SEABIRDS NEAR AN OREGON ESTUARINE SALMON HATCHERY IN 1982 AND DURING THE 1983 EL NINO

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ABSTRACT

In the summer of 1982, 14.4 million salmon, *Oncorhynchus* sp., smolts were released at the Yaquina Estuary, OR; and in the summer of 1983, 12.8 million salmon smolts were released. Within hours after release, fish-eating seabirds aggregated at the estuary mouth. In 1982, the number of no seabirds was significantly correlated with the number of days since a release. In 1983, however, numbers of common murres, *Uria aalge*; gulls, *Larus* sp.; and brown pelicans, *Pelecanus occidentalis*, were significantly inversely correlated with the date of a release, and the number of cormorants, *Phalacrocorax* sp., was significantly more abundant the second day after a release. In contrast, numbers of Caspian terns, *Sterna caspia*, and pigeon guillemots, *Cepphus columba*, showed no relationship with releases in 1983.

There were significantly more cormorants and marbled murrelets, *Brachyramphus marmoratus*, in 1983 than in 1982. There were also significantly more murres in 1983 than in 1982 before 1 August, but fewer afterwards. Gull and brown pelican numbers were about the same between years, but significantly fewer pigeon guillemots were present in 1983 than in 1982.

Seabirds have been estimated to consume 29% of the pelagic fish production within 45 km of a British seabird colony (Furness 1984b), and several simulation models for various geographical areas indicate that 20-30% of the annual pelagic fish production may be preyed upon by seabirds (Furness 1984a). Since the mortality of salmon, *Oncorhynchus* sp., smolts as a result of predation and environmental factors is greater shortly after they first enter the ocean than after they move offshore (Parker 1962, 1968), the impact of seabird predation on salmon smolts just released along a coast could also be significant.

El Nino is the intrusion of anomalously warm water off the coast of Peru and Ecuador (Barber and Chavez 1983); an El Nino of varying intensity occurs on the average of every 3-5 yr (Quinn et al. 1978; Duffy 1983a). Along the Oregon coast, warm-water conditions concurrent with an El Nino appear much more rarely, and in the last century have occurred only in 1983, 1957-1958, and perhaps in 1941 (Huyer 1983; Reed 1983). The impact of seabirds on hatchery-released salmon smolts would be expected to be greater in years of anomalously warm water associated with El Nino, when natural prey for seabirds become rare and seabirds starve or have low nesting success (Boersma 1978; Duffy 1983a, b; Ainley 1983; Schreiber and Schreiber 1984).

Here, I correlate bird numbers with salmon smolt releases at Yaquina Estuary, OR, and examine variation in bird numbers between the summer of 1982 and the summer of 1983, when warm water associated with an El Nino was present.

STUDY AREA AND METHODS

Yaquina Estuary (Fig. 1) is located on the mid-Oregon coast and is a drowned river valley. It has an intertidal and submerged area of 15.8 km^2 (Oregon State Land Board 1973). During this study, all releases were from the site designated as OAF in Figure 1.

The most abundant seabird nesting nearby was the common murre, *Uria aalge*, but western gulls, *Larus occidentalis*; Brandt's cormorants, *Phalacrocorax penicillatus*; pelagic cormorants, *P. pelagicus*; and pigeon guillemots, *Cepphus columba*, also nested there (Table 1; Pitman et al. in press). Within Ya-

TABLE 1.—Distance of nesting birds from the mouth of Yaquina Estuary in 1979 (calculated from Pitman et al. in press).

	Cumulative number of nesting birds				
	<7 km	<20 km	<25 km	<45 km	<50 km
common murres[1]	[2]2,800	[2]6,800	[2]6,800	[2]6,800	[3]22,000
western gulls	398	528	536	541	1,231
cormorants	418	653	1,581	1,727	3,041
pigeon guillemots	45	191	201	206	220

[1]Includes all breeding and nonbreeding adults at colony.
[2]Estimated for 1983 (USFWS, aerial survey; pers. obs.).
[3]Includes 1983 as well as 1979 estimates.

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Manuscript accepted July 1985.
FISHERY BULLETIN: VOL. 84, NO. 2, 1986.

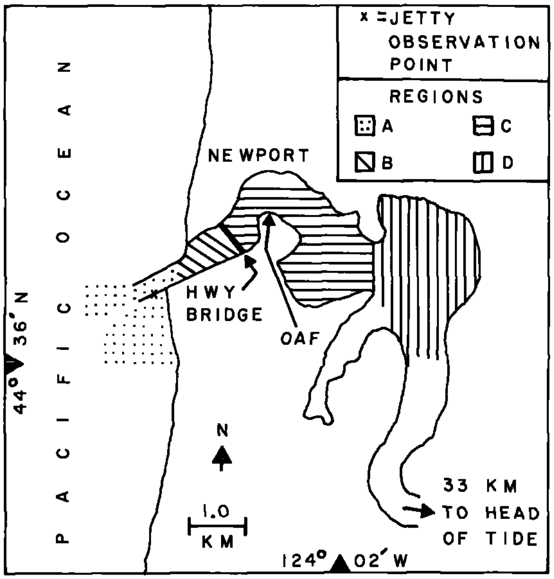

FIGURE 1.—Yaquina Estuary study regions. OAF indicates site of smolt releases.

quina Estuary, <30 pairs of western gulls (Bayer 1983) and an undetermined number of pigeon guillemots also nested in association with manmade structures. The typical nesting phenology of these birds at Yaquina Head (which is about 6.5 km north of Yaquina Estuary) has been examined by Scott (1973) and Bayer (1983) with murres beginning to fledge young in early July, gulls and pelagic cormorants in late July, and Brandt's cormorants and pigeon guillemots in early to mid-August. However, it would be invalid to assume that nesting in 1983 followed the chronologies of typical years because nesting success for cormorants and murres was abnormally low in 1983 with eggs and young being abandoned (Bayer[2]). Although the nesting success of gulls was not unusually low in 1983 (Bayer fn. 2), the chronology of their nesting might have been different than in 1982. Thus, comparing 1982 and 1983 bird numbers at Yaquina Estuary for the same stage of the nesting cycle would be tenuous. Brown pelicans, *Pelecanus occidentalis*, and Caspian terns, *Sterna caspia*, do not nest in this area.

I divided the estuary and the area around its mouth into four censusing regions (Fig. 1) with region A having an area of about 1.8 km^2; region B, 0.5 km^2; region C, 3.0 km^2; and region D, 3.2 km^2. I censused birds from observation points where I could overlook the estuary or estuary mouth with a 20× telescope when glare, heat waves, and water conditions did not obscure birds. I censused the areas around the mouth of the jetties from an observation point about halfway out on the south jetty (Fig. 1). The boundaries of region A were estimated by using the distance to the first navigation buoys to the west of the jetties as a radius that was about 1.5 km from the observation point and 1.0 km from the end of the jetties to estimate the outer boundary. All taxa except pigeon guillemots were censused during a single continuous sweep of nonoverlapping portions of a region; pigeon guillemots were enumerated during two sweeps per portion with the maximum number of the two sweeps recorded.

I censused "active" (see below) gulls and cormorants, nonflying common murres and pigeon guillemots (including guillemots standing on stationary objects), roosting Caspian terns, all brown pelicans, and all marbled murrelets, *Brachyramphus marmoratus*. "Active" gulls were those that flew over or sat in the water (gulls sitting on stationary roosts were not included). Gull species included western, glaucous-winged, *L. glaucescens*, and western × glaucous-winged gull hybrids (Hoffman et al. 1978). Cormorants present were usually either Brandt's or pelagic cormorants, but some double-crested cormorants, *P. auritus*, were also included. "Active" cormorants were those on the water surface or those making short flights in association with a feeding flock; cormorants on transit flights through a region or roosting on stationary objects were not counted. Only nonflying murres and guillemots were included because others flew through regions A and B without landing (and feeding). Although roosting Caspian terns were obviously not feeding, they were recorded because their numbers were an index of the total numbers present and because it was not possible to count foraging (i.e., flying) Caspian terns accurately. There were 166 censuses during 37 d from 1 June to 16 September 1982 at regions A-D during variable tidal conditions, and 39 censuses within 2 h of low tides before 1500 Pacific Daylight Time (PDT) during 39 d from 1 June to 30 August 1983 at regions A-C. Each census took 45-75 min, depending upon the number of birds present.

Comparisons of bird numbers between 1982 and 1983 were only made for censuses within 2 h of low tides before 1500 PDT. Comparisons were made during the 1 June to 30 August period for brown pelicans, "active" cormorants, "active" gulls, and

[2]Bayer, R. D. In prep. Breeding success of seabirds along the mid-Oregon coast concurrent with the 1983 El Nino. Unpubl. manuscr. P.O. Box 1467, Newport, OR 97365.

pigeon guillemots because the numbers of these birds during this period did not show any signs of seasonal variation. But for common murres, the periods of comparison were 1 June-31 July and 1-30 August, and the periods for Caspian terns were 1 June-10 July, 11 July-5 August, and 6-30 August. The periods for common murres and Caspian terns were chosen because in one or both years there were marked seasonal changes in bird numbers between or among these periods.

The number of days postrelease refers to the number of daylight periods after a smolt release (Myers 1980). For example, if smolts were released on Monday night or early Tuesday morning, then Tuesday after dawn would be considered as 1-d postrelease (i.e., the first day, or first daylight period, after a release).

If variances were not significantly different, then the student's t-test for two means or the analysis of variance (ANOVA) for three or more means were calculated to determine statistical differences between or among means. If variances were significantly different, the Mann-Whitney U test or normalized Mann-Whitney z test (Zar 1974, p. 109-113) for two samples or the Kruskal-Wallis rank H or H_c (if ranks were tied) test (Zar 1974, p. 139-142) for three or more samples was used. All tests were two-tailed.

RESULTS AND DISCUSSION

Smolt Releases

Oregon Aqua-Foods, Inc. (OAF) has released 2 million or more salmon smolts (almost all coho salmon, *Oncorhynchus kisutch*) each year since 1977 into Yaquina Estuary between June and August. In 1982 and 1983, the proportion that were coho salmon was 98% and 94%, respectively; the remainder were chinook salmon, *O. tshawytscha*. Until 1983, these releases were under variable tidal conditions in the evening just after dark to minimize bird predation of smolts as they were released. In 1983, salmon smolts were released either in the evening or early morning ón the ebbing tide while it was still dark.

Salmon smolts do not immediately swim to the ocean after they are released. Myers (1980) found that the number of OAF smolts in the Yaquina Estuary declined exponentially after a release. During June-August releases in 1978, half the smolts left the estuary within an average of 3.9 d (SE = 0.7 d, range 1.7-9.0 d, N = 9 releases) with a few smolts remaining in the estuary several months (calculated from Myers 1980). There are no data to determine if the smolt residency time in the estuary differed between 1982 and 1983.

In 1982 and 1983 from June through August, the interval between releases averaged <2.5 d, and an average of 0.2-0.3 million fish were released each time (Table 2). Although the average release interval was longer and the number of fish per release usually greater in 1983, these differences were not significant (Table 2). But the biomass of fish per release was significantly greater in 1983 than in 1982 in the June-July and June-August periods (Table 2). Overall, 1.6 million fewer fish were released in 1983 than 1982, but the total biomass released was almost 38 metric tons (t) greater (Table 2); this resulted from smolts weighing more on the average in 1983 (32.9 g/smolt) than in 1982 (26.7 g/smolt) (calculated from Table 2).

Bird Predation of Salmon Smolts

Although all birds in this study except marbled murrelets were observed with salmon smolts in their bills, the importance of smolts in these birds' diets was not documented in this study. However, Matthews (1983) found that coho salmon smolts com-

TABLE 2.—Releases of salmon smolts in 1982 and 1983 at Yaquina Estuary. Total = total number or biomass of fish released during a period. Differences between years tested with student's t, Mann-Whitney U, or normalized Mann-Whitney z test. NS = not significant.

Period	Year	Releases	Release interval (d)			No. fish/release (millions)				Fish biomass/release (t)			
		N	$\bar{x}$	SD	P	$\bar{x}$	SD	P	Total	$\bar{x}$	SD	P	Total
June-July	1982	30	2.0	1.2		0.3	0.1		9.6	7.5	2.4		225.3
	1983	25	2.4	1.7	NS	0.4	0.1	NS	9.0	11.3	4.6	<0.01	268.4
August	1982	20	1.6	0.7		0.2	0.1		4.7	7.9	3.4		158.6
	1983	12	2.4	1.6	NS	0.3	0.2	NS	3.7	12.8	9.0	NS	153.0
June-August	1982	50	1.8	1.0		0.3	0.1		14.4	7.7	2.8		383.9
	1983	37	2.4	1.6	NS	0.3	0.2	NS	12.8	11.8	6.3	<0.01	421.4

posed 13% of 287 prey items of common murres collected within 2 km of the Yaquina's jetties during the summer of 1982.

Salmon smolts appeared to be most vulnerable to predation soon after a release. When they first entered the estuary after exiting a pond through a large tube, smolts seemed disoriented and milled around the surface where they could easily be caught by birds. Night releases allowed smolts several hours to become adjusted before becoming vulnerable to predators at daylight. (The only somewhat significant nocturnal bird predator were heerman's gulls, *L. heermanni*, but they usually numbered <50 birds, were not present for every release, and were present mainly in late July and August.)

Within about 4 h after daylight after a release, some smolts were observed jumping at the mouth of the jetties in regions A and B, where birds also concentrated. For censuses of regions A-D within 2 h of low tides and within 2 d of a release in 1982, an average of 97.9% (SD = 6.3, N = 17 d) of the common murres, 91.5% (SD = 16.2, N = 17 d) of the "active" gulls, and 90.5% (SD = 26.8, N = 8 d) of the "active" cormorants censused were at regions A and B. But regions A and B accounted for only about 27% of the area of regions A-D. Evidently, the turbulent action of the estuarine water entering the ocean and/or the funneling effect of the jetties (Fig. 1) caused the smolts to be particularly vulnerable to predators there.

During the first 12 h of daylight after a release, some smolts within 0.5 km of the release site were still vulnerable to bird predation as many smolts were near the water surface. Many jumped out of the water, and some rolled on their sides exposing their silver undersides, which were highly conspicuous against the dark water background. Gulls often sat on the water and grasped a fish as it jumped into the air. Schools of smolts also milled near the surface where they were clearly visible to humans (and presumably birds).

Within-Day Variation in Bird Numbers

Bird abundance was clearly not constant within a day, and taxa did not reach maxima synchronously (Fig. 2). Censuses within 2 h of early low tides (i.e., low tides before 1500 PDT) averaged closer to the maximum number censused daily for all taxa, and censuses near high tide were usually closer to the daily maximum than counts within 2 h of evening low tides (i.e., after 1800 PDT) for all taxa except brown pelicans (Table 3). But differences in censuses among tidal conditions within a day were only significant for common murres and "active" gulls (Table 3).

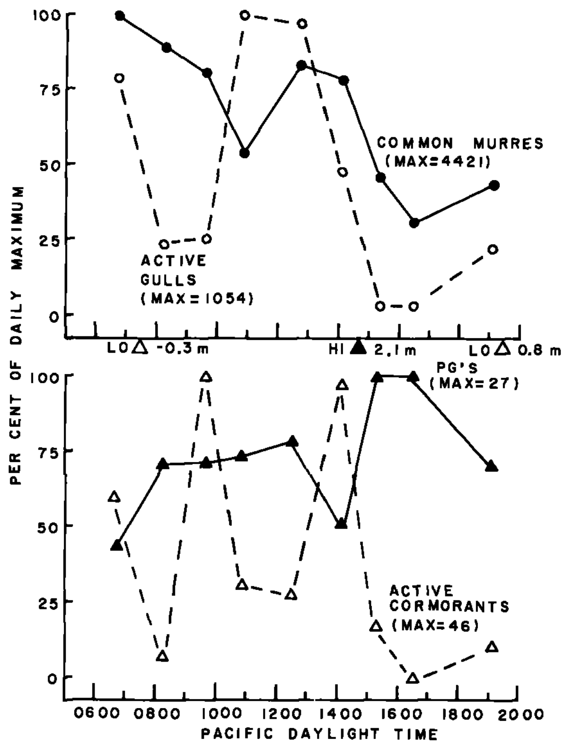

FIGURE 2.—Percentage of daily maximum number of common murres, "active" gulls, "active" cormorants, and pigeon guillemots (PG's) observed on 5 August 1982 (which was two days postrelease) at regions A-D. Times and heights of measured low (LO) and high (HI) tides are indicated by open and closed triangles, respectively. MAX = maximum number of birds seen on 5 August.

A single census at any time of day is unlikely to estimate accurately the maximum number of birds of any taxon present that day (Table 3). The average census only ranged from 10.8% to 63.7% of the daily maximum (Table 3). The best censuses to use for estimates would be those within 2 h of a morning or afternoon low tide because their averages (44-64% of daily maxima) were greater than for high and evening low tides, and their CV's (41-82%) were generally lower than for other tides (Table 3).

Daily Variation in Bird Numbers

On a day to day basis, bird numbers could often be seen to increase in the first day postrelease and then to decline (Fig. 3). However, the degree of increase was variable. Overall, murres, "active" gulls in 1983, and brown pelicans exhibited the same pat-

TABLE 3.—Percentage of daily maximum number of birds observed within 2 h of actual high tides, early low tides (i.e., time of low tide before 1500 PDT), and late low tides (i.e., time of low tide after 1800 PDT). Censuses between 6 July and 17 September 1982 at regions A-D with 9-11 censuses/d (i.e., 13-14 h period). N = total censuses; CV = coefficient of variation.

		Percent of daily maximum birds within 2 h of								
		High tide			Early low tide			Late low tide		
	Days	N	$\bar{x}$	CV (%)	N	$\bar{x}$	CV (%)	N	$\bar{x}$	CV (%)
common murres	9	31	[1]30.8	92.5	24	[1]63.7	55.3	11	[1]20.3	100.0
"active" gulls	10	35	[2]37.9	81.5	28	[2]49.5	71.9	11	[2]18.1	100.0
brown pelicans	6	21	[3]39.1	79.0	14	[3]44.0	81.8	8	[3]49.1	58.9
"active" cormorants	4	14	[4]32.6	112.6	7	[4]61.3	65.3	6	[4]10.8	142.6
pigeon guillemots	3	10	[5]52.9	58.8	8	[5]58.0	41.0	3	[5]33.9	93.8

[1]Heterogeneity, Kruskal-Wallis H_c = 16.36, $P < 0.01$.
[2]Heterogeneity, Kruskal-Wallis H_c = 7.62, $P < 0.10$.
[3]Heterogeneity, Kruskal-Wallis H_c = 0.80, $P > 0.10$.
[4]Heterogeneity, Kruskal-Wallis H_c = 5.62, $P > 0.10$.
[5]Heterogeneity, Kruskal-Wallis H_c = 1.87, $P > 0.10$.

tern of more birds present the first day after a release than later; this pattern, however, was significant only in 1983 (Tables 4, 5). In contrast, only "active" cormorants were more numerous the second day after a release than on the first day; however, the differences in cormorant numbers among days were only significant in 1983 (Table 5).

Numbers of pigeon guillemots and Caspian terns did not show any indication of dependence on the number of days postrelease. The differences in pigeon guillemot numbers in the 1 June-30 August period among 1, 2, and 3-6 d postrelease was insignificant (1982: F = 0.23, df = 2, 34; $P > 0.10$; 1983: Kruskal-Wallis H_c = 0.61, $P > 0.10$). Sample sizes were too small to test differences for Caspian terns in 1982, but in 1983 variation with 1, 2, and 3-6 d postrelease was insignificant in either the 1 June-14 July period (when there were few Caspian terns (Kruskal-Wallis H_c = 2.74, $P > 0.10$)) or the 15 July-30 August period (when they were abundant (Kruskal-Wallis H_c = 2.74, $P > 0.10$)).

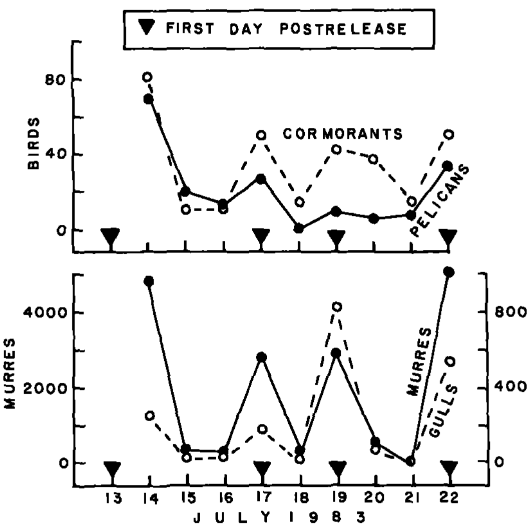

FIGURE 3.—Number of brown pelicans, "active" cormorants, "active" gulls, and common murres with relation to dates of salmon smolt releases during 14-22 July 1983 censuses that were within 2 h of low tides before 1500 PDT.

TABLE 4.—Numbers of common murres at regions A-C in 1982 and 1983 during the 1 June-31 July period when murres were abundant and the 1-30 August period when murres were infrequent in 1983. N = number of censuses (1 census/d within 2 h of low tides before 1500 PDT); MAX = maximum number of birds counted.

	1 June-31 July												1-30 August			
	1-d postrelease				2-d postrelease				3-6 d postrelease				1-3 d postrelease			
Year	N	$\bar{x}$	SD	MAX	N	$\bar{x}$	SD	MAX	N	$\bar{x}$	SD	MAX	N	$\bar{x}$	SD	MAX
1982	8	[1,2]3,053	967	4,310	6	[1,3]1,823	2,114	5,988	2	[1,4]1,276	824	1,858	4	[5]1,860	2,091	4,419
1983	13	[2,6]3,710	2,746	9,638	8	[3,6]2,462	2,063	6,206	6	[4,6]561	711	1,972	10	[5]106	280	901

[1]Heterogeneity among days: Kruskal-Wallis H = 4.86, $P > 0.10$.
[2]1982 vs. 1983: Mann-Whitney U = 52, $P > 0.10$.
[3]1982 vs. 1983: student's t = 2.12, df = 12, $P < 0.10$.
[4]1982 vs. 1983: not tested because of small sample sizes in 1982.
[5]1982 vs. 1983: Mann-Whitney U = 38, $P < 0.02$.
[6]Heterogeneity among days: Kruskal-Wallis H = 8.91, $P < 0.05$.

TABLE 5.—Comparison of bird numbers at regions A-C during 1 June-30 August period in 1982 with 1983. Day(s) = days postrelease of salmon smolts, N = number of censuses (1 census/d within 2 h of low tides before 1500 PDT), and MAX = maximum number of birds counted.

		"active" gulls			brown pelicans			"active" cormorants		
	Days(s):	1	2	3-6	1	2	3-6	1	2	3-6
1982	N	10	7	2	10	7	3	9	7	3
	Birds ($\bar{x}$)	[1]391	[1]381	[1]445	[2]31	[2]11	[2]7	[3]18	[3]28	[3]47
	SD	272	294	36	36	10	10	13	41	38
	MAX	919	729	470	106	30	19	38	110	88
1983	N	20	9	9	20	9	9	20	9	9
	Birds ($\bar{x}$)	[1]400	[1]332	[1]26	[2]25	[2]17	[2]7	[3]46	[3]81	[3]21
	SD	349	450	25	19	22	8	33	90	15
	MAX	1,311	1,200	77	84	69	20	128	286	52

[1]1 d vs. 2 d vs. 3-6 d: 1982, Kruskal-Wallis H_c = 0.44, $P > 0.10$; 1983, Kruskal-Wallis H_c = 14.62, $P < 0.01$. 1982 vs. 1983: 1 d, student's t = 0.07, df = 28, $P > 0.10$; 2 d, student's t = 0.25, df = 14, $P > 0.10$.

[2]1 d vs. 2 d vs. 3-6 d: 1982, Kruskal-Wallis H_c = 2.44, $P > 0.10$; 1983, Kruskal-Wallis H_c = 8.71, $P < 0.02$. 1982 vs. 1983: 1 d, Mann-Whitney U = 107, $P > 0.10$; 2 d, Mann-Whitney U = 32.5, $P > 0.10$; 3-6 d, Mann-Whitney U = 14, $P > 0.10$.

[3]1 d vs. 2 d vs. 3-6 d: 1982, Kruskal-Wallis H_c = 1.84, $P > 0.10$; 1983, Kruskal-Wallis H_c = 6.14, $P < 0.05$. 1982 vs. 1983: 1 d, Mann-Whitney U = 142.5, $P < 0.02$; 2 d, Mann-Whitney U = 49, $P < 0.10$; 3-6 d, Mann-Whitney U = 20, $P > 0.10$.

Yearly Variation in Bird Numbers

Cormorants were significantly more abundant for 1 and 2 d postrelease in 1983 than in 1982 but not for 3-6 d postrelease (Table 5). Brown pelicans were about as numerous in 1983 as in 1982 in the 1 June-30 August period (Table 5).

Gulls were not significantly more abundant in 1983 than in 1982 in the 1 June-30 August period (Table 5), and their nesting success was also not lower in 1983 than in other years (Bayer fn. 2). But Caspian terns were significantly more abundant during the 11 July-5 August period (when many emigrated) in 1983 than in 1982 (Bayer 1984).

There were an average of about 650 more common murres per census in 1983 than in 1982 during the 1 June-31 July period for either 1 or 2 d postrelease, but the differences were only significant for 2 d postrelease (Table 4). In contrast, there were more murres in 1982 than in 1983 during this period for 3-6 d postrelease, but there were only two samples in 1982 (Table 4).

In the 1-30 August period, there were significantly fewer murres in 1983 than in 1982 (Table 4). The low numbers in 1983 resulted from the mass exodus of murres after 31 July, whereas in 1982 murre numbers did not decline as dramatically until after 12 August. In fact, there were still more murres present within 2 h of low tides on 3 and 16 September 1982 (186 and 318 murres, respectively) than in 10 censuses on different days between 1 and 18 August 1983 (i.e., $\leq$56 murres). The early exodus of murres in 1983 probably resulted from them migrating north early because they were unusually numerous in inland marine waters of Washington during the summer of 1983 (Mattocks et al. 1983).

During the June through August period at regions A-C, pigeon guillemot numbers were about 29% greater during 1982 ($\bar{x}$ = 23.9, SD = 11.0, N = 13 d) than in 1983 ($\bar{x}$ = 17.1, SD = 7.8, N = 35 d), a significant difference (t = 2.39, df = 46, $P < 0.05$). This decrease could have resulted from the large number of mortalities in the spring of 1983 (Hodder[3]).

Marbled murrelets were not observed in any of 120 censuses of regions A-D in the June through 20 August period of 1982. In 1983 at regions A-C, they were observed in only 1 of 21 censuses in June and August, but an average of 3.9 murrelets/census (SD = 8.7, range 0-32, N = 17 censuses) were counted in July. The difference in the number of murrelets per census in July was significantly greater in 1983 than in 1982 (normalized Mann-Whitney z = 2.18, $P < 0.05$). They were only observed at region A.

CONCLUSIONS

It is not possible to relate the number of birds nesting near the Yaquina Estuary with the number feeding there for several reasons. First, the number of nesting and nonbreeding birds is unknown, so it is not possible to determine what proportion of the birds censused were nonbreeders. Second, censuses of feeding birds represent the number of birds feeding at only one point in time, but nesting birds probably fed serially at the Yaquina Estuary (i.e., birds came and went as individuals or small flocks not as massive synchronous flocks). With serial use, the number of nesting birds using the Yaquina Estuary could be much larger than indicated by censuses. Unfortunately, birds would have to be individually recognizable to determine the degree of serial use, and this was beyond the scope of this study.

It also was not possible to tell from how far nesting birds came to feed at the Yaquina Estuary in either year because birds were not individually marked. Murres, however, may have come from long distances. In both years, the average number of murres one day after a salmon release (Table 4) was greater than the number of murres at a colony <7 km away (Table 1), and the maximum number

[3]J. Hodder, Institute of Marine Biology, Charleston, OR 97420, pers. commun., 1984.

of murres simultaneously seen at the Yaquina (Table 4) was greater than the number of murres at colonies within 45 km of the Yaquina (Table 1).

It was somewhat surprising that more cormorants and common murres were not at the Yaquina Estuary in 1983, because they then had a poor nesting season, probably as a result of a food shortage (Bayer fn. 2). There are several possible reasons why there were not more cormorants and murres counted in 1983. First, the number of salmon smolts available at the Yaquina Estuary might have been insufficient or the distance between the Yaquina and their nesting site too great for these birds to be dependent solely on salmon smolt releases. If the salmon smolt releases had been oftener and nearer to bird nesting colonies, the numbers of birds present could have been much greater. Second, there may have actually been many more birds in 1983 than in 1982, but a single census per day regime was inadequate to measure this (Table 3). Censuses throughout the day in 1983 or measurements of the serial use of the Yaquina Estuary in 1982 and 1983 might have indicated that there were dramatically more birds using the Yaquina in 1983 than in 1982. Finally, the lack of there not being a greater influx of birds in 1983 might be because many of the murres and cormorants that normally remained near the Yaquina dispersed to avoid the generally poor feeding conditions between releases. Many Oregon pelagic and Brandt's cormorants had abandoned nesting by mid-July 1983 (see Bayer fn. 2; Hodder fn. 3), and many murres may have left the Oregon coast before it became apparent at the Yaquina Estuary at the end of July. Early dispersal or migration is known for southern seabirds during an El Nino (Duffy 1983a; Schreiber and Schreiber 1984).

ACKNOWLEDGMENTS

I am grateful to Bill McNeil, Vern Jackson, Rob Lawrence, Mike Bauman, and Andy Rivinus of Oregon Aqua-Foods for facilitating the logistics and funding of this project; to Dan Varoujean for advice about censusing murres prior to the 1982 field season; and to Jan Hodder, Dan Matthews, Daniel W. Anderson, Peter Stettenheim, and two anonymous reviewers for constructive comments on an earlier draft of this manuscript.

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