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Biology and migration of Eared Grebes at the Salton Sea

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Abstract

The Eared Grebe (*Podiceps nigricollis* Brehm) is the North American bird species most closely associated with highly saline habitats, and in winter and early spring it is the most abundant waterbird at the Salton Sea. During the fall, the great majority of the North American population stages at hypersaline lakes in the Great Basin, departing in early winter for wintering areas in southern California and Mexico, principally in the central Gulf of California. On the northward return flight, nearly all the population passes through the Salton Sea, where concentrations of >1 million have been reported in February–March. After staging for several weeks, grebes leave in March–April and migrate toward breeding grounds in the northern United States and southern Canada. The Sea's development as the species' major spring staging area may be as recent as the 1960s, and presumably awaited the establishment of appropriate prey populations of marine worms. In the past decades, two major dieoffs at the Sea each resulted in the undiagnosed death of tens of thousands of birds. Whether the cause(s) are endemic to the Sea or involve the grebes' migration routes and stopover locations is unknown. Because of problems in estimating numbers, the significance of these mortality events is hard to evaluate. Population trends are better studied at fall staging areas, especially Mono Lake, where population turnover is inconsequential, grebes are virtually the only species present, and numbers can be ascertained by aerial photography.

Introduction

Despite its location in the hottest desert in the southwest, the Salton Sink for thousands of years has intermittently held significant bodies of water (Waters, 1981; Cohen et al., 1999; Patten et al., MS). In 1905–1907, 400 years after the drying of Lake Cahuilla, the overnight creation of a major freshwater lake to be known as the Salton Sea created habitats that were immediately discovered and exploited by waterbirds (Grinnell, 1908; van Rossem, 1911). High evaporation rates and low water influx quickly led to its increased salinization. The ecological changes that followed permitted the introduction/establishment of marine invertebrates and fish (Walker, 1961) that became the base for the food chain of an increasingly diverse avifauna, including species that prefer marine habitats. The attractiveness of the Salton Sink area was further enhanced by burgeoning commercial agriculture, the creation and management of extensive wetlands at the Salton Sea National Wildlife Refuge area (established 1930; renamed Sonny Bono Salton Sea National Wildlife Refuge in 1998) and, in the past decade or so, the establishment of a major aquaculture (catfish farming) industry, with its associated ponds that also supply food for fish-eating birds. By the 1960s, at the latest, the Sea had become an internationally recognized concentration point for well over 100 species of migrating and breeding waterbirds, dominated by grebes, waterfowl, gulls, shorebirds, and herons (McCaskie, 1970).

Currently, the Salton Sea is highly saline ($\approx$43 g l^{-1}), and the Eared Grebe is the most prominent waterbird in winter and spring. Although this grebe breeds in freshwater lakes and marshes through the western United States and southern Canada, for most of the year it is the North American bird species most closely tied to highly saline habitats, where it feeds mainly on small invertebrates. Starting in late July, most of the population leaves the breeding areas and migrates directly to Mono Lake, California, and Great Salt Lake, Utah, to exploit the abundant brine shrimp (*Artemia* spp.) and alkali flies *(Ephedra* spp.). Grebes remain there until food resources are depleted, and then (usually November–December) make a non-stop flight across the deserts of southern Utah and California to wintering areas in Southern California and Mexico (Jehl, 1988, 1993; Jehl et al., 1999). Several tens of thousands move directly to the Salton Sea, and presumably remain there through the winter, but the great majority evidently bypass the area in favor of the mid-Gulf of California, where winter concentrations of hundreds of thousands have been reported persistently (R. Schreiber, S. Wilbur, D . Anderson, N. Roberts, pers. comm.; Jehl, 1988 and unpubl.). In fact, there seems to be little alternative to the Gulf's preeminence as a wintering site. Jehl (1988) was unable to find any evidence that substantial numbers currently wintered either in mainland Mexico or along the Pacific coast of Baja California, and there is no further information to the contrary. The population at the only other significant wintering location in Baja California – the salinas at Guerrero Negro (6000–9000, peak 13 790 in February–March; Carmona & Danemann, 1998) – is trivial compared to that in the Gulf.

In spring, wintering grebes reverse course and in late January–March congregate in large numbers (often >1million) at the Salton Sea (Fig. 1). They stage there for several weeks or longer and then depart in March–April, arriving at breeding areas in the northern United States and southern Canada in April–May (Jehl, 1988, 1993, 1997; Jehl et al., 1999; Cullen et al., 1999).

Despite its short history, the Salton Sea is probably the largest concentration point for Eared Grebes in North America and, indeed, the world, and on Christmas Bird Counts, the Sea routinely holds more Eared Grebes than are recorded over the entire rest of the censused winter range (Jehl, 1988 and unpubl.). The Sea's propensity to attract and concentrate migrants makes it potentially hazardous, as in recent years the Sea has experienced irregular and unexplained dieoffs of thousands of grebes (Jehl, 1996) and other waterbirds.

In this paper, we summarize information on the history and biology of the Eared Grebe at the Salton Sea and interpret it in light of extensive studies elsewhere in the western United States in the past two decades (e.g. Jehl, 1988; Cullen et al., 1999 and references therein).

Methods

Original data in this paper are mainly based on McKernan's >2 decades of studying bird life at the Salton Sea, and Jehl's winter/spring studies of Eared Grebes at the Sea since the mid-1980s. Jehl's work was designed to supplement information gathered at Mono Lake (1981–present) and other inland lakes on a broad range of studies concerning grebe natural history, physiology, migration, and mortality in the nonbreeding season.

A major goal of our studies was to document the number and schedule of grebes at the Sea. We used several methods to assess population size. Shore-based observations along the entire periphery of the Sea provide an overview of distributional patterns, and because grebes tend to be concentrated near shore in most seasons they can provide an index to population size. Although some proportion of birds in mid-Sea will be undetectable, omissions are unlikely to be important, except in spring, when large numbers assemble well offshore in preparation for migration.

To further study migration phenology and population size, McKernan conducted aerial surveys of the entire Sea, which were designed to encompass most of the fall , winter, and spring migration periods. Conducted intermittently, these surveys span the period 1982–83 to the fall of 1999, but are most complete for the 1990s. On each survey, data were gathered by two observers, usually from a Cessna 172 airplane flying at speeds of 55–65 mph and 100–200 m above the Sea. Although the Sea is large (roughly 56 × 16 km), it is also narrow, so that the majority of the surface can be scrutinized using three transect routes: (1) counterclockwise around the entire perimeter, starting at the north end, with the plane maintaining 1–2 km from shore; (2) north to south along the middle of the Sea, from the Whitewater River Delta to the mouth of the New River; and (3) south–north transect starting 3 km west of the New River ending 3 km west of the Whitewater River Delta. As needed, depending on the distribution and clumping patterns of migrants, surveys might be expanded to include replicate samples or supplement coverage. Flights were made at an altitude that was low enough to detect birds. Although these flights also elicited some diving behavior, it was largely restricted to birds seen directly under the flight path and did not contribute significantly to undercounting (Boyd & Jehl, 1998). On several occasions when grebes were concentrated offshore, McKernan used a small boat to access flocks and obtain an addi-

Figure 1. Huge numbers of Eared Grebes at the Salton Sea, February 1992.

tional estimate. In addition, we have each made dozens of trips to the Sea in November–April for various grebe-related studies.

Estimating numbers in flocks that may comprise thousands of birds is a major problem (Jehl, 1999). We think that our counts, including any errors resulting form diving birds, are probably accurate to within 30% when the population was small ($<$500 000) and dispersed, but could be greater during population highs and when birds were clumped. Although our independent estimates of flock size were similar, we had no ways of confirming accuracy. Aerial photography has been successful elsewhere (Boyd & Jehl, 1998), but is impractical at the Sea because images made from the required altitudes would not allow grebes to be differentiated from other waterbirds, especially Ruddy Ducks [*Oxyura jamaicensis* (Gmelin)]. However, because McKernan directed and took part in all the flights, we consider the data to be internally consistent and sufficiently accurate to show major trends.

We obtained data on the numbers of birds observed on Christmas Bird Counts from *Audubon Field Notes* (and its reincarnations *American Birds, Field Notes*), which should be consulted for precise locations. We used standard behavioral observations to study foraging. We obtained data on food habits from direct examination of the stomach contents of 40 grebes collected in conjunction with migration and disease studies, and of perhaps 100 more found freshly dead. While dead birds are usually of little value, the feather bolus in the gizzard of grebes entraps indigestible items and provides data on some kinds of prey that may have been taken days earlier.

We monitored Mono Lake to determine when grebes were leaving (Jehl, 1988 and unpubl.), and compared numbers and schedules of departing birds with arrival data from the Salton Sea. In 1982 and 1987–92, the Utah Division of Wildlife Resources carried out similar studies at Great Salt Lake (D. Paul, pers. comm.).

Results

A brief history

The Salton Sea was created in 1905–1907 and the Eared Grebe was one of the first species to be noted.

Joseph Grinnell (1908) saw several hundred that he considered transients (his description of small flocks is typical of birds in passage) on a "voyage" in mid-April 1908. Shortly thereafter, A. J. van Rossem (1911) spent eight weeks collecting around the Sea (1 December 1910–1 January 1911, 18–31 March 1911), which he thought was "rapidly drying up". Typical of collectors in that era, van Rossem was primarily interested in geographic variation in landbirds. Although he did visit the Sea itself, his sole mention of Eared Grebes was of "several individuals and sometimes small flocks from three to seven frequently seen..." in late March. Because March–April is the peak of spring migration, both Grinnell's and van Rosssem's findings indicate that grebes had no great affinity for the Sea in its early years. Neither Bent (1919) nor Dawson (1923) mention grebes there, and Grinnell & Miller's (1944) only mention was in passing and to establish this as a low altitude locality (−250 feet below sea level). By the late 1960s, however, McCaskie (1970) reported that Eared Grebes were "very abundant throughout the year". Subsequent authors (e.g. Small, 1974; Cogswell, 1977; Garrett & Dunn, 1981) also noted the species' general abundance, though almost casually and with little authority. But that is hardly surprising, as so little was known about biology in the nonbreeding season before the early 1980s, when studies were initiated at fall staging areas (e.g. Winkler & Cooper, 1986; Jehl, 1988).

Christmas Bird Counts

Evidence on when significant numbers of grebes began to use the Sea must be inferred from Christmas Bird Counts, which were started at the north end of the Sea in 1929 and at south end in 1940 (Fig. 2). That record is incomplete and difficult to evaluate because census localities were inconsistent prior to 1970, errors in estimating large numbers of birds are inevitable and, most importantly, phenology of migration is not constant; in some years grebes are still at staging areas at count time, whereas in others they left the lakes weeks earlier (Table 1), in which case they could have stayed at the Sea or continued south into Mexico. Nevertheless, those data and McCaskie's observations (1970) suggest that the large (>10 000) wintering populations became established in the 1960s. Why did this buildup occur so slowly, if the Sea had attained ocean salinity as early as 1920 (Fig. 2)? The most likely explanation is that its attraction for grebes awaited the development of appropriate food resources. This presumably occurred subsequent to 1935, when pile worms (*Neanthes succinea*, Frey and Leukart), the grebes' major current prey (see below), were first reported (evidently introduced in 1930; Carpelan & Linsley, 1961).

Population size, phenology of migration at the Salton Sea

When grebes leave staging lakes in fall, they make an overnight flight to the Salton Sea or Gulf of California (Jehl, 1988, 1993, 1997, 1999). Emigration takes place after food becomes too scarce to permit profitable foraging, and has occurred as early as late October or as late as early February (e.g. Jehl, 1988 and unpubl.; Table 1). In most years the number of potential emigrants from Mono Lake is probably 1–1.5 million (Boyd & Jehl, 1998; J. Jehl, S. Boyd, D. Paul & D. Anderson, unpubl.), and similar numbers are expected at Great Salt Lake (Jehl et al., 1999). Censuses at the Sea shortly after major departures from staging lakes have consistently failed to encounter anywhere near the number of potential immigrants that would be expected. For example (Table 1): in 1986 at least 745 000 grebes (and probably many more) left Mono Lake by the first days of November; on 11 November land-based observations around the entire Sea, conducted under ideal conditions, indicated that there were no more than 60 000 present. In 1999, over 2.5 million birds had left Mono Lake and Great Salt Lake by 8–10 December; a flight over the Sea on 17 December encountered 275 000. The only reasonable conclusion is that most southbound migrants bypass the Sea in favor of other wintering areas farther south (Jehl, 1988).

This is further indicated by aerial census data that establish general patterns of abundance. Thus (Fig. 3), numbers are trivial (usually <1000) until November–December, when grebes begin to leave staging areas. Late December counts average around 100 000, which is in accord with general Christmas Count estimates, once allowance is made for differences in the size of the areas surveyed. The population then increases quickly, and by February–March upwards of 1 million might be present. This influx must be from Mexico, as there is no other source for migrants at that season. Numbers subsequently drop off rapidly as the migrants move northward, with emigration from the Sea corresponding to the arrival of spring migrants at Great Salt Lake and the interior of the Great Basin (D. Paul, pers. comm.). By mid-April, nearly all migrants are gone. Lingering birds (a few of which summer) are rarely

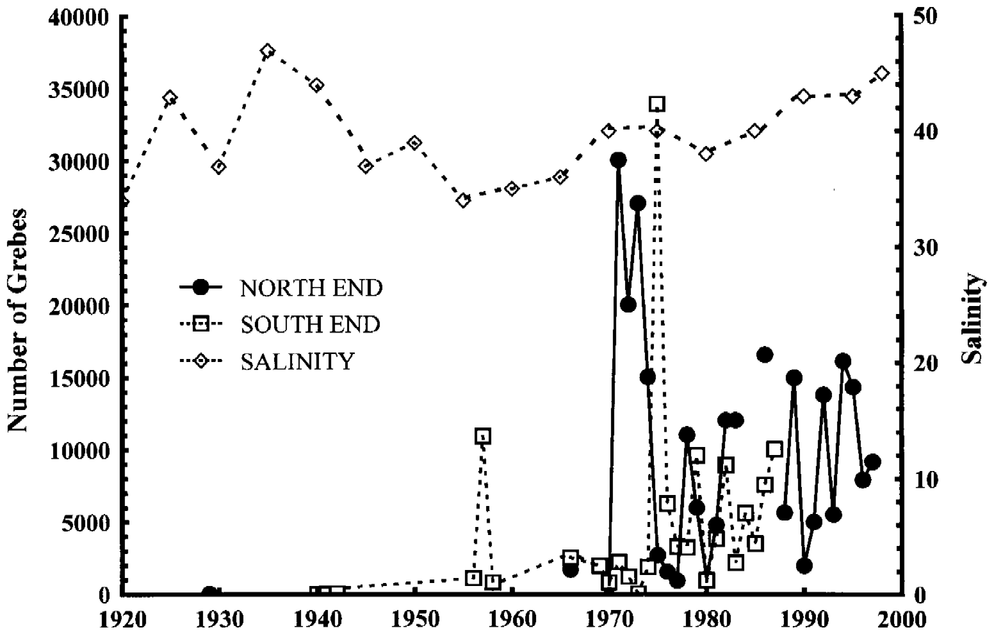

Figure 2. Salinity and Christmas Count data for Eared Grebes at the Salton Sea.

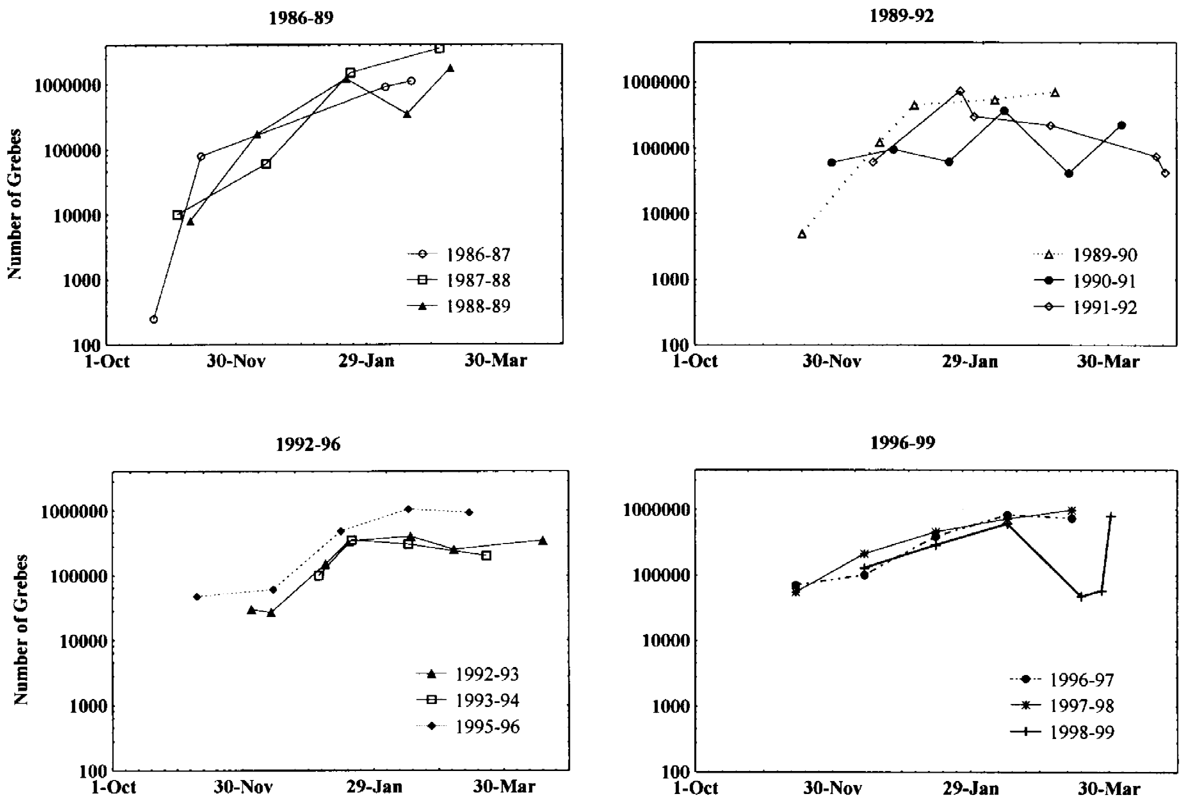

Figure 3. Aerial survey estimates of Eared Grebes at the Salton Sea.

Table 1. Estimates (in 1000s) of Eared Grebes at the Salton Sea based on aerial surveys. The dark bar indicates the departure periods of birds staging at Mono Lake, CA

Year	1982–83	1983–84	1986–87	1987–88	1988–89	1989–90	1990–91	1991–92	1992–93	1993–94	1995–96	1996–97	1997–98	1998–99	1999–00
Month															
Oct			(24)[a] 0.25												
			——									——	——		
Nov			(15) 80	(20) 10	(12) 8	(18) 5					(10) 47.3	(20) 71.1	(28) 55		(19) 173
					——		1 (60)		(5) 20–40		——		——	——	——
Dec	250	310		(15) 60	(10) 175	(22) 125	(28) 96	(19) 61	(14) 27	——	(14) 61	(10) 100	(27) 212	(15) 128	(17) 322
								——	——						
									(8) 100–200	(5) 100 (16–					
Jan	755	660		(23) 1500	(21) 1200	(6) 450	(21) 62	(26) 740	(19) 338	20) 300–400	(22) 479	(28) 389	(19) 458	(24) 290	
				——		——	——								
Feb			(8) 900		(18) 325	(10) 550	(14) 375	(1) 305	(16) 400	(15) 300	(27) 1050	(22) 829	(25) 721	(10 611	
									(8) 250					(19) 47.5	
Mar			(20) 1100	(5) 3500	(11) 1750	(8) 715	(14) 41.5	(6) 175–250	(18) 346	(23) 200	(15) 920	(10) 740	(14) 984	(28) 58.4	
								(21) <80							
Apr							(6) 229	(25) 42						(1) >800[b]	

[a] Actual dates in parentheses.
[b] Shore based observation at northend only (JRJ).

in breeding plumage and are probably first-year birds or nonbreeders, which begin to arrive at Mono Lake in April–May and remain through the following fall (Jehl, 1988 and unpubl.).

In some years, however, we have observed different patterns, which are probably real because population estimates from successive censuses are too different to result solely from counting errors. We can only guess at their causes. In 1988–89 for example, the population dropped from an estimated 1.2 million in January to 325 000 in February, the decline coinciding with a large dieoff. It then rebounded to 1.75 million in March. (No similar pattern was detected in the 1991–92 die-off.) In 1990–91, the population dropped by more than half between February and March, then increased in April. A similar pattern appeared in 1998-99, when February numbers of 611 000 dropped to about 50 000 in March, then increased to >800 000 in early April. These examples probably signal turnover and the northward departure of some birds in early March, to be replaced later in the month or early April by arrivals from the Gulf.

Food and foraging

Eared Grebes feed on a variety of prey but specialize on invertebrates, which they may probe or glean from the substrate or capture as free-swimming prey in the water column (Jehl, 1988; Cullen et al., 1999). No exhaustive studies of food habits at the Sea have been conducted. Nevertheless, stomach contents obtained incidental to other work and bolstered by behavioral and distributional information (below) show that from January to April, pile worms (*Neanthes succinea*) comprise >95% of the diet, the remainder being small amphipods and fish, or occasionally corixids (for birds feeding in lagoonal situations). Stomach analyses are inherently skewed in favor of indigestible matter, and bias is extreme in grebes because the feather bolus in their gizzard entraps and retains hard parts. Even so, the importance of pile worms can hardly be exaggerated. These worms occur in tremendous numbers (Carpelan & Lindsey, 1961, Detwiler et al., 2002) and gizzards from the Sea are invariably packed with hundreds or thousands of worm "teeth". Only rarely does one encounter fresh tissue of any kind anywhere the digestive tract.

The distribution of grebes on the Sea strongly parallels that of the pile worms. That is, they occur mostly in relatively shallow areas within 1 km (200–300 m) of the beach where the substrate consists of organic mud or, along the shoreline, algae-covered rocks (Detwiler et al., 2002; D. Dexter, pers. comm; pers. obs.). The turbidity of the water makes it impossible to observe how grebes catch food, and in some areas must restrict their ability to hunt visually. Although they dive and presumably, as elsewhere, obtain most of their food during the day, some diving and surface-feeding also takes place after dark (JJ), at least in some seasons. We infer that nocturnal feeding is associated with worms becoming available in the water column, when they leave the mud or rock substrates to reproduce (D. Dexter, pers. comm.). Nocturnal feeding is interesting because it has not been observed at the fall staging lakes (Winkler & Cooper, 1986; Jehl, 1988; Cullen et al., 1999). In periods of apparent food scarcity, we have also seen grebes tipping up like dabbling ducks and probing into the mud like sandpipers.

Any grebes foraging well offshore are probably taking free-swimming prey, because worms are absent from the anoxic muds in the deep water zones. In some oceanic environments, Eared Grebes may engage in group foraging, presumably for free-swimming or schooling prey (Cullen et al., 1999). The fact that we have never seen this behavior at the Salton Sea is further suggestive of their reliance on pile worms.

Behavior

During their sojourn at the Sea, grebes do little but swim, dive, preen, sleep, and increase their body mass by about 100 g (ca. 30%) to accumulate the fat needed for the next phase of the migration. Except for those that have just arrived or are about to leave, they do not fly. In fact, adjustments in body composition in the staging or non-migratory periods make them incapable of flight for several weeks or more (Jehl, 1997).

As the time for northward departure nears, hordes of grebes tend to accumulate along the north shore of the Sea, at the same time that huge flocks form offshore. The groups appear to be on quite different schedules and in different physiological condition. The former dive and feed actively, whereas the latter are quiescent and probably have stopped feeding and are preparing to leave (Jehl, 1997). The preparation involves further changes in body composition, including rebuilding of flight muscles that have been allowed to atrophy. It is signaled by wing-flapping exercises, and birds (often in small groups) racing across the surface in short practice flights are conspicuous in the March emigration period (Fig. 4).

Figure 4. Eared Grebes engaging in practice flights before departing Salton Sea in March.

Mortality

In some years, the fall population of Eared Grebes in North America has reached nearly 4 million birds (Boyd & Jehl, 1998; unpubl.). Considering that there are several estimates of 1–3 million at the Sea in spring – and those figures do not include migrants that had already passed through or had yet to arrive it follows that nearly all of the North American population passes through at that season.

Recent dieoffs of grebes and other waterbirds at the Sea have elicited much attention. One in January–March 1992 was estimated by the U.S. Fish and Wildlife Service to have involved an estimated 150 000 grebes; another perhaps of similar magnitude occurred in January–March 1989 (Jehl, 1996). While these dieoffs are unlikely to have had significant consequences for the population (they would have involved 3–5% of the North American population), they are worrisome because so many grebes pass through, and because most deaths remain undiagnosed, despite much study. The prevailing assumption is that the problem is endemic to the Sea. Perhaps so, but in view of the species' ability to fly hundreds of miles overnight, the possibility that disease (if that is the cause) could be imported cannot yet be excluded. "Caught there, or brought there," that is the question. And to resolve it requires detailed knowledge of basic natural history, and especially migration routes, timing, and stopover points discussed above.

Population studies

Appraising the population status of birds that congregate at restricted habitats for long periods of time would seem to be relatively easy (but see Jehl, 1999), and the Salton Sea would seem to be the prime site for surveying Eared Grebes, because so large a fraction of the population occurs there. In practice, however, there are many difficulties, the most important being our inability to count tens to hundreds of thousands of birds with measurable precision. At the Sea this is not possible either from shore-based or aerial estimates surveys (can anyone really tell the difference between, say, 400 000 and 600 000 birds?) or, as noted above, by using aerial photography. A second challenge is that the spring movement is protracted, and the rate of turnover is unknown (and probably unknowable). It is even possible that in some years birds may be moving south while others are moving north. Finally, migration schedules vary from year to year. Lacking information about the size and departure times of populations staging at Mono Lake, Great Salt Lake, and the Gulf of California, it would be impossible to determine the significance of the numbers at the Sea, and that would be true even if precise counts were forthcoming. It follows that current procedures – whether based on Christmas Counts or other surveys – are not useful for addressing year-to-year trends. If understanding trends in the North American population is the goal, efforts should be directed to Mono Lake in mid-late October, where the entire lake surface can be surveyed in few hours and photocensusing techniques can be applied. Because Eared Grebes make up >98% of the avifauna at that season, the population size can be determined with good accuracy (Boyd & Jehl, 1998). A further advantage is that the phenology of fall migration appears to be consistent (Jehl, 1988; Jehl & Johansson, 2002); because staging birds remain into late fall problems of turnover are insignificant. Accordingly, precise data can be generated from data gathered at the same time in different years (Boyd & Jehl, 1998; Jehl & Johansson, 2002), and this will allow for annual comparisons and trend analyses.

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