Die Vogelwarte 38, 1996: 217–224

Causes and trends of the mortality of Guillemots (*Uria aalge*) ringed on the island of Helgoland, German Bight

By Ommo Hüppop

Abstract: HÜPPOP, O. (1996): Causes and trends of the mortality of Guillemots (*Uria aalge*) ringed on the island of Helgoland, German Bight. Vogelwarte 38: 217–224.

Increased mortality of Guillemots and other seabirds in fishing gear is reported from several different areas. On the Island of Helgoland (German Bight, North Sea), 6,566 fledgelings of the Guillemot were ringed from 1912 to 1994 of which 605 were recovered (recovery rate = 9.2 %). The recoveries were analysed with regard to the causes of mortality over time and to probable effects on mortality rates.

Up to 1945, most Guillemots were killed by human persecution (71 % of all recoveries), whereas today (1989-94) less than 2 % are recorded as hunted. In contrast, the percentage of birds killed in fishing gear increased to almost 42 %. Mortality by oil pollution reached its highest proportion between 1970 and 1988 (24 %).

The geographical distribution of recoveries shows that hunting was the main cause of mortality in Norway and Germany. Most birds killed by oil pollution appeared along the shipping routes in the southern North Sea and birds drowned in fishing gear were primarily found in Sweden and Denmark.

In spite of severe shifts in the causes of death, the mortality rate remained virtually stable. Therefore, the increase in numbers of Guillemots in the Helgoland colony seems more likely due to better food supply rather than to decreased mortality.

Key words: Guillemot, *Uria aalge*, auks, ring-recoveries, mortality, hunting, pollution, fisheries.

Address: Institut für Vogelforschung „Vogelwarte Helgoland", Postfach 1220, D-27494 Helgoland, Germany.

1. Introduction

As a consequence of severe persecution by man since about 1800, Guillemots (*Uria aalge*) - and many other seabirds - have decreased considerably in numbers and disappeared from many parts of their former breeding range. With the introduction of laws for better protection many populations could recover mainly in the second half of our century (NETTLESHIP & BIRKHEAD 1985, LLOYD et al. 1991). On the island of Helgoland in the German Bight (North Sea, 54° 11' N, 7° 54' E) Guillemots were hunted during their breeding season at least until 1910 (WEIGOLD 1910, 1924). Whereas the Kittiwake (*Rissa tridactyla*) disappeared from the island as a breeding species in the beginning of the last century due to the severe persecution (e.g. WEIGOLD 1924), numbers of Guillemots were surprisingly unaffected, ranging between 1,500 and 2,500 pairs until World War II. Thereafter they dropped to less than 1,000 pairs before recovering continuously from approximately 750 pairs in 1975 to about 2,600 pairs in 1995 (VAUK-HENTZELT et al. 1986, HÜPPOP 1995 and unpubl.).

Contemporarily with the reduction of hunting mortality in Europe, two new possible threats for Guillemots and other seabird species appeared: oil pollution and drowning in fishing gear (MEAD 1974 and 1993, TASKER et al. 1987, LLOYD et al. 1991, ANON. 1992). The discussion of possible effects on population sizes and development is contradictory. Oil can particularly threaten local breeding populations of auks when an oil spill happens in vicinity of their breeding or feeding grounds (LLOYD et al. 1991). However, evidence for long-term adverse effects of oil spills on the size of seabird populations is very scarce (HÜPPOP 1991, LLOYD et al. 1991, WIENS 1995).

Further, most types of fishing gear can entangle seabirds, but some types are more likely to kill birds. Birds have been reported drowned particularly in gill and other static nets (KING 1984, ANON. 1992). Comprehensive studies of entanglement in the North Sea are missing, but mortality in fishing gear, specifically in gill nets, has been considered as a main reason for the 80 to 90 %

decline in the numbers of Guillemots in northern Norway since at least 1965. There, tens of thousands of auks are thought to have drowned in salmon fishing nets every year (VADER et al.1988, VADER 1990, STRANN et al. 1991). In a study area in Newfoundland, ringing recoveries from 1951 to 1977 and bycatch counts in 1972 and 1980/81 showed that 3 to 20 % of the breeding stock of Guillemots (but less than 1.6 % of breeding Puffins *Fratercula arctica*) drown annually in gill nets. The kill-toll of auks as offshore bycatches may be even more substantial in West Greenland or the Pacific (TULL et al. 1972, PIATT et al. 1984). In the rarest member of the family Alcidae, the Japanese or Crested Murrelet (*Synthliboramphus wumizusume*), the estimated mortality in high-seas drift net fisheries represents even a significant proportion of the total world population (PIATT & GOULD 1994).

Drowning in fish nets may be a threat as well for the Helgoland Guillemots, despite their increasing numbers. In the North Sea off the Netherlands, Germany and Denmark, there is presently only limited gill netting (ANON. 1992). But fishery biologists recommend increasing its use for economic reasons and to reduce the amount of unused bycatch compared to beam-trawls (STEINBERG 1990). And, in contrast to the coastal German bight, several reports from areas sought out by Helgoland Guillemots outside the breeding season (DROST 1930, STECHOW 1938, SCHLOSS 1969) reveal a high mortality of Guillemots in fishing gear. OLDÉN et al. (in ANON. 1992) estimated that 25,000 diving seabirds drowned in herring and cod gill nets in the southeastern Kattegat between 1982 and 1988. Ninety to 95 % of these birds were Guillemots. In eight days of fishing in January 1988, about 900 auks (mainly Razorbills *Alca torda*) were killed in nets at one place in the English Channel. The numbers caught at this single site are not significant at the North Sea population level, but this situation is probably typical of all sites where diving seabirds are common and netting is undertaken (ANON. 1992). Hence, Guillemots have also been recorded being caught in nets e.g. off the French Channel coast (more than 85 % Guillemots, VINCENT 1989), at beaches of the Netherlands (CAMPHUYSEN 1994) and western Germany (VAUK et al. 1989), on the Dogger Bank (TASKER in ANON. 1992), in the Skagerrak/Kattegat area (PETERZ & OLDÉN 1987), in Scotland (MURRAY 1995) and in the Baltic Sea. In the latter case, up to 20,5 % of the birds drowned were Guillemots (KIES & TOMEK 1990, STEMPNIEWICZ 1994, SCHAFSTALL pers. comm.). Furthermore, MEAD (1993) recently reported an increase in the proportion of recoveries as casualities in fish nets of Guillemots and Razorbills ringed in Britain. Facing the probability of higher numbers of set nets in the German Bight in near future, there should be concern that German Guillemots may be negatively affected by fishing gear as well.

On the basis of ring recoveries, this study analyses shifts in the causes of mortality for Guillemots on Helgoland since the beginning of their ringing in 1912. Possible effects on the overall mortality, i.e. on population dynamics, are evaluated.

2. Materials and methods

From 1912 to 1994, 6566 Guillemots were ringed as fledgelings. Because climbing is too dangerous in the crumbly sandstone cliffs, ringing can only be done when the young jump off their breeding cliffs and they can be grasped in the rocky intertidal during low tide in the evening hours.

Through the end of 1994, there were 605 recoveries of ringed Guillemots (9.2 % of ringed total). These were grouped for four periods (1912-45, 1946-69, 1970-88, 1989-94) by the cause of mortality. The first period covers the time of severe shooting pressure and the increasing introduction of ships fueled with oil. The second and the third period are characterized by the establishment of protection laws for seabirds in most parts of Europe. During the third one, the use of gill and other static fish nets increased. At the same time, economic reasons caused by the „oil crisis" led to an increased use of heavy fuel oils. With the beginning of period four, a cost-free oil waste management was introduced in German ports.

„Hunted" includes all birds shot or otherwise persecuted by man. All birds for which the cause of death was unknown or those reported without respective remarks by the finder were classified as „unknown".

Average annual mortality was calculated by the LACK-HALDANE-method for complete datasets (HALDANE 1955) for only those birds found 1 to 10 years after ringing.

I am very grateful to all persons that helped with ringing during numerous, often pretty cold evenings, to those reporting recoveries, to Prof. Dr. FRANZ BAIRLEIN and KARIN HAISCH for useful comments on an earlier draft, and especially to Dr. LINDA FRANKLIN for polishing my language.

3. Results and Discussion

Since 1912, the relative proportion of the various causes of mortality has shifted seriously (fig. 1). Through 1945, human persecution was the main mortality factor (71 % of all ringed Guillemots recovered). Subsequently its proportion dropped continuously, reaching less than 2 % in 1989-94. Although this decline may be biased to a certain extent by low reporting rates for birds illegally shot, it reflects the efficiency of protection laws in most European countries (LLOYD et al. 1991). The opposite pattern was found for drowning in fishing gear. The proportion of Guillemots found dead in nets etc. rose from 3.5 % and only 1.5 % in the first two periods to almost 42 % in the last one. With increasing fuel prices in the seventies, there was a tendency towards using more static nets, because this method of fishing consumes much less fuel than trawling (WEBER et al. 1990). This certainly can explain the increased proportion of Guillemots drowned in fishing nets.

The percentage of Guillemots found oiled rose from 8 % before 1946 to 24 % in 1970-88. Then it declined slightly. However, these figures have to be regarded with caution, since the percentages

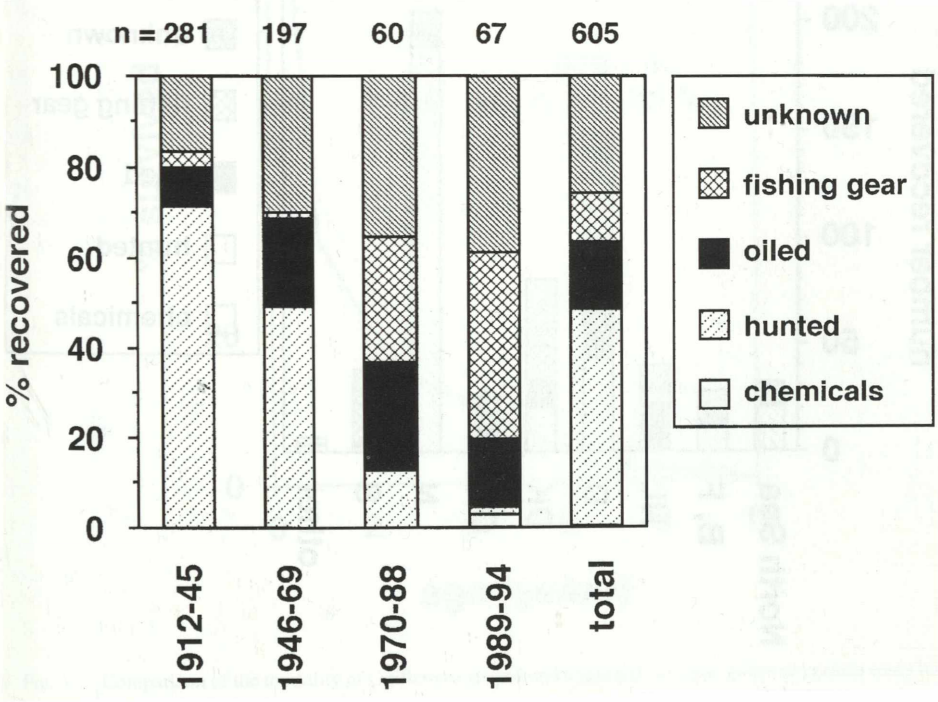

Fig. 1: Recoveries of Guillemots ringed on Helgoland from 1912 to 1994 grouped by time period and causes of mortality.
Wiederfunde auf Helgoland von 1912 bis 1994 beringter Trottellummen nach Zeiträumen und Todesursachen aufgeschlüsselt.

are probably severely influenced by changes in the other categories. Comparing absolute numbers will also result in biased figures, because the reporting rate for ringed birds can certainly not be assumed to be constant. Comparing the numbers of birds found oiled to those of birds reported as „unknown" may probably solve the problem. The proportion of „oiled" to „unknown" changed from 1:2 in 1912-45 to 1:1.5 in both 1946-69 and 1970-88 and to 1:2.5 in 1989-94. This presumably reflects an (absolute) increase in mortality by oiling with the rising number of ships fueled with oil. However, a further increase of oiled Guillemots as observed in beached bird surveys in Germany assumed to be due to the use of heavy fuel oils starting with the „oil crisis" in the seventies (HARTWIG et al. 1990) did obviously not affect the recovery proportions. The decrease in the proportion found oiled observed after 1988 might be explained by the cost-free waste management of oil in German ports started in that year (e.g. FLEET et al. 1995). However, the difference is not significant ($chi^2 = 1{,}82$) and the sample size is still too small (n = 11) for a more detailed analysis.

The geographical distribution of recoveries (fig. 2) shows that hunting took place mainly in Norway and in Germany (mainly near Helgoland) making up 64 and 15 % of all birds reported as hunted, respectively. In Norway, Guillemots have received complete protection since 1979 (LLOYD et al. 1991). Hence, the number of birds reported from Norway as „hunted" dropped from 107 birds (= 95 % of all recoveries) in 1912-45 and 77 birds (= 94 %) in 1946-69 to only 4 birds in 1970-88 and no birds after 1988.

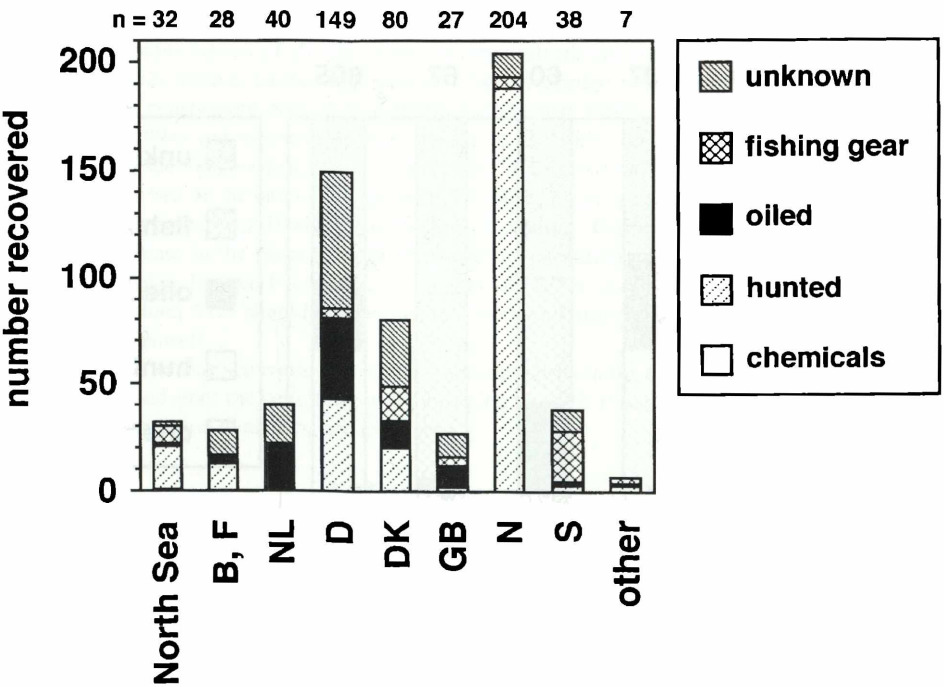

Fig. 2: Geographical distribution of recoveries of Guillemots ringed on Helgoland from 1912 to 1994 grouped by causes of mortality (n = 605).
Geographische Verteilung der Wiederfunde auf Helgoland von 1912 bis 1994 beringter Trottellummen nach Todesursachen (n = 605).

Most Guillemots found oiled were reported close to the main shipping routes in the southern North Sea, namely from Germany (42 %), the Netherlands (23 %), Denmark (14 %) and Great Britain (11 %), whereas most recoveries of birds found drowned in fishing gear originated from Sweden (36 %) and Denmark (25 %). Those parts of Norway where mortality in fishing gear is a major threat to auks and other diving seabirds (see introduction) are barely reached by Helgoland Guillemots. Hence only 8 % of all Guillemots that died in fishing gear were found in Norway.

Of course, this geographical comparison is biased. For example, the chance to detect a corpse washed ashore is much higher at a sandy beach in the densely populated central Europe than it is at

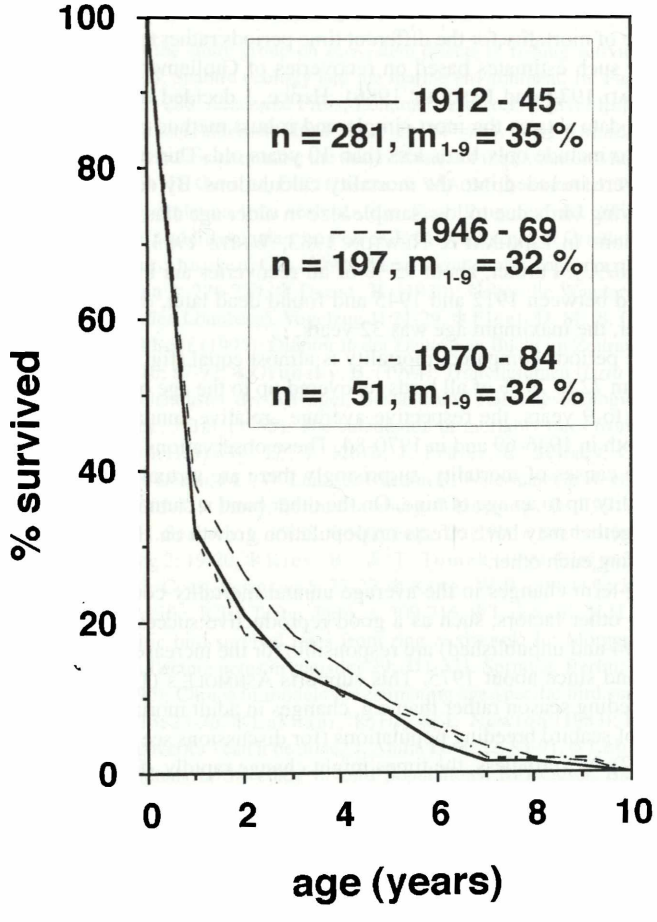

Fig. 3: Comparison of the mortality of Guillemots ringed on Helgoland for three different periods (only birds less than 10 years old are included, see text). m_{1-9}: average annual mortality over the age classes 1 to 9.
Vergleich der Mortalität auf Helgoland beringter Trottellummen für drei verschiedene Zeiträume (nur weniger als 10 Jahre alte Vögel wurden berücksichtigt, vgl. Text). m_{1-9}: durchschnittliche jährliche Mortalität über die Altersklassen 1 bis 9.

a rocky coast of Norway or Sweden. Furthermore, it can be assumed that almost all birds that die in fishing gear or that are hunted can be detected, whereas this is not realistic for individuals that die at sea. Whether these recoveries are reported or not certainly depends on the legal situation and on the pressure that governmental and private nature conservancy agencies put on fishermen or hunters. Nevertheless, the general pattern shown in fig. 2 should be realistic.

The serious shifts in the causes of mortality raise the question, whether this may affect the population dynamics of the isolated Guillemot colony at the island of Helgoland. There is much controversy about methods for estimating survival and mortality from ring recoveries (e.g. LAKHANI & NEWTON 1983, WHITE 1983, BIRKHEAD et al. 1985, LAKHANI 1985 and 1990, NETTLESHIP & BIRKHEAD 1985, LEBRETON & NORTH 1993). In this study, nothing is known about changes in durabilty of the ring material used over the decades or about probable changes in the recovery rate, both influencing mortality estimates. However, for the questions raised it is sufficient to have a comparable relative estimate of mortality for the different time periods rather than to approach an estimate of true mortality (for such estimates based on recoveries of Guillemots ringed on Helgoland see BIRKHEAD 1974, MEAD 1974 and PASQUET 1986). Hence, I decided to use the LACK-HALDANE-method for complete data sets as the most simple and robust method possible which is based on recoveries only, and to include only birds less than 10 years old. This means that only those birds ringed before 1984 were included into the mortality calculations. By doing this the probability of severe bias in long-living birds due to low sample size in older age classes or loss of rings is much reduced (see discussions in LAKHANI & NEWTON 1983, WHITE 1983, LAKHANI 1985 and 1990, LEBRETON & NORTH 1993). Further, about 95 % of all recoveries are included this method: From 281 Guillemots ringed between 1912 and 1945 and found dead later, only 15 (= 5.3 %) get older than 9 years. However, the maximum age was 32 years.

Among the three periods compared, mortality is almost equal (fig. 3). It is highest during the first year, ranging from 72 to 79 % of all birds recovered up to the age of 10 years. For Guillemots reaching an age of 1 to 9 years, the respective average „relative annual mortality" was 35 % in 1912-45, and 32 % both in 1946-69 and in 1970-84. These observations indicate that in spite of the severe changes in the causes of mortality, surprisingly there are virtually no long-term effects on average annual mortality up to an age of nine. On the other hand it cannot be excluded that all mortality causes taken together may have effects on population growth on Helgoland, i.e. that they are simply counterbalancing each other.

Because no long-term changes in the average annual mortality could be detected, it is most likely that up to now other factors, such as a good reproductive success due to a improved food supply (GRUNSKY 1994 and unpublished) are responsible for the increase in Guillemot numbers on the island of Helgoland since about 1975. This supports ASHMOLE's (1971) hypothesis that food supply during the breeding season rather than e.g. changes in adult mortality is mainly responsible for the development of seabird breeding populations (for discussions see BIRT et al. 1987, LLOYD et al. 1991, CAIRNS 1992). Nevertheless, the times might change rapidly, if there is a further increase in the use of static fish nets.

Zusammenfassung

Aus verschiedenen Regionen wurde über eine erhöhte Sterblichkeit von Trottellummen und anderen Seevögeln durch Fischerei-Geräte berichtet.

Von 1912 bis 1994 wurden auf Helgoland 6566 Trottellummen-Küken während des Lummensprungs beringt. Von diesen liegen 605 Rückmeldungen vor (Wiederfundrate = 9,2 %). Sie wurden hinsichtlich zeitlicher Veränderungen der Todesursachen und deren mögliche Auswirkungen auf die Überlebensrate analysiert.

Vor dem Zweiten Weltkrieg fielen die meisten Lummen der Jagd zum Opfer (71 % aller Rückmeldungen), während auf die Jagd heute (1989-94) weniger als 2 % der Meldungen entfallen. Umgekehrt stieg der Anteil der

in Fischnetzen und ähnl. umgekommenen Lummen gleichzeitig auf annähernd 42 %. Der Tod durch Verölung erreichte seinen Höhepunkt zwischen 1970 und 88 (24 %).

Die geographische Verteilung der Funde zeigt, daß Bejagung vor allem in Norwegen und Deutschland ein wichtiger Mortalitätsfaktor war. Die meisten Ölopfer wurden entlang der Schiffahrtsrouten in der südlichen Nordsee gefunden, während in Fisch-Netzen ertrunkene Trottellummen vor allem aus Schweden und Dänemark gemeldet wurden.

Trotz der gravierenden Verlagerung der Todesursachen ist die (relative) mittlere Mortalitätsrate (für Lummen im Alter von 1 bis 9 Jahren) annähernd konstant geblieben. Die Ursache für den starken Zuwachs der Helgoländer Kolonie ist also nicht in verminderter Mortalität sondern vermutlich in einem verbesserten Nahrungsangebot zu suchen.

References

Anonymus (1992): Report of the study group on ecosystem effects of fishing activities. ICES C.M. 1992 / G:11. ✻ Ashmole, N. P. (1971): Seabird ecology and the marine environment. In: Farner, D.S., & J.B. King (eds): Avian biology. Vol. 1: 223-286. Academic Press, London, New York. ✻ Birkhead, T.R. (1974): Movement and mortality rates of British Guillemots. Bird Study 21: 241-254. ✻ Birkhead, T.R., R.Kay & D.N. Nettleship (1985): A new method for estimating the survival rates of the Common Murre. J. Wildl. Mgmt. 49: 496-502. ✻ Birt, V.L., T.P. Birt, D. Goulet, D.K. Cairns & W.A. Montevecchi, W.A. (1987): Ashmole's halo: Direct evidence for prey depletion by a seabird. Mar. Ecol. Prog. Ser. 40: 205-208. ✻ Cairns, D.K. (1992): Population regulation of seabird colonies. In: Power, D.M. (ed.): Current Ornithology Vol. 9: 37-81. Plenum, New York, London. ✻ Camphuysen, C.J. (1994): Verstrikkingen van vogels in plastics en vistuig aan de Nederlandse kust, 1990-93. Sula 8: 226-229. ✻ Drost, R. (1930): Ueber die Wanderungen der Helgoländer Lummen (*Uria aalge helgolandica* Lönnberg). Vogelzug 1: 21-29. ✻ Fleet, D. M., S. Gaus, E. Hartwig, P. Potel & M. Schulze Dieckhoff (1995): Ölopfer in der Deutschen Bucht im Zeitraum 1. Oktober 1992 bis 31. Dezember 1994. Seevögel 16: 87-92. ✻ Grunsky, B. (1994): Trottellummen (*Uria aalge*) in der Brutkolonie auf Helgoland: Anwesenheitsmuster der Altvögel, Bestand und Nahrungsökologie der Jungen. Acta ornithoecol. 3: 33-45. ✻ Haldane, J.B.S. (1955): The calculation of mortality rates from ringing data. Acta XI Congr. Int. Ornithol.: 454-458. ✻ Hartwig, E., T. Köth, J. Prüter, E. Schrey, G. Vauk & E. Vauk-Hentzelt (1990): Seevögel. In: Lozán, J.L., W. Lenz, E. Rachor, B. Watermann & H. von Westernhagen (eds.): Warnsignale aus der Nordsee: 305-319. Parey, Berlin, Hamburg. ✻ Hüppop, O. (1991): Artenschutzprobleme im Nordseebereich. Seevögel 12, Sonderh. 1: 45-52. ✻ Hüppop, O. (1995): Brutbestände Helgoländer Seevögel. Jber. Institut Vogelforschung 2: 19-20. ✻ Kies, B., & T. Tomek (1990) Bird mortality in fishing nets in the Gulf of Gdansk, Polish Baltic Coast. Pelagicus 5: 23-27. ✻ King, W.B. (1984): Incidental mortality of seabirds in gillnets in the North Pacific. ICBP Techn. Publ. 2. 709-715. ✻ Lakhani, K.H. (1985): Inherent difficulties in estimating age-specific bird survival rates from ring recoveries. In: Morgan, B.J.T. & P.M. North (eds.): Statistics in ornithology. Lecture notes in statistics 29: 311-321. Springer, Berlin, Heidelberg, New York, Tokyo. ✻ Lakhani, K.H. (1990): Choice of models for estimating age-specific bird survaival rates using data from ringing recoveries. Ring 13: 23-36. ✻ Lakhani, K.H., & I. Newton (1983): Estimating age-specific bird survival rates from ring recoveries - can it be done? J. Anim. Ecol. 52: 83-91. ✻ Lebreton, J.D., & P.M. North (1993): Marked individuals in the study of bird populations. Birkhäuser, Basel, Boston, Berlin. ✻ Lloyd, C., M.L. Tasker & K. Partridge (1991): The status and conservation of seabirds in Britain and Ireland. Poyser, London. ✻ Mead, C. (1993): Auk mortality causes and trends. In: Andrews, J., & S.P. Carter (eds.): Britain's Birds in 1990-91: the conservation and monitoring review. British Trust for Ornithology and Joint Nature Conservation Committee, Thetford and Peterborough: 66-67. ✻ Mead, C.J. (1974): The results of ringing auks in Britain and Ireland. Bird Study 21: 45-86. ✻ Murray, S. (1995): Seabirds and salmon nets in Scotland and Northern Ireland in 1992. In: Tasker, M.L. (ed.): Threats to seabirds. Proc. 5th Int. Seabird Group Conf.: 33-34. ✻ Nettleship, D.N., & T.R. Birkhead (1985): The Atlantic Alcidae. Academic Press, Orlando. ✻ Nettleship, D. & J.F. Piatt (1982): Seabird mortality from gill-net fisheries in Newfoundland. In: Hope Jones, P. (ed.): Proc. Seabird Group Conf.: 16-17. ✻ Pasquet, E. (1986): Démographie des Alcidés: analyse critique et application aux populations francaises. L'Oiseau et R.F.O. 56: 1-53, 113-170. ✻ Peterz, M., & B. Oldén (1987): Origin and mortality of Guillemots *Uria aalge* on the Swedish west coast. Seabird 10: 22-27. ✻ Piatt, J.F., & P.J. Gould (1994): Postbreeding dispersal and drift-net mortality of endangered

Japanes Murrelets. Auk 111: 953-961. ✻ Piatt, J.F., D.N. Nettleship & W. Threlfall (1984): Net-mortality of Common Murres and Atlantic Puffins in Newfoundland, 1951-81. In Nettleship, D.N., G.A. Sanger & P.F. Springer (eds.): Marine birds: their feeding ecology and commercial fisheries relationships. Can. Wildl. Serv., Spec. Publ.: 196-206. ✻ Schloss, W. (1969): Funde Helgoländer Trottellummen (*Uria aalge*). Auspicium 3: 139-152. ✻ Stechow, J. (1938): Ueber die jahreszeitliche Verbreitung der europäischen Lummen (*Uria aalge* (Pont.)). Vogelzug 9: 125-138. ✻ Steinberg, R. (1990): Weitere Seezungenuntersuchungen. Fischerblatt 38: 218-221. ✻ Stempniewicz, L. (1994): Marine birds drowning in fishing nets in the Gulf of Gdansk (southern Baltic): numbers, species composition, age and sex structure. Ornis Svecica 4: 123-132. ✻ Strann, K.-B., W. Vader & R. Barrett (1991): Auk mortality in fishing nets in north Norway. Seabird 13: 22-29. ✻ Tasker, M.L., A. Webb, A.J. Hall, M.W. Pienkowski & D.R. Langslow (1987): Seabirds in the North Sea. Nature Conservancy Council, Aberdeen. ✻ Tull, C.E., P. Germain & A.W. May (1972): Mortality of Thick-billed Murres in the West Greenland salmon fishery. Nature 237: 42-44. ✻ Vader, W. (1990): Why has the Common Guillemot *Uria aalge* decreased in Norway? Pelagicus 5: 17-22. ✻ Vader. W., R. Barrett, K.E. Erikstad & K.-B. Strann (1988): Where have all the Guillemots (*Uria aalge*) gone? A situation report from north Norway. In: Tasker, M.L. (ed.): Seabird food and feeding ecology. Proc. 3rd Int. Conf. Seabird Group: 45. ✻ Vauk-Hentzelt, E., E. Schrey & G. Vauk (1986): Bestandsentwicklung der Trottellumme (*Uria aalge*) auf Helgoland 1956-1984. Seevögel 7: 40-45. ✻ Vincent, T. (1989): Les noyades d'oiseaux marins plongeurs dans les filets de peche: L'exemple des guillemots de troil en baie de seine. Cormoran 6: 289-291. ✻ Weber, W., S. Ehrich & E. Dahm (1990): Beeinflussung des Ökosystems Nordsee durch die Fischerei. In: Lozán, J.L., W. Lenz, E. Rachor, B. Watermann & H. von Westernhagen (eds.): Warnsignale aus der Nordsee: 252-267. Parey, Berlin, Hamburg. ✻ Weigold, H. (1910): Die diesjährige Lummen-"Jagd". Ornithol. Monatsschr. 35: 363. ✻ Weigold, H. (1924): Die Vogelfreistätten der Deutschen Nordsee. Meereskunde 14: 1-32. ✻ White, G.C. (1983): Numerical estimation of survival rates from band-recovery and biotelemetry data. J. Wildl. Mgmt. 47: 716-728. ✻ Wiens, J.A. (1995): Is oil pollution a threat to seabirds? Lessons from the Exxon Valdez oil spill. In: Tasker, M.L. (ed.): Threats to seabirds. Proc. 5th Int. Seabird Group Conf.: 50-51.