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BIRDS FEEDING ON HERRING EGGS AT THE YAQUINA ESTUARY, OREGON

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ABSTRACT.—I observed 17 bird species feeding on herring eggs throughout high and low tides at high rocky intertidal and low intertidal areas in an Oregon estuary. At low tide gulls fed directly on eggs, but at high tide they pirated eggs from diving birds or picked up eggs drifting in water. Brant, wigeon, and coots picked up eggs while walking, or tipping up or through piracy; in deeper water coots dove for eggs. Diving ducks obtained eggs by diving, by piracy, or by picking up eggs while swimming. Less than 25% of the gulls, coots, or Buffleheads, but as many as 45% of the scaups and 83% of the scoters observed in the lower estuary were in groups feeding on herring eggs. The species composition and abundance of birds varied within the estuary and probably reflected: 1) the onset of spring migration; 2) immigration of birds into the estuary to feed on eggs; 3) the presence of birds near a site of egg deposition; and 4) the domination of herring egg deposits by gulls in the upper intertidal zone.

Along the eastern Pacific Ocean, herring (*Clupea harengus*) are present from northern Baja California to the Beaufort Sea, spawning in estuaries and other coastal areas (Hart 1973). The fish aggregate and spawn in a California bay 4–7 times per spawning season at sites that vary in area from 42 to over 1 million m^2 (Hardwick 1973). Water-hardened eggs are about 1.3 mm in diameter and are laid in masses attached to eelgrass (*Zostera marina*), algae, rocks, piers, or other relatively immobile objects (Hart 1973).

Because herring spawn in late winter and early spring, their eggs may be important to birds as a source of nutrition for fat deposition prior to or during spring migration. Although spawning is infrequent, the amount of potential food available to birds may be as great as 1.3×10^5 kg eggs/site, with mean densities as great as 1.37 kg/m^2 (Hardwick 1973).

Several studies have described the species composition and measured the extent of bird predation on herring eggs (Munro and Clemens 1931, Munro 1941, Outram 1958, Taylor 1964, Steinfeld 1972, Hardwick 1973). Little attention has been given to changes in group composition or to the role of gulls in predation of eggs.

Here, I report the techniques whereby birds obtain herring eggs at the Yaquina River estuary, Oregon. I also relate species composition to sites where eggs are laid, seasonal changes in species abundance, and domination of egg deposition sites by gulls. Finally, I discuss the impact of bird predation on herring eggs and on macrophyton distribution.

STUDY AREA AND METHODS

The Yaquina River estuary, on the central coast of Oregon (Fig. 1), is a drowned river valley with an area of about 15.8 km^2 (Oregon State Land Board 1973). Tides have a range between Mean Lower Low Water (0.0 m, MLLW) and Mean Higher High Water of 2.55 m; Mean Tide Level is +1.40 m (Oregon State Land Board 1973). All elevations in this paper are relative to MLLW.

I found herring eggs on intertidal macrophyton as early as 26 December (in 1974); generally 3–7 spawnings per year occur from mid-January to mid-April (Steinfeld 1972; J. Butler, Oregon Department of Fish and Wildlife, pers. comm.). Spawning usually occurs in patches and is not synchronous throughout the estuary (Steinfeld 1972). Using a 20× telescope, I searched for any birds feeding on herring eggs two to five days per week from 8 February to 31 April 1979. Birds feeding on herring eggs were observed at only five sites (Fig. 1). They were found at these sites throughout the day and during all tide stages unless they were disrupted by fishermen, boats, or Bald Eagles (*Haliaeetus leucocephalus*). Bird groups were relatively undisturbed at sites 1, 2 and 5, and groups generally reassembled within 10 min after a disturbance. Fishermen so often disturbed birds at sites 3 and 4 that large groups seldom formed, and birds moved frequently between areas where fishermen were absent.

Because of frenzied bird activity and subtle interspecific plumage differences, not all of the birds in groups could be identified to species and counted. I divided gulls into two categories: large (Western, Glaucous-winged, and Western × Glaucous-winged hybrids [Hoffman et al. 1978]) and small (Ring-billed and Mew). White-winged and Surf scoters, as well as Greater and Lesser scaup, could not always be distinguished.

Using my telescope from a car, I censused selected aquatic birds over the area shown in Figure 1 by diagonal lines, at the time of high slack tides. The possibility of counting birds more than once was minimized by counting them during a continuous sweep of nonoverlapping parts of the estuary. Censuses of gulls and scoters were conducted in this manner twice monthly from 12 December 1978 through March 1979 and four times in April 1979. American Wigeon, Canvasbacks, Buffleheads, and Ruddy Ducks were censused on 15 December 1978 and 6 April 1979; American Coots were censused on these dates and also on 17 February 1979.

Birds feeding on herring eggs were present at site 1 from 18–25 February, at site 2 from 18–27 February, at sites 3 and 4 from 17–23 March, and at site 5 from 4–10 April. During these times, I noted species composition and bird behavior during 30–60-min observation periods that were at least 60 min apart: at site 1 on 6 days, 1–6 times daily; at site 2 on 4 days, once daily; at sites 3 and 4 on 5 days each, 1–3 times daily; and at site 5 on 7 days, 1–5 times daily. I did not determine group composition until 20 min after a disturbance, and the frequent disturbances at sites 3 and 4 made quantitative group composition determinations impossible. At site 2, I only qualitatively determined group composition. At all sites, data on group composition represent either composition of different groups on different days, different groups during the same day (i.e., groups disbanded and reassembled between determinations of group composition), or the same group at different times during the day.

Deposits of herring eggs differed in substrate and intertidal elevation. At site 1, eggs were deposited on *Gracilaria* spp., other algae, and eelgrass below +0.4 m (slightly below Mean Low Water). At sites 2–4 eggs were on fucoid algae on rocks at about +0.8 to +1.3 m. At site 5, eggs were on eelgrass and algae below +0.3 m.

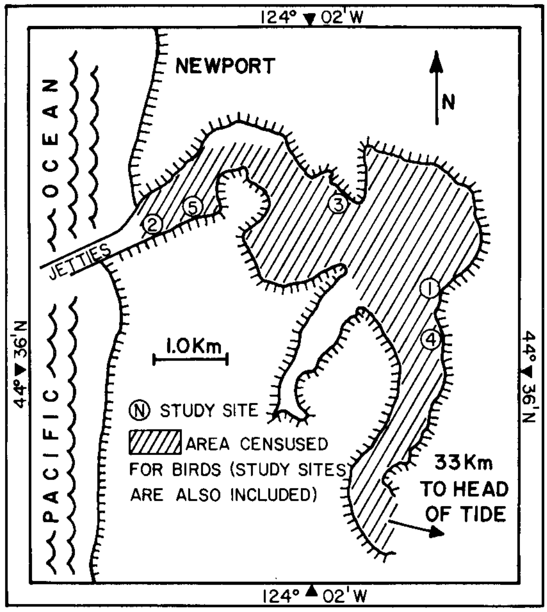

FIGURE 1. Locations (sites 1–5) of bird groups feeding on herring eggs in the lower Yaquina estuary from 8 February through 30 April 1979.

RESULTS

GENERAL FORAGING TECHNIQUES AND PIRACY

Black Brant, American Wigeon, and gulls collected eggs by tipping up while swimming, by walking, wading, swimming, or by piracy within and among species. Coots used these same methods as well as diving, but piracy was always intraspecific. Diving ducks obtained eggs or egg-covered macrophyton by diving or while swimming and picking up eggs; diving ducks never left the water to pick up eggs. Black Brant pirated eggs from coots; American Wigeon robbed coots and scaups; Buffleheads stole eggs from scaups. Brant, ducks, and coots pirated eggs by swimming towards other birds and pulling eggs from their bills.

The most conspicuous pirates were gulls, who stole eggs from many species (Table 1). In groups at site 1, I observed as many as 75 large-gull piracy attempts/min (n = 11 min); 20–40 attempts/min were common. Large gulls floated or swam and appeared to be constantly looking for birds with eggs. Gulls either swam or flew directly toward a bird with eggs. Their flights were short, with 88% (n = 100) lasting 2 s or less, 98% 5 s or less, and the longest flight only 13.5 s. Small-gull flights also were short. A single large gull approached a bird in 46% of observed large-gull flights (n = 245); two gulls more commonly approached a bird (30% of flights) than did three to five gulls (22%), or six or more gulls (2%).

When a gull landed near a bird with eggs, it tried to pull the eggs from the owner. The latter either dove (sometimes leaving the eggs behind) or it swam quickly (with flapping wings) away from the gull. Several times I observed a large gull grasp and hold the neck of a diving Canvasback until the duck pulled away. I also saw a large gull grasp the leg of a Bufflehead that did not have any food and hold the victim for about 30 s while it tried to swim away, flapping its wings.

Large gulls also attempted to steal from each other, usually by trying to pull food from another swimming individual; flight pursuits occurred in only 2% of 251 interactions between large gulls.

Large gulls did not try to steal eggs equally from all species (Table 2). They attempted to pirate significantly less often from Black Brant than from all other species combined (chi-square, $P < .02$), and significantly more from Canvasbacks than from scaups and Buffleheads ($P < .01$). Large gulls were not equally successful in obtaining eggs from species they approached (Table 2),

TABLE 1. Species identified in groups at all sites, birds seen eating eggs, species parasitized by large (L) or small (S) gulls, and the presence and abundance of taxa in groups at sites 1 and 5.

			Presence and abundance in groups						
			Site 1 (n = 17 Groups)[8]				Site 5 (n = 14 Groups)[9]		
	Ate herring eggs[1]	Piracy of eggs by gulls	% of groups	Number/Group n	Number/Group ($\bar{x}$)	Number/Group Max.	% of groups	Number/Group ($\bar{x}$)	Number/Group Max.
Common Loon (*Gavia immer*)			12	17	*[2]	1	7	*[2]	1
Western Grebe (*Aechmophorus occidentalis*)			29	16	*	1	0	0	0
Horned Grebe (*Podiceps auritus*)			0	17	0	0	29	*	1
Brandt's Cormorant (*Phalacrocorax penicillatus*)			24	17	*	4	7	*	1
Pelagic Cormorant (*P. pelagicus*)			6	17	*	1	0	0	0
Black Brant (*Branta bernicla*)	X*	L,S	35	13	4	36	100	79	237
White-fronted Goose (*Anser albifrons*)	X		0	17	0	0	50	*	1
American Wigeon (*Anas americana*)	X	L,S	88	10	17	58	7	*	1
European Wigeon (*A. penelope*)			12	17	*	1	0	0	0
Redhead (*Aythya americana*)	X	L,S	82	16	2	8	0	0	0
Canvasback (*A. valisineria*)	X	L,S	100	8	172	390	0	0	0
Greater Scaup (*A. marila*)	X*	L,S	100[3]	7	153[3]	350[3]	100	26	80
Lesser Scaup (*A. affinis*)	X	L,S	—	—	—	—	0	0	0
Common Goldeneye (*Bucephala clangula*)	*	L	100	7	15	28	14	*	1
Bufflehead (*B. albeola*)	X*	L,S	100	8	437	637	93	15	29
Harlequin Duck (*Histrionicus histrionicus*)	*		12	17	*	1	36	*	3
Oldsquaw (*Clangula hyemalis*)	*		35	17	*	3	14	*	1
Black Scoter (*Melanitta nigra*)	X*		18	17	*	3	100	556[4]	798[4]
White-winged Scoter (*M. deglandi*)	X*	L,S	100	9	457[5]	1,001[5]	100	—	—
Surf Scoter (*M. perspicillata*)	X*	L,S	100	—	—	—	100	—	—
Ruddy Duck (*Oxyura jamaicensis*)			6	17	*	1	0	0	0
Red-breasted Merganser (*Mergus serrator*)			18	17	*	1	50	1	5
Hooded Merganser (*Lophodytes cucullatus*)			6	17	*	1	0	0	0
American Coot (*Fulica americana*)	X*	L	53	14	7	39	0	0	0
Glaucous-winged Gull (*Larus glaucescens*)	X*	L	100	11	96[6]	282[6]	100	219[6]	539[6]
Western Gull (*L. occidentalis*)	X*	L	100	—	—	—	100	—	—
Ring-billed Gull (*L. delawarensis*)	X	L	78[7]	8	5[7]	15[7]	100	58[7]	190[7]
Mew Gull (*L. canus*)	X*	L	—	—	—	—	—	—	—
Bonaparte's Gull (*L. philadelphia*)	X		0	17	0	0	29	*	3

[1] Species I observed indicated by (X) and species observed by Munro and Clemens (1931), Outram (1958), Einarsen (1965), Hardwick (1973) indicated by an asterisk.
[2] Asterisk indicates an average greater than zero but less than one bird/group.
[3] Greater and Lesser scaup.
[4] Black, White-winged, and Surf scoters.
[5] White-winged and Surf scoters.
[6] Glaucous-winged, Western, and Glaucous-winged × Western gull hybrids.
[7] Ring-billed and Mew gulls.
[8] Composition was determined for all groups but abundance was not.
[9] Composition and abundance were determined for every group.

being significantly more successful against scaups than against Canvasbacks or scoters ($P < .05$). Small gulls also stole eggs from scoters and were successful in 47% of their attempts (n = 32); this proportion of successes was not significantly different ($P >$ .10) than that achieved by the large gulls.

SITE-SPECIFIC FORAGING TECHNIQUES

At site 1, birds fed in the water on herring eggs either by piracy or by diving, when tidal elevations were above +0.7 m. Below +0.7 m, Black Brant, American Wigeon, European Wigeon, and coots fed on egg-covered macrophyton while tipping up, walking, or wading. During tides below +0.4 m, gulls either remained in deep water where they obtained eggs by piracy or they fed directly on eggs along the shoreline, accompanied by crows (*Corvus* sp.).

At sites 2–4, birds obtained eggs by piracy or by diving when tides were above +1.3 m; at levels below +1.3 m (which occurred every low tide) gulls fed on eggs while walking or swimming at all these sites. Gulls chased intruders away by running or swimming toward them with outstretched wings; intruders such as coots or wigeon responded by moving to areas where gulls were absent. At site 5, birds were unable to

TABLE 2. Proportion of successful tip-ups (Black Brant only) or successful dives in which a bird was harassed by large gulls, and the proportion of piracy attempts in which a large gull obtained food.

	Gull harassment		Gull piracy success	
	Successful dives or tip-ups n	Piracy attempts (%)	Piracy attempts[1] n	Obtains food (%)
Black Brant	52	0	—	—
Canvasback	17	59	108	39
Scaups[2]	41	15	32	72
Bufflehead	29	17	36	56
Scoters[3]	45	33	30	43

[1] Includes gull piracy attempts from column to left as well as observations of gull piracy attempts for which the proportion of piracy attempts of successful dives was not determined.
[2] Greater and Lesser scaups.
[3] White-winged and Surf scoters.

feed on eggs while wading or walking because low tides were above +0.35 m and eggs were below +0.3 m.

GROUP COMPOSITION

I noted 30 species at sites of herring spawn, but not all of them fed on herring eggs (Table 1). Some normally piscivorous birds (e.g., loons, grebes, cormorants, and mergansers) probably were accidental to groups. I determined group composition at site 1 for birds swimming, diving, or tipping up in water, but not for birds wading or walking and picking up eggs or egg-covered macrophyton. At all other sites, species composition was determined for all birds, no matter how they obtained eggs.

Site 1. Twenty-seven species were seen (Table 1) with a mean of 13.9 species/group (range 10–19, n = 17 groups). I did not count all birds in all 17 groups (Table 1), but in seven groups, I found an average of 1,195 birds/group (range 462–2,072).

Site 2. Eleven species (Western Grebe, Horned Grebe, Harlequin Duck, Oldsquaw, Black Scoter, White-winged Scoter, Surf Scoter, Western Gull, Glaucous-winged Gull, Ring-billed Gull, and Mew Gull) were seen. Group sizes were not determined, but at times I counted as many as 643 gulls and 1,112 scoters.

Sites 3 and 4. Ten species (American Wigeon, Common Goldeneye, Black Scoter, White-winged Scoter, Surf Scoter, American Coot, Western Gull, Glaucous-winged Gull, Ring-billed Gull, and Mew Gull) were observed at both sites. Groups were frequently disturbed, but when groups were present at site 3, average group size was 179 (range 20–393, n = 10 groups). Most birds at both sites were gulls, which were as abundant as 387 birds/group.

Site 5. Twenty species were observed

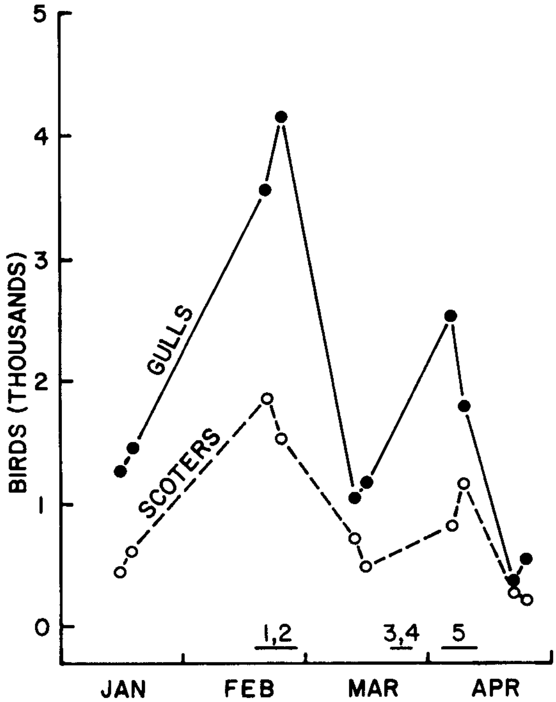

FIGURE 2. Abundance of gulls and scoters in the lower Yaquina estuary from 15 January to 23 April 1979 prior to, during, and after the presence of birds feeding on herring eggs at sites 1 and 2, 3 and 4, and then at site 5. Duration of bird groups at sites is designated by horizontal bars.

(Table 1), and the average number of species/group was 12.1 (range 8–15, n = 14 groups). Group size averaged 957 birds (range 309–1,298; n = 14 groups).

SEASONAL BIRD ABUNDANCES

Gulls and scoters. Over three times as many gulls and just over twice as many scoters were observed when bird groups were present at sites 1 and 2 than before or after this period (Fig. 2). This increase was not simply seasonal because the number of gulls and scoters during the same period did not change at the Alsea estuary, 13 km south of the Yaquina (unpubl. data). When groups were at site 5, the total number of gulls and scoters censused in the estuary also increased.

Gull populations in the estuary did not feed on herring eggs simultaneously. I observed at most 912 gulls feeding together at sites 1 and 2, but as many as 4,262 gulls were censused in the estuary at this time (Fig. 2). Again, at most 572 gulls were observed at site 5, but 2,552 gulls were then censused in the estuary (Fig. 2).

After herring had spawned, the majority of scoters in the estuary were in groups feeding on herring eggs. Groups at sites 1 and 2 included as many as 1,550 scoters, while I was censusing only 1,877 scoters in the entire estuary (Fig. 2). I saw as many as 798 scoters in feeding groups at site 5 (Table 1), and censused a maximum 1,191 scoters in the lower estuary at the same time (Fig. 2).

Other species. Several bird species became much less abundant between December and April (Table 3). No species appeared to increase in abundance during this time (pers. observ.). No species restricted itself to groups at sites of herring spawn. On 17 February I censused 384 coots in the estuary, but no more than 39 were in a group (Table 1); at site 5 no coots were observed (Table 1), but 199 were censused then (on 6 April) in the estuary. A maximum of only 11% of the Buffleheads (n = 262) and 45% of the scaups (n = 176) in the lower estuary were observed in groups during this period when birds were feeding at site 2.

DISCUSSION

Herring eggs constitute a seasonal, infrequently available, but abundant food supply for many bird species (Munro and Clemens 1931, Munro 1941, Outram 1958, Taylor 1964, Hardwick 1973, this study). Yocum and Keller (1961) did not find herring eggs in the stomachs of any aquatic birds at Humboldt Bay, California. However, their collections were infrequent. Because herring eggs are ephemerally available (7–10 days/spawning site, this study), their importance in the diet of aquatic birds would be missed unless birds were collected during the brief spawning period. As herring eggs are plentiful when they are available (Hardwick 1973) and can be consumed by thousands of birds at a site, they may be an important food allowing fat accumulation prior to or during migration.

GROUP COMPOSITION

Group composition differed among sites for several reasons. Seasonal increases in gulls and scoters probably resulted from immigrations into the estuary in response to availability of herring eggs. Human interference at sites 3 and 4 prevented large groups from assembling. Fewer herbivorous or diving waterfowl were present at site 5 than at site 1 (Table 1). This resulted in part from site location, because during winter and spring waterfowl were much more diverse and numerous at the embayment adjacent to site 1 than at sites 2 or 5 (Fig. 1).

TABLE 3. Numbers of birds censused in the lower Yaquina estuary.

	15 Dec. 1978	6 April 1979
American Wigeon	>100	2
Canvasback	1,579	2
Scaups[1]	561	176
Common Goldeneye	30	0
Bufflehead	1,092	262
Ruddy Duck	225	6
American Coot	400	199

[1] Greater and Lesser scaups.

The abundance and diversity of many waterfowl decreased between winter and spring (Table 3), probably due to spring emigration. The small numbers or absence of American Wigeons, Canvasbacks, Common Goldeneyes, Buffleheads, and coots in groups at site 5 compared to site 1 (Table 1) might have resulted in part from migration of many waterfowl by the time herring had spawned there (early April).

The location of herring spawn apparently affected group composition by making the eggs more or less accessible to gulls. Where eggs were deposited higher in the intertidal zone (sites 2–4) gulls could take them without having to rob. At these sites, gulls also could physically dominate the area of egg deposition so that other birds were less able to obtain eggs. Where eggs were deposited lower in the intertidal zone (i.e., below about +0.4 m, sites 1 and 5) species diversity was greater because birds other than gulls were able to obtain eggs with less harassment from gulls.

IMPACT OF PREDATION

Birds have been implicated as the chief predators on herring eggs, as a result of experiments in which nets excluded birds from spawn (Outram 1958, Taylor 1964, Steinfeld 1972). However, Ichinose (*in* Hardwick 1973) also observed fish and crabs feeding on herring eggs. Since netting would exclude these animals as well as birds, birds may not be the most important predators on the eggs.

Avian predation on herring eggs also affects the macrophyton that serves as their substrate. Coots, surface-feeding ducks, brant, and some diving ducks, such as Canvasbacks and Ruddy Ducks, feed largely on plant material (Yocum and Keller 1961, Palmer 1976, Johnsgard 1975). Although scoters and gulls are commonly considered to feed mainly on animal material (Yocum and Keller 1961, Johnsgard 1975, Palmer 1976), they also can heavily graze plants covered with herring eggs (Munro and Clemens 1931, this study). Although gulls may not digest the macrophyton associated with the eggs (Munro and Clemens 1931), the grazing of macrophyton by birds feeding on herring eggs may be a previously unrecognized factor in the patchiness and zonation of eelgrass (Bayer, in press) or algae at the Yaquina estuary and elsewhere.

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