The Condor 93:516–525

PERSISTENT SUMMER MORTALITIES OF COMMON MURRES ALONG THE OREGON CENTRAL COAST[1]

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Abstract. Common Murres (*Uria aalge*) were found dead on Oregon central coast beaches every July–September from 1978 through 1990, but the magnitude of the mortality varied yearly. Many more hatching-year (HY) than after-hatching-year (AHY) murres usually were found dead. In some years, most HY murre mortalities happened shortly after HY murres had departed their natal colony, but, in other years, most mortalities occurred after HY murres had been at sea for some time and had grown substantially. These summer mortalities are not a recent phenomenon and, in spite of these mortalities, the total number of AHY murres censused at 15 Oregon colonies did not decrease between 1979 and 1988. Shooting, oiling, or entanglement in fishing gear appeared to cause few HY mortalities. The greatest number of beached HY murres occurred just before the 1982–1983 El Niño, and the fewest were found in 1983 during the El Niño.

Key words: Common Murre; Uria aalge; *beached birds; wing length; El Niño; culmen length; bill depth.*

INTRODUCTION

The Common Murre (*Uria aalge*) is the most abundant nesting seabird in Oregon, with about 426,000 after-hatching-year (AHY) murres (i.e., murres hatched in a previous calendar year) counted at nesting colonies in 1988 (Lowe, unpubl. data). Each pair of murres rears one chick that usually leaves the colony 20–21 days after hatching (range 16–30 days) at about 18–28% of the weight of adults (Harris and Birkhead 1985). Immediately after leaving the colony, the flightless young murre swims off with, and is fed, by its father (Scott 1973:48, Varoujean et al. 1979, Harris and Birkhead 1985, Anker-Nilssen and Nygard 1987). It is not clear when a young murre becomes independent, but young can dive for food or fly by late summer (Swennen 1977, Hope Jones and Rees 1985).

Large numbers of dead murres have been reported along the Oregon and California coasts (Bodle 1969, Scott et al. 1975, Hodder and Graybill 1985). This mortality has been of concern because: (1) murre populations have recently declined in California (Takekawa et al. 1990) and Washington (U. Wilson, pers. comm.); (2) pesticide contamination or disease may be involved (Bodle 1969, Scott et al. 1975, Bourne 1976, Hill and Bogue 1978); (3) murres are very vulnerable to oiling or gill netting (Takekawa et al. 1990), and (4) the occurrence of numerous dead and dying birds attracts the attention of the general public and the news media.

In this paper, we examine the persistence and timing of summer murre mortalities and determine if murres die at a particular size or age. We also discuss the apparent growth of some hatching-year (HY) murres (i.e., a murre recovered away from its natal colony in the same calendar year as it was hatched, 1 January–31 December) to AHY size by late summer. Finally, we relate numbers of beached murres to the 1982–1983 El Niño.

STUDY AREAS AND METHODS

BEACH TRANSECTS

From January 1978 through December 1990, REL and assistants counted dead murres along 7.5 km of sandy beach (Beach #1). The northern boundary of Beach #1 was at 44°35′N, 124°04′W and was 9.8 km south of the nearest murre colony

[1] Received 21 December 1990. Final acceptance 14 February 1991.

at Yaquina Head (44°41′N, 124°05′W), where 19,147 AHY murres were counted on 9 June 1989 (Lowe, unpubl. data). Beach #1 was divided into sections, with each section surveyed at least once a week.

In July–October of 1986 through 1990, RWL and assistants tallied beached murres (i.e., murres that were alive or dead) along 7.1 km of sandy beach (Beach #2) south of Beach #1. The northern boundary of Beach #2 was at 44°29′N, 124°05′W and was 21.7 km south of the nearest murre colony at Yaquina Head. Beach surveys were conducted using an open three-wheel vehicle an average of 3.3 times/month (SD = 1.8, range 0–5).

From August 1985 through October 1990, RDB counted beached murres along 4.4 km of a sandy beach (Beach #3) north of Beaches #1 and #2. The northern boundary of Beach #3 was at 44°44′N, 124°04′W and was 6.2 km north of the Yaquina Head murre colony and 2.8 km south of the Gull Rock murre colony (44°45′N, 124°04′W), where 14,219 AHY murres were counted on 9 June 1989 (Lowe, unpubl. data). Beach #3 was divided into two sections, with each section usually walked once weekly. In July–September of 1986–1990, the northern section was walked an average of 4.3 times/month (SD = 1.0, range 2–6) and the southern section was walked an average of 4.6 times/month (SD = 1.2, range 2–7). For many murres, the length of the right wing chord was measured with a ruler to the nearest mm as shown in Ainley et al. (1980), and, in 1990, the exposed culmen and/or bill depth at the anterior edge of the nares was measured with dial calipers to the nearest 0.1 mm as described in Smail et al. (1972) and Ainley et al. (1980).

At each beach, murre carcasses were removed as they were tallied, to avoid recounting.

OBSERVATIONS OF MURRE CHICKS DEPARTING A COLONY

On 11 and 13 July 1989, RWL observed murre chicks fledging by jumping from the colony and gliding down to the ocean at the Southwestern Rock (USFWS Seabird Colony Catalog No. 243-056) of Three Arch Rocks National Wildlife Refuge (45°28′N, 124°W). We call such murre chicks, fledglings. For some dead fledglings found at the base of the Southwestern Rock, RWL and RDB measured the right wing chord with a ruler to the nearest mm. RWL also used a ruler to measure the right wing chord to the nearest mm and vernier calipers to measure the exposed culmen length to the nearest 0.1 mm for some live fledglings captured within 50 m of this Rock.

DISTINGUISHING HY AND AHY MURRES

The age-class of murres was easy to distinguish in June through August. AHY murres were much larger, were in breeding plumage with black or nearly all black heads, often had primaries with worn tips, or had obviously recently molted all their primaries.

In late September and October, it was not possible to distinguish all HY murres from AHY murres because some HY murres appeared to be the same size (see below) and had head plumage identical to AHY murres in basic plumage (e.g., Hope Jones and Rees 1985).

Similarly to Verwey (1922), we originally thought that AHY and HY murres differed in toe color. AHY murres in June–August usually had yellowish, yellowish-black, or dark-reddish toes, while freshly dead HY murres had black, grayish-black, or bluish-black toes (henceforth termed black-toed). Accordingly, we classed large murres in September–October as AHY if their heads were all black as in breeding plumage or mostly black from molting into basic plumage; if their primaries were worn; if their primaries had obviously been recently molted; or if they had yellowish, yellowish-black, or dark-reddish toes. Because several black-toed AHY murres were found in July and August 1990 and there are no data to indicate at what age the color of murre toes changes, a few AHY murres may have been included with murres classed as HY in late September and October.

RESULTS

PERSISTENT MORTALITIES

In 1978–1990, an average of 61 AHY and 421 HY and suspected HY murres were found at Beach #1 each June–September (Table 1). With the exception of 1983, many more HY than AHY murres were encountered each year (Table 1).

The magnitude of murre mortalities at Beach #1 varied markedly among years, with 100 or more AHY mortalities found during June–September of 1980, 1983, and 1988 (Table 1). But the highest number of HY and suspected HY mortalities in June–September occurred in 1982 and 1989, when over 1,000 were recovered (Table 1).

TABLE 1. Total number of dead AHY or HY and suspected HY Common Murres found each year in June–September, and percentage of June–September HY and suspected HY murres found each month at Beach #1.[a]

Year	Murres		% of HY murres or suspected HY murres[b]/month			
	AHY (n)	HY (n)	Jun	Jul	Aug	Sep[b]
1978	29	176	0.0	67.0	33.0	0.0
1979	18	144	0.0	2.1	97.2	0.7
1980	111	641	0.0	3.4	90.5	6.1
1981	45	165	0.0	35.2	42.4	22.4
1982	37	1,236	0.0	1.3	97.2	1.5
1983	191	33	0.0	90.9	6.1	3.0
1984	24	53	0.0	49.1	35.8	15.1
1985	17	118	0.0	1.7	70.3	28.0
1986	13	598	0.0	1.0	89.0	10.0
1987	41	515	0.0	19.8	21.4	58.8
1988	133	333	0.3	10.8	44.8	44.1
1989	85	1,073	0.0	23.9	51.8	24.3
1990	47	383	0.0	34.6	56.5	8.9
$\bar{x}$	60.8	420.5	<0.1	26.2	56.6	17.1
CV (%)	88.8	91.3	360.6	108.8	53.1	105.3
Min.	13	33	0.0	1.0	6.1	0.0
Max.	191	1,236	0.3	90.9	97.2	58.8

[a] n = number of murres; CV = coefficient of variation; Min. = minimum; Max. = maximum.
[b] Some of the suspected HY murres in September may have been AHY murres.

Although HY murres were found as early as 30 June 1988 at Beach #1 and 30 June 1990 at Beach #3, HY murre mortality in June was rare (Table 1). Since average monthly numbers of beached murres were greatest from July through September (Fig. 1) and few HY murres were found in June, the remainder of this paper deals mostly with beached murres from July through September.

When July–September surveys in 1986–1990 are pooled for Beaches #1–3, an average of 1,430.0 HY and AHY murres (SD = 741.6, range 713–2,641) per summer were found along 19.0 km of beaches. Only in 1988 was a total of less than 1,000 dead murres counted. At each of these beaches in 1986–1990, the greatest number of mortalities occurred in 1989, and the second greatest year was 1986. The relative order of mortalities in the remaining three years sometimes differed among the three beaches.

TIMING OF HY MURRE MORTALITY

Some HY murres were found dead shortly after they left the colony. Incidental observations indicated that the average date in many years when the first live HY murre was seen away from nesting colonies in the vicinity of Yaquina Head was 29 June (range 22 June–8 July) in 1970–1971, 1982, 1986–1988, and 1990 (Scott 1973:23, Bayer, unpubl. data). The first dead HY murre was found on Beach #1 or Beach #3 on an average date of 11 July (SD = 7.9 days, range 30 June–27 July) in 1978–1990.

At Beach #1, most HY murres were usually found in August, when an average of 57% of the June–September HY murres was recovered (Table 1). But the timing of beached HY murres was variable, since July or September had the majority of carcasses in some years, and the synchrony of dead HY murre recoveries was much greater in some years than in others (Table 1).

The month of peak mortality in 1986–1990 was the same at Beaches #1 and #3, but sometimes differed at Beach #2. In 1986 and 1987, most dead HY murres were found in the same month at all three beaches. In 1988, the peak month was not determinable at Beach #2 because there were no beach surveys there in August, but most dead HY murres were counted in September at Beaches #1 and #3. In 1989 and 1990, most HY murres were found in August at Beaches #1 and #3, but slightly more were discovered in July at Beach #2.

Substantial HY mortality may also occur occasionally in October–December, which we could not document because we were unable to distinguish HY from AHY murres at this time. For example, in the Octobers of 1987–1989, 126–241 suspected HY murres were found on Beach #1, many more than the 0–37 in previous Octobers or the 58 in October 1990. Further, in

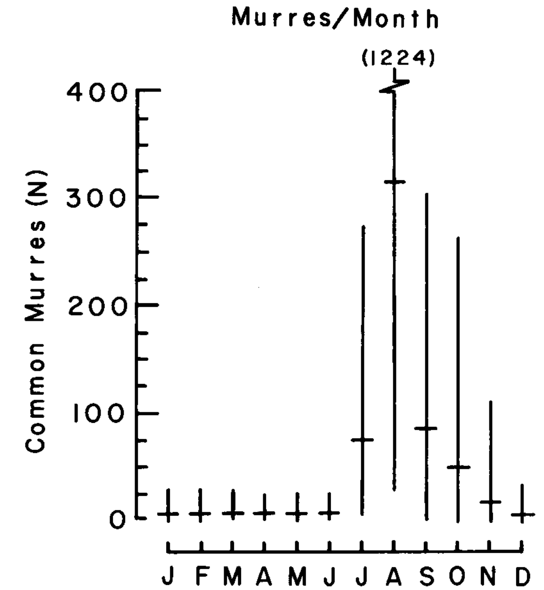

FIGURE 1. Number of HY + AHY Common Murres found each month along Beach #1 in 1978–1989. Monthly figures are $\bar{x}$ (horizontal line) and range (vertical line).

November 1987 and 1988, 72–113 HY and AHY dead murres were found on Beach #1, compared to 17 or less in prior or following Novembers. In December 1988, 33 dead HY and AHY murres were discovered on Beach #1, which was greater than the 0–8 murres found in previous or subsequent Decembers. The only month when more dead murres were encountered than in the preceding September was in October 1988.

SIZES OF FLEDGLINGS

The average right wing chord of 24 fledglings as they left the Southwestern Rock of Three Arch Rocks was 55.0 mm (SD = 7.9, range 41–71 mm). The average exposed culmen length for four of these live fledglings was 18.4 mm (SD = 1.5, range 16.3–19.5 mm).

SIZES OF BEACHED HY AND SUSPECTED HY MURRES

In June, 57% of the beached murres had wing chords of 74 mm or less (Table 2), so they were about the same size as fledglings. The remaining June HY murres had wing chords of 82 mm or less and were also probably fledglings, since Hatch (1983) found fledglings with wing chords as great as 104 mm in Alaska.

In July, 49% of beached HY murres had wing chords of 74 mm or less, and only 7% had wing chords longer than 104 mm (Table 2). But in following months, beached HY and suspected HY murres typically had larger wing chords than fledglings measured in Oregon or Alaska. In August, 77% of HY murres had wing chords greater than 104 mm, and, in September, the wing chords of HY and suspected HY murres began approaching those of AHY murres (Table 2). In October, the overlap in wing chords of suspected HY murres and AHY murres was extensive, although some birds were still distinguishable as HY murres because they had wing chords shorter than AHY murres (Table 2, Fig. 2).

Although data pooled for 1985–1990 summers in Table 2 illustrate that increases in wing chord were typical, data for a single year are necessary to show that the increase during a summer appears growth-like. Data for 1989 were chosen to display this because semi-monthly sample sizes were adequate throughout the summer of 1989 (Fig. 2). In 1989, wing chord lengths increased from July through early October (Fig. 2). The

TABLE 2. Right wing chord classes of HY or suspected HY Common Murres found on Beach #3 in 1985–1990.[a]

		% of murres/wing chord class (mm)						
	n	≤74[b]	75–104[c]	105–134	135–164	165–184	185–193	≥194[d]
Jun	7	57.1	42.9	0.0	0.0	0.0	0.0	0.0
Jul	323	48.6	44.0	7.1	0.3	0.0	0.0	0.0
Aug	655	2.3	20.3	56.4	18.8	2.0	0.2	0.0
Sep	251	0.0	0.0	6.4	16.7	30.7	16.3	29.9
Oct	140	0.0	0.0	0.7	2.1	3.6	13.6	80.0

[a] Some of the suspected HY murres found in September and October may have been AHY murres.
[b] RWL found that the longest wing chord of an Oregon fledgling was 71 mm, so most, if not all, HY murres in this class are the size of fledglings.
[c] Hatch (1983) reported that the longest wing chord of a fledgling at a colony in Alaska was 104 mm, so some murres in this class may have been fledglings.
[d] Storer (1952:173) indicates that the shortest wing chord for an adult in California or Oregon was 194 mm, so murres in this class have wing chord lengths overlapping those of adults.

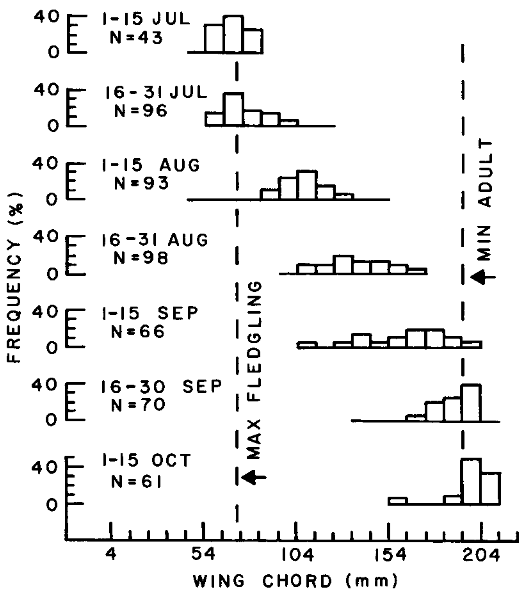

FIGURE 2. Frequencies (%) for 10.0 mm classes of right wing chord lengths of HY or suspected HY Common Murres recorded at Beach #3 in 1989. MAX FLEDGLING = maximum (71 mm) for 24 Oregon chicks at fledging found by RWL. MIN ADULT = minimum (194 mm) for adults in California or Oregon (Storer 1952:173).

small increase in average wing chord length between early and late July (Fig. 2) may result from the continual departure of fledglings, not a cessation in growth. For example, fledglings leave colonies during a 3–8 week period elsewhere (Swartz 1966, Hedgren 1980, Hatch 1983, Harris and Wanless 1988), and we found HY murres with lengths of Oregon fledglings (i.e., 71 mm or less) at Beach #3 as late as 30 July 1986, 16 August 1987, 24 July 1988, 5 August 1989, and 13 August 1990.

From 16 July–31 August (when HY and AHY murres were easily separable), the linear correlation between HY murre wing chord and date of recovery on Beach #3 was statistically significant each year from 1987 through 1990 (Table 3). This correlation was dissimilar among years, however, since slopes and y-intercepts were significantly different (Table 3).

Culmen lengths of beached HY and suspected HY murres also increased during the summer (Fig. 3), and the correlation between culmen length and recovery date was significant in 16 July–31 August 1990 (Table 3). In late September and October, many of those measured had culmen lengths either slightly less or overlapping those of AHY murres (Fig. 3).

Bill depths widened during the summer of 1990 for HY or suspected HY murres (Fig. 4), and bill depth was significantly correlated to recovery date during 16 July–31 August 1990 (Table 3). In late September and October, many murres appeared to have bill depths slightly less or more than the minima for AHY or adult murres, although there is great variability in AHY or adult bill depth minima (Fig. 4). This variability in minima could arise from two factors. First, bill depth is not as precise a measurement as wing chord or culmen length (e.g., Storer 1952:124), so some of the variation among researcher's measurements

TABLE 3. Linear regressions for right wing chord (mm), exposed culmen length (mm), or bill depth (mm) and date since June 30 (i.e., July 1 = 1) (X) when HY Common Murres were recovered on Beach #3 in 16 July–31 August.[a]

Year	Linear regression[b]	*n*	*r*	*t*	*P*	15 Sep (Ŷ)[c]	AHY min.[d]
			Wing chord				
1987	Y = 43.86 + 1.56X	79	0.74	9.68	<0.001	162.4	194
1988	Y = 48.94 + 1.48X	82	0.78	11.30	<0.001	161.4	194
1989	Y = 33.08 + 1.83X	287	0.80	22.25	<0.001	172.2	194
1990	Y = 29.02 + 2.13X	262	0.61	12.48	<0.001	190.9	194
			Exposed culmen				
1990	Y = 5.56 + 0.51X	61	0.75	8.79	<0.001	44.3	41.3
			Bill depth				
1990	Y = 6.34 + 0.08X	61	0.60	5.82	<0.001	12.4	≤12.4

[a] *n* = number of HY murres; *r* = correlation coefficient; *t* = Student's "*t*" test of correlation; *P* = two-tailed probability.
[b] Differences among 1987–1990 wing chord slopes: $F_{3,702}$ = 4.32, two-tailed $P < 0.01$; differences among 1987–1990 wing chord elevations (i.e., y-intercepts): $F_{3,702}$ = 7.25, two-tailed $P < 0.001$.
[c] Predicted 15 September values are extrapolated from regressions.
[d] AHY minima are discussed in text.

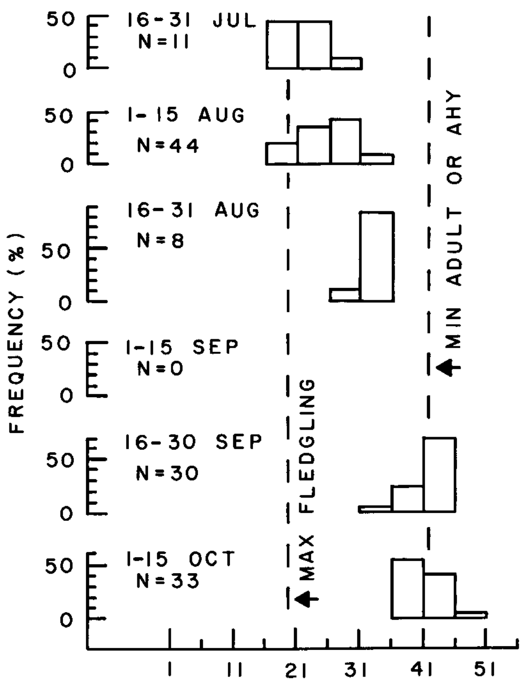

FIGURE 3. Frequencies (%) for 5.0 mm classes of exposed culmen lengths of HY or suspected HY Common Murres recorded at Beach #3 in 1990. MAX FLEDGLING = maximum (19.5 mm) of four Oregon chicks at fledging measured by RWL. MIN ADULT OR AHY = minimum for adults in California or Oregon (41.5 mm) (Storer 1952:175) and minimum for AHY murres at Beach #3 (41.3 mm).

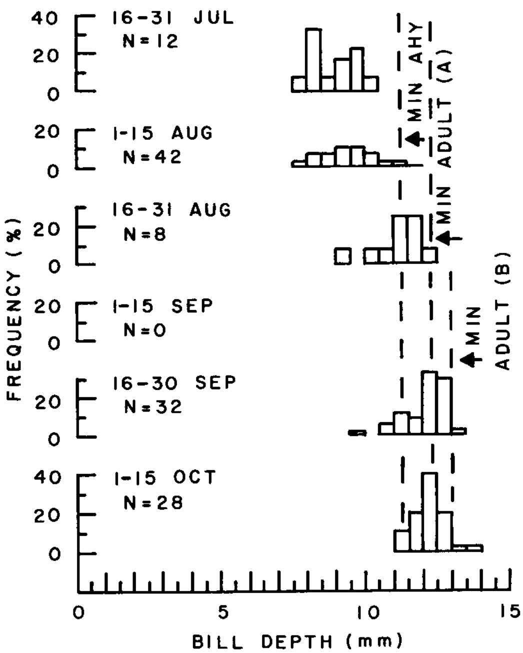

FIGURE 4. Frequencies (%) for 0.5 mm classes of bill depths of HY or suspected HY Common Murres recorded at Beach #3 in 1990. MIN AHY = minimum (11.3 mm) for AHY murres in late September and early October 1990 at Beach #3, MIN ADULT (A) = minimum (12.4 mm) for adults with unknown collection date in California or Oregon (Storer 1952:177), and MIN ADULT (B) = minimum (13.0 mm) for adults in late January off California (Smail et al. 1972).

could be from subtle differences in techniques. Second, AHY bill depths may change seasonally (Verwey 1922, Storer 1952:124). For example, in September and October 1990 at Beach #3, three AHY murres (with recently molted primaries or very worn primaries and/or with heads molting out of breeding plumage) had a range in bill depth of 11.3–12.5 mm compared to a bill depth range of 14.1–15.9 mm for eight AHY murres in 19 May–14 July 1990 at Beach #3.

EXTERNAL CONDITION OF BEACHED HY MURRES

Only 17 of 3,693 beached HY murres recovered on Beaches #2 and #3 in July–September of 1986–1990 were alive. Live birds were not counted on Beach #1, but five or less were estimated to have been seen each year.

In July–September 1978–1990, entanglement in fishing gear or other debris appeared to be a minor mortality factor because no entangled HY murres were found at Beaches #2 and #3, and only three were recorded at Beach #1.

Our impression is that oiling and shooting were insignificant sources of HY murre mortality, but we may have missed oiled or shot murres because some beached murres were decomposed or scavenged. Nevertheless, none of the HY murres at Beaches #2 and #3 seemed obviously oiled, and, at Beach #1, only one HY murre in June–September 1978–1990 was visibly oiled. We found no HY murre that appeared visibly wounded as if shot.

DISCUSSION

PERSISTENT SUMMER MORTALITIES

Although murre mortalities occurred every summer from 1978 through 1990 along the Oregon central coast (Table 1), this is not a recent phenomenon in this region. For example, many dead murres were noted in August 1909 along the

Washington coast (Reagan 1910). In Oregon, dead murres were found along beaches in August 1914, 1923, 1926, and 1928 (S. G. Jewett, unpubl. field notes); in August 1934 when over 500 dead murres were counted (Jewett 1934); on 8 August 1937 when 26 HY murres were noted along 1.6 km of beach (Bayer and Ferris 1987:101); in September 1967 (Crowell and Nehls 1968); and in July 1969 (Scott et al. 1975). Further, 25 of 33 murres banded as nestlings in 1936–1940 at Oregon colonies and recovered in their first year of life were found from July through September (Bayer and Ferris 1987:17–18).

Peak murre mortality in July–September is not limited to Oregon, as most beached HY murres were also found in California during these months (Stenzel et al. 1988). In eastern North America and Europe, however, peak HY murre mortality typically occurs in October (Birkhead 1974, Mead 1974) or from November through January or February (Johnson 1940, Swann and Ramsay 1983, Camphuysen 1989); although for some regions, the number of dead HY murres seemed to be approximately equal each month during the August–October period (Birkhead 1974, Birkhead and Hudson 1977). Summers with large numbers of mortalities (i.e., 500 or more dead HY or suspected HY murres per 7.5 km beach) occurred in five of 13 years at Beach #1 (Table 1). Such large numbers of summer mortalities in other areas appears to be much rarer (Bodle 1969, Scott et al. 1975, Bourne 1976, Stenzel et al. 1988), perhaps because their beach surveys were much less frequent (i.e., < 1/month) than at our Beach #1.

Despite these summer mortalities, the number of adult murres at Oregon colonies does not appear to be declining as in Washington (U. Wilson, USFWS biologist, pers. comm.) or California (Takekawa et al. 1990). For example, for 15 Oregon murre colonies in 1979 and 1988 where birds were counted from aerial photographs made during one visit in late May or June, the total number of AHY murres seemingly increased from about 95,000 in 1979 to 132,000 in 1988 (Lowe, USFWS unpubl. data). However, this apparent increase may be spurious because single counts can be misleading (e.g., Rodway 1990).

GROWTH OF HY MURRES AFTER COLONY DEPARTURE

The sizes of dead HY murres have not been examined by other researchers. Our results show that HY murres do not necessarily die simultaneously or at similar sizes; some had been growing at sea for some time before they died because they had longer wing chords or culmens than fledglings (Table 2, Figs. 2, 3).

Our data also indicate that growth rates of wing chords and exposed culmens may be greater for HY murres at sea than for nestlings. During the 16 July–31 August period (when HY and AHY murres were easily separable), the slopes for linear regressions of wing chord with recovery date ranged from 1.48–2.13 mm/day (Table 3). But slopes estimated from graphs of average wing chord sizes of murre nestlings during their last 10 days at a colony were only about 0.25–0.40 mm/day (Birkhead 1977, Mahoney and Threlfall 1981). The regression slope of exposed culmen length in 1990 at our Beach #3 was 0.51 mm/day (Table 3), which is greater than slopes estimated from graphs for nestlings during their last 10 days at a colony of about 0.14–0.40 mm/day (Johnson and West 1975, Mahoney and Threlfall 1981). But just as more growth is apportioned to legs and feet of nestling murres (e.g., Mahoney and Threlfall 1981), growth is probably more apportioned to wings and culmen length of HY murres at sea. Thus, our data do not show how total HY murre growth at sea compares to that of nestlings.

The slopes and y-intercepts for our linear regressions for wing chord length with recovery date during 16 July–31 August differed significantly among years (Table 3). Although differences in growth among years could be one reason for this variation, these differences could also have arisen from annual variation in the timing or synchrony of colony departure by HY murres, in changes in currents and winds that swept carcasses ashore, and/or from differences in the relative sizes of HY murres that were dying.

Based on extrapolations from 16 July–31 August 1990 measurements, some HY murres would have nearly reached or surpassed adult minima for wing chord, exposed culmen, or bill depth by 15 September 1990 (Table 3). Thus, it is not unexpected that some beached HY murres found in late September had attained adult minima (Table 2; Figs. 2–4). Similarly, preliminary results abstracted in Varoujean et al. (1979) indicate that HY murres off Oregon reached 90–95% of adult weight 45–60 days after colony departure, so HY murres departing on 1 July would nearly reach adult weight in late August. Further, Anker-Nilssen and Nygard (1987) found that at least one of three HY murres weighed as much as accompanying adults off Norway on 22 August.

BEACHED HY MURRES AND THE 1982–1983 EL NIÑO

The 1982–1983 El Niño was first detected along the Oregon coast in October 1982 (Huyer and Smith 1985). Any effect of this El Niño on Oregon seabirds in 1982 has not been previously noted, but it is thought to have lowered the nesting success of many Oregon seabirds in 1983 (Hodder and Graybill 1985, Bayer 1986a, Pearcy and Schoener 1987). However, the greatest number of HY murres at Beach #1 in 1978–1990 occurred almost entirely in August of 1982 (Table 1), about two months before the El Niño commenced. Whatever decreased HY murre survival in Oregon in 1982 started in July or earlier, since large numbers of HY murres at Beach #1 were first found on 4 August 1982. Similarly, the breeding of some seabirds at Christmas Island was adversely affected in the months prior to the onsets of El Niños in 1982 and 1986 (Schreiber and Schreiber 1989).

In 1983, more AHY, but fewer HY murres, were found than in any other year (Table 1). The AHY murre mortality could be ascribed to the 1982–1983 El Niño (Hodder and Graybill 1985), but the low HY murre mortality is probably because murre breeding success in Oregon was low in 1983. For example, many dead murre chicks were abandoned on the Yaquina Head colony (Bayer 1986a), and few live HY murres were seen at sea (Hodder and Graybill 1985, Bayer 1986a). Since few HY murres apparently left their natal colony in 1983, few could die at sea and, subsequently, wash ashore.

The 1982–1983 El Niño ended off Oregon in September 1983 (Huyer and Smith 1985), so seabird breeding could be expected to have recovered in 1984. But the nesting success of Pelagic Cormorants (*Phalacrocorax pelagicus*) in Oregon (Hodder and Graybill 1985, Bayer 1986a) and numbers of various nesting seabirds, including Common Murres, in California (Boekelheide et al. 1985) were still markedly reduced in 1984. Unfortunately, no data about murre breeding success in Oregon are available for 1984, but the low number of beached HY murres in 1984 (Table 1) could be because few made it to sea where they could die, not because of high HY murre survival at sea.

CAUSES OF HY MURRE MORTALITY

We found no murres that appeared to have been shot and very few that had been visibly oiled or entangled in fishing gear; these factors are the cause of death for many murres elsewhere (Birkhead 1974, Swann and Ramsay 1983, Camphuysen 1989). Similarly, oiling or entanglement was not cited as causes of death in previous studies of Oregon murre mortalities (Scott et al. 1975, Hodder and Graybill 1985). Further, gill nets in Oregon did not appear to kill murres as they have elsewhere (Swann and Ramsay 1983, Stenzel et al. 1988, Takekawa et al. 1990) because no murres were found caught in large-mesh gill nets set for sharks (Stick and Hreha 1988, 1989), and this brief experimental fishery was the only one involving gill nets along the Oregon coast.

An average of 26% of the HY murre mortality occurring in June–September was in July, which is also when most HY murres were found in 1978 and 1983 (Table 1). Most HY murres beached in July were still the size of fledglings (Table 2, Fig. 2), which indicates that they may have died while leaving the colony or very shortly thereafter. These July mortalities are not surprising, since many fledglings die by falling on rocks while leaving the colony, from hypothermia after leaving the colony before their plumage is waterproof, from predation, or from starvation after being separated from their fathers while leaving the colony (e.g., Tuck 1960, Swartz 1966, Hedgren 1980, Harris and Wanless 1988).

The greatest number of dead HY and suspected HY murres was found in August and September (Table 1), when HY murres may be becoming increasingly dependent on their own foraging success. For example, in Britain, Hope Jones and Rees (1985) observed that some HY murres still accompanied by adults were actively feeding as early as late July, and Swennen (1977: 20) observed captive HY murres diving and feeding within a week of taking to water. If food abundance or availability is low as HY murres become dependent on their own foraging, they are vulnerable to mortality because they probably forage less efficiently than AHY murres. Synergistic mortality factors in August and September include starvation, disease, parasites, predation, and chemical contamination (e.g., Tuck 1960, Swartz 1966, Bodle 1969, Scott et al. 1975, Bourne 1976, Hill and Bogue 1978, Hedgren 1980, Hatch 1983, Hodder and Graybill 1985, Bayer 1986b).

ESTIMATING TOTAL HY MURRE MORTALITY IN OREGON

Using our results to extrapolate the number of dead HY murres in Oregon is inappropriate for three reasons. First, many seabird carcasses do not reach shore (e.g., Piatt et al. 1990), so many dead HY murres may not have washed up on our beaches. Second, some murres may have washed ashore but were not counted because they were buried in sand, carried off by people or dogs, or washed back out to sea (e.g., Piatt et al. 1990). Third, the number of HY murres/km on our beaches may not be representative of all Oregon beaches.

Even if we were able to estimate the total number of dead HY murres, we could not estimate the percentage of Oregon HY murres dying each year because we do not know the annual reproductive success of nesting murres in Oregon. Further, not all HY murres hatched in Oregon that die may wash ashore on Oregon beaches because many Oregon HY murres move northward (Storer 1952:157), with some reaching Washington waters in August (Bayer and Ferris 1987:18).

ACKNOWLEDGMENTS

We thank Sara and Don Brown, Jon Anderson, and Kim Thounhurst for conducting beach walks on REL's or RWL's beaches. We are grateful to Susan Gilmont and Janet Webster of the Oregon State University Marine Science Center Library for obtaining references. We thank Harry Carter, Ulrich Wilson, and Sanford Wilbur of the U.S. Fish and Wildlife Service; and two anonymous reviewers for their comments on earlier drafts of this paper.

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