GENERAL NOTES

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Great Blue Heron eggshell thickness at Oregon estuaries.—The thickness of eggshells of Pacific coast Great Blue Herons (*Ardea herodias*) has decreased since the pesticide era began in California (Wilburn, Lincoln Great Blue Heron Rookery Study, 1970–1971, California Dept. Fish Game, Spec. Wildl. Invest., 1972; Faber et al., Environ. Pollut. 3:111–122, 1972; Ives, California Dept. Fish Game, Spec. Wildl. Invest., Admin. Rept. No. 72-9, 1972) and in inland Oregon (Blus et al., Murrelet 61:63–71, 1980). Herein, I report eggshell thicknesses at eight colonies near four Oregon estuaries. I also document yearly and intraseasonal variation in thickness. These latter aspects have not been previously examined for any herons, and yearly variation has been measured only in Brown Pelicans (*Pelecanus occidentalis*) (Mendenhall and Prouty, Proc. Colonial Waterbird Group 2:65–70, 1978; Schreiber, Bioscience 30:742–747, 1980).

Study area and methods.—I designated heron colonies by the estuary name and the cardinal compass direction of the heronry from the estuary. The four study estuaries (colony names in parentheses) were the Yaquina (Yaquina-N, -S and -E), the Alsea (Alsea-S), the Coos (Coos-N, -W and -S) and the Coquille (Coquille-N). Yaquina-E and Coquille-N were mapped as the Mill Creek and Bandon colonies, respectively, in Werschkul et al. (Murrelet 58:7–12, 1977); and the other colonies are mapped in Bayer and McMahon (Murrelet, In Press). Chemical contaminants that may have influenced eggshell thickness could have resulted from agricultural or forestry practices at all four estuaries, and/or from pulp and paper plants at the Yaquina and Coos estuaries.

Eggshells dropped from the nest to the ground by the parents after hatching or through accident were collected during visits to Yaquina-S from 1973–1979, to Coquille-N and Coos-N, -W and -S in 1975, to Alsea-S in 1975 and 1976, and to Yaquina-N and -E in 1979.

Eggshells were rinsed after collection to remove debris; those collected from 1973–1978 were dried at room temperature until June 1979, when their thickness was measured. Eggshells from 1979 were dried at room temperature for at least 74 days before measurement. If the end of the shell had been chipped away it was regarded as one from which a young bird had hatched; all other eggshells were considered to be from unhatched eggs (see Faber et al. 1972).

Shell thickness was measured with a Starrett micrometer fitted with a ball to measure curved surfaces. I calculated a mean from thickness measurements made at three sites along the equator where the shell membrane was still attached to the shell.

Results and discussion.—The mean annual percentage of unhatched eggshells at Yaquina-S was 7.8% (range = 7–10%, N = 6) and was ≤8% at Coquille-N, Coos-W and Coos-S. However, at Coos-N and Alsea-S more eggshells were unhatched (16 and 17%, respectively); most of the unhatched eggshells at these two colonies were found a few days after high winds. The higher proportion of unhatched eggs at these two colonies, which were more exposed to wind than other colonies, probably resulted from the wind destroying nests or blowing eggs out of nests rather than from pesticides or eggshell thinning. I did not find at any colony shells that appeared crushed or dented, and only at Yaquina-E in 1979 were eggs found that broke when picked up. There was a nonsignificant correlation ($r = -0.33$, df = 11, $P > 0.10$) between the proportion of unhatched eggshells and mean hatched eggshell thickness. In contrast, a much higher percentage (29–67%) of unhatched shells was found in some California colonies (Page, Sec. Prog. Rept., San Joaquin River Rookery Study, 1971, California Dept. Fish Game, Spec. Wildl. Invest., 1971; Faber et al. 1972; Wilburn 1972).

The mean thickness of hatched eggshells was significantly less than the pre-1947, pre-

TABLE 1
GREAT BLUE HERON PRE-1947 WHOLE EGG AND POST-1972 HATCHED EGGSHELL THICKNESS

Area		Eggshell thickness (mm)			% change from pre-1947 mean[c]
		N	$\bar{x} \pm$ SD	Range	
Pacific northwest	pre-1947	186[a]	0.3861 ± 0.021[a]	0.290–0.437[b]	—
Yaquina-N and -E	1979	20	0.3240 ± 0.015	0.285–0.348	−16.1
Yaquina-S	1973	70	0.3467 ± 0.025	0.252–0.391	−10.2
Yaquina-S	1974	50	0.3520 ± 0.027	0.279–0.391	−8.8
Yaquina-S	1975	46	0.3542 ± 0.021	0.300–0.403	−8.3
Yaquina-S	1976	128	0.3562 ± 0.024	0.277–0.394	−7.7
Yaquina-S	1977	86	0.3542 ± 0.024	0.300–0.414	−8.3
Yaquina-S	1978	41	0.3759 ± 0.018	0.338–0.424	−2.6
Yaquina-S	1979	63	0.3362 ± 0.023	0.264–0.396	−12.9
Alsea-S	1975	36	0.3466 ± 0.029	0.227–0.417	−10.2
Coos-N	1975	61	0.3549 ± 0.023	0.315–0.406	−8.1
Coos-W	1975	42	0.3529 ± 0.019	0.300–0.381	−8.6
Coos-S	1975	35	0.3597 ± 0.023	0.269–0.396	−6.8
Coquille-N	1975	36	0.3490 ± 0.020	0.300–0.378	−9.6

[a] From Anderson and Hickey (pp. 514–540 *in* Proc. XV Int. Ornithol. Congr., K. H. Voous, ed., 1972) and H. M. Ohlendorf (pers. comm.) for whole eggs.
[b] From H. M. Ohlendorf (pers. comm.) for whole eggs collected at nest.
[c] Differences significant at $P < 0.05$, df ≥ 204, means compared using student's t-test.

pesticide era thickness in all years (Table 1). However, there was yearly variation at Yaquina-S with mean thickness relatively stable from 1973–1977, increasing in 1978, and decreasing to a minimum for all years in 1979 (Table 1). Yaquina-S means were significantly different among all years (1973–1979) ($F = 12.22$; df = 6, 477; $P < 0.01$).

Eggshell thickness sometimes varied among colonies. In 1975, the means for the Coos colonies and Yaquina-S did not differ significantly from each other ($F = 0.42$; df = 3, 181; $P > 0.05$), but the combined mean of the Coos colonies and the Yaquina-S colony differed significantly ($F = 3.05$; df = 2, 254; $P < 0.05$) from the means of Alsea-S and Coquille-N (also see Table 1). In 1979, Yaquina-N and -E mean thickness was significantly less ($F = 6.00$; df = 1, 81; $P < 0.05$) than the mean for Yaquina-S, but these means were lower than all means in previous years (Table 1).

Eggshell thicknesses did not show consistent patterns of increase or decrease within a breeding season (Fig. 1). The mean thickness of eggshells for any particular date was within 4.7% of the mean for the entire breeding season, but means for dates within a season varied by as much as 7.3% (Fig. 1). Mean thickness for a given date within a season was not significantly different from others in 1976 ($F = 1.25$; df = 6, 121; $P > 0.05$) or 1979 ($F = 0.70$; df = 6, 56; $P > 0.05$) but were in 1977 ($F = 8.33$; df = 3, 80; $P < 0.01$). Therefore, differences between pre-1947 and current eggshell thicknesses or the actual mean thickness during a breeding season may either be obscured or biased by collections of eggshells from a single visit.

I found that the mean thickness for hatched eggshells from all colonies ($\bar{x} = 0.3518 \pm 0.024$ mm, range = 0.252–0.424 mm, N = 720) was significantly greater ($t = 4.60$, df = 759, $P < 0.01$) than for unhatched shells ($\bar{x} = 0.3324 \pm 0.430$ mm, range = 0.229–0.389 mm,

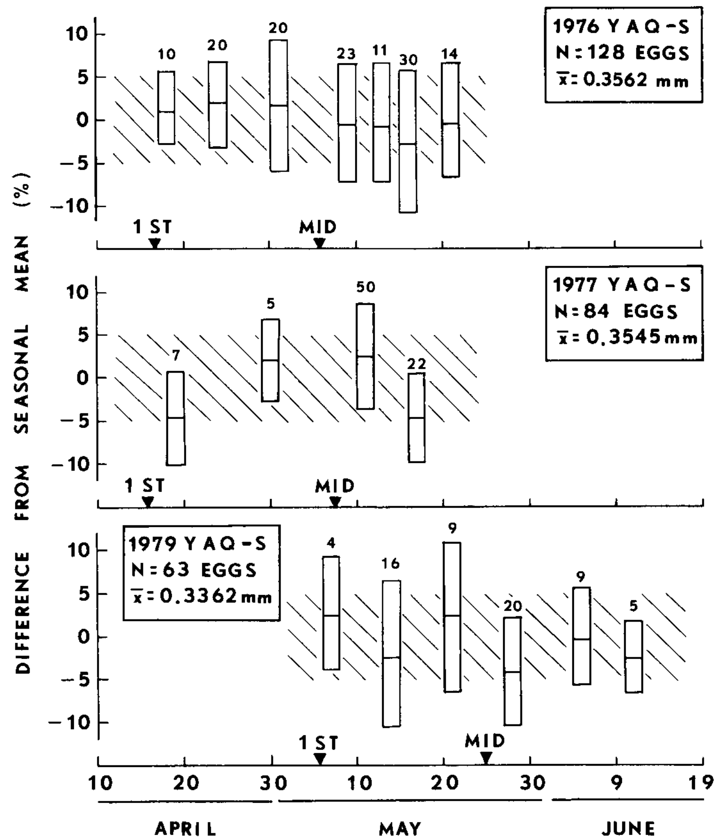

FIG. 1. Percent difference of hatched eggshell mean thickness/visit (horizontal line) and standard deviation of mean/visit (vertical bar) from hatched eggshell mean thickness/breeding season ($\bar{x}$ in yearly legend) at Yaquina-S. Dates of first (1ST) and 50% (MID) hatching from Bayer and McMahon (In Press). Number of eggshells/visit is above vertical bar. Crosshatching represents thicknesses within 5% of breeding season mean.

N = 41). Both means were significantly thinner than the pre-1947 mean given in Table 1 (hatched: 8.8% less, $t = 16.92$, df = 904, $P < 0.01$; unhatched: 13.9% less, $t = 11.25$, df = 225, $P < 0.01$). Similarly, Faber et al. (1972) and Ives (1972) showed that hatched eggshells of Great Blue Herons were thinner than pre-1947 eggshells (7.8 and 10.6%, respectively) and that hatched eggshells were generally thicker than unhatched eggshells. The thinnest eggs may have had the highest probability of not hatching because of behavioral abnormalities of the parents (e.g., egg piercing or rejection, see Milstein et al., Ardea 58:171–257, 1970; Cooke et al., Environ. Pollut. 11:59–84, 1976) or because of decreased viability resulting from increased pesticide loads (Cooke et al. 1976). In fact, the difference in thickness between hatched and unhatched eggshells may have been even greater when eggs were first laid, since incubation may typically reduce thickness by about 8% in several species (Kreitzer, Poult. Sci. 51:1764–1765, 1972; Rothstein, Wilson Bull. 84:469–474, 1972; Capen, Wilson Bull. 89:99–106, 1977; Pulliainen and Marjakangas, Ornis. Scand., Fenn. 57:65–70, 1980; but see Ohlendorf et al., U.S.D.I., Fish and Wildl. Serv., Spec. Sci. Rept. Wildl. No. 216, 1979). However, incubation thinning is apparently not equal for all eggs of a species (Capen 1977).

Unfortunately, pre-1947 Great Blue Heron eggshells were probably not incubated long, so a comparison between pre-1947 and current eggshells dropped from the nest will not be rigorous until there are data available concerning thinning during incubation of eggshells of *A. herodias.* Nevertheless, using 8% as a standard of incubation thinning (Pulliainen and Marjakangas 1980), I estimate that much of the difference I found between pre-1947 and current-hatched eggshell thicknesses may result from this form of thinning. However, the yearly variation in thicknesses and the variation among colonies (Table 1) indicates that incubation thinning is not the only cause of current eggshells being thinner than those prior to 1947. In any case, I found that the degree of thinning of current-hatched eggshells compared with pre-1947 eggshells was generally less than the 15–20% thinning associated with declining bird populations (Anderson and Hickey 1972).

Research design.—To make collections of eggs yielding the most information one should collect both whole eggs and dropped eggshells. Whole eggs are necessary for the determination of pesticide or heavy metal levels. Collecting eggs at the same stage of incubation as represented by pre-1947 eggshells (generally shortly after being laid [see Anderson and Hickey, Wilson Bull. 82:14–28, 1970]) is required to compare present day and pre-1947 shells. However, collecting eggs that have fallen from the nest is often the only practical way to collect eggshells in inaccessible colonies, e.g., at Yaquina-S where nests are 20–30 m above the ground, or to determine the thickness of shells of hatched or unhatched eggs and the proportion of unhatched eggs. Furthermore, collection of eggshells from the ground minimizes disturbance to nesting birds while maximizing the proportion of the colony's eggshells sampled.

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Nesting phenology of the Double-crested Cormorant.—The Double-crested Cormorant (*Phalacrocorax auritus*) is a locally common, colonially nesting bird of the lakes, rivers and estuaries of much of North America. The nesting cycle of the cormorant is decidedly seasonal over much of this range. Published accounts indicate spring–sumer nesting to be the rule (e.g., Bent, U.S. Natl. Mus. Bull. 121, 1922; Palmer, Handbook of North American Birds, Yale Univ. Press, New Haven, Connecticut, 1962; Weseloh et al., Proc. Colonial Waterbird Group 2:10–18, 1977). A few data suggest that cormorants may have a longer reproductive season in Florida, where nesting has been reported as early as December and as late as October (Palmer 1962). In this note, we describe the nesting cycle and other population characteristics of cormorants in southern Florida.

Methods.—Cormorant colonies were located and the number of nests were counted to