NEW WORLD SECTION

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COPPER RIVER DELTA/ORCA INLET FACILITIES

Goose Cove Lodge on Orca Inlet, adjacent to the Copper River Delta, Alaska, was opened this spring. A large fraction of the estimated 20 million shorebirds that use the area in the spring can be observed and studied on the flats immediately in front of the lodge. Goose Cove Lodge is owned and operated by Pete and Belle Mickelson. Pete has been studying Alaskan geese for over 15 years, and Belle is active in Alaskan environmental education. A full program is available for birdwatchers and other vacationers. Special arrangements may be available for researchers wishing to work in the area. For particulars contact: *Pete and Belle Mickelson, Alaska Wild Wings, Dept. WSG, Box 325, Cordova, AK 99574, U.S.A.*

AGE AND SEX COMPOSITION OF WINTERING DUNLIN POPULATIONS IN WESTERN WASHINGTON

by J.R. Buchanan, L.A. Brennan, C.T. Schick , S.G. Herman and T.M. Johnson

INTRODUCTION

Published accounts of the age and sex structure of wintering Dunlin *Calidris alpina* populations in North America have been reported only from the central coast of California (Holmes 1966, Page 1974). Results from these studies suggest that age-ratios and sex-ratios of wintering Dunlin populations are variable. At Bolinas Lagoon, California, Page (1974) found that females were less common in winter than males. In the same study, the age structure of the Bolinas population shifted during the course of the winter from an abundance of immature birds to a roughly equal proportion of adults and immatures. These findings led Page to speculate that the geographic distribution of wintering Dunlins was in some way organized according to age and sex. In this note we present data from various sources and years concerning the age and sex composition of several wintering Dunlin populations in western Washington, and speculate about possible causes for the observed patterns.

METHODS

During the 1980-81 winter we collected a total of 226 Dunlins from four estuaries in western Washington (Figure 1) as part of an organochlorine contamination study (Schick *et al.* in prep.). Dunlins were collected at each site in both early and late winter. This sample will be referred to below as Set I. For each bird in Set I we recorded sex from gonadal inspection, and age class by primary feather wear and the presence in immatures of chestnut/buff colouration at the distal edge of the innermost tertial feathers (Prater *et al.* 1977).

A discriminant function model developed from the 1980-81 sampling (Brennan *et al.* 1984) was used to predict the sex of Dunlins netted at one study site (Nisqually) during the winters of 1979, 1981, 1982, and 1983. Dunlins netted at Nisqually during the 1976 and 1977 winters were sexed using bill-length only, assuming that birds with bill-lengths <37.7 mm were males, while those >39.8 mm were females (Page 1974). Birds which fell between these limits were excluded from the sample.

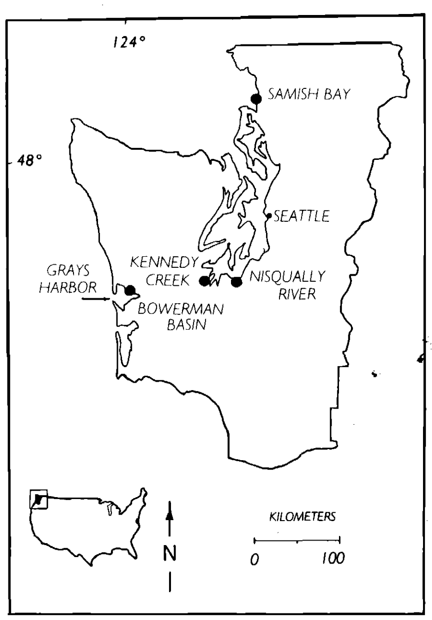

Figure 1. Geographic locations of the four study areas in western Washington state.

Additional specimens were obtained from law enforcement personnel who had retained them for evidence after the birds had been shot illegally, and from other collections made by the authors for organochlorine analysis. These additional samples were not obtained on a regular schedule and are analyzed as Set II. Study sites are described in Brennan *et al.* (1985).

RESULTS

Age-ratios

In Set I, adults outnumbered juveniles at three of the four sites and were more numerous than juveniles overall (Table 1). Age ratios changed little at three of four sites during the course of winter, but the percentage of juveniles at Bowerman decreased greatly between early and late winter (Table 1).

Set II samples had varying proportions of adults and immatures. Of 214 Dunlins netted at Nisqually (November-March 1976-83), only 21% were immature (Table 2). In contrast, Dunlin samples collected by shotgun at Nisqually and other sites had higher proportions of immatures.

We also investigated the proportions of adults and immatures within each sex class. The proportions of immatures present in each sex-class were very similar (Table 4), although immature males were more abundant than immature females overall in the total sample (see Tables 2, 3 and 4).

Sex-ratios

Sex ratios showed very little change at three of the four sites over the 1980-81 winter, but at Kennedy the percentage of females decreased from 68% in early winter to 35% in late winter (Table 5). Within Set I, males did not outnumber females significantly, although there was a slight bias towards males (Table 5).

Three collections (from Set II) exhibited nearly equal sex composition: Nisqually in November-December 1973 and 1974 (combined), Padilla in November 1978 and Kennedy in December 1979 (Table 3). One additional collection was skewed significantly in favour

Table 1. Dunlin age ratios at four sites in western Washington during 1980-81.

	Collection Date								
	Nov.-Dec. 1980[a]			March 1981[b]			Both Collections		
Location	Adult	Immature	% Imm.	Adult	Immature	% Imm.	Adult	Immature	% Imm.
Bowerman	7	18	72	31	1	3	38	19	3
Kennedy	26	2	7	24	2	8	50	4	7
Nisqually	21	5	19	35	7	17	56	12	18
Samish	14	11	44	12	10	46	26	21	45
ALL SITES	68	36	35	102	20	16	170	56	25

[a]Nov.-Dec. collection dates for each site are as follows: Bowerman (9 Nov.), Kennedy (9 Dec.), Nisqually (10 Dec.), Samish (13-14 Dec.).
[b]March collection dates for each site are as follows: Bowerman (12 Mar.), Kennedy (9,11 Mar.), Nisqually (10 Mar.), Samish (15 Mar.).

Table 2. Age and sex[a] of Dunlins netted at Nisqually Nov.-Mar. 1976-83.

	Females		Males			
Date	Adult	Immature	Adult	Immature	% Imm.	% Female
Feb.1976	13	8	23	12	36	38
Mar. 1976	3	4	2			
Nov. 1977	17		29	7	13	32
Mar. 1979	3		5			
Jan. 1981	2		3			
Nov. 1981	1	3	1	1		
Jan. 1982		1	1	1		
Mar. 1982	4	1	2	2		
Nov. 1982	15(3)[b]	3	22(2)	2	11	45
Dec. 1982	3(1)	1	17(5)		4	19
Mar. 1983			2(3)			
TOTAL	61	21	107	25	21	38

[a]Sex determination for the 1976-77 sample is based on bill length only (see methods). Sex determination for the 1979-83 sample is based on a discriminant function model (Brennan *et al.* 1984) with posterior probability of correct classification 0.51. Within the sample used in Brennan *et al.* (1984) (n=200), the sex ratio did not change when using posterior probabilities of correct classification ranging from 0.51 to 0.91. Thus we used 0.51 so that the entire sample was used.

[b]Previously netted Dunlins (in parentheses) are included in calculations for monthly ratios only.

Table 3. Additional Dunlin age and sex[a] data from western Washington.

Location	Date	Females Adult	Females Immature	Males Adult	Males Immature	% Imm.	% Female
Nisqually[b]	Nov.-Dec. 1973 & 1974	5	9	12	4	43	47
Bowerman[c]	Nov. 1975	8	1	4	3		
Samish[c]	Jan. 1978			3			
Samish[c]	Mar. 1978	3	1	19	7	27	13
Padilla[b,d]	Nov. 1978	7	9	6	10	59	50
Willapa[b,e]	Nov. 1979		1	1	6		
Kennedy[c]	Dec. 1979	7	3	7	3	30	50
Kennedy[b]	Nov. 1983		1	4	4		
TOTAL		30	25	56	37	42	37

[a]Sex determination based on gonad inspection.
[b]Sample shot illegally by hunters.
[c]Collected under permit for organochlorine study.
[d]1 km west of Samish Bay.
[e]28 km south of Grays Harbor.

Table 4. Age and sex-specific analysis of Dunlin population structure in western Washington.

Sample	Adult No. Females (%)	Immature No. Females (%)	Male No. Immatures (%)	Female No. Immatures (%)
1. Nisqually nettings: 1976-77	33 (38)	12 (39)	19 (26)	12 (27)
2. Nisqually nettings: 1979-83	28 (35)	9 (60)	6 (10)	9 (24)
Combined netted sample	61 (34)	21 (46)	25 (19)	21 (28)
3. Collected: 1980-81	74 (44)	15 (27)	41 (30)	15 (17)
4. Collected 1973-83	30 (35)	25 (40)	37 (40)	25 (46)
Combined Collected sample	104 (41)	40 (34)	78 (34)	40 (28)
All samples	165 (39)	61 (37)	103 (29)	61 (27)

of males: Samish in March 1978 (X^2 = 16.1, df=1, p<0.001). Dunlins netted at Nisqually in December 1982 were also skewed significantly towards males (X^2 = 16.1. df=1, p <0.001) even though the sex ratio had been nearly 1:1 in the previous month (Table 2). Of 148 Dunlins netted at Nisqually during the 1976 and 1977 winters, 73 were males, 45 were females and 30 were unsexed (Table 2). Excluding the unsexed birds, 38% of this sample (n = 118) were females.

When the entire sample was pooled (all collections and netted birds, n=588) the sex-ratio was skewed significantly in favour of males (X^2 = 31.5, df=1, p<0.001) (see Table 4).The overall proportions of each sex within the 2 age-classes were similar (Table 4).

DISCUSSION

Age-ratios

Holmes (1966) assumed an equal age ratio in Dunlin populations wintering in California, but this assumption was based on relative numbers of adults and immatures in museum collections (Page 1974). In a netting study, Page (1974) found immature Dunlins to outnumber adults (83% to 17%) at Bolinas Lagoon, California during fall and early winter (October-December). During the course of the winter, the age ratio of the Bolinas population shifted, and by March-April immatures made up only 55% of the population. A differential capture rate of Dunlins in mist nets was suggested as one

Table 5. Dunlin sex ratios at four sites in western Washington during 1980-81.

	Collection Date												
	Nov.-Dec. 1980				March 1981				Both Collections				
Location	Males	Females	% Female	p[a]	Males	Females	% Female	p	Males	Females	% Female	p	df
Bowerman[b]	16	9	36	0.10	18	13	42	0.25	34	23	40	0.25	1
Kennedy	9	19	68	0.05	17	9	35	0.10	26	28	52	0.90	1
Nisqually	17	10	37	0.10	26	15	37	0.05	43	25	37	0.50	1
Samish	18	7	28	0.025	16	6	27	0.025	34	13	28	0.05	1
ALL SITES	60	45	43	0.25[c]	77	44	36	0.25[c]	137	89	39	0.10[c]	3

[a]Chi-square significance: the probability that the observed sex ratio equals 1:1.
[b]All single collection analyses have df = 1.
[c]Pooled chi-square analysis with expected values based on weighting factors corresponding to the relative population size at each site. See Brennan *et al.* (1985) for population data. All pooled chi-square analyses have df = 3.

probable cause for this apparent shift, although differential mortality rates or movement patterns were not rejected as alternative possibilities. Recently, Kus *et al.* (1984) stated that this change in the age ratio at Bolinas Lagoon was related to differing arrival times for immature and adult Dunlins, late arriving adults balancing the large number of immatures present in fall and early winter, and thus stabilizing the age ratio by mid-winter.

In this study, the higher number of immatures in the early winter collection at Bowerman in 1980 may be attributed to the much earlier collection date there: 9 November as compared to December collections at the other sites (Table 1). The 72% immatures in the November sample at Bowerman compares to only 3% immatures in March at the same site, which is similar to the pattern found by Page (1974) and Kus *et al.* (1984), though much more pronounced. No change occurred in age structure at the other three sites from December to March (Table 1). There are several possible explanations for the change noted at Bowerman. Firstly, high mortality of immature birds may occur in early winter, reducing the proportion in the population by mid-winter; secondly, late arriving adults may balance the high number of immatures in early winter and stabilize the age ratio by mid-winter; and thirdly, some immature Dunlins may have a protracted southward movement during November, so that the age structure in wintering populations is not stable until at least December.

The magnitude of mortality necessary to reduce the large proportion of immatures in the population would be unrealistically high for the first hypothesis to be correct. The second hypothesis, that late-arriving adults stablize the age ratio by December may be unlikely adult Dunlins reach the Wadden Sea earlier than juveniles (van der Have *et al.* 1984). Similarly adults in Alaska and Washington may arrive at wintering grounds ahead of most immatures (Holmes 1966), unless the adults stop to moult further north. This leaves us to support tentatively our third hypothesis, that some immature Dunlins have a protracted southward migration in November. However, netting results from Nisqually in November 1982, however, do not support this claim: only 5 (10%) of 50 Dunlins captured in that sample were immature. All the netting data from Nisqually (combined) shows that only 21% of the birds were immature (Table 2). Consequently, we can speculate further that the protracted southward movement of immature Dunlins is concentrated along the coastline proper (where Bowerman is located), and that large numbers of "drifting" immatures do not follow the migratory route that takes Dunlins through the Puget Sound trough in western Washington where Nisqually and the other two estuaries studied are located (Figure 1). Clearly more data are needed to investigate seriously this possibility.

The similarity in the age-ratios between early and late winter at 3 of 4 sites in western Washington (Table 1) indicates stability in the age structure of these wintering populations. Assuming that local or regional movements are minimal after migration is completed, which appears to be reasonable for this species (Pienkowski and Pienkowski 1983), such a stability in age structure suggests that mortality rates for adults and immatures are nearly identical in western Washington during mid-winter. However, Kus *et al.* (1984) found that at Bolinas Lagoon, California, immature Dunlins were taken more frequently by Merlins *Falco columbarius* than adults, and this in a population with an apparently stable age structure after mid-winter. Their study showed that even when one predator was known to cause heavier mortality on immature birds, the effect on the age structure of the population was not detectable. Falcon predation on wintering Dunlins is extensive in western Washington (pers. obs.), and our age ratio data indicate that this predation had no detectable effect on the age structure of the populations we studied.

Sex-ratios

Four of eight collections in 1980-81 had sex ratios differing significantly from the 1:1 ratio assumed for the entire population of *C. a. pacifica* (Table 5), and overall the ratio was slightly, though not significantly, biased towards males. When all samples from Sets I and II were pooled, the sex ratio was significantly biased towards males. Page (1974) also found that males at Bolinas Lagoon, California were more common than females. He suggested that sexual segregation, either geographical or ecological, may have been responsible. The trend towards similarity in the sex ratios in both age classes of Dunlins in western Washington (Table 4) suggests that whatever factors regulate segregation of the sexes in winter (see discussion in Myers 1981, and Ketterson and Nolan 1983), they are operating equally in immature and adult Dunlins. The same can be said about age ratios within the sex classes (Table 4).

A sample of 32 Dunlins from Padilla Bay in November 1978 had a 1:1 sex ratio (Table 3).

These birds were shot illegally by hunters at Padilla Bay, at least 2 km southwest of the Samish Bay collection site we used in March 1978 and 1980-81. Since mud is exposed much later in the tidal cycle at Padilla Bay than it is at Samish, the 1978 birds from Padilla must have been collected during a low or nearly low tide, whereas the Samish birds,where all 3 collections were skewed significantly towards males, were collected during the earliest phase of the falling tide period. All Samish and Padilla samples are from the same wintering population which moves between both areas on a tidal schedule (Brennan *et al.* 1985), and it is possible that some local segregation takes place.The observed differences in sex ratios from Kennedy Creek Delta (Tables 3 and 5) could also be related to such segregation. However, all samples were collected from the same area during similar tidal situations, illustrating the possibility for variation in sex-ratio data obtained from static collections.

Whether observed sex ratios from small samples of this type reflect the actual population structure, or local segregation, is unclear. Both trends may be masked by the variability which seems to result from static collections and captures. The best solution for obtaining accurate estimates of sex-ratios in wintering shorebird populations may be to gradually obtain large samples over a long period of time so as to not incur substantial and unnecessary mortality. Alternatively, collecting from a variety of sites, and at various times and tidal situations within an area of interest may be sufficient.

Further research on Dunlins along the North American Pacific coast is needed to provide more accurate information on: 1) the complete migratory schedule of Dunlins according to age and sex class; 2) the regional and local fluctuations in population structure during the wintering period; 3) the role of various sources of mortality (both breeding and non-breeding) in the regulation of population structure during the non-breeding season; and 4) the nature and controlling mechanisms of age and sex segregation on the wintering grounds.

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