THE *TRICOLOR* OIL SPILL: CHARACTERISTICS OF SEABIRDS FOUND OILED IN THE NETHERLANDS

C.J. CAMPHUYSEN[1,2] & M.F. LEOPOLD[2,3]

Camphuysen C.J. & M.F. Leopold 2004. The *Tricolor* oil spill: characteristics of seabirds found oiled in The Netherlands. Atlantic Seabirds 6(3/S.I.): 109-128. *Between 28 January and 9 February 2003, c. 4000 heavily oiled seabirds washed ashore in The Netherlands, representing 21% of c. 20,000 casualties of the* Tricolor *oil spill recovered in northern France, Belgium and The Netherlands. Common Guillemot* Uria aalge, *Razorbill* Alca torda *and Black-legged Kittiwake* Rissa tridactyla *together represented 91% of the birds found and collected. Nearly 600 Common Guillemots and 267 Razorbills were examined in more detail and a large part of these birds were dissected. Autopsies revealed that the auks were in excellent condition when they died, indicating instant death through suffocation in oil. Of 440 Guillemots that could be aged, 76% were mature birds, with a sex ratio significantly different from equal (65% males). Of 262 Razorbills, 77% were adults and 62% were males. Biometrics suggested that the Guillemots belonged to the nominate subspecies, whereas the Razorbills were classified as* A.t. islandica. *Using the European cline in wing length, the Guillemots possibly originated from Scottish colonies (57°N), a finding that was supported by ringing recoveries (Scottish east coast). The total mortality caused by the* Tricolor *spill, 2-5 times the number of casualties recovered, may be estimated at 40 000-100 000 seabirds (25 000-62 500 Guillemots, 8000-20 000 Razorbills). With such a high proportion of mature birds in excellent pre-breeding condition being killed, an immediate effect on the breeding population is foreseen, rather than a diffuse and delayed effect if more immatures would have been killed. It is argued that effect of the* Tricolor *on seabirds would have been considerably less, had the salvage operation be postponed till summer. The Channel area is of the highest vulnerability to oil pollution only in winter (Dec-Mar).*

[1]Royal Netherlands Institute for Sea Research, P.O. Box 59, 1790 AB Den Burg, Texel, The Netherlands, camphuys@nioz.nl, [2]Nederlandse Zeevogelgroep/ Werkgroep Nederlands Stookolieslachtoffer Onderzoek (NZG/NSO), Texel, [3]Alterra, P.O. Box 167, 1790 AD Den Burg Texel, The Netherlands.

INTRODUCTION

The *Tricolor*, a Norwegian flagged vehicle carrier built in 1987, sank on 14 December 2002 some 25 km north of the French coast in the English Channel (51°21.9'N, 02°12.6E) as a result of a collision with the *Kariba*, a Bahamian flagged container ship built in 1982. The collision occurred when both vessels

were about to enter into the north-south shipping lane through the English Channel. The *Tricolor*, struck by the *Kariba* on port side, capsized and sunk within 30 minutes. Two days later, on 16 December 2002, the unloaded German cargo vessel *Nicola* hit the wreck of the *Tricolor*. Tugs pulled the cargo ship from the wreck on the same day. Around this time, French authorities ordered the *Tricolor* to be removed, as it was perceived to represent a danger to shipping and the environment. On 1 January 2003, the *Tricolor* was struck again, this time by the Turkish tanker *Vicky*, carrying 77 000 tons of gas oil. It was only on 22 January 2003 that significant amounts of oil leaked from the *Tricolor* when a salvage tug accidentally damaged a temporary plug on one of the bunker tanks. A few days later, large numbers of heavily oiled seabirds started to wash ashore, first in France and Belgium and later also in The Netherlands.

Opening up the 'big bags': sorting and identification. Het openen van de 'grote zakken': sorteren en determineren. *(J.A. van Franeker)*

Between 29 January and 10 February 2003, large quantities of heavy bunker oil and numerous oiled seabirds washed ashore in The Netherlands. Standard beached bird surveys by the Dutch Seabird Group were promptly intensified to assess the damage and birds encountered by beach clean-up teams were collected and transported to laboratory facilities at the Royal Netherlands Institute for Sea Research on Texel for identification, counting and standard autopsies. This paper reports on the numbers of casualties found in The Netherlands, on species composition, and on characteristics (biometrics, sex ratio and age composition) of the most numerous seabirds affected by the spill. An attempt is made to identify the breeding areas where the stranded auks may have originated on the basis of their biometrics, and the results are compared with previous incidents as well as with material collected from chronic oil pollution in Southern North Sea (1982-2003; NZG/NSO unpubl. data).

METHODS

With daily strandings all over Zeeland and part of Zuid-Holland, daily beached bird surveys were attempted before clean-up teams could begin work and possibly remove corpses. Where clean-up teams were already deployed, local authorities arranged for corpses to be separated from the oil and bagged for subsequent analysis. Dedicated beached bird surveys were discontinued after 10 February 2003, when numbers of oiled casualties washing ashore were down to 'background' levels (< 1.0 km^{-1}). Two large sacks ($1m^3$ "big-bags") of material were transported to Texel for identification, counting and standard autopsies. A third sack was sorted and counted in Zeeland by Pim Wolf. The sacks transported to Texel were found to contain 929 corpses, 121 (13%) of which were birds that had died in the seabird rehabilitation centre "De Mikke" in Middelburg (Walcheren), the rest having been picked up from beaches. The corpses were sorted, identified, checked for rings and counted, while a subsample of heavily oiled, intact and rather fresh corpses was dissected and studied in more detail. Autopsies of Common Guillemots *Uria aalge* and Razorbills *Alca torda* included biometrics (bill length (feathers to tip and nostril to tip), bill depth (at base and gonys), head length, wing length (flattened, stretched), and body mass) where possible, examination of external age characteristics (plumage and/or beak development; Camphuysen 1995a), an assessment of the body condition at the time of death (scores of subcutaneous and deposited fat, condition of breast muscle; on a 4-point scale, from 0 = no reserves to 3 = excellent condition, very fat; *cf.* Van Franeker 1983), moult (*cf.* Ginn & Melville 1983), sex (gonadal inspection), age (presence and size of *bursa Fabricii*, gonadal development; *cf.* Stieda 1880, Van Franeker 1983, Jones 1985, Camphuysen 1987), and condition of major organs (lungs, liver,

kidneys, guts; on a 4-point scale, from 0 = severely affected to 3 = good condition; *cf.* Van Franeker 1983). Many corpses were heavily oiled and as a result, relatively few could be measured.

Differences between means were tested with a *t*-test assuming a normal distribution. Oiling rates were expressed as percentages of total body covered in oil, ranging from 0% (unoiled) to 100% (completely covered in oil). A separate category was used, labelled as 200% oiled) for birds that could not be visually identified, but needed to be touched instead (corpse surrounded by a thick layer of oil, hiding external features). Only oiled birds were included in the autopsies, for the unoiled birds were not related to the *Tricolor* incident.

Results were compared with autopsy results from 463 Common Guillemots and 174 Razorbills stranded in The Netherlands in earlier winters (Dec-Mar; 1982-2003) as a result of chronic oil pollution, and more specifically with heavily oiled casualties collected during oil incidents in April-May 1985 along the mainland coast (47 Guillemots, 6 Razorbills; Camphuysen 1990), off Zeeland in December 1991 (38 Guillemots; Camphuysen 1995b), and in February 1992 at Texel (76 Guillemots, 11 Razorbills; Leopold & Camphuysen 1992), all originating from winter/spring staging areas in the Southern Bight.

RESULTS

Birds found dead The first birds arrived around 28 January 2003 on the Dutch coast, following periods of predominantly southwesterly (22-26 January) and later westerly – occasionally gale-force - winds (27-28 January; Royal Netherlands Meteorological Institute (KNMI), station Vlissingen). Most casualties washed ashore before 9 February and a 20-day period of predominantly easterly winds (9-28 February 2003 SE-NE; KNMI Vlissingen) prevented any subsequent mass-strandings. Numbers of corpses peaked at Walcheren (Zeeland) with nearly 60 casualties km^{-1} (Table 1), while densities at Goeree (Zuid-Holland; 25km further to the north) were an order of magnitude lower (6.1 km^{-1}). Common Guillemots, Razorbills and Black-legged Kittiwakes *Rissa tridactyla* predominated in the kill, together representing 91% of 3300 casualties recovered on the Dutch coast (Table 2). In addition to this, approximately 700 casualties were received in seabird rehabilitation centres. A total of 4000 stranded individuals is a conservative estimate of the total number of *Tricolor* casualties that washed ashore in The Netherlands.

Table 1. Densities of oiled dead birds found in Zeeland (Z) and Zuid-Holland (ZH), late January - early February 2003.
Tabel 1. Dichtheden van gevonden olievogels in Zeeland (Z) en Zuid-Holland (ZH), eind januari-begin februari 2003.

Area	Province	km	Oiled birds found	Density n km^{-1}
Zeeuws Vlaanderen	Z	14	436	31.1
Walcheren	Z	37	2211	59.8
Neeltje Jans	Z	3	68	22.7
Schouwen	Z	18	489	27.2
Goeree	ZH	16	98	6.1
		88	3302	37.5

Table 2. Species composition of oiled birds found dead following the Tricolor *spill in Zeeland and Zuid-Holland, late January - early February 2003.*
Tabel 2. Soortensamenstelling van de olieslachtoffers die na de Tricolor*-ramp in Zeeland en Zuid-Holland werden gevonden.*

Species	Oiled birds found	%
Common Guillemot *Uria aalge*	2081	63.0
Razorbill *Alca torda*	819	24.8
Black-legged Kittiwake *Rissa tridactyla*	101	3.1
Black Scoter *Melanitta nigra*	60	1.8
Common Eider *Somateria mollissima*	32	1.0
Atlantic Puffin *Fratercula arctica*	28	0.9
Red-throated Diver *Gavia stellata*	27	0.8
Northern Gannet *Morus bassanus*	27	0.8
Northern Fulmar *Fulmarus glacialis*	22	0.7
Herring Gull *Larus argentatus*	22	0.7
Great Crested Grebe *Podiceps cristatus*	18	0.6
Little Auk *Alle alle*	17	0.5
Common Guillemot / Razorbill *Uria aalge / Alca torda*	16	0.5
Eurasian Oystercatcher *Haematopus ostralegus*	14	0.4
Great Black-backed Gull *Larus marinus*	4	0.1
Other species	13	0.4
	3302	

Table 3. Sex ratio and age composition of Common Guillemots and Razorbills killed in the Tricolor *spill and found in The Netherlands late January - early February 2003.*

Tabel 3. Geslachtsverhouding en leeftijdssamenstelling van Zeekoeten en Alken die tijdens de Tricolor*-ramp zijn gestorven en eind januari-begin februari 2003 in Nederland werden gevonden.*

	Adult	Immature	First year	Total	Sex ratio
Common Guillemot					
Female	60	12	16	88	35%
Male	114	15	35	164	65%
Total[1]	335	27	78	440	
Age composition	76%	6%	18%		
Razorbill					
Female	44	11	5	60	38%
Male	79	14	7	99	62%
Total[1]	200	37	25	262	
Age composition	77%	16%	8%		

[1]including unsexed birds

Sex, age and condition A total of 598 Common Guillemots and 267 Razorbills were examined in more detail. Of birds that could be aged (n = 437 Guillemots, 262 Razorbills), over three quarters were mature in both species (Table 3) with a sex ratio significantly different from equal in Guillemots (65% males; G_{adj} 12.71, P <0.001; n = 246) as well as in Razorbills (62% males; G_{adj} 5.41, P <0.001; n = 158). Only nine Guillemots were unoiled (1.7%), while oiling was unclear in a further 36 cases (probably post-mortem oiling; hence, n = 562). The remainder was classified as slightly oiled (6.4%), heavily oiled (10.3%) or more or less completely covered with oil (81.7%). Among the last group were 333 casualties (59.2%) classified as 200% oiled. In Razorbills (n = 263 when possibly post-mortem oiled birds were omitted), 1.9% were unoiled, 1.5% slightly oiled, 9.3% heavily oiled, 87.3% more or less completely oiled (190 scored as 200%; 72.2%).

The physical condition at the time of death was good in a large number of stranded individuals in both species. Of 250 Common Guillemots, only 20.0% were classified as severely emaciated (score 0-3 on a scale ranging from 0-9), 30.4% as having at least some traces of fat (score 4-6), and 49.6% as fat or very fat (score 7-9). Of 163 Razorbills, 16.0% were classified as emaciated, 20.2%

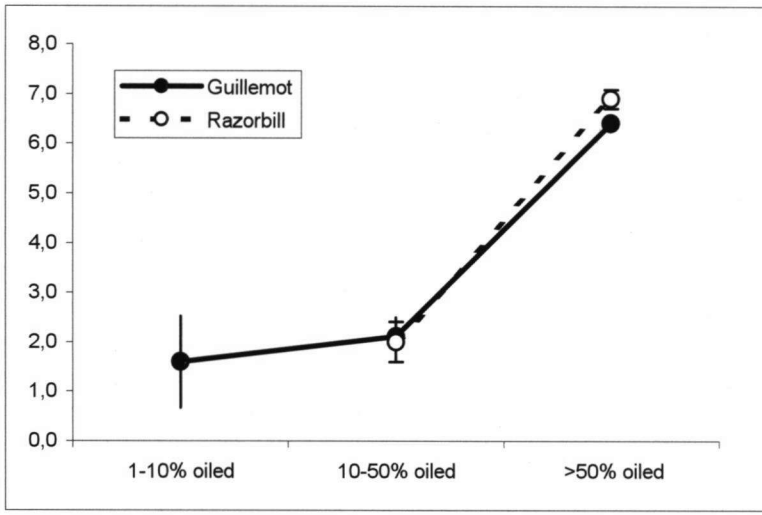

Figure 1. Body condition index and oil rate in Common Guillemots and Razorbills found dead (mean ± SE).

Figuur 1. Conditie-index en oliebevuilingspercentage van dood gevonden Zeekoeten en Alken (gemiddelde± SD).

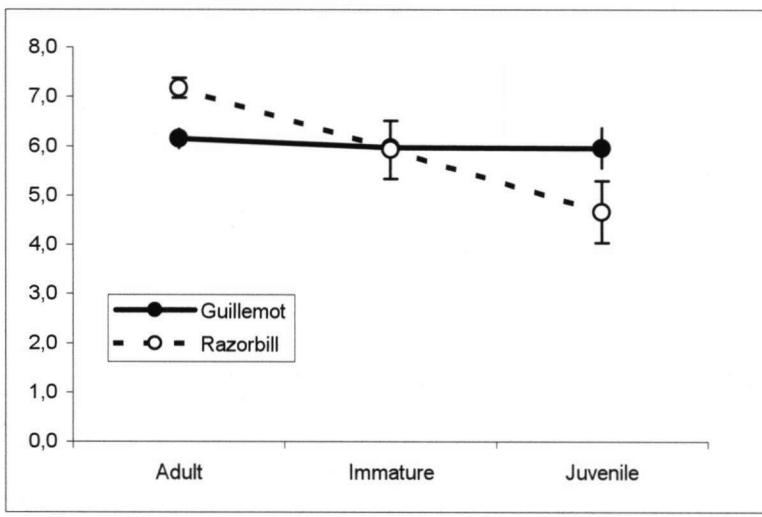

Figure 2. Body condition index and age in Common Guillemots and Razorbills found dead (mean ± SE).

Figuur 2. Conditie-index en leeftijd van dood gevonden Zeekoeten en Alken (gemiddelde ± SD).

Table 4. Biometrics of Common Guillemots killed in the Tricolor *spill and found in The Netherlands late January - early February 2003.*
Tabel 4. Biometrische gegevens van Zeekoeten die het slachtoffer waren van de Tricolor-*ramp en eind januari-begin februari 2003 in Nederland werden gevonden.*

	Bill tip-feathers	Bill nostril-tip	Bill depth at base	Bill depth at gonys	Wing length L	Wing length R
Adult female						
Sample	13	13	13	12	11	11
Mean±SE	46.6±0.7	40.2±0.6	13.9±0.2	12.5±0.2	203.0±1.4	203.0±1.4
Range	41.3-49.5	36.0-44.1	13.0-15.7	11.6-13.4	196-211	196-211
Immature female						
Sample	4	2	3	3	4	4
Mean±SE	47.8±2.6	38.5±1.0	14.2±0.4	13.5±0.0	205.0±2.4	204.5±2.7
Range	41.4-52.8	37.4-39.5	13.5-15.0	13.4-13.5	201-212	199-212
Juvenile female						
Sample	5	5	5	5	5	5
Mean±SE	44.6±0.96	36.9±1.1	11.8±0.46	10.6±0.51	192.4±2.8	192±2.8
Range	43.1-48.3	34.4-40.1	10.4-13.0	9.1-12.2	187-203	187-203
Adult male						
Sample	17	17	16	16	12	12
Mean±SE	49.1±0.5	42.2±0.5	14.8±0.4	13.1±0.2	204.8±1.9	204.6±1.8
Range	45.8-52.6	39.0-45.7	13.0-19.2	11.6-14.4	194-214	194-213
Immature male						
Sample	5	5	5	5	4	4
Mean±SE	47.9±0.9	41.2±0.9	14.1±0.7	12.6±0.6	202.7±2.6	202.7±2.6
Range	45.1-50.3	40.0-45.1	12.8-16.8	11.3-14.9	195-206	195-206
Juvenile male						
Sample	7	6	6	6	7	7
Mean±SE	46.3±1.0	40.2±0.9	13.1±0.3	11.8±0.2	195.9±1.3	195.9±1.3
Range	42.2-48.8	36.5-42.5	12.2-13.8	11.1-12.2	191200	191200

as in moderate condition, and 63.8% as being fat or very fat. In both species, a positive correlation was found between the condition index and the amount of oil on the birds: very heavily oiled individuals were usually in good condition when they died (Fig. 1). Because of the correlation between level of oiling and body condition, heavily oiled adult (96.8% of all examined adults) and juvenile Razorbills (91.7% of all juveniles) were compared separately. There was no change in the outcome, however, with a mean condition of 7.2 ± 0.2 in heavily oiled adults, as opposed to 4.9 ± 0.6 in heavily oiled juveniles. In Common

Table 5. Biometrics of Razorbills killed in the Tricolor *spill and found in The Netherlands late January - early February 2003*
Tabel 5. Biometrische gegevens van Alken die het slachtoffer waren van de Tricolor*-ramp en eind januari-begin februari in Nederland werden gevonden.*

	Bill tip-feathers	Bill nostril-tip	Bill depth at base	Bill depth at gonys	Wing length L	Wing length R
Adult female: bill W+ 1.5-2						
Sample	6	6	6	6	2	2
Mean±SE	30.3±1.1	20.9±0.4	16.8±0.4	19±0.6	203±1.0	203±1.0
Range	25.5-32.7	19.9-22.6	15.9-18.1	16.9-20.4	202-204	202-204
Juvenile female: bill 0+0						
Sample	2	2	2	2	2	1
Mean±SE	30.2±1.4	20.4±0.0	13.8±0.4	14.7±0.8	191±4.0	187
Range	28.8-31.5	20.3-20.4	13.4-14.1	13.9-15.4	187-195	
Adult male: bill W+ 1-2						
Sample	16	16	15	16	12	12
Mean±SE	32.9±0.3	21.6±0.3	17.7±0.4	19.9±0.2	194.8±0.6	194.6±0.6
Range	30.4-35.1	19.4-24.3	15.4-20.9	18.2-21.3	191-198	191-198
Immature male: bill W+0						
Sample	4	4	4	4	4	4
Mean±SE	30.4±0.7	20.3±0.4	15.3±0.3	17.4±0.3	193.3±1.0	193.3±1.0
Range	28.5-31.8	19.4-21.1	14.6-16.0	16.7-17.9	191-196	191-196
Juvenile male: bill 0+0						
Sample	2	2	2	2	2	2
Mean±SE	30.9±1.0	21.0±1.0	14.2±0.0	13.8±0.1	188.5±0.5	188.5±0.5
Range	29.9-31.9	20.0-22.0	14.2-14.2	13.7-13.8	188-189	188-189

Guillemots, condition indices were similar for adults (6.1 ± 0.2), immatures (6.0 ± 0.5), and juveniles (6.0 ± 0.4; Fig. 2). In Razorbills, however, condition indices were significantly higher in adults (7.2 ± 0.2) than in immatures (5.9 ± 0.6; $t_{149} = 2.38$, $P < 0.02$), and rather low in juveniles (4.7 ± 0.6), but not significantly different from immatures ($t_{36} = 1.26$, n.s.). Condition indices in adult Razorbills were significantly higher than in adult Common Guillemots ($t_{294} = 3.56$, $P < 0.01$), but similar in immatures and juveniles of either species (juvenile Razorbill versus Guillemot: $t_{61} = 1.41$, n.s.).

The condition of the lungs in the heavily oiled Common Guillemots (CI 0.9 ± 0.1, $n = 229$, on a scale ranging from 0-3) and Razorbills (1.0 ± 0.1, $n = 156$) was generally very poor compared to all other organs (gut, kidney and liver, range 2.5-2.9). It was observed that most of the casualties had inhaled oil

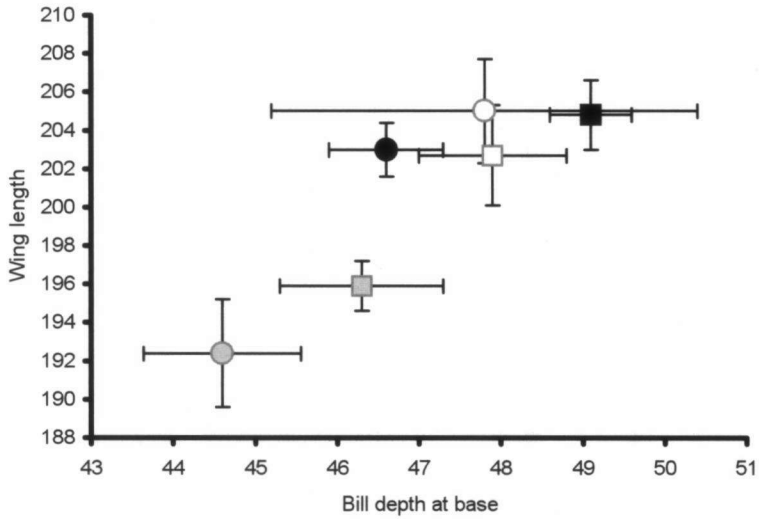

Figure 3. Bill length versus wing length (mean ± SE) in adult (black), immature (white) and juvenile (grey) male (squares) and female (circles) Common Guillemots. Sample size in Table 4.

Figuur 3. Snavellengte versus vleugellengte (gemiddelde ± SD) bij adulte (zwart), onvolwassen (wit) en juveniele (grijs) mannelijke (vierkant) en vrouwelijke (cirkel) Zeekoeten. Steekproefgrootte in tabel 4.

and as a result the lungs were shiny black. Rather low condition indices were found in moderately oiled Common Guillemots (1.8 ± 0.3, $n = 9$), but otherwise, the organs in slightly oiled, moderately oiled as well as heavily oiled auks ranged on average between 2.0 and 3.0 on the CI scale.

Biometrics The biometrics for Common Guillemots and Razorbills are tabulated in Tables 4 and 5. Wing length versus bill length (tip to feathers), two often-used biometrics to discriminate between Common Guillemot populations and age categories, are plotted in Fig. 3. In Common Guillemots, mean wing length was significantly different between adult and juvenile females ($t_{14} = 3.52$, $P < 0.01$), between immature and juvenile females ($t_7 = 2.93$, $P < 0.01$), between adult and juvenile males ($t_{17} = 3.14$, $P < 0.01$), and between immature and juvenile males ($t_9 = 2.39$, $P < 0.05$). Within age categories between the sexes, mean wing length was not statistically different. Mean bill length was significantly different between adult males and adult females ($t_{26} = 2.80$, $P <$

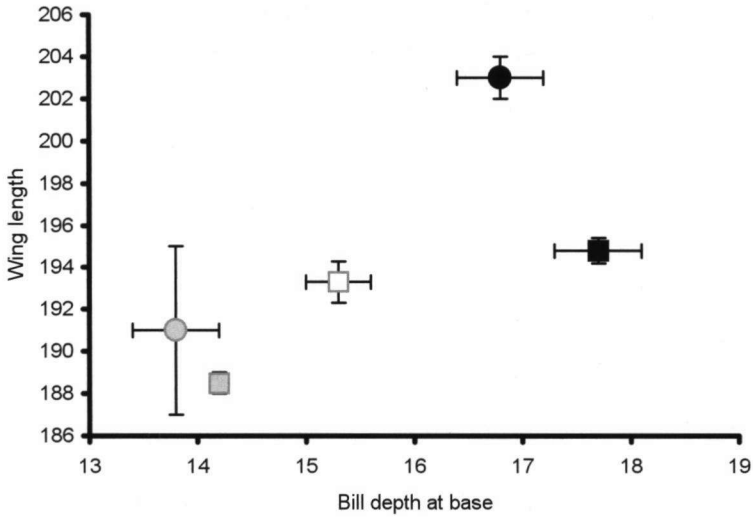

Figure 4. Bill depth at base versus wing length (mean ± SE) in adult (black), immature (white) and juvenile (grey) male (squares) and female (circles) Razorbills. Sample size in Table 5.

Figuur 4. Snavelhoogte aan de snavelbasis versus vleugellengte (gemiddelde ± SD) bij adulte (zwart), onvolwassen (wit) en juveniele (grijsy) mannelijke (vierkant) en vrouwelijke (cirkel) Alken. Steekproefgrootte in tabel 5.

0.01), between adult males and juvenile males (t_{22} = 2.78, P< 0.05), but not between adult females and juvenile males (t_{18} = 0.24, n.s.), juvenile females and juvenile males (t_{10} = 1.08, n.s.), adult males and immature males (t_{18} = 1.07, n.s.), or immature males and juvenile males (t_{10} = 1.10, n.s.). In Razorbills, sample sizes were rather small in most sex/age categories. The two often-used biometrics to discriminate between Razorbill populations (wing length and bill depth at base) are plotted in Fig. 4. Mean bill depth was similar in adult males and adult females (t_{19} = 1.38, n.s.), but significantly different between adult males and immature males (t_{17} = 3.19, P< 0.01). The wing length of only two suitable adult females was strikingly different from adult males, as well as from juvenile females (Fig. 4).

Table 6. Mean condition index (CI) ± SE of Common Guillemots and Razorbills killed in the Tricolor *spill, in three other spills in The Netherlands (December 1991, February 1992, April-May 1985), and due to chronic oil pollution (Dec-Mar 1982-2003).*

Tabel 6. Gemiddelde conditie-index (CI) ± SD van Zeekoeten en Alken die om zij gekomen bij de Tricolor*-ramp vergeleken met drie andere olierampen in Nederland (december 1991, februari 1992, april-mei 1985) en met sterfte als gevolg van chronische olieverontreiniging (dec-mrt 1982-2003).*

		Guillemot		Razorbill	
	Oiling	CI ± SE	*n*	CI ± SE	*n*
NSO chronic	Light-moderate	1.3 ± 0.1	444	1.1 ± 0.2	151
Spring 1985	Heavy	7.0 ± 0.2	47	7.2 ± 0.7	6
Texel 1992	Heavy	7.9 ± 0.1	76	8.0 ± 0.1	11
Zeeland 1991	Heavy	7.7 ± 0.3	38		
Tricolor	Heavy	6.1 ± 0.2	250	6.8 ± 0.2	163

DISCUSSION

Condition, age composition and sex ratio The condition index (CI) of both Common Guillemots (7.7 ± 0.3) and Razorbills (6.8 ± 0.2) was very high and this may be considered typical for oil incidents where birds get simply smothered in oil (Table 6). The presence of fat stores and breast muscles in good condition is believed to indicate instant death, as opposed to a prolonged trajectory of starvation and decline in lightly or moderately oiled casualties that try to stay clear of the coast for as long as they can. Most organs were in good condition, except the lungs in the heavily oiled casualties, as opposed to autopsy results in usually partly oiled birds that died from chronic oil pollution (gut infections in most casualties as well as pneumonia rather than lungs smothered in oil; NZG/NSO unpubl. data), generally confirming the observations based on the presence of reserve tissue and breast muscles: very healthy birds have been killed in the *Tricolor* spill and death was instant.

In Common Guillemots killed in the *Tricolor* incident, an extraordinary 76% were classified as adult birds (n = 437). This ratio was significantly different from the 1991 spill in Zeeland (21.1% adults, n = 38; G_{adj} = 45.3, df = 2, P< 0.001), from the Texel spill in 1992 (14.5% adults, n = 76; G_{adj} = 107.9, df = 2, P< 0.001), from winter birds killed by chronic oil pollution (47.2% adult, n = 462; G_{adj} = 91.5, df = 2, P< 0.001) and certainly from the spring 1985 incident, when adults are presumed to have returned to the colonies (6.5%

adults, $n = 46$; $G_{adj} = 88.7$, df = 2, $P < 0.001$). In Razorbills, where a similar 77% of the *Tricolor* casualties were found to be adults ($n = 262$), the age composition was not significantly different from Dutch winter birds killed by chronic oiling (72.3% adults; $G_{adj} = 1.85$, df = 2, n.s.). Small samples obtained in oil spills in spring 1985 (16.7% adults, $n = 6$) and winter 1992 (9.1% adults, $n = 11$) were rather different. These results indicate that, unlike most other strandings, a vital part of the wintering Common Guillemot population was affected: mature birds in excellent pre-breeding condition. It is interesting to note that in the *Prestige* oil spill, happing only a month earlier in NW Spain, 85% of the affected Common Guillemots were juveniles (*pers. obs.* CJC). For Razorbills, where also mainly adults in excellent condition were hit, these results may be less unusual. Since the number of Razorbills was larger than in most previous events, and while the population size of Razorbills is comparatively small, the *Tricolor* spill can be considered one of the more serious oil incidents in recent years affecting this species in the North Sea.

Both in Common Guillemots and in Razorbill, with sex ratios significantly different from equal, the samples were biased towards males and this was true for all age categories. The sex ratio in adult Guillemots from the *Tricolor* (65.5% males, $n = 174$) was significantly different from the large sample of adult winter birds killed by chronic oiling (54.8% males, $n = 210$; $G_{adj} = 4.58$, df= 1, $P < 0.01$) and the same was true for juveniles, which were slightly biased towards females in the material obtained from chronic oiling (*Tricolor* 68.6% males, $n = 51$; chronic oiling 46.7% males, $n = 135$; $G_{adj} = 7.24$, df= 1, $P < 0.01$). When the sex ratio of the *Tricolor* birds for each of the age categories was compared with material from any of the other spills, the differences were either not significant, or the samples were to small to warrant any testing. A bias towards males seems a general phenomenon in Dutch winter material. In adult Razorbills, the sex ratio of adult *Tricolor* casualties (64.2% males, $n = 123$) was significantly different from adult birds obtained as a result of chronic oiling in winter (49.1% males, $n = 112$; $G_{adj} = 5.45$, df= 1, $P < 0.01$). Samples of immatures and juveniles were generally too small to allow any sensible testing.

The biometrics of the Common Guillemots would point at the *U. a. aalge* subspecies (Cramp 1985). The wing length can be compared with the European cline in wing length drawn together by Peter Hope Jones (Jones 1984, 1988). A mean length of 203±1.4 mm as in adult females and 204.8±1.9 mm as in adult males would be consistent with Scottish breeding birds at approx. 57°N latitude. This suggestion is confirmed by an analysis of ringing recoveries based on *Tricolor* casualties (Grantham 2004), where the east coast of Scotland was identified as the area where ringed individuals mostly originated from. For Razorbills, the situation is more complex. The biometrics in Table 5 for adult males and immatures are consistent with measurements of the *islandica*

subspecies anywhere in Britain, Ireland or Iceland (Cramp 1985); a more precise location cannot be pinpointed. Two adult females were remarkably long-winged, but with beak measurements that were consistent with the *islandica* subspecies. Grantham (*pers. comm.*) confirms the subspecies from ringing recoveries and indicates that the east coast of Scotland is again a likely breeding area from where many casualties may have originated.

Previous oil incidents Following a westerly storm in December 1991, hundreds of heavily oiled Common Guillemots washed ashore at Walcheren, originating probably from the same wintering grounds as the casualties found in The Netherlands following the *Tricolor* spill (Camphuysen 1995b). As indicated before, however, with only 21.1% adults in 1991, the age composition of the Guillemots found dead was strikingly different from that during the *Tricolor* spill. Similar in both kills were the excellent condition of the auks at the time of death (Table 6) and the severe oiling of the casualties ('200%').

Using back-calculations based on wind-drift models, Leopold & Camphuysen (1992) expected the wintering grounds of auks that were found on Texel in February 1992 to be situated in the central Southern Bight, about 110 km north of the *Tricolor* wreck site. Again, the age composition of the Guillemots found dead was significantly different from that during the *Tricolor* spill, with only 14.5% classified as mature birds in 1992. Condition at the time of death (Table 6) and the severe oiling were again similar.

Even further to the north, a spring staging area just north of the Brown Bank, was the calculated area where hundreds of heavily oiled Common Guillemots found dead in April-May 1985 along the mainland coast of Noord-Holland originated (Camphuysen 1990). A similar scenario (instant death due to heavy oiling; excellent condition at the time of death) was reported as during the *Tricolor* spill, but the incident took place when most adults had already returned to their breeding colonies: only 6.5% were recorded as mature birds.

These four spills are subsamples of what could have been the same wintering population, at slightly different times of the year. Three spills could not be attributed to a particular source (characteristic of chronic oil pollution), but the events were clear-cut in time and space and could therefore be isolated as particular incidents. The most striking difference between the three smaller incidents and the *Tricolor* spill is the age-composition in the affected Common Guillemots and the seemingly high proportion of mature birds in the latter. Routine beached bird surveys provide some insight in the age composition of stranded Common Guillemots, because juveniles can be separated with a high degree of certainty from immatures and adult birds on the basis of their underwing pattern (white tips on greater under wing coverts are characteristic for juvenile birds; Sandee 1983; Camphuysen 1995a). Summarising beached

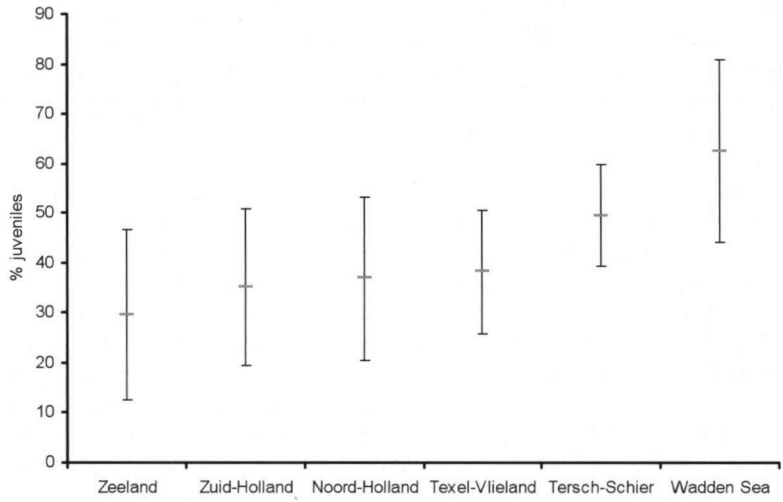

Figure 5. Mean proportion (± SD) of juvenile Common Guillemots based on white tips at greater under wing coverts during routine beached bird surveys in The Netherlands, 1980-2003 (cf Camphuysen 1995a) for each major subregion. Samples are based on at least 10 corpses each winter (Nov-Apr).

Figuur 5. Gemiddeld aandeel van juveniele Zeekoeten (witte toppen op ondervleugeldekveren) tijdens de reguliere stookolieslachtoffertellingen in Nederland, 1980-2003 (cf Camphuysen 1995a) per kustgedeelte. Steekproeven zijn gebaseerd op minimaal 10 kadavers per winter (nov-apr).

bird survey data collected between 1980 and 2003, using 7798 properly aged casualties found in winter (Nov-Apr), suggest a south → north increase in the proportion of juvenile birds (Fig. 5) and, more importantly, that a proportion as found in the *Tricolor* spill is by no means unusual (range 61.7 ± 12.4 % to 70.4 ± 17.0 % 'non-juveniles' in the four most southerly subregions). Grantham (2004) observed a similar pattern, where "birds recovered further north were more likely to be immatures, whereas birds recovered further south in the North Sea were more likely adults". With a general tendency of juvenile Common Guillemots to winter further to the south from their natal colonies than adults (Harris & Swann 2002), it should be realised that the adults and immatures recovered in a single spill might well originate from different breeding areas. With regard to the *Tricolor* spill, most (ringed) adults originated from the well-studied Scottish east coast, where ringing effort is rather high. The immatures and juveniles found during the incident, very few of which were ringed, might

as well have originated form colonies further to the north, where ringing effort is considerably less. The biometrics obtained from these not fully grown individuals are unlikely to provide the evidence to support this, in the absence of back-ground data that can be used to discriminate between populations for young birds.

Numbers of birds With approximately 4000 birds found in The Netherlands, about 21% of the total number of casualties of the *Tricolor* spill recovered along the eastern seaboard of the English Channel crossed Dutch borders. Approximately 9200 casualties were found in Belgium (Velter & Rodts 2003; Stienen *et al.* 2004), another 5500 were recovered in Northern France (Jacques *et al.* 2003). Common Guillemots predominated in all countries (70% in France, 65% in Belgium, 63% in The Netherlands), with Razorbills ranking second in all areas (17% in France, 22% in Belgium, 25% in The Netherlands). Numbers of Great Crested Grebes were low in The Netherlands (0.6%) in comparison with numbers recovered in France (4.0%) and Belgium (3.3%). An estimated 20 000 individuals may have washed ashore, while unknown numbers may have gone lost at sea, particularly after 9 February.

Using daily weather reports (KNMI Vlissingen, mean wind direction and mean wind velocity; http://www.knmi.nl/voorl/weer/), assuming a corpse drift between 2 and 4% of the wind speed (Bibby & Lloyd 1977; Jones *et al.* 1978; Bibby 1981), vectors calculated from Westkapelle (Walcheren) would lead to the wreck site at 24 January 2003 (assuming max. corpse drift; Fig. 6). Alternatively, vectors would lead to the wreck site on 22 January 2003 when 3% of the wind speed is assumed. This exercise suggests that the birds most likely originated from an offshore area between Fairy Bank, North Falls, and Oost-Hinder, probably with additional casualties from Bligh Bank and Thornton Bank, but that the deadly slicks crossed more typical Great Crested Grebe habitat (coastal waters 10m deep or less) rather swiftly during stormy weather on 28 January. From the wind data, it seems unlikely that slicks and corpses travelled much further to the north than Schouwen (and indeed, densities at Goeree were an order of magnitude lower than those at Walcheren). In France (66%) and Belgium (54%) proportionally many more casualties were still alive when found ashore (only 19% of those recovered in The Netherlands), indicating active movements rather than passive, wind-influenced corpse drift.

Winds were very favourable for rapid strandings, so that relatively few birds may have disappeared unrecorded at sea, at least until 9 February 2003. However, with such thick oil, birds may sink or go unrecorded during clean-up operations at sea (mechanical clean-up) or on beaches. Therefore, estimates ranging from twice to at most five times the stranded numbers seem reasonable, suggesting a kill of between 40 000 and 100 000 seabirds, the majority of which

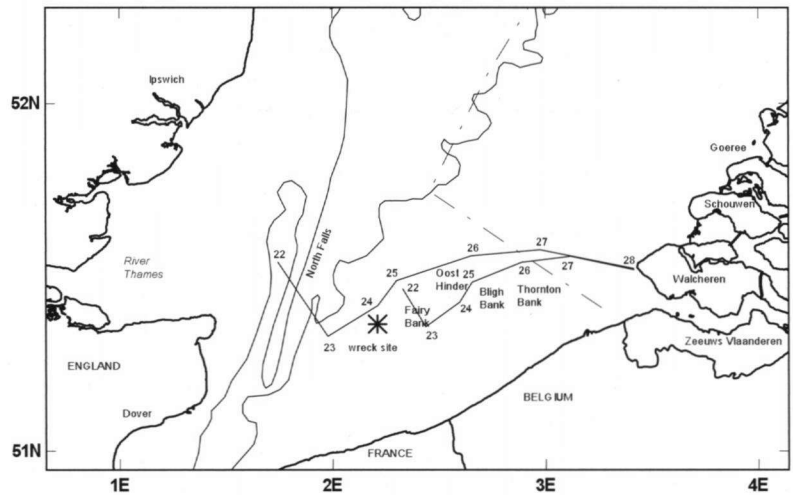

Figure 6. Wreck site of the Tricolor *and back calculations of floating corpses using daily wind data measured at Vlissingen (Walcheren) and assuming 4% of wind speed (far-ranging) and 3% of wind speed (southern leg) between 22 and 28 January 2003. Boundaries of the Dutch sector of the North Sea are indicated by a dashed line, 30m depth contours indicate the deeper water region of the central Channel area.*

Figuur 6. Ligging van de gezonken Tricolor *en de berekende positie van drijvende kadavers aan de hand van de dagelijkse windgegevens van meetpost Vlissingen (Walcheren). Hierbij is uitgegaan van 4 en 3% van de windsnelheid voor respectievelijk de verre en de minder verre route. De begrenzing van de Nederlandse sector van de Noordzee is aangegeven met een onderbroken lijn. De 30-meter dieptelijnen markeren het diepere water van de centrale kanaalzone.*

were Common Guillemots (25 000-62 500) and Razorbills (8000-20 000). The 20-day period of easterly wind in the rest of February may have sent corpses of birds to England and it is noteworthy that the late February 2003 beached bird survey in SE England had the highest oil rates since at least 1991 (68.8% oiled for all species combined, versus 19.8% in 2002; Royal Society for the Protection of Birds, unpubl. data).

That very large numbers of seabirds could have been killed in a mid-winter oil incident in the English Channel was foreseen. Carter *et al.* (1993) categorised the area where the *Tricolor* sank as of the highest vulnerability between December and March, mainly because of offshore concentrations of

auks and nearshore concentrations of divers and seaduck. Offringa *et al.* (1996) and Seys *et al.* (2001) have highlighted the importance of the English Channel as a wintering area for seabirds in more recent years. The fact that a salvage operation, ultimately causing the *Tricolor* bunker tanks to leak oil, was not postponed until April was unfortunate, for that would have saved many thousands of seabirds from a miserable death. On the other hand, the repeated collisions of cargo vessels and tankers with the sunken wreck (plus a dozen or so near-hits reported from the area; Hans van Rooij, Smit Salvage *pers. comm.*) made the wreck a time-bomb that would explode anyway, possibly within the same time-frame, and possibly with even more oil spilled if for example a laden tanker struck the wreck and spilled it's own cargo. With the risk of greater disaster in mind, the untimely salvage operation could be defended. It is doubtful, however, if the responsible authorities fully appreciated the environmental risks taken with that decision and if they had a copy of the JNCC vulnerability atlas at hand (Carter *et al.* 1993).

The combination of data strongly points at the NW North Sea as a breeding area of both the Common Guillemots and the Razorbills affected by the *Tricolor* spill and the sheer number of casualties, as well as the very high proportion of mature birds, would lead to the expectation that an immediate effect on the breeding population has to be expected (extra adult winter mortality, lower returns into the colonies in the 2003 season). A follow-up project is required to assess the damage in the affected populations and it is a fortunate coincidence that the Isle of May, one of the best-studied auk colonies is situated in that area.

ACKNOWLEDGEMENTS

F. Arts, A. Dijkstra, S. Hart, J. van der Hiele (Rijkspolitie Zeeland), J. Goedbloed, M. van de Kasteele, P. de Keuning, M. Klootwijk, J. de Korte, S. Lilipaly, P.L. Meininger, K. Minnaar, A. Schellevis (Rijkswaterstaat), L. Stout, J. Tramper, T. van Wanum, L. van de Weele, D. Wisse, en P. Wolf performed the necessary beached bird surveys. Jaap van der Hiele and Pim Wolf were particularly helpful when an intervention was needed to timely collect corpses that were about to be sent to the destruction. The authors were greatly assisted by Laurens van Kooten and Piet Wim van Leeuwen during the transport up north to Texel and when chemical waste was subsequently returned to Zeeland. Jan de Leeuw (Royal NIOZ) kindly gave permission to use NIOZ facilities for autopsies. Phil Battley, Peter de Boer, Maarten Brugge, Jan Andries van Franeker, Arnold Gronert, Yvonne Hermes, Folkert Janssens, Guido Keijl, Leon Kelder, Suzan van Lieshout, Luc Meeuwisse, André Meijboom, Bob Loos, Sue Moore, Peter Spannenburg, and Hans Witte kindly assisted the authors with the autopsies. The project was aided by a financial grant of BirdLife The Netherlands (Vogelbescherming Nederland).

HET *TRICOLOR* OLIE-INCIDENT: KARAKTERISTIEKEN VAN DE IN NEDERLAND AANGETROFFEN OLIESLACHTOFFERS

Tussen 28 januari en 9 februari 2003, spoelden ongeveer 4000 zwaar met olie besmeurde zeevogels aan op de Nederlandse kust: 21% van de ongeveer 20 000 olieslachtoffers die als gevolg van de olieramp met de *Tricolor* op de kust van Noord-Frankrijk, België en Nederland zijn gevonden. 91% van de gevonden vogels waren Zeekoeten, Alken en Drieteenmeeuwen. Ongeveer 600 Zeekoeten en 267 Alken werden aan een nadere inspectie onderworpen en een groot deel van deze dieren werd inwendig onderzocht. De dissecties wezen uit dat de alkachtigen in een uitstekende conditie verkeerden op het moment dat zij met de olie in aanraking kwamen; een indicatie voor een plotselinge dood als gevolg van verstikking in teer. Van 440 Zeekoeten waarvan de leeftijd kon worden bepaald was 76% adult en er waren meer mannetjes dan wijfjes getroffen (65% man). Van 262 Alken was 77% adult en ook hier overheersten mannetjes het monster (62%). Op grond van biometrische bepalingen wordt verondersteld dat de meeste Zeekoeten tot de subspecies *Uria aalge aalge* behoorden, terwijl de Alken werden geclassificeerd als *Alca torda islandica*. Op grond van de vleugellengte waren de Zeekoeten vermoedelijk van Schotse kolonies afkomstig (57°NB), een bevinding die door ringmeldingen werd ondersteund. De totale sterfte als gevolg van het lek in de *Tricolor* (2-5x het gevonden aantal vogels) bedroeg vermoedelijk ongeveer 40 000-100 000 zeevogels (25 000-62 500 Zeekoeten, 8000-20 000 Alken). Met een zodanig hoog percentage adulte vogels onder de getroffen alkachtigen, klaarblijkelijk kerngezonde broedvogels, mag een onmiddellijk effect op de getroffen populaties worden voorzien: een verminderde terugkeer van broedvogels in het seizoen 2003. Indien meer jonge vogels zouden zijn getroffen, dan zou zo'n effect worden uitgesteld over meerdere jaren en is er doorgaans weinig van te merken. Opgemerkt dient te worden dat het effect van de *Tricolor* aanzienlijk geringer zou zijn geweest indien de bergingsoperatie (waardoor het lek werd veroorzaakt) zou zijn uitgesteld tot de zomer. De kwetsbaarheid van het gebied is buitengewoon hoog, maar vooral in de winter (dec-mrt).

REFERENCES

Bibby C.J. 1981. An experiment on the recovery of dead birds from the North Sea. Orn. Scand. 12:261-265.

Bibby C.J. & Lloyd C.S. 1977. Experiments to determine the fate of dead birds at sea. Biol. Conserv. 12: 295-309.

Camphuysen C.J. 1987. Problems with age-determination of seabirds due to heating of the corpses. Sula 1(1): 13-14.

Camphuysen C.J. 1990. Dieet, leeftijd en geslacht van de Zeekoet *Uria aalge* in de Nederlandse Noordzee in het voorjaar. Sula 4(2): 41-54.

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

Camphuysen C.J. 1995b. Voedsel van Zeekoeten *Uria aalge* voor de Zeeuwse kust, december 1991. Sula 9(4): 164-166.

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.

Cramp S. (ed.) 1985. The Birds of the Western Palearctic, 4. Oxford Univ. Press, Oxford.

Franeker J.A. van 1983. Inwendig onderzoek aan zeevogels. Nieuwsbr. NSO 4(4/5): 144-167.

Ginn H.B. & Melville D.S. 1983. Moult in Birds. BTO Guide 19, BTO, Tring.

Grantham M. 2004. Age structure and origins of British and Irish Common Guillemots *Uria aalge* recovered in recent European oil spills. Atlantic Seabirds 6(3/S.I.): 95-108.

Harris M.P. & Swann R. 2002. Common Guillemot *Uria aalge*. Wernham C. et al. (eds). The migration atlas: movements of the birds of Britain and Ireland: 397-400. T. & A.D. Poyser, London.

Jacques J.P., Charpentier J.M., Lastavelle A. & Maytas N. 2003. Case histories: Tricolor spill on French littoral. Oral presentation 7th International Conference Effects of Oil on Wildlife, 14-16 October 2003, Hamburg.

Jones P.H. 1984. Skins of Guillemots *Uria aalge* and Razorbills *Alca torda* examined at Cascais, Portugal, in May 1982. Memorias do Museo do Mar, Ser. Zool. 3(27): 1-10.

Jones P.H. 1985. Determination of age, sex and origin of guillemots and razorbills killed in oil spills and other incidents. M. Sc. Thesis, Open University.

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

Jones P.H., Monnat J.-Y., Cadbury C.J. & Stowe T.J.S. 1978. Birds oiled during the Amoco Cadiz incident: An interim report. Mar. Poll. Bull. 9(11): 307-310.

Leopold M.F. & Camphuysen C.J. 1992. Olievogels op het Texelse strand, februari 1992. Oiled seabirds on Texel, February 1992. NIOZ-Report 1992-5, Netherlands Institute for Sea Research, Texel, 29 pp.

Offringa H., Seys J., Bossche W. van den & Meire P. 1996. Seabirds on the Channel doormat. Le Gerfaut 86: 3-71.

Sandee H. 1983. Kleurcontrast in de vleugeldekveren bij Alk en Zeekoet. Nieuwsbr. NSO 4: 133-143.

Seys J., Offringa H., Waeyenberge J. van, Meire P., Vincx M. & Kuijken E. 2001. Distribution patterns of seabirds in Belgian marine waters. In: Seys J. Sea- and coastal bird data as tools in the policy and management of Belgian marine waters: 22-39. PhD-thesis, University of Gent, Gent.

Stieda L. 1880. Ueber den Bau und die Entwicklung der *Bursa fabricii*. Z. wiss. Zool. 34: 296-309.

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(3/S.I.): 129-146..

Velter C. & Rodts J. 2003. Tricolor collision and seabird rescue in Belgium. Oral presentation 7th International Conference Effects of Oil on Wildlife, 14-16 October 2003, Hamburg.