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REPRODUCTION AND SURVIVAL OF SEABIRDS IN OREGON DURING THE 1982–1983 EL NIÑO

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ABSTRACT.—The 1982–1983 El Niño was associated with higher than normal sea surface temperatures in Oregon during much of the 1983 seabird breeding season. Concurrently, reproductive success was reduced in at least three species of marine birds. Brandt's (*Phalacrocorax penicillatus*) and Pelagic cormorants (*P. pelagicus*) fledged fewer young per nest in 1983 than they did in previous years. Pigeon Guillemot (*Cepphus columba*) mortality was high before the onset of nesting, but those birds that nested in the Coos estuary were as successful at raising chicks in 1983 as they had been in 1982. The number of Common Murre (*Uria aalge*) chicks that left the breeding sites in 1983 was considerably lower than in 1982. Survival of adult murres was also affected, as significantly more were found dead on the beach during the 1983 breeding season.

El Niño events in the tropical eastern Pacific are characterized by the appearance and persistance, for six to 18 months, of anomalously warm water. Such events are cyclical phenomena, occuring on average once every four years (Cane 1983), and they usually result in a decrease in primary productivity and a reduction in the numbers of fish and seabirds (Cowles et al. 1977, Barber and Chavez 1983, Cane 1983). The 1982–1983 El Niño was particularly well developed and resulted in an intense, broad-scale warming of ocean waters (Cane 1983). The appearance of anomalously warm water off the coast of Oregon in the early months of 1983 (Huyer 1983) was tied to the El Niño event in the tropics (Reed 1983). To determine whether the warmer waters influenced the nesting activities of Oregon's seabirds, we compared data from the 1983 nesting season to similar information that had been gathered in previous years at various locations in Oregon for four species of seabirds: Brandt's Cormorant (*Phalacrocorax penicillatus*), Pelagic Cormorant (*P. pelagicus*), Common Murre (*Uria aalge*), and Pigeon Guillemot (*Cepphus columba*). We chose these species because, in most cases, comparable data were available on previous nesting seasons. We also compared seabird mortality, assessed by surveys of dead birds that were found on beaches during the 1983 breeding season, with similar data from the previous five years. Finally, as a measure of oceanographic conditions, we compiled data on local sea surface temperatures before and during the 1983 breeding season and compared them with information from previous years.

METHODS AND STUDY AREA

Sea surface temperatures have been measured every month since January, 1972, at a station 1.5 km inside the mouth of the Coos River estuary, Oregon (43°20′N, 124°20′W). Temperatures were taken by A. McGee, (Oregon Dep. of Fish and Wildlife, ODFW) on an average of 18 times a month at the time of the daylight high tide, the time most likely to reflect the conditions in the immediate coastal area. Offshore sea surface temperatures during the 1983 seabird breeding season were derived from satellite imagery and measurements at sea compiled by the National Oceanic and Atmospheric Administration, Northwest Service Center, Seattle.

Seabird mortality from 1978 to 1983 was measured by B. Loeffel (ODFW), who counted the number of dead birds found on a 7.4-km strip of beach in Lincoln County (Fig. 1). The beach was divided into four sections and coverage alternated between the sections so that the entire 7.4-km strip was surveyed at least once a week. From 1978 to 1983, the entire strip was surveyed at least four times per month from April to September. Dead birds were thrown above the tide line to prevent recounts on subsequent surveys. As far as possible, each bird was identified, but for our analysis all species were combined except for Common Murres, which occured in large enough numbers to be treated as a separate species. During April–August, 1983, we collected dead Common Murres and Pigeon Guillemots as we found them on four other beaches in Oregon (Seal Rocks, Bastendorff Beach, Lighthouse

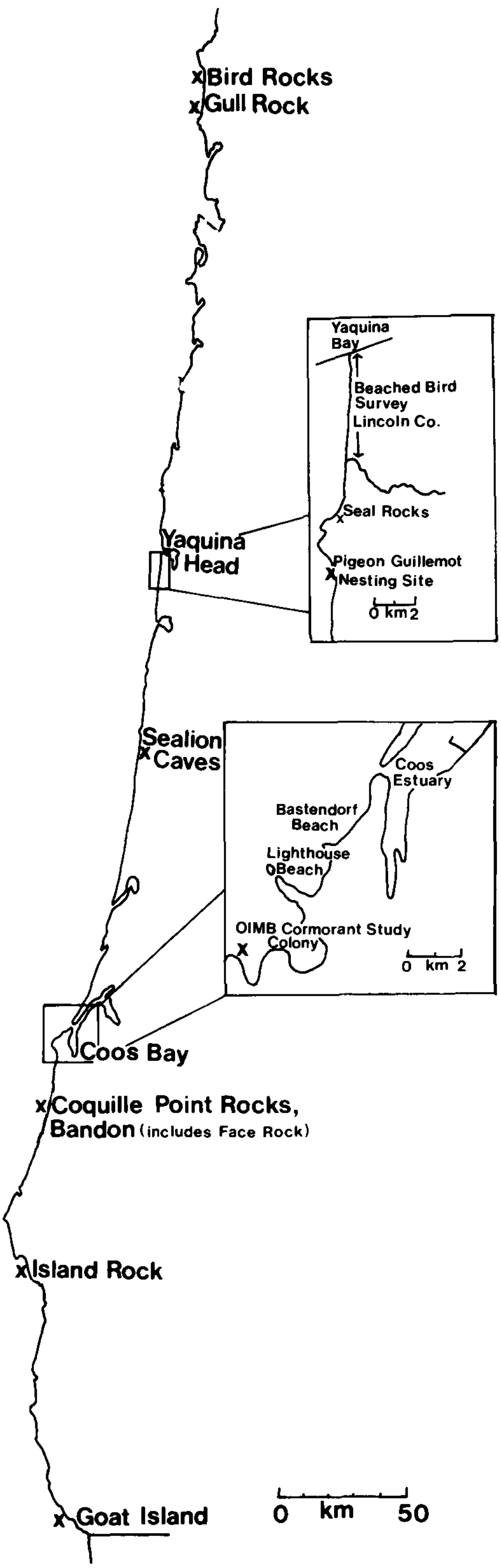

FIGURE 1. Location of the seabird colonies in Oregon where data were collected.

Beach, and Bandon; Fig. 1). We determined the sex and breeding condition of the murres by examining the brood patch, if present, and the gonads.

The location of the seabird colonies where we worked is shown in Figure 1. For Brandt's Cormorants, we counted the number of nests that were constructed and the number of chicks that were present at a colony north of Sealion Caves on 24 June, 8 and 17 July 1983. We counted the number of occupied nests at three colonies at Coquille Point Rocks, Bandon, on 23 June, 12 and 28 July 1983. At these latter sites, we compared colony occupation with similar data collected by Pitman et al. (in press) in 1979.

During seven visits from 15 May to 20 August 1983, we recorded the number of nests built, clutch size, hatching success, and fledging success for Pelagic Cormorants at a colony south of Coos Bay. These data were compared with similar information collected here by students at the Oregon Institute of Marine Biology (OIMB) during 1973, 1975–1978, and 1980–1982 (OIMB, unpubl. data). Numbers of active and failed Pelagic Cormorant nests were noted at Coquille Point Rocks on 28 July and 8 August 1983.

Clutch size, hatching success, and fledging success were determined for two populations of Pigeon Guillemots in 1983. Between 15 May and 31 August 1983, 28 visits were made to an abandoned pier in the Coos River estuary where 89 pairs of guillemots nested in 1983. These results were compared with similar data that we obtained during 20 visits between 15 May and 13 August 1982. In addition, seven visits were made to 11 pairs of guillemots nesting at Seal Rocks between 12 May and 20 August 1983.

Common Murre chick production was assessed by counting the numbers of chicks seen in a 200-m wide strip transect 1 km offshore from Coos Bay conducted on 12 July and 4 August 1983; these data were compared with similar transects that we conducted on 13 July and 5 August 1982. On 3 July 1983, the U.S. Fish and Wildlife Service (USFWS) conducted an aerial survey of six seabird colonies in Oregon (Bird Rocks, Gull Rock, Yaquina Head, Face Rock [Coquille Point Rocks], Island Rock, and Goat Island). The number of murres were counted from photographs taken during these surveys. We compared these data on colony attendance with those collected in the same way and from the same colonies during the 1979 USFWS census of Oregon seabird colonies (Pitman et al., in press). Statistical tests follow Sokal and Rohlf (1981).

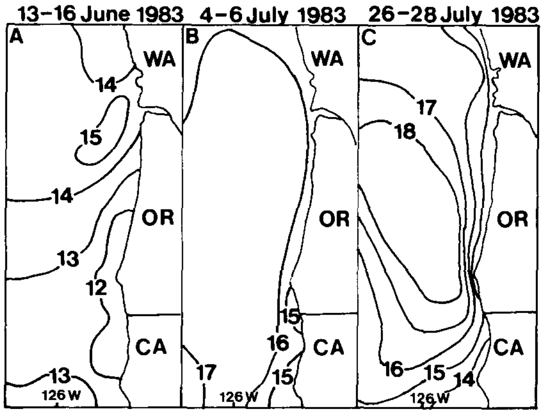

FIGURE 2. Sea surface thermal analyses of the coastal areas of Oregon for the periods 13–16 June 1983, 4–6 and 26–28 July 1983. Temperatures are in °C. WA—Washington, OR—Oregon, CA—California.

RESULTS

SEA SURFACE TEMPERATURES

Summer sea surface temperatures in the coastal zone of Oregon normally range from 7–11°C (Huyer 1977). Sea surface thermal analyses for 13–16 June and 4–6 and 26–28 July 1983 (Fig. 2) showed coastal sea surface temperatures to be considerably higher than the normal summer pattern. By 4–6 July, the bulk of water offshore had warmed to over 16°C (Fig. 2B), and surface temperatures continued to rise, reaching a maximum of 18°C offshore during 26–28 July (Fig. 2C).

Mean monthly sea surface temperatures from the Coos Bay shore station for October, 1982 to August, 1983 were, with the exception of June, at least 1.0°C higher than the previous twelve-year monthly means. The maximum anomaly occurred in July, 1983, when the mean temperature was 2.2°C higher than the previous twelve-year monthly mean.

SEABIRD MORTALITY

The number of adult Common Murres found dead on the Lincoln County beach was significantly higher in 1983 than in the previous five years (Table 1). Of 98 dead adult murres examined in 1983, 79% were in breeding condition and all had no fat deposits under the skin or around the viscera, suggesting starvation as the cause of death. We sexed 68 of the murres; 24 were males and 44 were females. Assuming a 1:1 sex ratio, this suggests that mortality was greater for females than for males ($\chi^2 = 5.88$, df = 1, $P < 0.05$). As assessed by the number of dead birds on the beach, mortality of murre chicks after they had left the colonies in 1983 appeared to be low but was not statistically different from previous years (Table 1).

During April, 1983, we found 27 dead Pigeon Guillemots on the Lincoln County beach. The highest number for this month in the previous five years was three dead birds in 1981. Surveys of Lighthouse and Bastendorff Beach, Coos County, during April, 1983, also revealed many dead guillemots. Of 26 dead birds collected from Lighthouse Beach on 13 April 1983, 10 were male and 16 were female, all were in summer plumage, no brood patches were present, and the gonads showed no signs of recrudescence. None of the birds that we

TABLE 1. Common Murre mortality (number of dead birds/km) from a 7.4-km beach in Lincoln County, Oregon.

	Adults						Chicks		
Year	April	May	June	July	Aug	Sept	July	Aug	Sept
1978	0.07	0.06	0.20	0.30	0.49	0	3.49	2.02	0
1979	0.07	0.07	0.06	0.25	0.21	0.14	0.09	6.01	0.05
1980	0.04	0.14	0.11	0.15	2.05	0.57	0.68	13.98	1.32
1981	0.08	0.18	0.48	0.40	0.34	0.13	1.65	2.36	0.93
1982	0.47	0.33	0.22	0.16	0.59	0.07	0.43	30.72	0.64
1983	0.63	0.74	0.72	3.38	1.42	0.08	0.81	0.07	0.05

2 × 2 analysis of variance on $x^{1/2}$ transformation of data

	Adults		Chicks	
Source	S.S.	°F	S.S.	°F
Years	1.52*	5	6.80	5
1983 vs. others	1.28**	1	1.39	1
All others	0.24	4	5.41	4
Months	1.18*	5	12.44*	5
Error	1.89	25	13.67	25
Additivity[a]	0.22	1		
Residual	1.67	24		

[a] Tukey's test for non-additivity (Sokal and Rohlf 1981, p. 414–416).
* = $P < 0.01$.
** = $P < 0.001$.

TABLE 2. Seabird mortality (excluding Common Murres) expressed as the number of dead birds/km from a 7.4-km beach in Lincoln County, Oregon.

Year	April	May	June	July	Aug	Sept
1978	0.45	0.78	1.16	0.36	0.98	0.21
1979	0.26	0.65	0.20	0.25	0.64	0.36
1980	0.50	0.71	1.56	0.28	0.60	0.95
1981	0.45	0.41	0.45	0.57	0.64	0.68
1982	0.37	0.36	0.37	0.32	0.95	1.11
1983	0.99	0.74	0.90	2.70	1.28	0.11

2×2 analysis of variance on $x^{1/2}$ transformation of data

Source	S.S.	°F
Years	0.49	5
1983 vs. others*	0.30	1
All others	0.19	4
Months	0.21	5
Error	1.66	25
Additivity[a]	0.14	1
Residual	1.52	24

[a] Tukey's test for non-additivity (Sokal and Rohlf 1981).
* = $P < 0.01$.

examined had fat deposits under the skin or around the viscera. Analyses of seven guillemots by the U.S. Fish and Wildlife Avian Toxicology Laboratory found no toxins or pathological conditions, indicating that the birds had starved (USFWS, Finley Wildlife Refuge, Corvallis, Oregon, unpubl. data).

The number of dead seabirds other than Common Murres found during 1983 in the Lincoln County beached bird survey was also significantly higher than in previous years (Table 2). Because this group includes species that do not breed in Oregon, in addition to some local breeders, it is not possible to determine whether the increased mortality is a result of the higher sea surface temperatures, or a reflection of conditions encountered by migrant birds far from Oregon's waters.

SEABIRD BREEDING BIOLOGY

By 12 July 1983, all Brandt's Cormorants had abandoned their nests at two of the three colonies at Coquille Point Rocks. On 11 July 1979, 196 occupied nests were present at these sites (Pitman et al., in press). At the third site, less than 0.5 km from the above two, some Brandt's Cormorants succeeded in raising chicks, although 26 of the 50 nests built there in 1983 failed to produce chicks.

Between 24 June and 17 July 1983, at a site north of Sealion Caves, the number of active Brandt's Cormorant nests declined from 82 to 42, but the number of chicks present declined only from 51 to 49. We saw no recently hatched chicks on 17 July, and except for two individuals, those chicks present at the end of June were apparently still there in mid-July. This suggests that birds which nested at some sites early in the season in 1983 managed to raise some young, whereas those who began nest building later in the season were unsuccessful in their attempts. The only comparable data available for Brandt's Cormorants in Oregon come from the Yaquina Head colony, where Scott (1973) determined a fledging rate of 1.56 birds/nest built. Our value of 0.58 chicks/nest constructed at the site north of Sealion Caves is considerably lower than Scott's figure. Moreover, we may have over-represented the fledging success of Brandt's Cormorants in 1983, since in Oregon this species does not begin to fledge until around the second week of August (Scott 1973).

In 1983, the number of nests constructed at the OIMB Pelagic Cormorant colony was not significantly different from previous years, but the percentage of nests in which at least one chick fledged was considerably lower (Table 3). The mean number of chicks fledged per successful nest was also considerably lower than in previous years. Pelagic Cormorants also abandoned their nests at Coquille Point Rocks, where 62% of the nests were abandoned by 8 August 1983 (Table 3).

At three southern colonies, Face and Island rocks and Goat Island, far fewer Common Murres were present on 3 July 1983 than were present in 1979 (Table 4). Colonies in the north of the state did not show such a decline. Single aerial surveys cannot adequately describe Common Murre colony attendance. The number of birds in a colony varies with time of day (Birkhead 1978, Slater 1980), nesting chronology (Sowls et al. 1980), tidal state, and

TABLE 3. Pelagic Cormorant nesting success at two sites along the Oregon coast. N/D = no data are available.

Site	Year	Total nests constructed	% nests successful[a]	Mean no. of chicks fledged/successful nest[b]
OIMB Cormorant Colony	7 yr mean[c] 1973–1982	35 ± 18[d]	80.0 ± 10[d]	2.70 ± 0.42 (15–45)
	1983	42	48	1.35 ± 0.72 (20)
Bandon	1983	29	38	N/D

[a] A successful nest is one in which at least one chick was fledged.
[b] Mean ± SD (range of nest numbers or number of nests).
[c] Does not include 1974 or 1979.
[d] Mean ± SD.

weather conditions (Slater 1976). The large reduction in the number of murres present in the colonies in the south of the state, however, suggests that the low numbers were associated with the anomalous warm water rather than a result of the timing of the surveys.

Unfortunately, the presence of adults in a colony cannot be correlated with the number of chicks produced. Murre chicks leave the colonies in early July before they are able to fly (Storer 1952), after which they are at sea accompanied by an adult bird. Offshore of Coos Bay, the mean number of murre chicks that were seen at sea on 12 July and 4 August 1983 was less than 1/km. This is considerably less than the 3.6 chicks/km seen on 13 July 1982 and the 6.9 chicks/km on 5 August 1982. The small number of murre chicks seen at sea and in the beach survey (Table 1) indicates that survival in the colony and possibly production of murre chicks was substantially reduced in 1983.

At the Coos River estuary pier, 19% fewer Pigeon Guillemot nests were present in 1983 (n = 89 nests) than were present in 1982 (n = 110 nests), and the mean clutch size of 1.57 eggs/nest was significantly lower than the 1.76 eggs/nest in 1982 ($t = 6.56$, df = 197, $P < 0.001$). The mean number of chicks fledged/nest in 1983 (0.72) was not significantly different from the mean number/nest in 1982 (0.74; $t = 1.20$, df = 89, $P > 0.1$). The reproductive success of guillemots nesting south of Seal Rocks (n = 11 nests) in 1983 was also high: mean clutch size was 1.6 eggs/nest and 1.3 chicks/nest fledged.

TABLE 4. Number of Common Murres at six colonies in Oregon determined by aerial censuses conducted by USFWS.

Colony	No. of birds 1979 (date)[a]	No. of birds 1983 (date)
Bird Rocks	3,750 (7/16)	4,500 (7/3)
Gull Rock	3,200 (7/16)	2,000 (7/3)
Yaquina Head	3,000 (7/16)	2,769 (7/3)
Face Rock	3,500 (5/21)	800 (7/3)
Island Rock	6,600 (7/11)	133 (7/3)
Goat Island	1,850 (7/11)	0 (7/3)

[a] Data from Pitman et al. (in press).

DISCUSSION

The 1983 nesting season for Common Murres and Brandt's and Pelagic cormorants in Oregon was considerably less successful than previous years. The failure of these species to successfully rear chicks corresponded with significantly higher ocean surface temperatures before and during the nesting season (Reed 1983; Miller et al. 1985). This warming was not restricted to the surface layers. Huyer (1983) found, in April, 1983, that anomalously warm water extended at least 200 km out from the Oregon coast and down to depths of more than 100 m. Thus, even if coastal upwelling did occur during the summer of 1983, the normal replacement of nutrient-depleted warm water by cooler nutrient-rich water that is a common phenomenon during the summer months in Oregon (Bryden 1978) was not occurring. This lack of nutrient replenishment has been recorded from coastal Peru during El Niño events (Barber and Chavez 1983).

The results of the 1983 seabird breeding season in Oregon were similar to those documented in the eastern tropical Pacific during previous El Niño episodes (Murphy 1936, Boersma 1978, Cushing 1981). In the tropics, the unusually high ocean temperatures and the subsequent reduction in primary productivity disrupted normal coastal food webs, which apparently resulted in reduced breeding success and mortality of several marine bird species. Unfortunately, it is not possible to directly correlate the observed nesting failures in Oregon with the temperature anomalies. Appropriate data connecting seabirds, their prey, and the effects of the increased sea surface temperatures do not exist for the 1983 breeding season. Zooplankton densities, however, were about 30% of those in non-El Niño years (Miller et al. 1985), suggesting that ocean productivity was much lower than usual. There remains the possibility that other factors, such as oceanographic or weather conditions at the birds' wintering ground may have impaired breeding success.

Cormorants commonly desert their nests during El Niño periods in the eastern tropical Pacific (Cushing 1981): nest abandonment by Brandt's and Pelagic cormorants was widespread in Oregon during 1983. Seabird mortality was higher than in previous years for species that breed in Oregon, and for species that breed elsewhere. This observation was not an isolated event; widespread die-offs of adult seabirds in 1983 were also reported from California (Ainley 1983) and the Gulf of Alaska (Nysewander and Trapp 1984).

In Oregon, Pigeon Guillemots return to the nesting sites around the middle of March (Hodder and Graybill, unpubl. data), having wintered away from the immediate coastal zone. Their feeding habits during the winter period are not well documented. In 1983, many guillemots died just after they had returned to the nesting sites and, as a result, fewer birds nested in the Coos River estuary than in 1982. Clutch size was lower, but reproductive success was not significantly different in 1983, as the mean number of chicks fledged per nest was similar to 1982. Possibly the epibenthic fish on which guillemots primarily feed during the breeding season (Ainley and Sanger 1979; Graybill and Hodder, unpubl. data) were not so affected by the decreased productivity associated with the warm water conditions. Many estuarine fish feed on organisms that are members of the detritivore food web (Darnell 1961) and as such are probably buffered from decreases in primary productivity, such as those which occur in open ocean plankton populations during an El Niño event (Guillen and Calienes 1981). Common Murres and Brandt's Cormorants in Oregon experienced relatively greater reproductive failure in 1983. These species feed primarily on fish (Scott 1973, Ainley et al. 1983, Matthews 1983), many of which are planktivorous species (Hart 1973, Moyle and Cech 1982) and thus are likely to be more rapidly affected by a decrease in primary productivity.

Marine birds have the potential to be comparatively long-lived (Lack 1968). Thus, not breeding for a year, or abandoning a nesting attempt early in the season, would not be disadvantageous during periods of food shortages. Schreiber and Schreiber (1983) suggested that individuals who can successfully breed during a period of food scarcity thrive. Alternatively, those individuals who attempt to complete the nesting season during such a period so weaken themselves that they reduce their chance of survival and subsequent reproductive attempts. It would be necessary to have a population of marked known-aged individuals in order to tell if birds which bred successfully in 1983 will, over their life span, be the most successful in terms of number of offspring produced. The periodic nature of El Niño conditions provides a good opportunity to test these hypotheses and thus should provide incentives to collect long-term information on individuals' reproductive histories.

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RECENT PUBLICATIONS

Bird census and atlas studies. Proceedings of the VIII International Conference on Bird Census and Atlas Work.—Edited by K. Taylor, R. J. Fuller, and P. C. Lack. 1985. British Trust for Ornithology. 437 p. Paper cover £10.00. Source: B.T.O., Beech Grove, Station Road, Tring, Herts. HP23 5NR, England. In the opening paper of this volume, Jacques Blondel notes that the formerly distinct fields of research into the distribution and the abundance of birds have merged into a common discipline. This is due in part to the international conferences on bird census and atlas work that have been held biennially since 1969 in several different European countries. (For a notice of the 1981 conference proceedings, see Condor 86:186.) Proceedings of the 1983 conference, held in England, are given here. They begin with a thoughtful critique of bird distribution and abundance studies by Blondel, and a summary of such activities in North America by Chan Robbins. There follow 63 papers and abstracts, grouped as to study design and methods, monitoring, habitat and community studies, and atlas and grid mapping studies. Virtually all of them concern land birds or shorebirds, with one paper on seabirds at sea. They are also largely about European species and habitats, but many of their findings transcend such limits. Just as the proceedings of the Asilomar conference on "Estimating numbers of terrestrial birds" (Condor 84:39) have been of wide interest to census and atlas workers, so should these be. They bear out Blondel's final point that "what we need is not to know numbers of birds *per se* but rather to know them for some definite purpose." Graphs, maps, combined list of references.

The atlas of Australian birds.—M. Blakers, S. J. J. F. Davies, and P. N. Reilly. 1984. Melbourne University Press. 738 p. Hard cover. $60.00. Distributed in North America by International Specialized Book Services, Inc. Imagine undertaking an atlas of U.S. birds with only a few hundred known field ornithologists and no funds! Undaunted, the Royal Australasian Ornithologists Union did the equivalent for Australia, its nearby islands and waters. They organized the project, mustered financial support and a few thousand birders, supervised field work for five years, and produced the results in this book. The volume is large, well thought-out, and attractively designed. Its introduction fully explains the scope and procedures of the atlas project, organization of the book, and the environment of Australia. Accounts are given for all Australian breeding birds and regular migrants, for a total of 656 species. Most species have been allocated one page containing a map, an explanatory text, and a pen-and-ink drawing of the bird. These maps show the grid blocks in which the species was recorded (1° blocks for most species; 10′ blocks for the 11 Tasmanian endemics) with color symbols to indicate status and frequency of reporting. (Available at a small charge from the RAOU is a set of six transparent overlay maps that show several kinds of environmental information, an aid to interpreting the distribution maps.) The text "deals mainly with range and movements but also identifies the species' known requirements and, if possible, factors on which these depend." Following are summarized records for 102 uncommon and vagrant species, mostly sea- and shorebirds. Lastly, in the Historical Atlas, data from notebooks, published records, and museum specimens have been sifted to prepare, for 38 species, maps of their known status and distribution during three periods in the past. This atlas contains a wealth of information yet will doubtless arouse fresh research to refine and interpret the patterns of distribution. The RAOU and the atlas participants may well be proud of their immense collective enterprise. References index.