslow 1966)	
1960–64		Oil rates of pelagic seabirds in southern North Sea c. 76–98%, coastal birds c. 44–76% *
1962	OILPOL updated	
1963	Aeromagnetic and seismic surveys south of 58°N following the major gas discoveries	
1964	Geneva convention (1958) on the territorial seas comes into force, settling the subdivision of North Sea sectors for oil/gas exploration	
1964	Continental Shelf Act (UK), governing drilling for oil on the continental shelf around the British Isles	
1965	British Petroleum (BP) discovers first commercial hydrocarbons, West Sole gasfield	
1967	Stranding of the *Torrey Canyon*, Land's End, Cornwall, UK	International commotion following event
1968	Start of beached bird surveys in Denmark (Joensen 1972)	
1965–69		Oil rates of pelagic seabirds in southern North Sea c. 92–99%, coastal birds c. 78–99%
1969	Phillips make first commercial oil discovery, Ekofisk oil field	
1969	OILPOL updated	
1969	Start of European 'International Beached Bird surveys' (annual mid-winter censuses; Bourne & Devlin 1970)	Small mystery spill off the Dutch Wadden Sea islands, tens of thousands of sea ducks dead (Swennen & Spaans 1970)
1970–71	BP, Amoco and Shell make further commercial oil discoveries in the North Sea (e.g. Forties, Brent, Clair fields)	
1971	OILPOL updated, following oil accident with *Oceanic Grandeur* causing concerns about Great Barrier Reef	
1973/78	International Convention for the Prevention of Pollution from Ships (MARPOL) adopted at IMO	
1970s	Aerial surveys to detect oil slicks visually	
1970s–80s	Rapid development of oil fields in the North Sea, submarine pipeline constructions	
1970–74		Oil rates of pelagic seabirds in southern North Sea c. 84–98%, coastal birds c. 54–93%
mid-1970s		Densities of auks washing ashore in the southern North Sea much reduced in comparison to earlier decades
1977	*Ekofisk Bravo* blow-out, Norwegian sector North Sea	

1978	Stranding of the *Amoco Cadiz*, Les Sept Iles, Brittany, France	International commotion following event
1978	MARPOL Protocol of 1978 adopted in response to a spate of tanker accidents in 1976–77 (MARPOL still not into force)	
1975–78	Construction of Sullom Voe oil terminal in Shetland, UK	
1977	Opening of Flotta oil terminal in Orkney, UK	
1975–79		Oil rates of pelagic seabirds in southern North Sea c. 79–96%, coastal birds c. 58–89%
1978	Large oil spill at Sullom Voe, *Essa Bernicia* leaks 1,174 tons of heavy fuel oil	3,700 seabirds found oiled (Richardson *et al*. 1982)
1978–79		c. 6,800 oiled seabirds washed ashore in the Northern Isles (Shetland and Orkney) after the opening of oil terminals (Richardson *et al*. 1982)
1978–82	Remote sensing techniques developed to detect oil slicks at night and in poor weather during aerial surveys	
1979		Minor spill in north Norway kills 10,000–20,000 seabirds, mostly Brünnich's Guillemots (Barrett 1979)
1979	Formation of UK Nature Conservancy Council's Seabirds At Sea Team; the onset of systematic ship-based surveys in the North Sea	
early 1980s		Sharp increase in densities of auks and Black-legged Kittiwakes washing ashore in the southern North Sea in comparison to 1970s
1983	MARPOL Annex 1 enters into force, prevention of oil pollution by oil and oily water, 2 October 1983	
1980–84		Oil rates of pelagic seabirds in southern North Sea c. 88–90%, coastal birds c. 37–78%
1984	First atlas of seabird distribution in the North Sea published (Blake *et al*. 1984)	
1985–89		Oil rates of pelagic seabirds in southern North Sea c. 72–90%, coastal birds c. 23–90%
1989	Stranding of the *Exxon Valdez*, Alaska, USA	International commotion following event
1991	The Gulf War oil spill, or Persian Gulf oil spill, one of the largest oil spills in history, resulting from the Gulf War	
1993	Stranding of the *Braer*, Shetland, UK	International commotion following event
1993	First atlas of (area) vulnerability to surface pollutants in the North Sea published (Carter *et al*. 1993; Begg *et al*. 1997)	
1994	Satellite oil slick detection (SAR), to improve oil slick detections (independent of aeroplanes with relatively small coverage)	
1990–94		Oil rates of pelagic seabirds in southern North

		Sea c. 54–74%, coastal birds c. 13–67%
1995	Adoption of Oiled Seabird EcoQO, OSPAR	
1997	MARPOL new protocol adopted to amend the Convention, Annex VI added (prevention of air pollution from ships)	
1995–99		Oil rates of pelagic seabirds in southern North Sea c. 53–57%, coastal birds c. 9–69%
1998		Beached bird surveys indicate decline in chronic oil pollution in the North Sea (Camphuysen 1998)
1999	*Erika* oil spill, Bay of Biscay (France)	
1999	Northwest European waters Special Area under MARPOL	
2002	Small *Tricolor* oil spill off the coast of northern France and Belgium	Following *Tricolor* spill, thousands of seabirds washed ashore in four North Sea countries
2002	*Prestige* oil spill, Bay of Biscay (Spain)	
2000–04		Oil rates of pelagic seabirds in southern North Sea c. 56–78%, coastal birds c. 4–58%
2005		Confirmation that frequency of tanker spills, worldwide, declines (Huijer 2005, ITOPF 2008)
2005	MARPOL 1997 protocol on air pollution from ships enters into force, 19 May 2005	
2005–09		Oil rates of pelagic seabirds in southern North Sea c. 28–44%, coastal birds c. 2–38%
2009	*Full City* oil spill, Rognsfjorden, Norway	
2010		Beached bird surveys indicate further decline in chronic oil pollution in the North Sea (Camphuysen 2010; Lagring *et al.* 2012)
2010	Deepwater Horizon/BP oil spill in the Gulf of Mexico, largest spill in US history	International commotion following event
2011		Decline in oil slick detections in the southern North Sea reported (Zoest *et al.* 2011)
2011	*TK Bremen* oil spill, Brittany	
2011	*Gannet Alpha* platform oil spill, northwest North Sea	
2010–14		Oil rates of pelagic seabirds in southern North Sea c. 3–28%, coastal birds c. 1–5%
2016	*Clair* platform oil spill, Shetland, UK	
2015–19		Oil rates of pelagic seabirds in southern North Sea c. 6–9%, coastal birds c. 0–5%
2020–21		Oil rates of pelagic seabirds in southern North Sea c. 5–10%, coastal birds c. 0%

* North Sea oil rates are based on beached bird surveys in winter in The Netherlands, summarising a five-year period, with Common Guillemots *Uria aalge*, Razorbills *Alca torda* and Black-legged Kittiwakes *Rissa tridactyla* representing 'pelagic seabirds', and Common Eiders *Somateria mollissima*, Common Scoters *Melanitta nigra* and Herring Gulls *Larus argentatus* representing 'coastal birds'. Percentages are fractions oiled of all intact birds found in these periods.

Strandings data used here were extracted directly from the beached bird survey database of the Dutch Seabird Group (Nederlands Stookolieslachtofferonderzoek, NSO), collected between 1901 and 2020 (14,600 counts, covering 79,812 km, resulting in 303,090 reported birds or marine mammals of which at least 53,236 were Guillemots). The quality of these datasets ranged from incidental (often published) accounts (1901–1946) to more or less systematic beached bird surveys (1947–2020), year-round, or at least representing the winter periods (Mörzer Bruijns 1959; Tanis & Mörzer Bruijns 1962; Camphuysen 1989a, 2020, 2021). Early data are often snapshots highlighting particular strandings, and lack negative findings. Most recent data include more exact information on date and location, the 'completeness' of the count, identification protocols, species, age, sex, oiling, and the condition of the corpse, whenever this was available. Most importantly, recent data (i.e. the systematic beached bird surveys) hold information on all beach visits, even when there was nothing to report (null counts). During the peak of observer effort (since the late 1970s) corpses were marked by clipping wing tips to avoid double counts. Densities (N km^{-1}) are based on surveys in which the survey effort (distance walked in km) is known.

Given differences in offshore (foraging) habitat, species found were usually grouped into three major categories: pelagic seabirds (tubenoses, gannets, skuas, Black-legged Kittiwakes *Rissa tridactyla* and auks), coastal species (divers, grebes, cormorants, sea ducks, all other gulls, and terns), and land birds (not considered in this contribution). The consistent differences in oil rates (percentage oiled of all found dead) between the pelagic seabirds and coastal species (Camphuysen 2007a), seen as the group-specific risks to become

Plate 2. Common Guillemots *Uria aalge* lined up for necropsies, NIOZ, Texel, 11 October 2021. © *Kees Camphuysen*

contaminated with oil while at sea, are used to illustrate long-term trends over five-year winter periods in Table 1.

Since the early 1980s, following recommendations by Peter Hope Jones among others, necropsies formed part of the annual protocols in several areas around the North Sea, resulting in detailed information on age composition and sex ratios of the collected birds (4,943 seabirds, including 2,129 Guillemots). Guillemots were aged on the presence or absence of white tips on greater underwing coverts (Kuschert *et al*. 1981; Camphuysen 1995a), or on colour contrast on the greater primary coverts (Sandee 1983), or following a necropsy on the basis of the presence or absence of the bursa Fabricii and the development of the gonads (Franeker 1983; Hope Jones 1985; Camphuysen 2007b), or based on a combination of all characteristics.

Presented biometrics are exclusively for sexually mature Guillemots, unless clearly indicated otherwise. Standard biometrics included bill length (tip to feathers (bill1), tip to nostril (bill2)) and bill depth (at base (depth1), at gonys (depth2)), all to 0.1 mm, head length (back of the head to bill tip), wing length (flattened, stretched, maximum chord), and tarsus, all in millimetres, plus body mass (for intact dry corpses) in grams. Plumage patterns ranged from full summer plumage (B), via transitional stages (T) to winter plumage (W), based on the head pattern, taking individual variation in winter plumage patterns into account. Internal ageing was based on the presence and size of the bursa Fabricii and the development of the gonads (details in Camphuysen 2007b). Birds were thus classified as first-year (juvenile) versus second-year (immature) and adult. External ageing was based on the presence (GUC+) or absence (GUC–) of white tips to the greater underwing coverts of the secondaries, which meant a split between first-year birds (juveniles) and the rest (a mix of adults and immatures). The accuracy of this simple external characteristic (GUC+/GUC–) was high, according to internal investigations (gonads and bursa), with 97.5% (N = 1,217) of all dissected and clean Guillemots being correctly aged. Juvenile birds (checked internally) had white tips on their greater underwing coverts (GUC+) in 98.7% of all cases (N = 456). Immatures (5.6%, N = 196) and adults (2.3%, N = 565) scored significantly lower. If 'silvery white fringes' (frequent in adult summer-plumage birds) had been excluded from the GUC+ group, the score would have been even better.

Oil rates (% oiled of all birds found) were based on intact corpses only, and trends in oil rates were calculated using linear regression over time, following logit transformation of the annual or seasonal values (Camphuysen 1995b, Camphuysen & Dahlmann 1995, Camphuysen & van der Meer 1996). Following instructions adopted under the OSPAR oiled-Guillemot-EcoQO, a five-year running mean of (winter, i.e. November to April) oil rates was calculated. That is because the oiled-Guillemot-EcoQO, as agreed by the Fifth North Sea Conference, was defined as 'the proportion of such birds should be 10% or less of the total found dead or dying, in all areas of the North Sea' (Anon. 2002), later refined to target mean proportions of 20% in 2020 and 10% in 2030 over periods of at least five years (Anon. 2012).

A short history of oil and oil pollution

The modern history of petroleum began in the nineteenth century with the refining of paraffin from crude oil. The Elisabeth Watts, a sailing vessel, is generally credited with being the first ship to carry a full cargo of oil across the Atlantic (Anon. 2021). She commenced her career in 1861. Fuel oil and diesel engines were first employed in shipping in the decade before the First World War. Significant losses of oil at sea following these innovations in ship propulsion and auxiliary machinery may have occurred, but they went unnoticed. Oiled seabirds, as a novel phenomenon, were first reported in the early twentieth century (Anon. 1910; Dawson 1911; Verwey 1915). The very first reports of oil pollution sounded alarming, but they also indicated that oiled birds, and even the source of the oil, were already known. An example is Dawson (1911), reporting from the Farallon Islands in California:

> *Murres are said to be less abundant than in the days of the eggers. If this be so, it is because of the domination of the Western Gull, this and the ravages of the crude-oil plague. The region just outside of the Golden Gate is especially cursed by this unlawful practice, the cleaning out of the water (and oil waste) ballast of the 'tankers' just previous to entering the harbor. That this is an active factor in bird destruction is attested by the abundance of oil-soaked carcasses which line the sparse beaches of the southeast Farallon. Murres are the chief sufferers, but Grebes, Loons, Scoters, and Pigeon Guillemots are frequent victims, and the destruction goes relentlessly on in winter as well as summer.*

In Europe, the First World War can be seen as the period in which oil pollution became more prominent, and war activities in the North Sea (e.g. torpedoed vessels) were thought to be responsible for the earliest oil slicks (Verwey 1915). The war ended, but the oil problem remained in peace time and even increased. Numerous reports were published between 1918 and 1930, dealing with sometimes very large numbers of seabirds, often completely smothered in oil. 'Tar birds' (teervogels) became a new name for Guillemots in The Netherlands (Tromp 1927; Jongens 1937). The oil on beaches became a year-round nuisance, and oiled seabirds washed ashore every single winter, often in large numbers, with Guillemots most prominent among them.

Major oil incidents occurred, sometimes killing many thousands of seabirds and waterfowl with a single blow. Examples of some more recent shipping accidents in northwest Europe are: Torrey Canyon (1967), Tank Duchess (1968), Hamilton Trader (1969), Texaco Westminster (1969), Pacific Glory (1970), Elisabeth Knudsen (1971), Olympic Alliance (1975), Pacific Colocotronis (1975), Athenian Victory II (1976), Amoco Cadiz (1978), Eleni V (1978), Esso Bernicia (1978), Andros Patria (1979), Stylis (1981), Katina (1982), Benetank (1982), Nordlys (1982), Yumpa (1982), Vostosc II (1983), Bayard (1984), Mont Louis (1984), Borcea (1988), Rose Bay (1990), Norgas (1991), Nordfrakt (1992), Braer (1993), Mairbritt Terjkol (1993), Sherbro (1994), Sea Empress (1996), Pallas (1998), Erika (1999–2000), Sloman Traveller (2001), Tricolor (2002), Prestige (2002–2003), Andinet (2003), Assi Euro Link (2003), Rocknes (2004), Napoli (2007), Statfjord (2007), Full City (2009) and

TK Bremen (2011). The list is seemingly endless, but around 2005 came confirmation that tanker spills, worldwide, decreased (Huijer 2005; ITOPF 2008). Each and every spill was different in the impact on resident seabirds (local breeding populations) or wintering birds (breeding elsewhere), and there is no (positive) correlation between the amount of oil spilled and the number of casualties counted or otherwise retrieved (Camphuysen *et al.* 2005). That is because some spills occurred in areas were high concentrations of sensitive seabirds were present, whereas others occurred in areas of lower sensitivity (Carter *et al.* 1993). Oil spills near wintering concentrations of seabirds and waterfowl produced many more casualties than most summer spills or blow-outs.

Meanwhile, the endless stream of oiled birds on beaches could not usually be attributed to a particular source of oil. Oil pollution had become 'chronic'. Every now and then the mortality from localised but otherwise unattributed spills was considerable, with wildlife losses far in excess of those caused by several of the 'major' spills (e.g. Swennen & Spaans 1970; Barrett 1979). Within the North Sea, most minor spills clearly originated from shipping, given that nearly all oil slicks that were found during visual inspections and with remote sensing techniques marked the major shipping lanes (Figure 1; Camphuysen & Vollaard 2015; Carpenter 2015). The spatial match between oil slicks and stranded oiled Guillemots sparked the interest of authorities, not least because there were almost 'clean areas', such as around Orkney and Shetland, that could be used as reference areas or target conditions (Heubeck *et al.* 1992; Heubeck 1992, 1995; Furness & Camphuysen 1997; OSPAR & Camphuysen 2005).

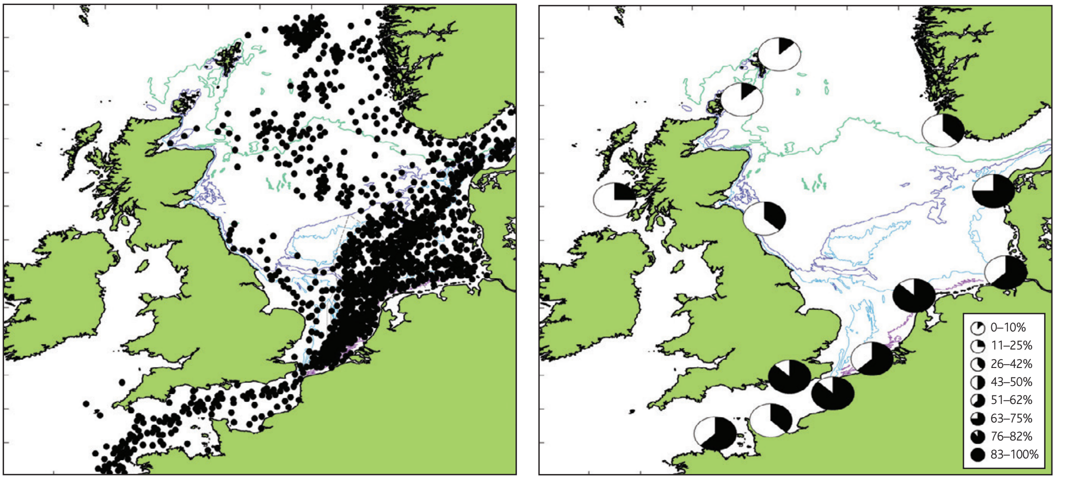

Figure 1. Left: From 1998 to 2004, 4,900 oil slicks were detected in the North Sea by aerial surveillance by the members of the Bonn Agreement (Belgium, Denmark, France, Germany, The Netherlands, Norway, Sweden, United Kingdom), accurately reflecting the major shipping lanes through the English Channel and into the southeast North Sea towards the Baltic as well as the numerous oil production platforms in the central and northern North Sea (EC MIDIV project of the EU Joint Research Centre by the Institute for the Protection and Security of the Citizen, Italy). **Right:** Spatial patterns in oil rates of Common Guillemots *Uria aalge* washed ashore matched the spatial pattern of released slicks, with particularly high oil rates around the busiest shipping lanes in the southeast and south (International Beached Bird Surveys, 1980s–1990s).

For the North Sea, the discovery of huge gas fields in Lower Permian sandstones onshore in Groningen (The Netherlands) by Shell in 1959 was another turning point (Larminie *et al*. 1987). Given similar geological formations under England and the southern North Sea, the expectations were considerable. What followed, also triggered by the Suez crisis (1956/57), was a North-Sea-wide search for (commercial) oil and gas deposits, and the first successes were finds by British Petroleum (BP) in 1965 (Sole gasfield), Shell/Esso in 1966 (Leman gasfield), and Phillips in 1969 (Ekofisk oil field). BP, Amoco and Shell made further commercial oil discoveries in the North Sea in the early 1970s (e.g. Forties, Brent, Clair fields). Rather than just a busy sea in terms of shipping and oil transport, the North Sea was now a basin in which oil and gas drilling became a major industry. Effects on at-sea wildlife soon became apparent and, for example, virtually all of the clusters of detected oil slicks shown in Figure 1 in the central and northern North Sea originated from offshore platforms.

Major spills and accidents from oil or gas platforms in the North Sea were the Ekofisk Bravo blow-out (1977), the Alexander L Kieland capsize (1980), the Piper Alpha explosion (1988), the Statfjord oil spill (2007), the Gannet Alpha oil spill (2011) and the Clair oil spill (2016). Many of these resulted in several human deaths and to the tightening of health and safety regulations in the offshore industry. There is little doubt that the environment also benefited from some of the new restrictions imposed. However, major incidents aside, as late as 2014 the UK Maritime and Coastguard Agency (MCA) revealed that even just the British offshore oil and gas platforms reported a total of 601 accidental releases of oil and chemicals in a single year (Mackay 2016). Barely 60 years after the initial discoveries of commercial oil and gas throughout the North Sea, many of the earliest offshore platforms are now defunct or no longer productive, and these are about to be dismantled and removed (Grol 2021).

Legislation, counter-measures and surveillance

Early concerns leading to measures to try and reduce oil pollution had an economic rather than an ecological incentive. The amounts of petroleum oil leaked into harbours, canals and river mouths was so immense that harbour authorities came with local restrictions as early as in the 1920s (Anon. 1923). Damage to wooden structures in harbours and canals and the risk of fire were considered unacceptable. At sea, oil was not recognised as a real problem until the amounts released, dumped and leaked were so high that ship-owner organisations such as the Koninklijke Nederlandsche Reedersvereeniging recognised the economic costs of the release of oil products that would have been perfectly usable if kept on board (Anon. 1955). Information brochures and specific training programmes for ships' crews were implemented, and, arguably, these measures led to swifter and more drastic reductions of oil pollution than anything that followed.

Growing awareness of the impact of oil pollution on the marine environment led to the introduction of further measures to reduce or eliminate pollution from shipping and the offshore oil industry (Carpenter 2019). The first international treaty was the

International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL, 1954; amended in 1962 and 1969). OILPOL focused on operational releases of oil in coastal areas and areas of special importance, such as coral reefs. In practice, it just safeguarded coastal areas; other locations were out of sight, out of mind. And then in 1967 the Torrey Canyon ran aground near Land's End (Cornwall, UK) (Anon. 1967; Bourne 1967, 1970; Bourne *et al*. 1967). The Torrey Canyon was a first-generation supertanker c. 300 metres in length, and until that date it was the largest vessel to be wrecked, resulting in the world's largest oil spill and the UK's worst environmental accident. The wreck has often been described as the world's first major oil tanker disaster. It attracted massive coverage in the media, and triggered further measures and international negotiations. The next treaty, the International Convention for the Prevention of Pollution from Ships (MARPOL, 1973/78; adoption 1973 [Convention], 1978 [Protocol], entered into force October 1983), would have been different if the stranding of the Torrey Canyon had not occurred. Its urgency was further underlined in 1978 by the wreck of another mammoth tanker, the Amoco Cadiz, near Les Sept Isles, Brittany, France (Hope Jones *et al*. 1978, 1982). MARPOL aimed at further prevention of pollution by oil from operational measures as well as from accidental discharges. MARPOL made it mandatory for new oil tankers to have double hulls and brought in a phase-in schedule for existing tankers to fit double hulls, which was subsequently revised in 2001 and 2003.

With respect to chronic oil pollution, the specific designation of 'Special Areas' under MARPOL Annex 1 (the oil pollution annex) was particularly important, because it seriously restricted the amounts of oil still permitted to be released at sea during operational procedures. Unfortunately, there was substantial reluctance to designate the North Sea as such. While the Mediterranean and the Baltic were adopted immediately, in 1973 (in effect from 1983), together with relatively poorly policed waters such as the Black Sea, the Red Sea and the 'Gulfs area', the North Sea was adopted only in 1997 as part of the 'North West European waters' Special Area, and this entered into force only on 1 February 1999 (in effect on 1 August of that year).

The key steps to consider when looking at long-term trends, or the most prominent measures taken with respect to oil pollution in the North Sea, are summarised in Table 1. Distance to the coast of the observed oil slicks was considered of importance almost throughout this time frame. Oiled birds were bad television, so much was clear, but preventing these birds washing ashore meant minimising oil pollution *nearer* coasts. Open sea, the prime habitat for the more pelagic seabirds, was not an area of particular concern. Aerial surveys to detect illegal operations or oil slicks were primarily visual initially. Remote sensing techniques were developed in the late 1970s and early 1980s; satellite detection became operational much later. Despite numerous detected (illegal) oil slicks at sea, mostly around shipping lanes, only a handful of shipping companies were sued and prosecuted.

Despite the aforementioned international conventions and agreements, oil pollution was still at an unacceptably high level at the end of the twentieth century (Anon. 1995). Beached oiled seabirds during large spills had always caught the immediate attention of the general public, and since the 1950s systematic beached bird surveys had been used to demonstrate the impact of 'chronic oil pollution'. Nonetheless, it took until 1995 before the value of beached bird surveys to monitor oil pollution trends was recognised by international authorities and governments (Anon. 1995). As usual, the actual implementation took a few more years.

Beached bird surveys and the assessments of oil rates

Reports of oiled birds washing ashore were first published in the mid-1910s. Sometimes the birds were counted, sometimes it was just noted that 'many' or 'a lot of' oiled birds were found, with the species name, a date and a location. Verwey (1915) was evidently surprised by his first mass stranding: 'Wednesday I found along the beach 18 guillemots, six gannets, four razorbills, two crows, one curlew and a diver, all but five covered in tar. It seems that a ship full of tar has been torpedoed at sea.' Only six years later, he had established a private research project to study age, moult and migratory movements of Guillemots and Razorbills *Alca torda*, using the hundreds of stranded birds that he could buy for a cent or two from 'boys' roaming the beaches around his home town, Noordwijk aan Zee in The Netherlands (Verwey 1922, 1923, 1927a, 1927b). An early Hope Jones *avant la lettre*, in other words. It demonstrates that oiled seabirds littering our beaches had become mainstream in no time, even in the absence of known major spills or accidents at sea. A new normal. Following an accident involving two American vessels running aground, Woltman (1920) saw his beach on the island of Schiermonnikoog, The Netherlands, flooded with oiled seabirds (mostly Guillemots). Most other authors reporting oiled birds in those early years could not figure out where the pollution came from; it was basically always there, a chronic problem in other words. Numbers washing up fluctuated from year to year, however. Particularly large numbers of oiled seabirds were reported in January 1921, winter 1921/1922, January–February 1928, winter 1929/1930, March 1934, April 1935, October–November 1936, November 1938, February 1946 and March 1949 (Camphuysen 1989a). Most of these mass strandings occurred in winter (November–April).

The ongoing, annual, oil-related seabird mortality triggered a more systematic programme of beached bird surveys in the late 1940s and early 1950s in Belgium and The Netherlands (Hautekiet 1955; Mörzer Bruijns 1959), in the 1960s in the United Kingdom (e.g. Parslow 1966), and subsequently in all countries bordering the North Sea. The results were submitted to the International Council for Bird Preservation (ICBP) for use in a general campaign against oil pollution of the sea. A trial scheme for an international beached bird survey (IBBS) concentrated around the North Sea and eastern Atlantic was established, with systematic coverage of coastlines on specific predetermined dates following the example of the International Wildfowl Counts. Eckhart Kuijken was the first organiser (Hudson 1969).

Oiled seabirds continued to wash ashore every winter, often in high numbers, indicating that chronic oil pollution remained a serious problem. Particularly large numbers were reported in winter 1949/1950, December 1954, May 1958, January 1960, February 1961, April 1965 and December 1967 (Camphuysen 1989a). A 'mystery spill', in January–February 1969, north of the Wadden Sea islands, arguably led to the highest mortality of wintering seabirds ever witnessed within The Netherlands. At least some 30,000–40,000 sea ducks (Common Eider *Somateria mollissima* and Common Scoter *Melanitta nigra*) were affected (Swennen & Spaans 1970). During the 1970s and early 1980s, the oil rates (% oiled of all birds found dead ashore) amounted to 92% in divers (Gaviidae; N = 615), 60% in grebes (Podicipedidae; N = 2,574), 87% in Northern Gannets (*Morus bassanus*; N = 561), 96% in scoters (*Melanitta* sp.; N = 10,963), 84% in Black-legged Kittiwakes (N = 7,000), 89% in Razorbills (N = 4,115) and 89% in Guillemots (N = 14,554). Taken together, oil rates of pelagic seabirds calculated over five-year winter periods varied between 80% and over 95%, and for coastal species between 50% and 95% (Table 1). Such high oil rates, a result of chronic oil pollution rather than of major oil incidents, were among the highest values in the world (Camphuysen 1989a).

Strandings of Guillemots as an indicator

Picking up the data in the early 1960s, and using Dutch results of beached bird surveys for Guillemots as an example, we see that the numbers washing ashore fluctuated considerably between years (Figure 2), while the oil rate was comparatively constant (Figure 3). All pelagic species show similar patterns (Camphuysen & Heubeck 2001; Camphuysen 2021). The oil rate was therefore thought to reflect species-specific variations in the risk of becoming oiled at sea, a function of differences in exposure (Camphuysen 2007a). The oil rate was seen as the more stable and therefore more useful monitoring instrument. Initially, oil rates remained consistently very high, but a gradual decline commenced somewhere in the 1980s (Figure 3).

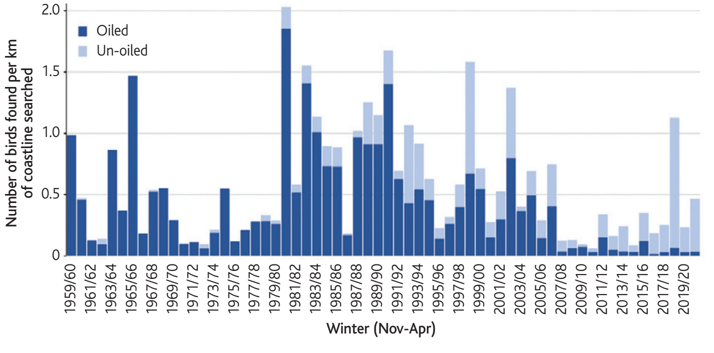

Figure 2. Annual variation in winter densities of Common Guillemots *Uria aalge* washed ashore in The Netherlands, bordering the Southern Bight (November–April, 1959/60–2020/21; after Camphuysen 2021). Numbers oiled were based on oil rates assessed at the time of these surveys; in recent years (since c. 1977) this was based strictly on intact carcasses for which all feathers could be examined.

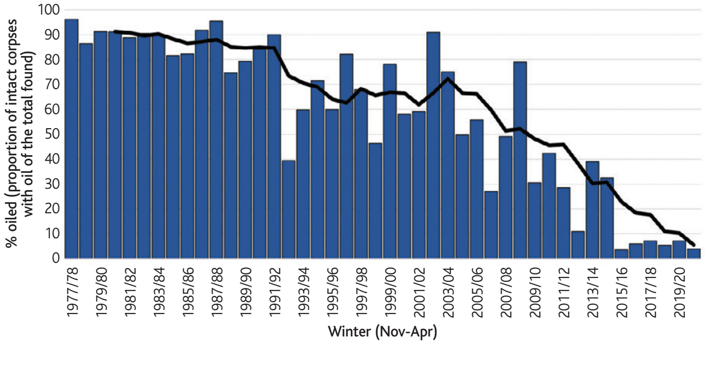

Figure 3. Decline in the proportion (%) of Common Guillemots *Uria aalge* with oil of the total numbers found per winter (November–April, 1977/78–2020/21) in The Netherlands (after Camphuysen 2021). The line shows the five-year running mean.

The international beached bird survey programme came under threat as a result of 'poor results' in the mid-1970s, notably along the shorelines of continental Europe. Fewer carcasses meant that volunteers got bored and less inclined to participate. The initial enthusiasm of the late 1960s, fuelled by the stranding of the Torrey Canyon, gradually faded away. It took another major disaster to renew their interest and commitment: the Amoco Cadiz, which ran aground in Brittany in 1978. The regular systematic surveys were still not very productive in terms of stranded bird numbers, but the headlines in newspapers surrounding that oil spill in France were such that public outrage peaked again.

Numbers of birds washing ashore increased dramatically in the 1980s, with thousands of seabirds found every single winter (Figure 2), still with very high oil rates. Given that the number of birds recorded is only a fraction of the numbers that die at sea (Bibby & Lloyd 1977; Bibby 1981; Keijl & Camphuysen 1992; Hlady & Burger 1993; Ebbesmeyer 2004), concerns were legitimate (Camphuysen 1989a), but was it indeed the oil that mattered most? Picking up the oil rates in the 1970s, we see stable, very high levels initially (Guillemots c. 90% oiled), followed by a gradual, slow but steady decline in the 1980s. In the early 1980s, oil rates of pelagic seabirds calculated over five-year winter periods varied between 88% and 90%, and for coastal species between 40% and 80%, but this fell to 72–90% and 23–90% respectively (in other words much more variable) at the end of that decade (Table 1). Coastal species in particular seemed exposed to fewer and fewer oil slicks at sea. In the early 1990s, this decline continued (pelagic seabirds 55–75%, coastal birds 15–65%), and again into the late 1990s (pelagic seabirds 50–60%, coastal birds 10–70%; Table 1). A (linear) trend analysis for (logit transformed) oil rates in Guillemots showed a highly significant long-term decline, apparently accelerating after 2005 to the current very low levels (Figure 4).

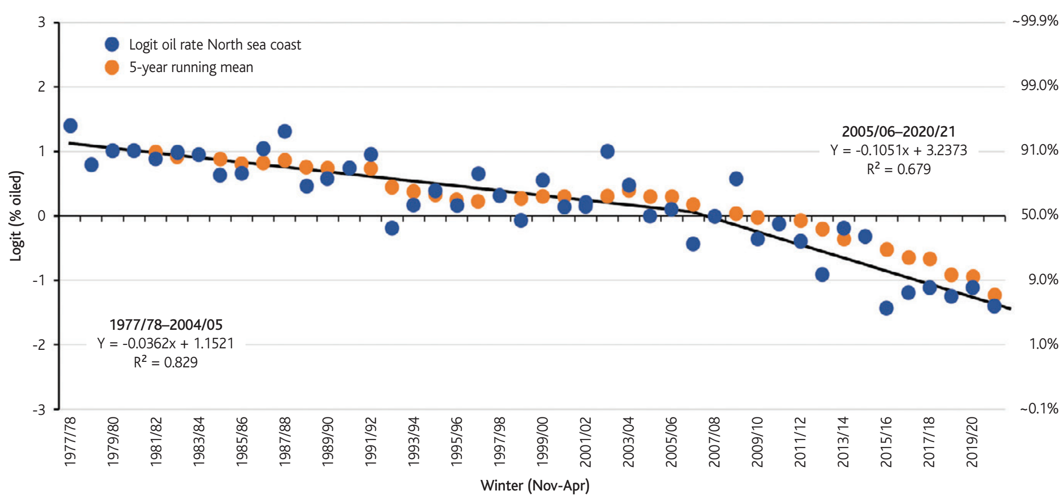

Figure 4. Decline in the logit-transformed proportion (%) of Common Guillemots *Uria aalge* with oil of the total numbers found per winter (November–April, 1977/78–2019/21) in The Netherlands (after Camphuysen 2021, modified). The line shows the linear trends over annual values, split between 1977/78–2004/05 and 2005/06–2020/21 given the apparent acceleration of the decline around that time.

Since 2015, oil rates of pelagic seabirds calculated over five-year winter periods have varied between 5% and 10% and for coastal species between zero and 5% (Table 1). Coastal species are now typically clean (unoiled), and the oil rate of Guillemots has been consistently below 10% for a number of years, despite some minor incidents (isolated slicks) that occurred in some winters. Hence, in a recent annual report covering the 2019/20 season, it could be concluded that:

> *This current figure is the fifth value ever measured within The Netherlands below 10%, and it consolidates the sharp drop in oil-rates that occurred after winter 2014/2015. The most recent data confirm the declining trend once more, as a result of which the 5-year running mean of oil rates in Common Guillemots has now arrived at 5.8 ± 1.5% (mean ± S.D.) for all [Dutch] North Sea beaches combined. The OSPAR target of 20% over periods of at least 5 years for 2020 has evidently been exceeded and that for 2030 (10%) has been reached.* (Camphuysen 2020)

Coastal species showed a steeper and earlier decline in oil rates than the more pelagic species, suggesting that coastal waters were essentially free of oil well before the offshore waters could be considered clean (cf. Camphuysen 2010).

Possible origins of Guillemots stranded in The Netherlands

Few Guillemots found dead ashore during beached bird surveys carried rings (0.1% of birds reported since 1980, N = 47,369), and therefore it was difficult to know the origin of these stranded birds. Witherby (1926) and Witherby *et al.* (1952) described northern Guillemots *U. a. aalge* from Shetland and the Outer Hebrides as being larger and darker, with more blackish upperparts than southern Guillemots *U. a. albionis*, from England, Wales and Ireland, which were smaller and paler brown rather than black, especially on the head. Early pioneer Jan Verwey (1927a) used Witherby's (1923, 1926) characteristics to assess the breeding origin of his specimens, and concluded that most 'typical *aalge*' in his collection had washed ashore in November, December and January, while 'typical *albionis*' occurred all year round. He concluded that summering birds were all of the southern form. According to Verwey, '"mid-European" birds take part in the first and in the last migratory movements respectively', while 'It follows … that more northern birds replace the southern birds during winter, which then presumably move southward.' Also based on his seawatching data he continued that 'English ornithologists call their breeding birds "resident", I think with little right' (Verwey 1927a, 1927b).

Peter Hope Jones visited the Zoological Museum in Amsterdam in the early 1980s, to study specimens and to discuss the possibilities of subspecific identification by using plumage characteristics of individual Guillemots with Dutch experts. He soon gave up the use of plumage characteristics, because the results were inconsistent, and also for practical reasons. Subtle colour differences are almost impossible to distinguish on wet corpses under poor light conditions, adding to the margins of error that are already quite considerable in clean museum specimens. As he rightfully pointed out, however, just *wing length* (as a proxy for overall size) could give a useful

Figure 5. Wing length (mm) of adult Common Guillemots *Uria aalge* washed ashore since 1980 along the Dutch coast. All birds aged through internal inspection during dissections. (NZG/NSO database, unpublished data)

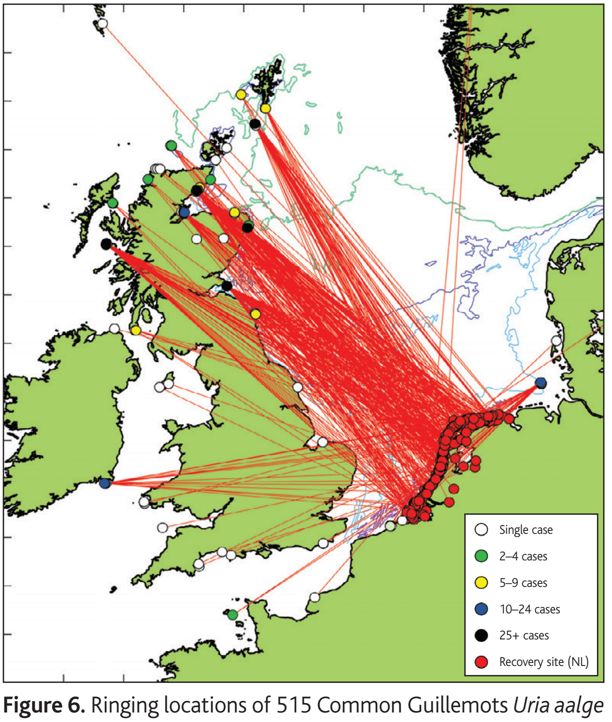

Figure 6. Ringing locations of 515 Common Guillemots *Uria aalge* with foreign rings found along the Dutch coast or elsewhere in The Netherlands (1935–2020). Recovery locations in red, and colour of ringing site indicates the number of individuals reported from The Netherlands. Dataset Vogeltrekstation, Heteren (NL), courtesy of Dr Henk van der Jeugd.

hint: colonies in the south have smaller birds than colonies in the north (Hope Jones 1985, 1988). Small samples of breeding birds measured at the Berlengas (Portugal, 39°41'N 9°51'W; Hope Jones 1984), Skomer (Wales, 52°74'N 5°30'W) and Great Saltee (Ireland, 52°12'N 6°62'W; both Hope Jones 1988) had wings on average just under 200 mm in length, whereas various colonies in Scotland and at Græsholmen in the Baltic (55°32'N 15°18'E) had wings of 201–204 mm in length (Hope Jones 1988; Mudge & Aspinall 1985), birds from Shetland and the Faroes (59–62°) 206–207 mm, north Norwegian birds (68–70°N) c. 210 mm (all Hope Jones 1984), and individuals from Jan Mayen (71°04'N 8°29'W) well over 210 mm (Camphuysen 1990). This idea, using the cline in wing length, made sense, and Barrett *et al*. (2008) completed the list by adding biometrics from Guillemots measured in Norwegian (59–70°N, 74°N), northwest Russian (69°N) and Icelandic (63–67°N) breeding colonies. The strong positive correlation between breeding latitude and Guillemot wing length was confirmed.

In adults found in The Netherlands, the mean (± standard deviation) wing length of 551 Guillemots (adults; aged in the laboratory during internal inspections) was 203.8 ± 5.9 mm (range 173–221; Figure 5), suggesting that mainland Scotland and the northern part of England are 'prime suspects' as breeding areas where these birds most likely came from. This suggestion is in line with the results of an early analysis of EURING ringing data (Wijs 1985), and is consistent with the later and more comprehensive analysis by Harris & Swann (2002) for UK ringing results. British Guillemots are now seen as dispersive rather than migratory, with many adults present in seas neighbouring their breeding grounds throughout the year (Reynolds *et al.* 2011). A compilation of the origin of all ringed Guillemots found dead in The Netherlands (all data 1935–2020, N = 515, Vogeltrekstation Arnhem) confirmed these findings (Figure 6). Note that the ringing effort differed considerably between areas of origin, so that some well-worked colonies are probably over-represented relative to others. A more recent tracking study, however, using geolocators deployed on adult Guillemots from a colony in southeast Scotland, corroborated the ringing results and showed the significance of the southeastern North Sea as a moulting and wintering area (Harris *et al.* 2015).

Based on wing length, it must be concluded that genuinely northerly birds, such as individuals from the Faroe Islands, Iceland, northern Scandinavia or (sub-) Arctic regions, are rare in Dutch waters (biometrics of winter birds in Appendix 1). Also based on wing length, there was no (recent) evidence for a possible replacement of 'more southerly' birds by 'more northerly' individuals in any particular season, as suggested by Verwey (1927a).

Age composition and chick development

After 1980, volunteers participating in beached bird surveys were instructed to age the Guillemots they encountered using simple plumage characteristics (see Methods). The results showed that juvenile birds formed a high proportion in some years, but were almost absent in others (Figure 7). In line with ship-based surveys, where the crossing of 'father-chick' combinations from Scottish and English waters towards a nursery off the Frisian Islands in the Southern Bight was documented (Camphuysen 2002), it appeared that chicks arrived as downy young on Dutch shores in some years (Figures 8 and 9b), together with flightless moulting adult males. Juvenile wings reached full length around late October or shortly thereafter, but did not reach adult length (Figure 8).

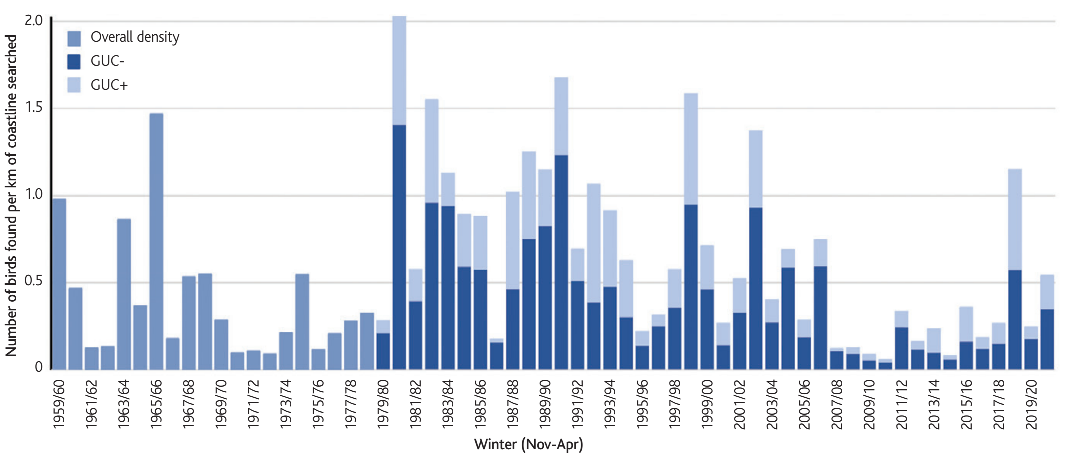

Figure 7. Annual variation in winter densities of Common Guillemots *Uria aalge* washed ashore in The Netherlands (November–April, 1959/60–2019/20). Since the early 1980s, birds were aged on the basis of the presence (GUC+) or absence (GUC–) of white tips on the greater underwing coverts, representing juveniles (light grey) and older birds (black) respectively. (NZG/NSO database, unpublished data)

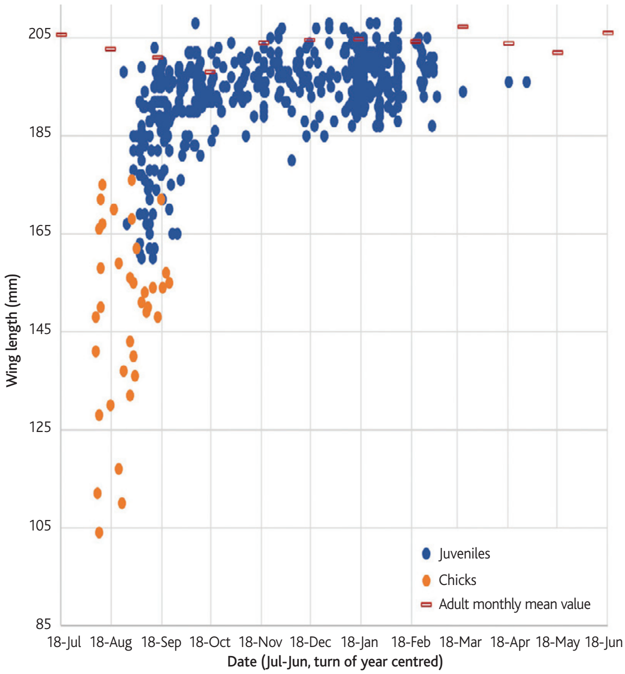

Figure 8. Seasonal changes and variability in wing length of juvenile (GUC+) Common Guillemots *Uria aalge* washing ashore in The Netherlands (November–April, 1980/81–2019/20). Developing chicks with downy remains were usually labelled as 'chicks'. Primary growth continued until at least mid-October, but never reached the same mean length as birds identified as adults (red bars). All birds aged through internal inspection during dissections. (NZG/NSO database, unpublished data)

Moult of the head and neck feathers from breeding to winter plumage, and vice versa, is also completed mostly at sea. In birds aged as 'sexually mature' on the basis of their wings (hence, including immature birds), breeding plumage was rarely observed in autumn (September–November), followed by a gradual increase in frequency until June, when 100% of the birds found had attained summer plumage (Figure 9a). As expected, summer plumage was attained much later in juveniles, if at all (Figure 9b).

Discussion

It is a characteristic of natural populations that losses due to a disaster are made good in a comparatively short time.... What birds cannot do is to survive the continual, annual battering given by the present chronic pollution of the seas. In other words, a Torrey Canyon, every once in a while, is less serious than smaller, persistent annual spillages. The latter could be stopped. As usual, prevention is far better than cure. (Perrins 1969)

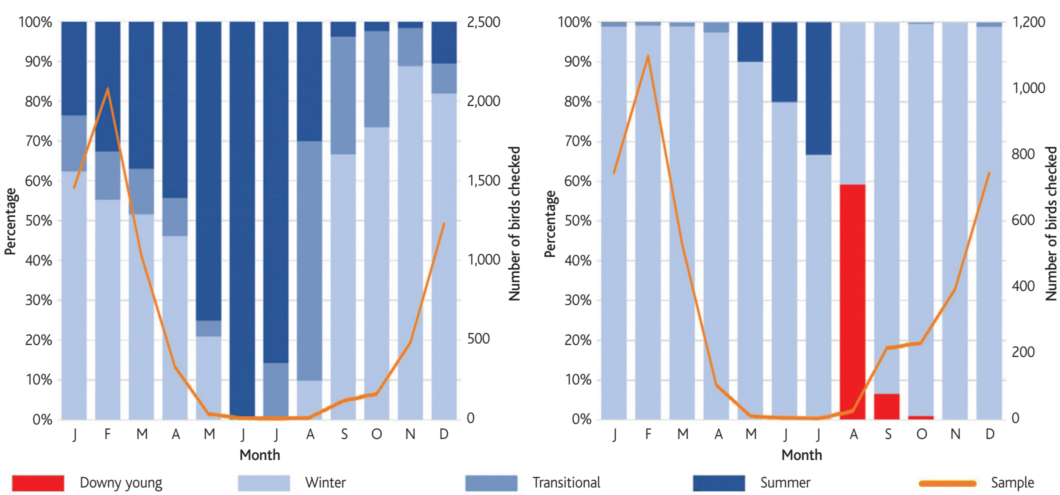

Figure 9. Seasonal variation in plumage of **(left)** 'adult' (GUC–) and **(right)** juvenile (GUC+) Common Guillemots *Uria aalge* washed ashore in The Netherlands (November–April, 1980/81–2019/20). Developing chicks with downy remains on head and neck were found exclusively in August–October. (NZG/NSO database, unpublished data)

That is exactly what happened. The 'smaller, persistent annual spillages' have almost completely disappeared, even from the most heavily polluted parts of the North Sea (Camphuysen 2010, 2021; Zoest *et al.* 2011; Lagring *et al.* 2012), and few who frequented beaches in the 1970s to the 1990s had seen that coming. The gradual improvement was perhaps first evident in the 1980s, when oil rates became lower, little by little (Figure 3), and was found throughout the North Sea (Heubeck & Mellor 2016). However, despite a highly significant and linear long-term decline, between seasons there was considerable variability at first (Figure 4). The initial decline in the proportion of birds that were oiled coincided with a marked increase in numbers washing ashore, at least in some years. Rather large numbers of clean or only very slightly oiled birds were found in some years or in some of these mass strandings (Blake 1984; Camphuysen 1992). Such birds were all in a very poor physical condition and severely underweight when they died. Hence, other mortality factors interfered with the oil-pollution monitoring instrument: starvation was probably a major factor in the death of the auks, perhaps related to a combination of adverse weather conditions and changing patterns of prey abundance or availability in the North Sea (see also Heubeck & Mellor 2016). A new line of research developed, and with hindsight, just for Guillemots over a 70-year period (1950s–2020), at least 30 mass mortality events, probably food-related and properly termed seabird 'wrecks', could be identified (Appendix 2).

The upsurge in stranded Guillemots in the 1980s was surprising, and fortunately it coincided with a new line of research: ship-based surveys of seabirds at sea (Mitchell *et al.* 1980). The establishment of the European Seabirds at Sea database (ESAS) was another multinational project involving all countries around the North Sea. For the first time, seabirds were being systematically studied away from their breeding colonies (Stone *et al.* 1995). The new knowledge regarding the at-sea whereabouts of seabirds in winter, combined with the results of beached bird surveys, was particularly instructive when considering the year-round ecology of pelagic seabirds. The significance of other parts of the North Sea (away from breeding colonies) became evident, and the high numbers of seabirds washed ashore in some years on continental beaches thereby better understood. Sensitive areas were not necessarily just around major (British) seabird colonies, as suggested by Nye *et al.* (1973) at the North Sea Science Conference in Aviemore (Scotland) in 1971.

That numbers stranded in the southern North Sea had been so low in the 1970s (compared to the 1960s), and that numbers were so much higher again in the 1980s, might have been the result of changes in wintering distribution, wind and (adverse) weather, changes in winter food availability, or a combination of such factors. The measurements of Guillemots collected in The Netherlands suggested that northerly birds, originating from colonies in northern Scandinavia or (sub-) Arctic regions, are rare in the Southern Bight. Early claims of the even larger and blacker subspecies *U.a. hyperborea* had mostly been rejected (Wijs 1981), leaving only a single record of an unringed female as 'acceptable'

(Camphuysen 1989b, Berg & Bosman 2001). Guillemots of Arctic or sub-Arctic origin are apparently just about as unusual in Dutch waters as Brünnich's Guillemots *U. lomvia* (Berg & Bosman 2001). All the evidence presented in this paper points to overwhelmingly 'Scottish' Guillemots washing ashore in The Netherlands. Links between mass mortality events in winter and population dynamics in breeding areas should be investigated by sharing information between these areas. The analysis by Reynolds *et al*. (2011), suggesting that certain aspects of the winter environment are responsible for spatiotemporal variation in survival of British Guillemots, would call for a combination of various datasets to shed more light on at-sea factors driving large-scale population dynamics of the species.

As Peter Hope Jones correctly pointed out at the time, the effect of catastrophic oil spills would be larger, or at least more immediate, if the adults in a population were primarily affected. Adults form the pool of birds preparing to breed in the next summer. If juveniles alone were affected, any population-level effect would be delayed for several years. A lower number of recruits over a number of years (and in many colonies that are unmonitored or inadequately monitored) would be very difficult to detect. That is why ageing stranded seabirds became part of the package during oil-spill impact assessments. In a species for which ageing was not straightforward, solely on the basis of plumage characteristics and/or soft parts, or when the amount of oil on the birds prevented any observations, necropsies were conducted. The results show that juvenile birds were found in high numbers in some years (particularly during wrecks), and were almost absent in other years. The major oil spill resulting from the Tricolor in 2003, for example, was found to have affected primarily adult birds (Stienen *et al*. 2004; Camphuysen & Leopold 2005). Another major spill, the Prestige in Spain, killed almost exclusively young birds (Fernández Boán *et al*. 2005). Whether the fluctuations in the numbers of juveniles washed ashore in the North Sea could be linked to variations in reproductive success on the English and Scottish breeding grounds is a different matter, but certainly something to consider.

The fact that prospecting adult Guillemots usually return early to the breeding ledges on favourable days, in full breeding plumage, suggests that in the non-breeding season they remain relatively close to the colonies in the North Sea. Many British Guillemots spend only a short time in winter plumage; by early December 50% of prospecting adults returning to their ledges on the Isle of May, southeast Scotland, UK, were found to be in full summer plumage (Harris & Wanless 1990). The strandings data from coastlines further from the breeding colonies suggest that mature birds leave the southern North Sea as soon as they have moulted and return to their native areas. As a result, the proportion of adult birds in full summer plumage found ashore in The Netherlands in any given month would always be lower than in that age group in the North Sea as a whole. This suggests (in part supported by birds found dead and dying in spring) that it is particularly the 'unfit' part of the population that remains at a greater distance from the breeding sites, such as in the Southern Bight.

Oiled Common Guillemot *Uria aalge*, Texel, 25 December 2015. © *Jan van Franeker*

Observations such as the wing development of downy young and the progress of the adult (complete) postnuptial moult are an easy by-product of work conducted for other reasons, allowing us to a study processes that are normally completed at sea, far away from colonies and researchers. Studies like these, but also investigations of the stomach contents of Guillemots in seasons when they are not normally studied (carefully separating starved birds from the healthy/fit segment of the population; Ouwehand *et al*. 2005), should hopefully be continued, even if beached bird surveys are no longer needed to monitor any effects of oil pollution.

From the timeline (Table 1), a number of conclusions can be drawn. It required a number of major oil incidents to push the community into action. The process of international conventions was notoriously slow, and the implementation of concrete measures even slower. Arguments raised over and over again included high costs, the impossibility of controlling spills, and an unwillingness to disadvantage the competitive positions of harbours, shipping companies and industries. Mostly economic arguments, in other words. It took far too long before the North Sea became part of a Special Area under MARPOL, meaning that the amount of oil legally released into the open sea could finally be dramatically reduced. Meanwhile, specific education of new sailors had an effect, tankers became safer, and oil reception facilities became widely available. When all these conditions were met, notably in the late 1990s and early twenty-first century, chronic oil pollution largely disappeared from the North Sea. We have not yet reached perfection, but the situation is now much better than before.

Considering the effects of oil pollution on seabirds, one aspect has not been touched upon yet, and that is the animal welfare component. There has always been some doubt over whether seabird populations were actually negatively affected by oil pollution. Other factors (food-related, climate-related, hunting-related or otherwise) were often seen as more urgent. Very few people, however, enjoyed the sight of a seabird ashore struggling to breathe, unable even to spread its wings as a result of oil covering its body, facing an unnecessary death. Regardless of whether this triggered a care and rescue response or euthanasia, there were plenty of reasons to try and stop the suffering of thousands and thousands of seabirds. One question that was harder to answer was: how important was oil actually on the list of causes of death for all these birds in winter? How many birds were slightly oiled, but would have died anyway for other reasons? Guillemots continue to wash ashore on Dutch shores, simply because there is a large wintering population, but most are now clean. A high proportion of the youngest birds and around 10% of the adults are expected to die in any given year, and some of their corpses will wash ashore. One notable exception, a group barely touched upon in this paper, is the divers (loons, Gaviidae), a highly oil-sensitive group of primarily coastal seabirds that winter in large numbers in the shallow southern North Sea. Around 90% of all divers found ashore between the 1960s and the 1980s were contaminated with oil, and they were commonly encountered during beached bird surveys (Camphuysen 1995b). But while the wintering numbers of divers have doubled or tripled in recent decades (Camphuysen

2009), both their oil rates and the numbers found ashore have fallen to very low levels (Camphuysen 2020). In this case, it seems that oil pollution was an important cause of (additional) winter mortality.

In conclusion, oil pollution is still an issue, and we have to stay alert for accidental spills and mismanagement, but the chronic component is much reduced, not only in the North Sea. Seabirds are benefiting from that, whether or not their populations were ever under pressure from the extra mortality induced by oil (Dunnet 1982; Votier *et al.* 2005). Seabirds benefit, even just from an animal welfare perspective. The short histories and timeline presented in this paper – illustrating the worrying signals published since the early twentieth century and the measures taken to reduce the oil problem – clearly illustrate how long it took, from the first reports to the current situation, and for how long there was little or no improvement to be seen. The story of oil pollution in the North Sea may be instructive in a wider context, given the global environmental issues we currently face.

References

Anon. 1910. Eisentenhavarie bei Dago. *Neue Baltische Waidmannsblätter* 6: 489.

Anon. 1923. Duitschland - Tegen olievervuiling. *Gooi en Eemlander* 23 juni 1923.

Anon. 1934. Stookolie. *Amoeba* 13: 79.

Anon. 1955. Handleiding ter voorkoming van de verontreiniging van de zee door olie. Koninklijke Nederlandsche Reedersvereeniging, 's-Gravenhage.

Anon. 1967. The '*Torrey Canyon*'. Presented to Parliament by the Secretary of State for the Home Department, April 1967. HMSO, London.

Anon. 1995. JAMP Guidelines on standard methodology for the use of oiled beached birds as indicators of marine oil pollution. Monitoring guidelines, OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic, Ref. No. 95–06e.

Anon. 2002. Bergen Declaration. Ministerial declaration Fifth International Conference on the Protection of the North Sea, 20–21 March 2002, Bergen, Norway.

Anon. 2012. Mariene Strategie voor het Nederlandse deel van de Noordzee 2012–2020, Deel 1. Rapport, Ministeries I&M en ELI, 's-Gravenhage.

Anon. 2021. January 1862: Elisabeth Watts exports first Pennsylvania oil to London. www.energyglobalnews.com/january-1862-elisabeth-watts-exports-first-pennsylvania-oil-to-london.

Barclay-Smith, P. 1930. Progress made in combatting oil discharges at sea. *Bird Lore* 32: 397–400.

Barrett, R. T. 1979. Small oil spill kills 10–20,000 seabirds in North Norway. *Marine Pollution Bulletin* 10: 253–255.

Barrett, R. T., Anker-Nilssen, T., Bakken, V., Strøm, H. Krasnov, Y. & Aarvak, T. 2008. Biometrics as a determinant of the origins of seabirds killed in oil spills and other incidents. *Bird Conservation International* 18: 229–241.

Begg, G. S., Reid, J. B., Tasker, M. L. & Webb, A. 1997. Assessing the vulnerability of seabirds to oil pollution: sensitivity to spatial scale. *Colonial Waterbirds* 20: 339–352.

van den Berg, A. B. & Bosman, C. A. W. 2001. *Zeldzame vogels van Nederland. Tweede druk; Avifauna van Nederland, 1*. KNNV Uitgeverij Utrecht en GMB Uitgeverij, Haarlem.

Bibby, C. J. 1981. An experiment on the recovery of dead birds from the North Sea. *Ornis Scandinavica* 12: 261–265.

Bibby, C. J. & Lloyd, C. S. 1977. Experiments to determine the fate of dead birds at sea. *Biological Conservation* 12: 295–309.

Blake, B. F. 1984. Diet and fish stock availability as possible factors in the mass death of auks in the North Sea. *Journal of Experimental Marine Biology and Ecology* 76: 89–103.

Blake, B. F., Tasker, M. L., Jones, P. H., Dixon, T. J., Mitchell, R. & Langslow, D. R. 1984. Seabird Distribution in the North Sea. Nature Conservancy Council, Huntingdon.

Bootsgezel, J. J. 1933. Stookolie. *De Levende Natuur* 38: 285–287.

Bourne, W. R. P. 1967. The *Torrey Canyon* disaster. *Seabird Bulletin* 3: 4–11.

Bourne, W. R. P. 1970. Special review: after the '*Torrey Canyon*' Disaster. *Ibis* 112: 120–125.

Bourne, W. R. P. 1976. Seabirds and pollution. In: Johnston R. (ed.), *Marine Pollution*: 403–502. Academic Press, London.

Bourne, W. R. P. & Devlin, T. R. E. 1970. International Beached Bird Survey 1969. *Birds* 3: 12–13.

Bourne, W. R. P., Parrack, J. D. & Potts, G. R. 1967. Birds killed in the Torrey Canyon Disaster. *Nature* 215: 1123–1125.

Brada, J. D. 1950. Olieslachtoffers. *Vanellus* 3: 2–4.

Camphuysen, C. J. 1983. Leeftijdsbepaling en ondersoorten bij de Papegaaiduiker *Fratercula arctica*. *Nieuwsbrief NSO* 4: 28–32.

Camphuysen, C. J. 1989a. Beached Bird Surveys in The Netherlands 1915–1988: seabird mortality in the southern North Sea since the early days of oil pollution. Techn. Rapport Vogelbescherming 1, Werkgroep Noordzee, Amsterdam.

Camphuysen, C. J. 1989b. Vondst van een noordelijke Zeekoet *Uria aalge hyperborea* in Nederland. *Limosa* 62: 47–48.

Camphuysen, C. J. 1990. Biometrics of auks at Jan Mayen. *Seabird* 12: 7–10.

Camphuysen, C. J. 1992. Auk wrecks in the southern North Sea, 1981–1991: oil pollution or food shortage? In: Tasker, M. L. (ed.), *Proceedings of the Seabird Group Conference, 'European Seabirds', Glasgow, 27–29 March 1992*: 23.

Camphuysen, C. J. 1995a. Leeftijdsbepaling van Zeekoet *Uria aalge* en Alk *Alca torda* in de hand. *Sula* 9: 1–22.

Camphuysen, C. J. 1995b. Olieslachtoffers langs de Nederlandse kust als indicatoren van de vervuiling van de zee met olie. *Sula* 9 (special issue): 1–90, I–XX.

Camphuysen, C. J. 1998. Beached bird surveys indicate decline in chronic oil pollution in the North Sea. *Marine Pollution Bulletin* 36: 519–526.

Camphuysen, C. J. 2002. Post-fledging dispersal of Common Guillemots *Uria aalge* guarding chicks in the North Sea: the effect of predator presence and prey availability at sea. *Ardea* 90: 103–119.

Camphuysen, C. J. 2007a. Chronic oil pollution in Europe, a status report. Report Royal Netherlands Institute for Sea Research, commissioned by International Fund for Animal Welfare (IFAW), Brussels.

Camphuysen, C. J. 2007b. Alcidae Auks. In: Camphuysen, C. J., Bao, R., Nijkamp, H. & Heubeck, M. (eds.), *Handbook on Oil Impact Assessment*. Technical document 4.1, Assessing the damage. Report to DG Environment, European Commission, Grant Agreement 07.030900/2005/42907/ SUB/A5, Version 1.0, Royal Netherlands Institute for Sea Research, Texel. Available at www.oiledwildlife.eu.

Camphuysen, C. J. 2009. Het gebruik van zeetrektellingen bij de analyse van populati-eschommelingen van duikers Gaviidae langs de kust. *Sula* 22: 1–24.

Camphuysen, C. J. 2010. Declines in oil-rates of stranded birds in the North Sea highlight spatial patterns in reductions of chronic oil pollution. *Marine Pollution Bulletin* 60: 1299–1306.

Camphuysen, C. J. 2020. Beached bird surveys in The Netherlands, winter 2019/20. NIOZ Report, RWS Centrale Informatievoorziening BM 20.24, Royal Netherlands Institute for Sea Research, Texel.

Camphuysen, C. J. 2021. Beached bird surveys in The Netherlands, winter 2020/21. NIOZ Report, RWS Centrale Informatievoorziening BM 21.16, September 2021. Royal Netherlands Institute for Sea Research, Texel.

Camphuysen, C. J. & Dahlmann, G. 1995. Guidelines on standard methodology for the use of (oiled) beached birds as indicators of marine pollution. Ad Hoc working group on Monitoring, Oslo and Paris Convention for the Prevention of Marine Pollution. MON 95/7, Agenda item 7, 13–17 November 1995, Copenhagen.

Camphuysen, C. J. & Heubeck M. 2001. Marine oil pollution and beached bird surveys: the development of a sensitive monitoring instrument. *Environmental Pollution* 112: 443–461.

Camphuysen, C. J. & Leopold, M.F. 2005. The *Tricolor* oil spill: characteristics of seabirds found oiled in The Netherlands. *Atlantic Seabirds* 6: 109–128.

Camphuysen, C. J. & van der Meer J. 1996. Recent trends in oiled seabirds. Ad Hoc working group on Monitoring, Oslo and Paris Convention for the Prevention of Marine Pollution, Environmental Assessment and Monitoring Committee (ASMO). MON 1995 summary record: 20–48, Copenhagen.

Camphuysen, C. J. & Vollaard, B. 2015. Oil pollution in the Dutch sector of the North Sea. In: Carpenter, A. (ed.), *Oil Pollution in the North Sea*: 117–140. Springer-Verlag, Berlin.

Camphuysen C. J., Chardine, J., Frederiksen, M. & Nunes, M. 2005. Review of the impacts of recent major oil spills on seabirds. In: Anon. (ed.) Report of the Working Group on Seabird Ecology, Texel, 29 March–1 April 2005. Oceanography Committee, ICES CM 2005/C:05, Ref. ACME+E, International Council for the Exploration of the Sea, Copenhagen, Denmark.

Carpenter, A. (ed.) 2015. *Oil Pollution in the North Sea*. Handbook of Environmental Chemistry. Springer-Verlag, Berlin, Heidelberg, New York.

Carpenter, A. 2019. Oil pollution in the North Sea: the impact of governance measures on oil pollution over several decades. *Hydrobiologia* 845: 109–127.

Carter, I. C., Williams, J. M., Webb, A. & Tasker, M. L. 1993. Seabird concentrations in the North Sea: an atlas of vulnerability to surface pollutants. Joint Nature Conservation Committee, Aberdeen.

Clark, R. B. 1984. Impact of oil pollution on seabirds. *Environmental Pollution Series A* 33: 1–22.

Clark, R. B. 2001. *Marine Pollution*, 5th edition, Oxford University Press, Oxford.

Croxall, J. P. 1977. The effect of oil on seabirds. *Rapports et Procès-Verbaux des Réunions du Conseil Permanent International pour l'Exploration de la Mer* 171: 191–195.

Dahlmann, G., Timm, D., Averbeck, C., Camphuysen, C. J. & Skov, H. 1994. Oiled seabirds: comparative investigations on oiled seabirds and oiled beaches in The Netherlands, Denmark and Germany (1990–1993). *Marine Pollution Bulletin* 28: 305–310.

Danielsen, F., Skov, H., Durinck, J. & Christensen, K. D. 1990. Seabirds and oil pollution in Danish waters 1984–89. *Dansk Ornitologisk Forenings Tidsskrift* 84: 8–9.

Dawson, W. L. 1911. Another fortnight on the Farallones. *Condor* 13: 171–183.

Drost, R. 1959. Oil pollution on the coast of the German Federal Republic. *Proceedings of the International Conference on Oil Pollution of the Sea*, Copenhagen, 3–4 July 1959: 73–75.

Dunnet, G. M. 1982. Oil pollution and seabird populations. *Philosophical Transactions of the Royal Society of London B* 297: 413–427.

Dunnet, G. M. 1987. Seabirds and North Sea oil. *Philosophical Transactions of the Royal Society of London B* 316: 513–524.

Ebbesmeyer, C. C. 2004. Where the toys are. *Beachcombers' Alert!* 8: 1–8.

European Commission 2010. Issue 4 (Seabirds), EcoQO element (f), Commission Decision of 2010, Chapter 8.2, Effects of contaminants; EU 2010.

Fernández Boán M., García, L., Ramos, A., Dopico, M., Bigas, D., Castelló, J., Bao, R. & Camphuysen, C. J. 2005. Características generales de la población de Arao Común (*Uria aalge*) afectada por el accidente del petrolero Prestige en la costa de A Coruña. Oral presentation VI Congreso Galego de Ornitoloxía e V Jornadas Ornitológicas Cantábricas, in Viveiro, Lugo (Spain), 29–31 October, 2005.

van Franeker, J. A. 1983. Inwendig onderzoek aan zeevogels. *Nieuwsbrief NSO* 4: 144–167.

Furness, R. W. & Camphuysen, C. J. 1997. Seabirds as monitors of the marine environment. *ICES Journal of Marine Science* 54: 726–737.

Gandini, P., Boersma, P. D., Frere, E., Gandini, M., Holik, T. & Lichtstein, V. 1994. Magellanic Penguins (*Spheniscus magellanicus*) affected by chronic petroleum pollution along the coast of Chubut, Argentina. *Auk* 111: 20–27.

Grol, C. 2021. Oliebedrijven gaan samen opruimen in de Noordzee. *Financieel Dagblad* 5 February 2021.

Harris, M. P. 2014. Aging Atlantic Puffins *Fratercula arctica* in summer and winter. *Seabird* 27: 22–40.

Harris, M. P. & Swann, B. 2002. Common Guillemot *Uria aalge*. In: Wernham, C. *et al.* (eds.), *The Migration Atlas: Movements of the Birds of Britain and Ireland*: 397–400. Poyser, London.

Harris, M. P. & Wanless, S. 1990. Moult and autumn colony attendance of auks. *British Birds* 83: 55–66.

Harris, M. P., Wanless, S., Ballesteros, M., Moe, B., Daunt, F. & Erikstad, K. E. 2015. Geolocators reveal an unsuspected moulting area for Isle of May Common Guillemots *Uria aalge*. *Bird Study* 62: 267–270.

Hautekiet, M. R. 1955. Vijf jaar stookolieslachtoffers. *Wielewaal* 11: 289–294.

Heubeck, M. 1992. The occurrence of dead auks on Shetland beaches, March 1979 to February 1992. In: Osborn, K. (ed.), *Shetland Bird Report 1991*: 94–103. Shetland Bird Club, Lerwick.

Heubeck, M. 1995. Shetland beached bird surveys: national and European context. *Proceedings of the Royal Society of Edinburgh* 103: 165–179.

Heubeck, M., Meek, E. & Suddaby, D. 1992. The occurrence of dead auks (Alcidae) on beaches in Orkney and Shetland, 1976–91. *Sula* 6: 1–18.

Heubeck, M. & Mellor, M. 2016. SOTEAG Ornithological Monitoring Programme, 2016 report. The Shetland Oil Terminal Environmental Advisory Group 2016, Univ. of Aberdeen.

Hlady, D. A. & Burger, A. E. 1993. Drift-block experiments to analyse the mortality of oiled seabirds off Vancouver Island, British Columbia. *Marine Pollution Bulletin* 26: 495–501.

Hope Jones, P. 1984. Skins of Guillemots *Uria aalge* and Razorbills *Alca torda* examined at Cascais, Portugal, in May 1982. *Memorias do Museo do Mar, Serie Zoologica* 3: 1–10.

Hope Jones, P. 1985. Determination of age, sex and origin of guillemots and razorbills killed in oilspills and other incidents. MSc thesis, Open University.

Hope Jones, P. 1988. The European cline in wing length of Guillemots *Uria aalge*. *Seabird* 11: 19–21.

Hope Jones, P. & Morgan, P. J. 1979. Collection and use of oiled seabirds in Wales. *BTO News* 99: 4.

Hope Jones, P., Monnat, J. Y., Cadbury, C. J. & Stowe, T. J. 1978. Birds oiled during the *Amoco Cadiz* incident: an interim report. *Marine Pollution Bulletin* 9: 307–310.

Hope Jones, P., Monnat, J. Y. & Harris, M. P. 1982. Origins age and sex of auks (Alcidae) killed in the 'Amoco Cadiz' oiling incident in Brittany, March 1978. *Seabird Report* 6: 122–130.

Hudson, R. 1969. Beached birds survey. *British Birds* 62: 45–46.

Huijer, K. 2005. Trends in oil spills from tanker ships 1995–2004. International Tanker Owners Pollution Federation (ITOPF), London. www.itopf.org/knowledge-resources/documents-guides/trends-in-oil-spills-from-tanker-ships-1995-2004-2005.

ITOPF 2008. Tanker spills: the last 40 years. Ocean Orbit: the Newsletter of the International Tanker Owners Pollution Federation Limited September 2008: 5.

Joensen, A. H. 1972. Studies on oil pollution and seabirds in Denmark 1968–1971. *Danish Review of Game Biology* 6: 1–24.

Jongens, G. W. 1937. Olieslachtoffers. *De Levende Natuur* 41: 382.

Keijl, G. O. & Camphuysen, C. J. 1992. Resultaten van een verdriftingsexperiment voor de Nederlandse kust, februari 1991. *Sula* 6: 41–49.

King, J. G. & Sanger, G. A. 1979. Oil vulnerability index for marine oriented birds. In: Bartonek, J. C. & Nettleship, D. N. (eds.), *Conservation of Marine Birds of Northern North America*: 227–239. Wildlife Research Report 11. Fish & Wildlife Service, Washington DC.

Kuschert, H., von Ekelöf, H. O. & Fleet, D. M. 1981. Neue Kriterien zur Altersbestimmung der Trottellumme (*Uria aalge*) und des Tordalken (*Alca torda*). *Seevögel* 2: 58–61.

Lagring, R., Degraer, S., de Montpellier, G., Jacques, T., Van Roy, W. & Schallier, R. 2012. Twenty years of Belgian North Sea aerial surveillance: a quantitative analysis of results confirms effectiveness of international oil pollution legislation. *Marine Pollution Bulletin* 64: 644–652.

Larminie, F. G., Clark, R. B., Rudd, J. K. & Tasker, M. L. 1987. The history and future of North Sea oil and gas: an environmental perspective. *Philosophical Transactions of the Royal Society of London B* 316: 487–493.

Leopold, M. F., Kik, M., van Tulden, P., van Franeker, J. A., Kühn, S. & Rijks, J. 2019. De Zoe en de zeekoet: Een onderzoek naar de doodsoorzaak en de herkomst van de zeekoeten die massaal strandden op de Nederlandse kust in januari en februari 2019. Unpublished Research Report C026/19. Wageningen Marine Research, Den Helder.

Maas, F. J. 1983. Leeftijdsbepaling en ondersoorten bij de Alk *Alca torda*. *Nieuwsbrief NSO* 4: 61–65.

Mackay, N. 2016. North Sea oil industry under fire as spills rise. (www.heraldscotland.com/news/14791148.north-sea-oil-spills-reach-record-high). *Sunday Herald*. Accessed March 2021.

Mitchell, R., Langslow, D. R., Blake, B. F., Jones, P. H., Dixon, T. & Tasker, M. L. 1980. Investigation of the distribution of seabirds at sea: first annual report, November 1979 to November 1980. Nature Conservancy Council, Aberdeen.

Mörzer Bruijns, M. F. 1959. Stookolievogels op de Nederlandse kust. *De Levende Natuur* 62: 172–178.

Mudge, G. P. & Aspinall, S. J. 1985. Seabird studies in East Caithness, summer 1985. Royal Society for the Protection of Birds, Sandy.

National Research Council (NRC) 1985. *Oil in the Sea: Inputs, Fates and Effects*. National Academies Press, Washington DC.

Nye, S. M., Bellamy, D. J. & Holden, M. J. 1973. Resource map of the North Sea: a first attempt. In: Goldberg, E. D. (ed.), *North Sea Science*: 481–485. MIT Press, Cambridge, MA.

OSPAR & Camphuysen, C. J. 2005. Background Document on the Ecological Quality Objective on Oiled Guillemots. North Sea Pilot Project on Ecological Quality Objectives, Biodiversity Series. OSPAR publication number: 2005/252.

OSPAR Commission 2009. EcoQO handbook for the application of Ecological Quality Objectives in the North Sea, second edition. EcoQO Handbook, OSPAR Commission, Oslo www.ospar.org.

OSPAR Commission 2010. OSPAR Commission 2010. Regional Implementation Framework for the EU Marine Strategy Framework Directive, MSFD Road Map. OSPAR publication no. 501/2010.

Ouwehand, J., Leopold, M. F. & Camphuysen, C. J. 2005. A comparative study of the diet of Guillemots *Uria aalge* and Razorbills *Alca torda* killed during the Tricolor oil incident in the south-eastern North Sea in January 2003. *Atlantic Seabirds* 6: 147–164.

Parslow, J. L. F. 1966. Oil pollution survey. *British Birds* 59: 390–392.

Perrins, C. 1969. Rehabilitation of Oiled Seabirds: A Report to the Advisory Committee on Oil Pollution of the Sea. By R. B. Clark & R. J. Kennedy. [Book review]. *British Birds* 62: 241–242.

Reineking, B. & Vauk, G. 1982. *Seevögel: Opfer der Ölpest*. Jordsandbuch Nr 2. Herausgegeben vom Verein Jordsand zum Schutz der Seevögel e.V, Otterndorf.

Reynolds, T. J., Harris, M. P., King, R., Swann, R. L., Jardine, D. C., Frederiksen, M. & Wanless, S. 2011. Among-colony synchrony in the survival of Common Guillemots *Uria aalge* reflects shared wintering areas. *Ibis* 153: 818–831.

Richardson, M. G., Heubeck, M., Lea, D. & Reynolds, P. 1982. Oil pollution, seabirds, and operational consequences, around the northern isles of Scotland. *Environmental Conservation* 9: 315–321.

Sandee, H. 1983. Kleurcontrast in de vleugeldekveren bij Alk en Zeekoet. *Nieuwsbrief NSO* 4: 133–143.

Stienen, E. W. M., Haelters, J., Kerckhof, F. & van Waeyenberge, J. 2004. Three colours of black: seabird strandings in Belgium during the Tricolor incident. *Atlantic Seabirds* 6: 129–146.

Stone, C. J., Webb, A., Barton, C., Ratcliffe, N., Reed, T. C., Tasker, M. L., Camphuysen, C. J. & Pienkowski, M. W. 1995. An atlas of seabird distribution in north-west European waters. Joint Nature Conservation Committee, Peterborough.

Swennen, C. & Spaans, A. L. 1970. De sterfte van zeevogels door olie in februari 1969 in het Waddengebied. *Het Vogeljaar* 18: 233–245.

Tanis, J. J. C. & Mörzer Bruijns, M. F. 1962. Het onderzoek naar stookolievogels van 1958–1962. *De Levende Natuur* 65: 133–140.

Tromp, J. 1927. Teervogels. Het Vaderland: staat – en letterkundig nieuwsblad 28 January 1927.

Verwey, J. 1915. De Trekvogels, de Oorlog en nog wat. *De Levende Natuur* 20: 20.

Verwey, J. 1922. The moult of *Uria troille* (L.) and *Alca torda* (L.). *Ardea* 11: 99–116.

Verwey, J. 1923. De rui van *Uria troille* (L.). *Ardea* 12: 31–336.

Verwey, J. 1927a. On the movements of the southern and northern Guillemots off the Dutch coast. *Ardea* 16: 32–35.

Verwey, J. 1927b. Geslechtsreife und Prachtkleid der Vögel II. Zwischenkleid von *Uria aalge* (L.). *Zoologischer Anzeiger Leipzig* 71: 1–4.

Votier, S. C., Hatchwell, B. J., Beckerman, A., McCleery, R. H., Hunter, F. M., Pellatt, J., Trinder, M. & Birkhead, T. R. 2005. Oil pollution and climate have wide-scale impacts on seabird demographics. *Ecology Letters* 8: 1157–1164.

Wardley-Smith, J. 1976. The Control of Oil Pollution on the Sea and Inland Waters. Graham & Trotman, London.

Westhoff, V. 1936. Teerslachtoffers. *Amoeba* 15: 27.

de Wijs, W. J. R. 1981. *Uria aalge hyperborea* in Nederland? *Limosa* 54: 63–64.

de Wijs, W. J. R. 1985. Herkomst en leeftijd van Zeekoeten *Uria aalge* in Nederland. *Limosa* 58: 61–64.

Witherby, H. F. 1923. Notes on the Common Guillemot, a new British form. *British Birds* 16: 323–324.

Witherby, H. F. 1926. On the distribution of the Southern and Northern Guillemots, in Great Britain. *British Birds* 19: 274.

Witherby, H. F., Jourdain, F. C. R., Ticehurst, N. F. & Tucker, B. W. 1952. *The Handbook of British Birds*, 5. Seventh impression, H. F. & G. Witherby, London.

Wolfe, D. A. 1985. Fossil fuels: transportation and marine pollution. In: Duedall, I. W., Kester, D. A., Park, P. H. & Ketchum, B. H. (eds.), *Wastes in the Ocean*, 4: 45–94. Wiley-Interscience, Hoboken, New Jersey.

Woltman, D. 1920. Olie en vogels. *De Levende Natuur* 25: 61.

Zoest, R. van Verduin, E. & Visser, A. 2011. Het aantal olievlekken op de Noordzee daalt. *Nieuwsbrief Integraal Beheer Noordzee* 2011: 4.

Appendix 1

Winter (November–April) biometrics of Common Guillemots *Uria aalge*, aged and sexed, found dead in The Netherlands since 1980 (NZG/NSO unpublished data)[1].

	Bill 1	Bill 2	Depth 1	Depth 2	Head	Tarsus	Wing	Mass
Adult female								
Average	47.6	40.8	13.9	12.8	111.7	37.7	204.5	746.7
SD	2.2	1.9	0.8	0.7	3.2	1.7	5.9	147.7
Min	41.0	36.0	12.0	11.0	101	34	182	435
Max	53.5	48.6	16.0	14.6	121	42	221	1175
Sample	238	203	207	237	199	60	237	195
Immature female								
Average	47.5	40.3	13.1	12.2	111.1	37.6	201.5	736.9
SD	2.3	1.8	0.7	0.7	3.1	1.5	5.2	175.8
Min	41.4	35.9	11.9	10.6	103	35	189	530
Max	52.8	44.0	15.0	13.8	118	41	214	1140
Sample	82	53	54	81	55	20	81	72
Juvenile female								
Average	44.8	38.1	12.3	11.4	108.3	37.0	197.3	624.3
SD	2.7	2.3	0.6	0.6	3.9	1.5	5.1	100.1
Min	35.6	28.6	10.4	9.1	92	35	185	450
Max	51.6	44.9	13.7	12.9	121	41	208	985
Sample	124	95	95	126	98	39	125	110

	Bill 1	Bill 2	Depth 1	Depth 2	Head	Tarsus	Wing	Mass
Adult male								
Average	49.9	42.5	14.4	13.3	115.4	38.7	203.0	743.0
SD	2.3	3.3	0.9	0.7	3.0	1.4	6.9	142.3
Min	43.4	2.2	12.5	11.4	107	35	169	520
Max	57.7	48.1	18.1	15.7	126	42	218	1290
Sample	289	234	232	284	221	85	280	239
Immature male								
Average	49.6	42.3	13.7	12.7	114.1	37.9	202.0	716.5
SD	2.4	1.9	0.7	0.6	3.0	1.2	4.9	146.0
Min	42.9	38.9	12.4	11.0	106	36	188	510
Max	56.0	48.1	16.8	14.9	121	40	212	1190
Sample	105	67	67	105	68	23	105	93
Juvenile male								
Average	46.6	39.4	13.0	12.0	110.8	38.1	197.1	684.0
SD	3.1	2.5	0.8	0.7	3.8	1.3	4.9	151.6
Min	34.3	30.4	10.9	9.9	99	35	180	460
Max	56.2	46.3	15.3	13.3	121	41	208	1105
Sample	138	107	109	138	110	54	141	124

[1] Bill 1 = tip to feathers, Bill 2 = tip to nostril, Depth1 = bill depth at base, Depth2 = bill depth at gonys, Head = head length (back of the head to bill tip). Measurements in millimetres. Mass (grams) for clean, dry, intact birds only.

Appendix 2

Published and unpublished mass strandings of Common Guillemots *Uria aalge* that either at the time or with hindsight were characterised as 'wrecks'. Unpublished Dutch wrecks were selected from the beached bird survey database; these include mass mortality incidents with most casualties oiled, certainly prior to 1980, but exclude identified oil incidents.

USSR 1940s – Dement'eva 1951. *Ptitsy Sovetskogo Soyuza*, 2. Moskva.
The Netherlands 1959/60
The Netherlands 1963/64
Irish Sea 1969 – Bourne & Mead 1969. *BTO News* 36: 1–2.
W Scotland 1969 – Stewart 1970. *Scottish Birds* 6: 142–149.
Firth of Clyde 1970 – Bourne 1970. Seabird Report 2: 27–32.
Irish Sea & Firth of Clyde 1974 – Lloyd *et al*. 1974. *Marine Pollution Bulletin* 5: 136–140.
The Netherlands 1980/81
France 1980/81 – Debout 1982. *Le Cormoran* 24: 227–230.
The Netherlands 1982/83
E England/E Scotland 1983 – Underwood & Stowe 1984. *Bird Study* 31: 79–88.
The Netherlands 1983/84
Moray Firth 1984 – Mudge *et al.* 1992. *Seabird* 14: 48–54.
The Netherlands 1984/85
W Scotland 1985 – Craik 1992. *Sula* 6: 125–138.
Moray Firth 1985 – Mudge *et al.* 1992. *Seabird* 14: 48–54.
The Netherlands 1985/86
Moray Firth 1986 – Mudge *et al*. 1992. *Seabird* 14: 48–54.
SW Norway 1987 – Anon. 1987. *Vår Fuglefauna* 10(2): 128.
The Netherlands 1987/88
The Netherlands 1988/89 – Camphuysen 1989. *Sula* 3: 22–25.
The Netherlands 1990 – Camphuysen 1990. *Sula* 4: 23–25.
The Netherlands 1992/93
UK North Sea coast 1994 – Early 1994. *Marine Pollution Bulletin* 28: 342; Harris & Wanless 1996. *Bird Study* 43: 220–230.
Grampian, Moray Firth 1996 – Swann & Butterfield 1996. *Scottish Bird News* 43: 4–5.
The Netherlands, Germany 1999 – Fleet & Reineking 1999. *Seevögel* 20: 63.
Rogaland, Norway 2003 – Aarvak & Anker-Nilssen 2005. *NINA Rapport* 92, NINA, Trondheim.
NW Scotland 2004 – Swann 2004. *Seabird Group Newsletter* 98: 12–14.
The Netherlands 2004/05
The Netherlands 2006/07
Bay of Biscay, east UK 2014 – Morley *et al.* 2016. *Seabird* 29: 22–38.
The Netherlands 2019 – Leopold *et al.* 2019
UK North Sea coast 2021 – Late summer wreck*
The Netherlands 2021 – Autumn wreck involving mostly moulting adult males and chicks*

* Related wrecks, highly unusual time of year; recorded at the time of writing the present paper.