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CONTENTS

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VARIATION IN THE GROWTH RATE OF PACIFIC HERRING FROM SAN FRANCISCO BAY, CALIFORNIA[1]

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From 1974 to 1982 the average annual increase in body weight of Pacific herring from San Francisco Bay, California was 31%, 22%, 16%, and 9% for ages 3, 4, 5, and 6 yr respectively. In 1983 there was no weight gain and growth in length was 80% below normal. Then in 1984, the weight was estimated to have increased 83%, 72%, 53%, and 40% for ages 3, 4, 5, and 6 yr respectively. Growth in length also improved dramatically in 1984. The cessation of growth in 1983 and improvement of growth in 1984 coincided with the beginning and end of the 1983 El Niño.

INTRODUCTION

Environmental conditions and their effect on fish populations are of primary concern to fishery managers. From late 1982 (Sund 1984) to early 1984 (Fiedler 1984a) the west coast of the United States experienced one of the most severe environmental anomalies ever to occur in the area. Ocean surface temperatures were raised above normal by the intrusion of warm equatorial water; this phenomenon is hereafter referred to as El Niño. Age and growth data on Pacific herring, *Clupea harengus pallasi,* from San Francisco Bay California are available from 1974 through 1985 (Spratt 1981, 1982a, 1983a, 1984a, 1985a) and provide an opportunity to study some of the effects that the El Niño had on the growth rate of Pacific herring in California. In 1983, during the height of the El Niño, mean size of herring in California declined drastically (Spratt 1984a). This report documents the variability that is possible in the growth rate of marine fishes.

The Pacific herring fishery in San Francisco and Tomales Bays, California has been sampled annually since the 1973–74 season for age and size composition of the purse seine, lampara, and gill net catch. However, only data from the San Francisco Bay purse seine and lampara fisheries were used in this study for the following reasons: (1) more data are available from the San Francisco Bay fishery, (2) the San Francisco Bay fishery data are continuous from 1974 to 1985, while data from other fisheries are not, and (3) purse seine and lampara fisheries are assumed to be unbiased with regard to size composition of herring in the catch.

The San Francisco Bay purse seine and lampara herring fishery is an excellent source of age and growth data. The fishing season is short, with most of the fish caught in a few weeks in January and February. Most fisheries are characterized by irregular pulse fishing that can make annual growth comparisons difficult. The herring fishery is confined to the spawning season, thus occurring at the same point in the herring's life cycle each year. It is believed to be a single stock fishery and minimizes variation caused by stock mixing or fishing multiple stocks. Finally, the purse seine and lampara fishery usually occurs during the latter part of the season when the age composition of the population has a consistent pattern of primarily young herring. This data base consists of 12 yr of data collected 12

[1]Accepted for publication September 1986.

months apart each season, and growth estimates are annual, with no need to back calculate or standardize data to a specific month.

METHODS

A herring sample consisted of 2.3 kg (5 lb) of herring taken with a hand held scoop or by hand from storage boxes. Collecting and processing of samples have remained unchanged since 1973 (Spratt 1981). All samples were processed in the following manner: (i) a 1-kg (2.2-lb) sub-sample was randomly selected from the initial sample; (ii) fish were weighed to the nearest 0.1 g; (iii) body length (BL) to the nearest mm was measured from the tip of the snout to the end of the silvery part of the body or very near the hypural plate; (iv) sex and maturity were determined; and (v) otoliths were removed for age determination. Herring were aged using criteria developed in 1973 (Spratt 1981). A total of 2,686 herring was collected from the San Francisco Bay roundhaul fishery from 1974–1985.

The Student's t test was used to test for homogeneity between the length and weight of males and females.

The condition factor ($100{,}000W/L^3$) or K was used in this context to estimate the relative well being of the San Francisco Bay herring population.

TABLE 1. Mean Length (mm BL) ± Standard Deviation and Number (N) of Herring Sampled from the San Francisco Bay Roundhaul Fishery by age and Season.

	Age					*Seasonal Unweighted Mean*
Season	*2*	*3*	*4*	*5*	*6*	
1973–74	162±8 (152)	174±8 (81)	189±8 (65)	198±8 (53)	206±9 (20)	186
1974–75	157±10 (52)	179±7 (24)	186±6 (16)	196±9 (13)	205±7 (12)	185
1975–76	158±9 (75)	174±9 (51)	190±6 (15)	204±10 (17)	210±10 (17)	187
1976–77	162±9 (96)	177±9 (138)	187±7 (83)	198±8 (37)	204±9 (21)	186
1977–78	162±11 (34)	174±7 (30)	185±9 (32)	190±11 (11)	199±11 (2)	182
1978–79	165±7 (34)	178±8 (50)	186±9 (35)	194±8 (36)	202±6 (14)	185
1979–80	160±9 (73)	177±8 (23)	191±7 (34)	196±8 (27)	204±8 (18)	186
1980–81	164±6 (96)	176±5 (96)	188±4 (42)	197±4 (14)	202±8 (18)	185
1981–82	163±6 (95)	175±5 (105)	184±5 (70)	192±5 (31)	199±4 (20)	183
1982–83	164±5 (34)	174±5 (56)	185±3 (66)	194±4 (47)	201±4 (23)	184
1983–84	152±8 (85)	164±6 (44)	179±5 (15)	188±6 (19)	195±4 (12)	176
1984–85	163±6 (85)	176±6 (53)	185±3 (34)	193±3 (23)	198±4 (12)	183
Unwt. Mean	161	175	186	195	202	184

RESULTS

Length data (Table 1) and weight data (Table 2) are summarized by season. Herring up to 9-yr-old were collected but only ages 2 through 6 were used in this analysis because older age classes composed less than 5% of the catch and were not present in samples every season. Mean length of females age 2 through 6 unweighted for yr class strength was 185 mm, while males averaged 183 mm. Females also weighed more averaging 99 g, while males averaged only 92 g. Neither length nor weight differences were significant ($t = -0.192$ and -0.625 respectively with 4 d.f.) and data for males and females were combined. The female to male sex ratio of the combined data base was 52:48.

Length Analysis

From 1973–74 to 1982–83 the combined seasonal average length of herring ages 2 through 6, unweighted for yr class strength, ranged from 182 to 187 mm BL (Table 1). In the 1983–84 season the combined unweighted average length decreased to 176 mm BL and then increased to 183 mm BL in the 1984–85 season. In the 1983–84 season, the mean length at age of 2 through 6-yr-old herring was 8 to 12 mm BL below the 10 yr mean length for each age (Table 2). The decrease in mean length of each age group during the 1983–84 season was not significant ($t = 1.248$ with 4 d.f.), nor was the increase in mean length significant in the 1984–85 season.

TABLE 2. Comparison of San Francisco Bay Herring 10 Yr Mean Length Data with 1983–84 and 1984–85 Length Data.

Age	*10-yr Unwt. Mean mm BL*	*1983–84 Mean mm BL*	*1983–84 mm BL Decrease*	*1984–85 Mean mm BL*	*1984–85 mm BL Increase*
2	162	152±2.4 *	10	163±1.2 *	11
3	176	164±2.5	12	176±1.6	12
4	187	179±3.6	8	185±1.0	6
5	196	188±3.9	8	193±1.2	5
6	203	195±3.7	8	198±2.4	3
Mean	185	176	9.2	183	7.4

* 99% Confidence Interval.

A better indicator of the effect of El Niño on growth is obtained if yr classes are followed from season to season. Average annual growth increment was 10 mm for all age classes combined from 1973–74 to 1982–83 (Table 3). In 1983 the combined average increase was only 2 mm, well below the 9-yr combined average increase of 10 mm per yr. In 1984, after El Niño ended, the growth rate was above normal with ages 3 through 6 gaining an average of 17 mm in length (Table 3). This resurgence in growth was sufficient to allow for a complete recovery in the mean length of herring by the 1984–85 season (Table 1).

TABLE 3. Annual Growth Increment of Pacific herring in mm BL by Age Groups.

Season	*Age 3*	*Age 4*	*Age 5*	*Age 6*	*Combined Average Increment*
9 yr ave.	14	11	9	7	10
1983–84	0	5	3	1	2
1984–85	24	21	14	10	17

Weight Analysis

Average weight at age of herring showed normal variation from the 1973–74 season until the 1982–83 season. During this time the combined seasonal average weight of all age classes, unweighted for yr class strength, ranged between 91 g and 101 g (Table 4). Then in the 1983–84 season, at the height of the El Niño, a severe decline in weight at age occurred that affected adult herring. Environmental conditions improved in 1984 with the weakening of El Niño, and in the 1984–85 season herring growth improved dramatically resulting in average weights at age that exceeded long term means for younger age classes (Table 4). Irrespective of ages, the length-weight relationship of San Francisco Bay herring in 1983–84 also represents a decrease of up to 7% in weight at length from earlier data (Reilly and Moore 1984).

TABLE 4. Mean Weight(g) at Age of Herring in the San Francisco Bay Roundhaul Fishery.

	Age					*Seasonal Unweighted Mean*
Season	*2*	*3*	*4*	*5*	*6*	
1973–74	57	73	95	109	128	92
1974–75	55	82	89	105	124	91
1975–76	57	77	108	122	142	101
1976–77	58	80	95	116	130	96
1977–78	66	85	106	114	111	96
1978–79	70	87	103	119	128	101
1979–80	68	79	102	119	132	100
1980–81	63	83	98	124	118	97
1981–82	61	82	98	113	124	96
1982–83	62	74	93	107	120	91
1983–84	46	58	75	91	103	75
1984–85	66	84	100	115	127	98
Average	61	79	97	113	124	95

The weight loss and subsequent recovery is more evident if year classes are followed. From 1975 to 1983 the average annual weight gain of herring 3 to 6-yr-old was 16 g per year, or an average weight gain of 20% per year (Table 5). The data indicate that during 1983, the same four age classes combined lost an average of 2 g in weight (Table 5). The below average growth increment in 1983 was significant ($t = -4.29$ with 3 d.f.).

TABLE 5. Annual Growth Increment (g) of Pacific Herring by Age Groups.

	Age				*Combined*
Season	*3*	*4*	*5*	*6*	*Average*
9 yr ave.					
Grams	19	18	16	10	16
Percent	31	22	16	9	20
1983–84					
Grams	−4	1	−2	−4	−2
Percent	−6	1	−2	−4	−3
1984–85					
Grams	38	42	40	36	39
Percent	83	72	53	40	62

At the end of the 1983–84 season, herring were underweight by at least 20%. When conditions improved in 1984, herring rapidly regained weight that was lost and by the 1984–85 fishery, herring were robust with average weights at age above long term means. Three-yr old herring gained 38 g on the average during

1984 for a total increase in weight of 83%; 4, 5, and 6-yr-olds also had large increases in average weight. The combined average increase in weight of 39 g was more than double the long term average increase and represents a 62% average increase in weight during one season (Table 5).

Condition Factor

From the 1973–74 to 1984–85 season, K averaged 1.48 for age groups 2 through 6 unweighted for yr class strength (Table 6).

The San Francisco Bay herring biomass estimates increased from 1978–79 to 1981–82, peaking at 100,000 tons (Spratt 1981, 1982b), then began a decline to 40,000 tons in the 1983–84 season (Spratt 1983b, 1984b). The increase in biomass was partly due to improved methodology (i.e. including subtidal spawning), but an actual increase in biomass probably occurred because the 1978, 1979, and 1980 yr classes were all above average strength (Spratt 1981, 1982a). During the four seasons that the herring biomass was increasing the annual K values were above average, indicating that herring were in relatively good condition at that time (Table 6). When the biomass declined the K values were below average (Table 6), indicating the relatively poor condition of herring during those years. Herring biomass increased to 46,000 tons in the 1984–85 season (Spratt 1985b), coinciding with the weakening of El Niño and above average K values (Table 6).

TABLE 6. Condition Factor ($100{,}000W/L^3$) for San Francisco Bay Herring, calculated from Tables 1 and 4.

	Age					*Seasonal unweighted*
Season	*2*	*3*	*4*	*5*	*6*	*mean*
1973–74	1.34	1.38	1.40	1.40	1.46	1.40
1974–75	1.42	1.42	1.38	1.39	1.43	1.41
1975–76	1.44	1.46	1.57	1.43	1.53	1.49
1976–77	1.36	1.44	1.45	1.49	1.53	1.45
1977–78	1.55	1.61	1.67	1.66	1.40	1.58
1978–79	1.55	1.54	1.60	1.61	1.55	1.57
1979–80	1.66	1.42	1.46	1.58	1.55	1.53
1980–81	1.42	1.52	1.47	1.62	1.43	1.49
1981–82	1.40	1.53	1.57	1.59	1.57	1.53
1982–83	1.40	1.40	1.46	1.46	1.47	1.44
1983–84	1.30	1.31	1.30	1.36	1.38	1.33
1984–85	1.52	1.54	1.57	1.59	1.63	1.57
Mean	1.45	1.46	1.49	1.51	1.49	1.48

DISCUSSION

Length

Growth in length slowed measurably in 1983 and then made a complete recovery in 1984. Reilly and Moore (1984, 1985) in an independent study, found that the average length at age of adult herring in San Francisco Bay was also below normal in 1983 and recovered in 1984. My data indicate a greater decline occurred, but the two studies do agree that growth was poor in 1983. Differences in growth estimates could be related to sample size, sampling gear, time of sampling, or aging differences.

Similar poor growth was noted for northern anchovy, *Engraulis mordax,* in southern California during 1983. Feidler (1984a) found that adult anchovies were abnormally small, with a mode of 100–105 mm compared to an expected mode of 115–120 mm.

Weight

The average weight at age of herring in San Francisco Bay decreased to an all time low of 75 g in 1983 (Table 4). While the data indicate that some individual herring lost weight in 1983, I believe that the overall population merely maintained their weight from 1982 to 1983. Poor growth was related to low primary productivity during the El Niño (Fiedler 1984b). Reilly and Moore (1984) found that herring fecundity did not decline significantly during the El Niño, suggesting that available energy was directed to gonadal development rather than growth.

Other recent work on central California fishes indicate that growth of blue rockfish, *Sebastes mystinus,* was also below normal in 1983. The weight-length relationship of adult females in 1983 was 20% below 1981 levels, strongly suggesting that blue rockfish may have lost weight in 1983 (D. VenTresca, Calif. Fish and Game, pers. comm.).

Population Growth Rate

Factors that cause changes in the growth rate of herring populations are either environmental, effecting primary productivity, or are related to population size and are density dependent. Both factors influenced herring growth in 1983 and 1984. The degree of change in the annual growth rate of a population is dependent on the age composition, because younger fish gain weight faster than older fish. Since the San Francisco Bay herring population is weighted toward younger age classes, it should respond significantly to factors that effect growth. Accordingly, the annual average population growth rate (weight gain) will be closer to the long term average increase for 3-yr-olds (31%) than the combined average increase of 20% for all age classes (Table 5). Similarly, the herring population growth rate in 1984 was probably closer to the increase exhibited by 3-yr-olds (83%) in 1984 than the average of 62% for all age classes combined (Table 5).

When the annual growth rate of a fish population fluctuates between zero and approximately 70%, growth or lack of growth can have a significant effect on biomass.

CONCLUSION

This study shows that there is wide variation in the San Francisco Bay herring population growth rate and indicates that the annual growth rate (weight) ranges between zero and 0.7 with a mean of about 0.3. The weight at age of herring and the overall mean weight of the catch was depressed in 1983 and then recovered quickly in 1984. Therefore the weight gain in 1984 represents the maximum recorded growth rate for San Francisco Bay herring. The 1983 and 1984 growth fluctuations coincided with the 1983–84 El Niño event.

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Calif. Fish and Game 73(3): 139–155 1987

MIGRATION AND DISTRIBUTION OF NORTHERN PINTAILS BANDED IN CALIFORNIA[1]

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Migration routes and distribution of northern pintails, *Anas acuta,* were determined by analysis of band recoveries from 234,061 pintails banded at 12 stations in California from 1948 to 1979. Males were the first to arrive in California during fall migration resulting in a differential distribution of harvest. Females were harvested closer to the breeding grounds than males, whereas males were harvested farther south. Males tended to range wider and were more apt to be recovered in Mexico and Central America or one of the other three flyways than were females. Females showed a greater homing instinct to the area of banding than did males. Proportionately fewer bands were recovered in the Sacramento Valley from preseason versus postseason banding at Gray Lodge, suggesting that some preseason banded pintails were only passing through the Sacramento Valley on their way farther south. The large number of local recoveries from the San Francisco Bay-Delta, especially Suisun Marsh, suggest this area was a highly desirable pintail wintering area in the 1950's. Los Banos banded pintails were more closely aligned with Mexico and the other flyways than were birds banded in other areas of northern California. Imperial Valley pintails were a separate population from those of northern California. Pintails banded preseason in the Imperial Valley wintered in four general areas: Imperial Valley, northern California, Mexico and in the Central and Mississippi Flyways. Some pintails that migrated to Mexico returned to the breeding ground via the Central and Mississippi flyways on a counterclockwise migration, whereas others migrated up through California on a clockwise migration. Thus, several subpopulations were banded at each station partially accounting for the spread of recoveries.

INTRODUCTION

An average of two million northern pintails winter in California (Bellrose 1976). About 71% of the U.S. harvest occurs in the Pacific Flyway, and over half in California (Geis and Cooch 1972). Texas and Louisiana are the only significant harvest areas outside of the Pacific Flyway. Most pintails wintering in the Pacific Flyway are produced in prairie Canada and Alaska (Bellrose 1976). Pintails banded in Alaska show 70% being recovered in the Pacific Flyway, and 41% of the Pacific Flyway recoveries came from California (Bird Banding Laboratory, unpubl. data). Pintails were harvested in larger numbers than other species of ducks in California.

The purposes of this study were to describe migration patterns and distribution of pintails banded pre- and postseason in California to provide a basis for management and to determine the relative importance of California as a wintering area and harvest area for California banded pintails.

METHODS

Pintails were banded by the Waterfowl Studies Project of the California Department of Fish and Game (CDFG), in cooperation with the U.S. Fish and Wild-

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life Service (USFWS) during 1948–79. Most pintails were caught in swim in baited wire traps, but cannon nets were also used postseason at Gray Lodge Wildlife Area and in Imperial Valley. Of total ducks banded, 175,985 were preseason, 69,189 postseason, 4,371 within season and 6,008 between split seasons. However, only those banded preseason (174,896) and postseason (59,165) that were recovered through the 1979 band recovery year were used. In the 1950's and early 1960's, pintails were banded on several waterfowl concentration areas in California. However, from 1964 to 1979, only the Klamath Basin NWRs and the Gray Lodge Wildlife Area were used as pintail banding stations. Banding on these two areas has been continuous since 1948.

Recoveries from each banding station, when warranted, were analyzed separately. However, data from stations with similar recovery distributions were pooled. Data from each age and/or sex class were pooled where there were no obvious differences noted. All percentages used in this report were expressed as proportions of total recoveries resulting from a particular banded sample.

Direct and indirect recoveries were used. Direct recoveries are banded birds killed or found dead during the first hunting season after banding. Indirect recoveries are band recoveries in subsequent band recovery years following the year of banding. All recoveries were from normal wild birds in banded samples of 100 or more.

California was divided into eight band recovery areas (Figure 1). Each area represents a major subdivision separated by geographic features, waterfowl distribution and harvest. The most important were northeastern California; Sacramento, San Joaquin and Imperial Valleys; and San Francisco Bay-Delta as determined from waterfowl populations using the areas.

RESULTS AND DISCUSSION

Migration, Bandings and Recoveries

Klamath Basin NWRs (Northeastern Recovery Area): Banded 52,130 preseason, 1948–1979.

Distribution of direct recoveries of immature males and females (Table 1) banded on the Klamath Basin NWRs were similar. Recoveries of adults differed for northeastern California, Sacramento Valley, and San Franciso Bay-Delta recovery areas and were treated separately.

There was a predominance of males during the August and September preseason banding in the Klamath Basin; 43,306 males and 8,824 females were banded. By the time hunting began in mid-October, many adult males had moved south, so fewer were shot in the Klamath Basin compared to later migrating adult females. Consequently, a higher proportion of band recoveries were obtained for females (20.9%) from the Klamath Basin than for males (12.6%). This was shown in both direct and indirect band recoveries (Table 1). Delayed female migration was also shown by the proportion of indirect recoveries from Canada, where 9.8% of the females were recovered compared to 3.6% for males, and also by the number of recoveries obtained in Washington and Oregon (females 9.4% vs. males 5.2%). Bellrose et al. (1961) stated that excess hen pintails in the hunter bag in Manitoba was caused by the dispersal of many adult drakes away from the area prior to the hunting season. As a result of differential

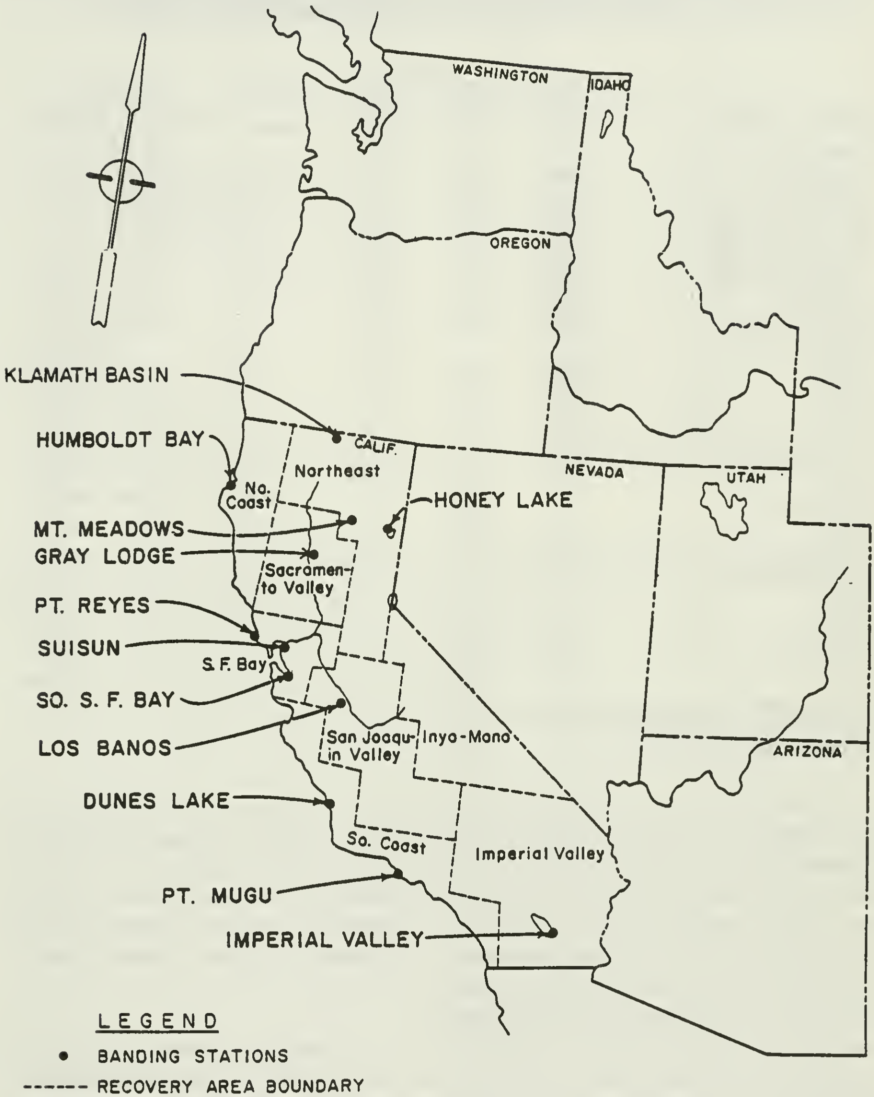

FIGURE 1. Pintail Banding Stations and Recovery Areas.

migration, indirect recoveries of males exceeded those of femalesin the Sacramento Valley (27.9% vs. 24.5%) and San Francisco Bay-Delta (28.6% vs. 14.7%). The data suggest that most females had fixed migration routes from which they rarely deviate, whereas males were more apt to stray from one route to another.

Over 80% of male and 70% of female indirect recoveries of pintails banded on Klamath Basin NWRs occurred in California (Table 1). Thus, pintails migrated to California prior to the opening of the hunting season or with a minimum of stopovers along the way.

TABLE 1. Distribution of Band Recoveries (Percent of Recoveries) From 29,922 Adult Male, 13, 384 Immature Male, 3,910 Adult Female and 4,914 Immature Female Pintails Banded Preseason at Klamath Basin National Wildlife Refuges, 1948–79

	Direct				*Indirect*+	
*Recovery Areas**	*Imm. male*	*Adult male*	*Imm. female*	*Adult female*	*Males*	*Females*
California						
Northeast	34.8	21.5	33.7	44.2	12.6	20.9
North Coast	1.1	0.9	0.7	1.8	1.0	0.9
Sacramento Valley	15.3	25.1	17.4	17.7	27.9	24.5
San Francisco Bay	22.3	27.4	20.0	17.7	28.6	14.7
South Coast	3.0	1.8	2.6	3.5	1.1	1.5
San Joaquin Valley	11.1	13.0	13.0	11.5	11.5	10.1
Imperial	0.9	0.1	0.4	–	0.4	1.2
Washington Coast	1.3	0.8	2.6	–	1.1	2.1
Oregon						
Coast	3.8	2.5	3.0	–	2.4	3.4
South	1.0	0.6	1.1	1.8	1.2	1.8
Nevada	–	0.2	1.1	–	0.5	0.3
Utah	0.1	0.5	–	–	0.8	0.9
Alaska	0.2	–	–	–	0.9	0.6
British Columbia	0.5	0.3	1.9	–	0.5	1.8
Alberta	–	0.2	–	0.9	1.9	4.9
Saskatchewan	–	0.2	–	–	0.9	2.8
Mexico	2.3	1.4	1.1	–	1.5	1.8
Central Flyway	1.2	2.0	0.4	–	2.5	2.7
Mississippi Flyway	0.3	1.3	–	–	0.9	0.3
Russia	–	0.1	–	–	0.8	0.3
Oceana	0.1	–	0.4	0.9	–	–
All Other≠	0.8	0.5	1.2	–	1.2	2.1
Total Recoveries	1006	1138	270	113	3538	326

* Table includes data for recovery percentages $\geq$ 0.7 only.
+ Birds in their second year or older.
≠ Recovery areas with $\leq$ 0.7

To determine if the distribution of band recoveries changed during the study, Klamath Basin data for the 1950's, 1960's, and 1970's were compared (Table 2). Combining sexes, there was a downward trend in recoveries from the San Francisco Bay-Delta Recovery Area (29.2%, 28.6%, 23.9%) and Canada (6.2%, 3.1%, 2.3%), and an upward trend for recoveries from the Sacramento Valley (24.7%, 27.3%, 31.8%) and northeastern California (12.7%, 10.3%, 17.9%). Except for females recovered in the San Francisco Bay-Delta, the same trends occurred when sexes were treated separately.

Later migrations may have resulted in more banded birds being available to hunting in the Klamath Basin. In the 1950's and early 1960's, pintails were banded on Klamath Basin NWRs in August. However, by the late 1960's, early movement of pintails into the Klamath Basin declined and was delayed by about one month. Consequently, banding was not done until September. Thus, more banded birds were on the area at a later date. Increasing numbers of pintails over-wintering in Klamath Basin (H. McCollum, pers. commun.) could also contribute to the increased recoveries. The cause of fewer recoveries from the San Francisco Bay-Delta Recovery Area may reflect the change in northeastern California.

In 1957, on the Klamath Basin NWRs, two preseason samples of pintails were banded. The early sample (N=1963) was banded in August, and the late sample (N=1,697) was banded just prior to the October opening of hunting season. The only noticeable difference in distribution of recoveries between the two samples

TABLE 2. A Comparison of Indirect Band Recoveries (percent of recoveries) Among 3 Decades of 48,121 Pintails Banded Preseason at the Klamath Basin National Wildlife Refuges, 1950–79

Recovery Area *	*1950–59*	*1960–69*	*1970–79*
California			
Northeast	12.7	10.3	17.9
North Coast	0.8	0.7	1.3
Sacramento Valley	24.7	27.3	31.8
San Francisco Bay	29.2	28.6	23.9
South Coast	1.4	1.0	0.9
San Joaquin Valley	9.6	14.1	11.0
Utah	1.2	0.8	0.5
Alaska	1.0	0.8	0.7
Alberta	3.1	1.7	1.4
Saskatchewan	1.9	0.8	0.5
Mexico	1.8	1.6	1.3
Central Flyway	4.1	1.9	1.2
All Other +	8.7	10.4	7.6
Total Recoveries	1455	1343	985

* Table includes data from recovery percentages ≥0.7 only. Complete list available from author.
\+ Recovery areas with ≤ 0.7.

was the number of local recoveries (August 11.8%; October 30.7%). Direct recoveries outside the State were about the same for both periods which suggests that both samples were from the same population.

Honey Lake Wildlife Area and Mountain Meadows (Northeastern Recovery Area): Banded 20,638 preseason, 1950–1958.

Recovery locations of pintails banded at Mountain Meadows and Honey Lake Valley were no different, so data were pooled (Table 3). There were differences in recovery areas between Honey Lake and Klamath Basin banding stations even though the stations are only 240 km apart. Local indirect recoveries in Northeastern California from Honey Lake—Mountain Meadow birds was 9.0% (Table 3) compared to 12.6% (Table 1) for Klamath Basin birds. This same pattern held for direct recoveries of immatures. Thus, some of these pintails used different migration routes or there was greater hunting pressure in the Klamath Basin.

Fewer Honey Lake than Klamath Basin banded pintails were recovered in the Sacramento Valley (18.8% vs. 25.8%) and San Francisco Bay-Delta (27.7% vs. 31.0%). More were recovered in the San Joaquin Valley (16.2% vs. 9.6%), southern California (3.2% vs. 1.9%), Mexico (3.3% vs. 2.0%) and other flyways (7.5% vs. 4.8%).

Gray Lodge Wildlife Area (Sacramento Valley Recovery Area): Banded 68,584 preseason and postseason, 1949–1979.

The proportional distributions of direct recoveries were the same for immature males and females (Table 4), as in the Klamath Basin. Immatures tended to disperse farther than did adults (Table 4). Direct recoveries in the Sacramento Valley were high compared to indirect recoveries (Table 4). This difference was expected since pintails were banded shortly before the hunting season.

Males showed more proportionate recoveries from the San Francisco Bay-Delta (31.7%) than did females (20.4%) and fewer from the Sacramento Valley (36.7% vs 40.7%) respectively (Table 4). Other differences in band recoveries such as 2.8% for males in northeastern California compared to 6.0% for females

TABLE 3. Distribution of Band Recoveries (percent of recoveries) from 20,638 Pintails Banded Preseason at Honey Lake Wildlife Area and at Mountain Meadows, 1950–58

	Direct		
*Recovery Area**	*Immature*	*Adult*	*Indirect⁺*
California			
Northeast	23.9	15.3	9.0
Sacramento Valley	14.2	14.5	18.8
San Francisco Bay-Delta	26.8	34.8	27.7
South Coast	2.6	3.2	2.3
San Joaquin Valley	19.1	20.8	16.2
Imperial Valley	0.8	1.1	0.9
Washington	0.8	0.3	1.3
Oregon	1.8	0.8	2.5
Nevada	0.4	1.3	1.2
Utah	0.1	0.5	1.2
Alaska	0.1	0.3	0.7
Alberta	0.1	0.5	3.0
Saskatchewan	–	–	1.6
Mexico	4.4	1.1	3.3
Central Flyway	1.8	4.2	5.5
Mississippi Flyway	1.6	1.1	2.0
Russia			0.7
All Other ≠	1.4	0.3	2.1
Total Recoveries	754	379	1420

* Table includes data from recovery percentages ≥ 0.7 only. Complete list available from author.
⁺ Birds in their second year or older.
≠ Recovery areas with ≤ 0.7.

and 4.7% for males on the breeding grounds of Alaska and Canada compared to 9.2% for females show later southward migration of females.

A greater proportion of indirect recoveries of pintails banded preseason at Gray Lodge come from south and east of California than recoveries from postseason banded birds (Tables 4 and 5). Thus, some of the preseason banded birds were only passing through the area on their way farther south; whereas, birds banded postseason were on their wintering grounds or migrating north. Preseason direct recoveries also indicate this continuation of the migration south and east after banding (Table 4).

Preseason versus postseason bandings at Gray Lodge also showed a marked difference in the distribution of band recoveries within California. About 38% of pintails banded preseason were recovered in the Sacramento Valley compared to 46.3% from postseason bandings. There was also a greater dispersal of pintails from preseason bandings compared to postseason bandings.

The difference in number of indirect recoveries within northeastern California from preseason (male 2.8% vs. female 6.0%) and postseason bandings (male 6.3 vs. female 7.0%) at Gray Lodge resulted from differential migration (Tables 4 and 5). Males causesd most of this variation (preseason 2.8% vs. postseason 6.3%), whereas females were similar (preseason 6.0% vs. postseason 7.0%). Thus, preseason banded pintails, especially males, migrated earlier than those birds banded postseason. They passed through northeastern California prior to or shortly after opening of the hunting season, thereby resulting in fewer bands being recovered for that area.

TABLE 4. Distribution of Band Recoveries (percent of recoveries) from 15,446 Adult Male, 11,824 Immature Male, 7,535 Adult Female and 9,500 Immature Female Pintails Banded Preseason at Gray Lodge Wildlife Area, 1949–79

	Direct				*Indirect* +	
Recovery Areas *	*Imm. male*	*Adult male*	*Imm. female*	*Adult female*	*Males*	*Females*
California						
Northeast	1.2	–	0.6	0.5	2.8	6.0
Sacramento Valley	54.5	49.8	54.4	59.7	36.7	40.7
San Francisco Bay-Delta	28.5	32.8	25.9	28.3	31.7	20.4
South Coast	0.8	1.0	1.4	1.0	1.2	1.2
San Joaquin Valley	11.1	13.4	14.3	10.5	12.2	10.8
Imperial Valley	0.5	0.3	0.4	–	0.8	0.7
Washington	–	–	0.1	–	0.8	0.9
Oregon	0.4	0.3	0.8	–	2.9	3.4
Utah	–	–	–	–	0.8	1.2
Alaska	–	0.2	0.2	–	1.2	1.6
British Columbia	–	0.3	–	–	0.7	0.6
Alberta	–	–	–	–	1.7	5.3
Saskatchewan	–	–	–	–	0.8	1.7
Mexico	1.4	0.2	1.0	–	1.2	0.6
Central Flyway	0.7	1.5	0.4	–	1.7	0.5
Russia	–	–	–	–	0.7	0.9
All Other≠	0.6	–	0.5	–	2.3	3.1
Total Recoveries	943	618	491	191	2356	813

* Table includes data for recovery percentages ≥ 0.7 only. Complete list available from author.
\+ Birds in their second year or older.
≠ Recovery areas with ≤ 0.7.

TABLE 5. Distribution of Indirect Band Recoveries (percent of recoveries) from 15,672 Male and 8,607 Female Pintails Banded Postseason at Gray Lodge Wildlife Area, 1954–79

Recovery Areas *	*Male*	*Female*	*Combined*
California			
Northeast	6.3	7.0	6.4
Sacramento Valley	44.2	53.6	46.3
San Francisco Bay-Delta	22.7	10.1	19.9
San Joaquin Valley	12.7	10.6	12.2
Imperial Valley	0.7	–	0.5
Washington	0.8	2.2	1.1
Oregon	3.1	4.3	3.4
Nevada	1.1	2.2	1.3
Utah	1.0	1.4	1.2
Alaska	0.8	1.0	0.8
British Columbia	0.8	1.9	1.0
Alberta	2.2	1.4	2.0
Saskatchewan	0.5	1.4	0.9
Central Flyway	0.4	0.7	0.5
Russia	0.6	1.0	0.7
All Other +	2.1	1.2	1.8
Total Recoveries	1438	416	1854

* Table includes data from recovery percentages ≥ 0.7 only. Complete list available from author.
\+ Recovery areas with ≥ 0.7.

Band recoveries for Gray Lodge bandings were also compared for the 1950's, 1960's and 1970's (Table 6). There was an increase in percentage of recoveries from the Sacramento Valley during the 1950's through the 1960's (33.2%—42.4%) and a leveling off in the 1970's (40.2%). Increases were also shown for the San Francisco Bay-Delta (26.2%, 30.4%, 32.8%) and San Joaquin Valley (10.4%, 11.7%, 13.6%), whereas, there was a downward trend in Canada (7.5%, 2.3%, 1.9%).

TABLE 6. A Comparison of Indirect Band Recoveries (percent of recoveries) Among 3 Decades of 39,504 Pintails Banded Preseason at Gray Lodge Wildlife Area, 1950–79

Recovery Areas *	*1950–59*	*1960–69*	*1970–79*
California			
Northeast	4.8	1.4	3.3
Sacramento Valley	33.2	42.4	40.3
San Francisco Bay-Delta	26.2	30.4	32.8
South Coast	1.7	0.9	0.3
San Joaquin Valley	10.4	11.7	13.6
Oregon	3.8	3.3	1.1
Utah	1.1	0.4	0.4
Alaska	1.3	1.2	1.5
Alberta	4.2	1.7	0.9
Saskatchewan	1.9	–	0.5
Mexico	1.8	0.2	0.3
Central Flyway	2.9	0.8	0.6
Mississippi Flyway	0.8	0.1	0.3
Russia	0.3	1.3	1.1
All Other+	5.7	3.9	2.6
Total Recoveries	1507	694	938

* Table includes data from r;ecovery percentages ≥ 0.7 only. Complete list available from author.

+ Recovery areas with ≤ 0.7

Point Reyes, Suisun, and South San Francisco Bay (San Francisco Bav-Delta Recovery Area): Banded Suisun, 8,715; South San Francisco Bay, 4,089; and Point Reyes, 1,589 preseason, 1951–1958.

Recoveries from pintails banded on these stations had similar distribution so data were pooled (Table 7). These three banding stations had a higher proportion of local direct (adults 79.6%, immatures 74.4%) and indirect (58.6%) recoveries than found for Gray Lodge (52.2%, 54.5%, 37.7% respectively; Table 4).

Once pintails arrived in the San Francisco Bay-Delta area, they remained there. Those banded on other areas of the wintering grounds had a greater tendency to disperse.

Coastal Banding Stations (North Coast and South Coast Recovery Areas): Banded Humboldt Bay, 121; Dunes Lake, 535; and Point Mugu, 813 preseason, 1953–1958.

Recoveries from the coastal stations did not reveal any different migration patterns than were found for the inland stations. Of the 85 indirect recoveries, two might be regarded as coming from the direction of the Canada breeding grounds (one was from Canada) and four from the direction of Alaska (one from Siberia). Direct recoveries indicated that some continued on to the Central Flyway and Mexico.

TABLE 7. Distribution of Band Recoveries (percent of recoveries) From 14,393 Pintails Banded Preseason at Point Reyes, Suisun and South San Francisco Bay, 1951–58

	Direct		*Indirect*⁺
Recovery Areas *	*Immature*	*Adult*	
California			
Northeast	0.4	–	2.6
Sacramento Valley	10.2	9.9	15.7
San Francisco Bay-Delta	74.3	79.6	58.6
South Coast	1.4	0.5	1.0
San Joaquin Valley	10.2	7.0	9.9
Washington	0.4	–	0.8
Oregon	–	0.2	1.2
Utah	–	0.2	0.8
Alberta	–	0.2	2.4
Saskatchewan	–	0.4	0.9
Mexico	1.1	0.4	0.7
Central Flyway	0.8	0.7	1.4
All Others ≠	1.2	1.0	3.9
Total Recoveries	1007	554	1096

* Table includes data from recovery percentages ≥ 0.7 only. Complete list available from author.
⁺ Birds in their second year or older.
≠ Recovery areas with ≤ 0.7

Los Banos (San Joaquin Valley Recovery Area): Banded 28,623 preseason and postseason, 1948–1962.

Much of the information already learned from the other banding stations also applies to Los Banos (Tables 8 and 9), e.g., the delayed migration of females from the breeding grounds, the greater number of females than males recovered in the area of banding, and the greater percentage of recoveries from postseason bandings in the area of banding compared to preseason bandings.

San Francisco Bay-Delta Recovery Area was an important harvest area for males banded at Los Banos. In fact, more indirect recoveries of Los Banos males banded preseason were recovered in the San Francisco Bay-Delta (30.7%) than in the San Joaquin Valley (25.8%) where they were banded (Table 8). However, recoveries from postseason banding show more males recovered in the San Joaquin Valley (35.7%) than in the San Francisco Bay-Delta (25.7%, Table 9).

Direct recoveries suggested immature males wandered farther from the banding area than did adult males and females. For example, 16.4% of direct recoveries for immature males were recovered outside of California compared to 10.1% for adult males, 7.0% for immature females and 1.1% for adult females (Table 9). This difference was greater than among Gray Lodge pintails (3.1% immature males, 3.0% immature females and 0.0% adult females) recovered outside of the State (Table 4). Mexico and the Central and Mississippi flyways accounted for the majority of these out of state recoveries (14.2% immature males, 4.0% immature females). Thus, Los Banos banded pintails were more closely aligned with Mexico and the other flyways than were birds banded in other areas of northern California.

Imperial Valley (Imperial Valley Recovery Area): Banded 48,228 preseason and postseason, 1951–1973.

Reports on lesser snow geese, *Anser c. caerulescens* (Rienecker 1965), American wigeon, *Anser americana* (Rienecker 1976), and green-winged teal, *Anser* crecca carolinensis (Moisan et al. 1967), showed that species which winter in the Imperial Valley were different populations than those wintering in northern California. The distribution of pintails banded in the Imperial Valley followed this pattern. Most indirect recoveries from postseason banded pintails occurred in the Imperial Valley (41.1%, Table 10). Utah was second in number of recoveries (14.2%); thus, pintails stopped in Utah before continuing into the Imperial Valley. Also, 21.5% of the postseason banded pintails were recovered in the Central Valley of California. The peak month of band recoveries, both direct and indirect, was October for the San Joaquin Valley, November for the San Francisco Bay-Delta, and November–December for the Sacramento Valley (Table 11).

As shown by the northern California bandings, winter banded females showed greater homing to the area of banding than did males. About 46% of the females were recovered in Imperial Valley from postseason banding compared to 38.9% for males. Preseason bandings show a much higher proportion of local indirect recoveries among females (34.8%) than males (16.3%, Table 12), suggesting that males dispersed widely.

More Imperial Valley preseason banded male pintails were harvested in Mexico and Central America (10.3%) than for males banded preseason at Gray Lodge (1.3%, Table 4). This is reasonable since Imperial Valley borders on Mexico.

There were marked differences between Imperial Valley preseason and postseason bandings. Fewer bands were recovered from the recovery area where banded when banding occurred preseason compared to postseason. For example, pintails that were banded in Imperial Valley had recoveries of males

TABLE 8. Distribution of Band Recoveries (percent of recoveries) From 9,961 Adult Male, 7,891 Immature Male, 2,090 Adult Female and 4,913 Immature Female Pintails Banded Preseason at Los Banos, 1948–62

	Direct				*Indirect*	
Recovery Areas *	*Imm. male*	*Adult male*	*Imm. female*	*Adult female*	*Males*	*Females*
California						
Northeast	0.8	0.3	0.3	–	3.4	1.9
Sacramento Valley	13.2	11.8	11.4	8.5	15.2	13.6
San Francisco Bay-Delta	27.1	26.3	30.2	23.4	30.7	23.0
South Coast	4.2	2.5	2.2	3.2	1.5	1.1
San Joaquin Valley	34.9	48.0	48.5	62.8	25.8	36.3
Imperial Valley	2.3	0.5	–	1.1	1.3	1.1
Oregon	0.7	0.2	1.1	–	0.5	1.4
Nevada	0.3	0.2	0.3	–	1.1	1.9
Utah	–	–	–	–	1.1	3.6
Alaska	0.2	0.2	–	–	0.9	0.3
Alberta	–	–	–	–	1.9	5.5
Saskatchewan	–	–	–	–	1.5	0.6
Mexico	7.2	2.6	2.4	–	3.6	3.5
Central Flyway	6.7	4.7	1.1	1.1	7.3	1.7
Mississippi Flyway	0.3	1.0	0.5	–	1.9	1.4
All Other ≠	2.1	1.7	2.0	–	2.3	3.1
Total Recoveries	598	598	367	94	1498	361

* Table includes data for recovery percentages ≥ 0.7 only. Complete list is available from author.

+ Birds in their second year or older.

≠ Recovery areas with ≤ 0.7.

16.5% vs. females 34.8% for preseason and males 38.9% vs. females 46.2% for postseason bandings within the same area. Thus, most pintails banded preseason in Imperial Valley did not winter there but were only passing through on their fall migration to the wintering grounds.

TABLE 9. Distribution of Indirect Band Recoveries (percent of recoveries) From 2,277 males and 1,491 Female Pintails Banded Preseason at Los Banos, 1953–59

*Recovery Areas **	*Male*	*Female*	*Combined*
California			
Northeast	3.4	2.6	3.2
Sacramento Valley	18.6	13.8	17.5
San Francisco Bay-Delta	25.7	11.2	22.3
South Coast	2.9	2.6	2.8
San Joaquin Valley	35.7	50.0	39.0
Washington	0.9	–	0.6
Oregon	1.0	0.9	1.0
Nevada	0.8	0.9	0.8
Utah	2.1	2.6	2.2
Alaska	1.3	–	1.0
Alberta	1.6	2.6	1.8
Saskatchewan	1.0	2.6	1.4
Mexico	0.5	2.6	1.0
Central Flyway	1.3	2.6	1.6
All Others +	2.9	4.6	3.6
Total Recoveries	381	116	497

* Table includes data from recovery percentages ≥ 0.7 only. Complete list available from author.
+ Recovery areas with ≤ 0.7.

TABLE 10. Distribution of Indirect Band Recoveries (percent of recoveries) From 17,538 Male and 13,595 Female Pintails Banded Postseason at Imperial Valley, 1952–73

*Recovery Areas **	*Male*	*Female*	*Combined*
California			
Northeast	1.0	1.8	1.3
Sacramento Valley	4.3	2.9	3.9
San Francisco Bay-Delta	5.6	4.3	5.2
South Coast	2.0	2.4	2.1
San Joaquin Valley	14.9	6.5	12.1
Imperial Valley	38.9	46.2	41.1
Nevada	2.1	2.2	2.1
Utah	14.7	13.1	14.2
Arizona	1.4	1.3	1.5
Alberta	1.7	2.8	2.0
Saskatchewan	1.0	1.8	1.3
Canada (Other)	0.1	0.7	0.3
Mexico	7.2	6.7	6.9
Central Flyway	2.1	2.4	2.2
Russia	0.5	0.7	0.5
All Others+	2.8	3.9	2.7
Total Recoveries	1914	833	2747

* Table includes data from recovery percentages ≥ 0.7 only. Complete list available from author.
+ Recovery areas with ≤ 0.7.

TABLE 11. Month of Recovery for Pintails Banded Preseason in Imperial Valley *

Area Recovered		*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*Total*
Sacramento	–Direct			4(21.1) +	10(52.6)	3(15.8)	2(10.5)				19
Valley	–Indirect			6(12.0)	11(22.0)	21(42.0)	11(22.0)	1(2.0)			50
S.F. Bay	–Direct			8(27.6)	11(37.9)	7(24.1)	3(10.3)				29
Delta	–Indirect		1(0.9)	28(25.5)	33(30.0)	31(28.2)	16(14.5)	1(0.9)			110
San Joaquin	–Direct			42(55.3)	24(31.6)	7(9.2)	3(3.9)				76
	–Indirect			54(35.3)	45(29.4)	38(24.8)	16(10.5)				153
Utah	–Direct			3(33.3)	3(33.3)	1(11.1)			2(22.2)		9
	–Indirect	2(3.4)	3(5.1)	26(44.1)	21(35.6)	6(10.2)				1(1.7)	59
Mexico	–Direct		2(2.1)	10(10.5)	17(17.9)	20(21.1)	27(28.4)	8(8.4)	9(9.5)	2(2.1)	95
	–Indirect		6(6.7)	6(6.7)	17(19.1)	29(32.6)	16(18.0)	8(9.0)	3(3.4)	4(4.5)	89
Other	–Direct			2(3.0)	29(43.9)	24(36.4)	8(12.1)		1(1.5)	2(3.0)	66
Flyways	–Indirect			17(12.8)	64(48.1)	36(27.1)	16(12.0)				133
Total	–Direct		2(0.7)	69(23.5)	94(32.0)	62(21.1)	43(14.6)	8(2.7)	12(4.1)	4(1.4)	294
Recoveries	–Indirect	2(0.3)	10(1.7)	137(23.1)	191(32.2)	161(27.1)	75(12.6)	10(1.7)	3(0.5)	5(0.8)	594

* Table does not include all recovery areas.
+ Percent in parentheses

TABLE 12. Distribution of Band Recoveries (percent of recoveries) From 4,161 Adult Male, 7,078 Immature Male, 2,151 Adult Female and 3,715 Immature Female Pintails Banded Preseason at Imperial Valley, 1951–59

	Direct				Indirect +	
Recovery Areas *	*Imm. male*	*Adult male*	*Imm. female*	*Adult female*	*Males*	*Females*
California						
Northeast	1.6	0.4	0.5	–	1.4	1.3
Sacramento Valley	2.3	1.8	1.8	2.9	6.5	3.5
San Francisco Bay-Delta	4.1	3.1	0.9	2.9	12.4	7.0
South Coast	0.2	5.7	3.2	6.9	5.8	5.2
San Joaquin Valley	8.4	9.6	6.3	7.8	13.5	15.9
Inyo-Mono	0.2	0.4	–	–	0.3	0.9
Imperial Valley	60.2	58.3	70.6	62.7	16.3	34.8
Washington	0.2	–	–	–	0.6	1.3
Oregon	0.7	–	–	–	1.3	0.8
Nevada	0.2	–	–	–	0.8	1.7
Utah	1.4	1.3	–	–	5.9	6.5
Arizona	2.3	0.4	1.4	3.0	0.4	1.3
Alberta	–	–	–	–	1.5	3.0
Saskatchewan	0.2	–	–	–	1.3	2.6
Mexico	10.3	7.9	7.7	10.8	9.9	6.9
Central America	0.9	–	0.5	–	0.4	–
Central Flyway	5.9	7.0	4.1	2.9	13.1	5.2
Mississippi Flyway	1.1	1.3	2.3	–	2.9	0.4
Russia	–	–	–	–	0.5	0.9
All Others ≠	–	2.6	0.9	–	5.8	0.6
Total Recoveries	442	228	221	102	798	230

* Table includes data for recovery percentages ≥ 0.7 only. Complete list available from author.
\+ Birds in their second year or older.
≠ Recovery areas with ≤ 0.7.

ROUND-ROBIN MIGRATIONS

Direct and indirect recoveries suggest there were several migration routes converging during preseason banding at Imperial Valley. The main migration route came down through Utah to the Imperial Valley. One segment of the population remained there for the winter, while others continued on. One of these routes out of Imperial Valley accounted for 16.0% of the male and 5.6% of the female band recoveries and was directed toward the Central and Mississippi Flyways (Table 12). Peak months on these two flyways for both direct and indirect recoveries were November and December (Table 11). Thus, the birds were wintering there. Approximately 78% were recovered in Texas and Louisiana.

Another important segment of the population that passes through the Imperial Valley wintered in Mexico. Most of these pintails were recovered during November, December and January in west coast states. Pintails that migrate to Mexico by way of California may return to the Canadian breeding grounds via the Gulf Coast and the Central and Mississippi flyways (Low 1949). This was called a counterclockwise round-robin migration.

There is a possibility that some birds migrated to the Imperial Valley through northern California then returned to the Central Valley for winter. However, the more likely explanation is that the birds came through Utah to the Imperial Valley. From there they broke up into several segments, one of which turned north to the Central Valley. More of the indirect male recoveries from birds banded preseason in Imperial Valley came from the Central Valley (32.4%) than Imperial Valley (16.3%, Table 12). These birds probably arrived in the San Joaquin

Valley after passing through the Imperial Valley prior to the hunting season. Some remained there for the winter while others continued to the San Francisco Bay-Delta and Sacramento Valley. The route these birds took back to the breeding grounds was unknown.

While the counterclockwise round-robin migration has been documented (Low 1949), this report documents a clockwise round-robin migration passing through Utah to the Imperial Valley then up to the Central Valley. Approximately 15% of the immature and 21% of the adult direct recoveries of pintails banded in Imperial Valley were recovered in northern California. Thus the clockwise round-robin migration is important in the California pintail harvest.

If Los Banos banded pintails migrate through Utah then turn west to the San Joaquin Valley bypassing the Imperial Valley, more indirect recoveries would be expected from Utah than were recorded (males 1.1%–females 3.6%, Table 8). However, fall migration probably occurs through Utah and/or northern California before the hunting season, because all of the preseason bandings at Los Banos were completed by the end of August. The scarcity of band recoveries from north and east of California for all California banding stations suggest an early migration.

Pintails wintering in Mexico, Central and South America and along the Gulf Coast by way of the Pacific Flyway, have farther to go than those wintering in the Central Valley, so may start their migration earlier. All 25 recoveries from countries south of Mexico came from bandings in August during the 1950's and none in the 1960's and 1970's when banding was delayed until September.

Honey Lake banded pintails have closer ties to the San Joaquin Valley and the Central and Mississippi flyways than do pintails from other banding stations in northern California. Consequently, some birds migrate through Honey Lake to the San Joaquin Valley and Mexico and/or the Central or Mississippi flyways in a counterclockwise migration.

It is perplexing why pintails banded in August at Los Banos would be recovered in Alaska (2), British Columbia (5), Nebraska (4), and South Dakota (2) in October of the same year. Are these examples of an early, rapid round-robin migration, both clockwise and counterclockwise? As previously discussed, some Imperial Valley pintails follow a clockwise round-robin migration into the Central Valley. Those birds recovered in British Columbia and Alaska could be on a continuation of this route. Baysinger and Bauer (1971) mention an instance of reverse migration of an immature male pintail banded at Sacramento NWR on August 29, 1969, and recovered on October 11, in Alaska. Was this reverse migration or was it another instance of the clockwise round-robin migration? The six pintails recovered in Nebraska and South Dakota in October may have come from Alaska to California then over to the Central Flyway following a counterclockwise migration.

A pintail might winter in the San Joaquin one year and on the Gulf Coast the next and still be within its established migration route. Also, the Central Valley might be regarded as one large wintering area where a bird might winter in the San Joaquin Valley one year and the Sacramento Valley the next. The data suggest that this could have occurred and/or several sub-populations were banded at each station. However, recoveries obtained in this study suggest that most pintails returned to the same wintering area each year.

I assume that those pintails recovered in the north states of the Central and Mississippi flyways migrated from California to these states and then down the flyways. However, some pintails, especially those from the Imperial Valley, may take a more direct route to the Gulf Coast after spending the fall in Imperial Valley. In later years after being banded in California, some pintails may have bypassed California and migrated south in the other flyways.

Some of the following examples could have resulted from reverse or round-robin migrations; an immature male banded at Mountain Meadows on August 16, 1955, and recovered in Idaho on October 11; an immature male banded at Honey Lake on August 15, 1952 and recovered in Alberta on October 13; and an adult female banded at Tule Lake NWR on August 31, 1951, and recovered that hunting season in Alberta. Twenty-seven direct recoveries were obtained in British Columbia and nine in Alaska from banding stations in northern California. Nine direct recoveries were obtained in Utah from Imperial Valley banded pintails. One was an immature male banded September 17, 1954 and recovered 23 days later in Utah. These Utah recoveries could be examples of reverse migration or pintails moving from the Imperial Valley to the north states of the Central Flyway with a stopover in Utah.

CAUSES OF THE WIDE RANGING DISTRIBUTION

The wide ranging migration of males may have resulted from males pairing with females from different breeding grounds. Such males would be recovered on migration routes different from which they were banded. Bellrose (1968) believed that the wide dispersion of recoveries for some species is caused by the mixing of flocks on staging areas before migration. He stated that when flocks combine on staging areas, a small segment of a population may change flight routes and even flyways, thus accounting for a wider dispersal of bands than would seem warranted by the distribution of flight routes. The home range of breeding pintails on the nesting grounds is generally wider than other species of dabbling ducks and males are generally more mobile than females at all stages of the reproductive cycle (Derrickson 1978). These characteristics probably apply on the wintering grounds as well. Immatures, especially males, are more likely to be recovered at distant locations than adults; e.g., all 25 Central and South American recoveries were those of immatures; 7 of 9 recoveries from the South Pacific, Japan and Korea were immatures.

Questions and Conclusions

Two questions remain unanswered: (i) Since the 1950's what has caused pintails to delay their migration to the Klamath Basin? The early migrants could now be overflying the Basin and flying directly to the Central Valley and beyond; (ii) What is causing the downward trend during the past 30 years in band recoveries from Canada as indicated by both Klamath Basin and Gray Lodge bandings? This could have been caused by declining populations in Canada resulting in banding samples containing fewer pintails from Canada, thus declining proportions of recoveries. It also could be due to later opening dates of Canadian hunting seasons or earlier migrations resulting from poor nesting success.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Although much of this report deals with the confusing aspects of pintail migration, e.g., clockwise and counterclock-clockwise migration, reverse migrations, direct recoveries from distance points, etc., they are of comparatively minor significance within the overall pintail migration. The vast majority of pintails migrate directly from staging areas in southeastern Alberta, southwestern Saskatchewan and Alaska to the Central Valley where they spend the winter. All other routes of pintails banded in California are of less importance. However, the continued loss of good marsh and food sources in the Central Valley and Imperial Valley could lead to a loss of pintails from California to other wintering areas, e.g., Texas and Louisiana.

Color marking or biotelemetry of pintails in the Central Valley during the fall and winter would improve knowledge of daily and seasonal movements within this valley and provide data on the size of subpopulation wintering areas.

Because of early migrations of pintails prior to the hunting season, data on migration routes from breeding grounds to California were scarce. Did most of the pintails banded on the coastal stations migrate down the coast from Alaska or were their routes the same as found for birds banded on the inland stations? A telemetry or color marking program on the breeding grounds would improve knowledge on preseason migration routes. A similar marking program in Imperial Valley also would be of value in better understanding round-robin migrations.

Banding stations within the San Francisco Bay-Delta had a higher proportion of local recoveries than other stations in California. If the degree of homing to a particular wintering area could be used as an indication of the desirability to winter on that area, then it could be concluded that the San Francisco Bay-Delta, especially the Suisun Marsh, was the favored wintering grounds for pintails. Unfortunately, banding in this area was conducted only in the 1950's, and there have since been changes in distribution of recoveries in California. Thus, a leg banding program in Suisun Marsh, such as occurred in the 1950's would be helpful in determining what changes have taken place over the past 30 years.

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ANALYSIS OF THE DIETS OF MOUNTAIN SHEEP FROM THE SAN GABRIEL MOUNTAINS, CALIFORNIA [1,2]

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Abstract: **Dietary composition and quality of mountain sheep in the San Gabriel Mountains were determined by microhistological analysis and crude protein determination of fecal pellets. Five browse species together constitute 57% of the dietary makeup on an annual basis: mountain mahogany, *Cercocarpus betuloides,* the major shrub species taken, constitutes from 13.8 to 55.5% of the identifiable plant fragments in every month; California buckwheat, *Eriogonum fasciculatum,* and white sage, *Salvia apiana,* are important dietary components in winter and early spring; holly-leafed cherry, *Prunus ilicifolia,* is utilized most heavily in fall, but is a minor component in all months; silk-tassel bush, *Garrya veatchii,* is most frequently eaten in fall and winter. Grasses are eaten year-round, but are most important as dietary components (21.8 to 39.3%) from April through November. Forbs comprise only 2% of the identifiable food fragments in the diet. Crude protein content of the fecal pellets changes gradually from a high of 20% in April to a low of 9.9% in September.**

INTRODUCTION

Of the populations of mountain sheep, *Ovis canadensis nelsoni,* currently inhabiting the mountain ranges of southern California (Weaver 1982), the largest (mean 660, 1976–1985) occurs in the San Gabriel Mountains, northeast of Los Angeles. In view of the obvious importance of dietary information in the management of the population, the paucity of information on the food habits of the San Gabriel herd is surprising. Although dietary studies of mountain sheep in other locations are available, only three previous food habit investigations pertain to the sheep in the San Gabriel Mountains: Robinson and Cronemiller (1954) provided observational information on feeding preferences of the San Gabriel population on its summer range above 1900 m; Graham (1968) and Weaver et al. (1972) reported on the food habits of the animals on their winter range, based primarily on direct observation. With the exception of an analysis of the stomach contents of a single sheep provided by Graham, none of these authors made any attempt to quantitatively assess the diet.

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The objective of this study was to identify seasonal variation in the composition and quality of the diet of the mountain sheep in the San Gabriel Mountains. To accomplish these goals, we: (i) surveyed the vegetation to obtain a qualitative evaluation of forage availability; (ii) determined forage utilization by means of microhistological analysis of plant fragments in the feces; and (iii) assessed diets quality by determining crude protein content of the fecal material.

STUDY AREA

The study was conducted in the San Gabriel Mountains, Los Angeles County, California. This mountain range, extending approximately 100 km east to west, is bisected by numerous faults, and has many narrow ridgetops and steep eroding cliffs. Elevations range from 200 to 3000 m. Geologically, the mountains are relatively young; soils are rocky and poorly developed (Jaeger and Smith, 1966). Chaparral communities predominate on the lower slopes. At higher elevations there are coniferous forests; alpine communities occur on the highest peaks. Climate is Meditteranean with hot, dry summers and cool, moist winters. Most precipitation occurs from November to March.

The study area is located just southwest of Mt. San Antonio and includes the lower half of Cattle Canyon and the adjacent south-facing slopes of Cow Canyon. The 810 ha area extends in elevation from 900 to 1500 m. Vegetation is primarily chaparral, part of which (Cow Canyon) burned in 1975. The study area, an important winter range of the San Gabriel herd, supports about 130 mountain sheep (Holl and Bleich 1983), many of which are non-migratory animals.

METHODS

Five individual groups of fresh fecal pellets were collected each month. Pellets were collected immediately after defecation. Pellet groups were collected December 1979, January and October through November 1980, and February through September 1981. All samples were from ewe bands, i.e. bands containing fewer than 25% rams; in addition to adult females, the bands sampled included lambs, yearlings of both sexes, and rams.

Fecal pellet groups were air dried in paper bags and frozen in plastic bags. Before analysis, pellets were oven-dried (60°C for 24 h) and weighed. Ten pellets (two from each group) were picked at random from the five monthly samples. These were ground in a Wiley mill through a 20 mesh (1 mm) screen to insure uniform fragment size. The material was then prepared following the procedure of Hansen et al. (1977), and soaked in 60% perchloric acid to separate the epidermis from underlying tissues. Equal amounts of the fecal samples for each month were mounted on five microscope slides in a modified gum syrup medium (Williams 1959).

Plant fragments in the fecal material were identified and quantified as suggested by Sparks and Malechek (1968). On each of the five slides containing each monthly sample, 20 fields were selected randomly. Each of these 100 fields was observed at 100X with a phase-contrast microscope and the frequency of each identifiable plant species recorded. Shrub and forb fragments were identified to species; all grasses were grouped together. From these data the percent relative frequency of each plant species for each slide was calculated. These values were used to compute monthly and seasonal means, and standard deviations from the means, using frequency to density conversion as per Sparks and

Malechek (1968). (Since unidentifiable fragments found in some fields were included in the calculations, the relative percentages for identifiable species do not sum to 100.)

Plant fragments were identified by comparison with a reference collection of 84 plant species collected from the study area. Epidermal peels of leaves, stems, flowers and fruits of each species were taken following the procedure of Mohan Ram and Nayyar (1977), preserved in FAA, and mounted on reference slides. In addition, reference slides were prepared of dried leaves ground and processed in the same manner as were fecal pellets. Photomicrographs of reference slides facilitated comparison with the fecal samples.

A portion of each of the five fecal samples collected each month was analyzed for percent crude protein content using the micro-Kjeldahl method (AOAC 1960) by the Animal Nutritional Testing Laboratories, University of Nevada, Reno.

RESULTS

Browse species comprise 60% of the diet on a yearly basis. Browse is the major dietary component in every month, and in winter (January through March) it makes up more than 80% of the diet (Figure 1). Fourteen browse species were identified in fecal samples (Table 1). Of these, mountain mahogany, *Cercocarpus betuloides*, is the most common forage plant, with an annual percent frequency of 35%; its frequency ranges from 14% in September to over 55% in June. In every month but four (March, April, August, September) it is the most common component of the fecal samples. Four other shrub species, California buckwheat, *Eriogonum fasciculatum*, holly-leafed cherry *Prunus ilicifolia*, white sage, *Salvia apiana*, and silk-tassel bush, *Garrya veatchii*, occur with a frequency of from 5% to 7%. The nine other shrub species identified in the feces have a combined annual frequency value of about 3%.

FIGURE 1. Percent composition of forage classes in the diet of mountain sheep by month.

On an annual basis, grasses consistuted 22.5% in the diet. Grass utilization is highest from April through November and lowest from December through March (Table 1). All forbs together comprise less than 2% of the identified fragments in the pellets.

TABLE 1. Seasonal Means (± Standard deviation) of Fecal Composition Analysis. All Values Are Relative Percent Density (0 = No Individuals Detected). T = Trace (< 1%).

Species	*Season*			
	Winter	*Spring*	*Summer*	*Fall*
Browse				
Cercocarpus betuloides	34. 6 ± 12.8	36.1 ± 16.2	46.6 ± 15.0	23.9 ± 11.0
Salvia apiana	10.6 ± 9.1	10.8 ± 13.6	0	0
Eriogonum fasciculatum	15.2 ± 8.9	12.3 ± 12.7	T	0
Prunus ilicifolia	4.5 ± 5.9	2.1 ± 3.2	6.0 ± 4.6	11.7 ± 5.4
Garrya veatchii	9.4 ± 5.2	1.5 ± 2.1	2.6 ± 2.4	7.7 ± 5.4
Heteromeles arbutifolia	T	T	1.5 ± 1.9	T
Yucca whipplei	T	T	T	1.7 ± 1.9
Rhamnus crocea	T	0	T	1.9 ± 2.5
Encelia californica	0	T	T	T
Ceanothus leucodermis	0	0	T	T
Cercocarpus ledifolius	0	0	T	T
Rhus ovata	T	0	T	T
Rhamnus californica	0	0	T	T
Eriophyllum confertiflorum	0	0	0	5.6 ± 5.9
Leptodactylon californicum	0	T	T	0
Forbs				
Viola purpurea	0	0	T	0
Castilleja affinis	0	0	T	0
Mentzelia laevicaulis	0	0	T	0
Grasses				
all species	9.8 ± 7.5	25.6 ± 15.3	27.9 ± 14.6	28.5 ± 8.6

The occurrence of three of the five major browse species (California buckwheat, white sage, silk-tassel bush) peaks from December through March, when grass utilization is minimal. California buckwheat and white sage are virtually absent from the diet during the remainder of the year, but silk-tassel bush shows another peak of utilization during the fall, particularly the month of September. The fourth major browse species, holly-leafed cherry, is consumed mainly in fall (Table 1).

Some of the minor components of the diet, both forbs and browse, vary seasonally in occurrence. Eriophyllum, *Eriophyllum confertiflorum,* is found in the diet only in September and November; its frequency in those months exceeds 8%. Toyon, *Heteromeles arbutifolia,* and redberry, *Rhamnus crocea,* are eaten most commonly in summer and fall, but are occasionally consumed in winter and spring. Chapparal yucca, *Yucca whipplei,* is utilized irregularly throughout the year in small quantities, but in no month is its percent frequency higher than 2.5%

The maximum protein content of the fecal samples (20%) occurs in April and the minimum (9.9%) in September. From April to September the protein content drops gradually in each month, whereas from September to April it showed a fairly regular rise (Figure 2).

DISCUSSION

Our data indicate that for the mountain sheep population sampled, browse is the predominant dietary component. Grasses are the second most important

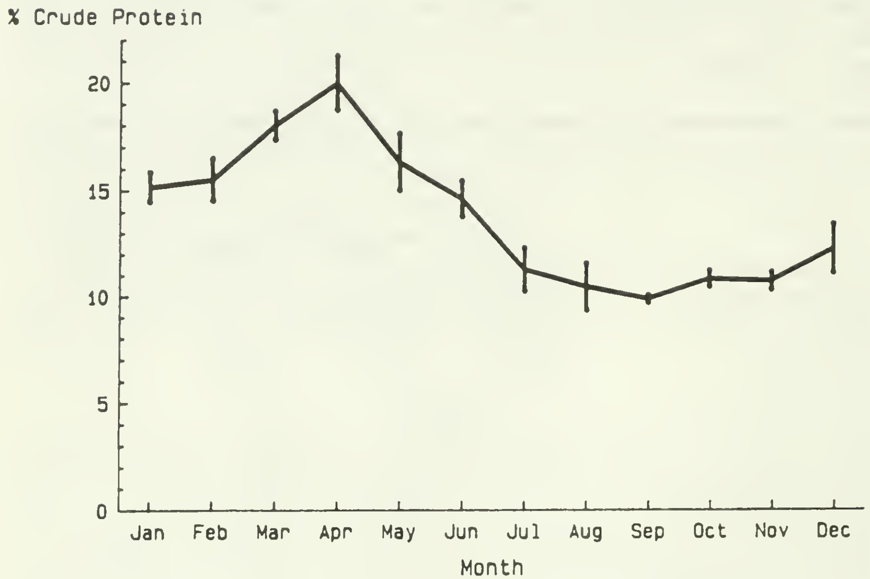

FIGURE 2. Mean percent crude protein (total nitrogen) in the fecal pellets by month (n=5). Bars indicate standard deviations from the mean.

constituent of the diet, but are eaten in only minor quantities in the winter months when what little grass available is dry. Forbs appear in the diet only rarely.

Of the five species of browse that make up the bulk of the food items identified in the feces, mountain mahogany is by far the most common. This plant was estimated to make up only about 6% of the shrub cover in the study site. In every month, however, it had a high frequency of occurrence in the fecal material, from 14 to 55%. It is unknown whether the plant is consumed so commonly because it is "preferred" by the sheep or because the animals spend the bulk of their time on the steepest slopes (escape terrain) where this species is locally abundant. The four other browse species commonly eaten (California buckwheat, holly-leafed cherry, white sage, silk-tassel bush) occur approximately as frequently in the fecal samples as would be expected from their abundance in the environment. All other shrub species identified in the feces appear to be of very minor importance in the diet. Four very common shrub species (chamise, *Adenostema fasciculatum*; yerba santa, *Eriodictyon crassifolium*; manzanita, *Arctostaphylos sp.*; hoary-leafed ceanothus, *Ceanothus crassifolius*), together accounting for about 50% of the shrub cover in the study area, were never recorded in the feces.

Our findings are generally consistent with those reported by others on the diet of the sheep in the San Gabriel Mountains. Graham (1968) reported the stomach contents of a single sheep from the South Fork of Lytle Creek, about 16 km east of our study site and in the same vegetational zone, to be 65% grass and 25% buckwheat with occasional forbs, oak leafage, and acorns. The much higher percentage of grasses than we report may be the result of "sampling error" (a single animal vs several in our study) or because of biases of different analytical techniques. In any case, the presence of large quantities of grass in the stomach is not inconsistent with our findings. Graham did not indicate the season of his sample, but the presence of acorns in the stomach suggests the animal died in the fall, a period when we found grass utilization to be high. Our findings also are generally consistent with the observations of Weaver et al. (1972) that mountain sheep in the Lytle Creek area feed mainly on browse but supplement this with grass and occasional forbs. Robinson and Cronemiller (1954), working at a higher elevation (> 1900 m) on summer ranges, also reported browse to be a preferred food with grasses eagerly sought in spring. The species of browse they reported being consumed differed from those we report, probably reflecting elevational differences. Among the five most frequently utilized species these authors identified were curl-leaf mountain mahogany, *Cercocarpus ledifolius,* and two herbaceous species of buckwheat, *Eriogonum ovalifolium* and *E. umbellatum.*

The diet of mountain sheep in other parts of its range often differs greatly from that of the San Gabriel herd. In Nevada, rumen contents were reported to average more than 65% grasses, about 28% shrubs, and 6.5% forbs (McQuivey 1978). In Death Valley National Monument (Welles and Welles 1961) and in Arizona (Russo 1956), mountain sheep are reported to take browse from trees and shrubs more commonly than grasses and forbs. More recently, however, Ginnett and Douglas (1982) reported browse to be most important among the Death Valley sheep; in their study 55.5% of the forage was browse whereas grasses and forbs constituted only 38.4% and 2.7%, respectively; the proportions of each in the diet varied little with the seasons. On the other hand, Seegmiller and Ohmart (1981) found mountain sheep in the Arizona desert to have a diet of 54% browse, 31% forbs, and 8% grasses on an annual basis. Although the relative importance of each of these forage categories varied seasonally, browse was preferred in summer, fall, and winter whereas forbs predominated in the diet in spring; grasses were taken in low quantities at all seasons.

Although our data suggest that forbs are a very minor component of the diet, it is likely that our estimate of their occurrence is low. Delicate and fragile forbs do not survive the digestive process as well as grasses and shrubs (Free, Hansen and Sims 1970, Slater and Jones 1971, Jacobs 1973, Stewart 1967, Smith and Shandruk 1979), leading to their under-representation in fecal samples. This conclusion is also supported by the visual observations of Graham (1968) and Weaver et al. (1972) that forbs are a significant portion of the diet of the San Gabriel herd.

Although the utilization of mast crops in the San Gabriel Mountains has been documented (Holl and Bleich 1983, Graham 1968), we found no evidence of acorns or other fruits in the fecal pellets. Perhaps such materials do not survive the digestive process in an identifiable state. On several occasions sheep were seen eating the fruits of holly-leafed cherry; none was ever seen eating acorns.

The gradual increase in fecal protein from fall to spring coincides with the southern California rainy season and with the concomitant emergence of annual grasses and the green-up of browse. This suggests that forage quality, specifically available protein, increases during this period and reaches a peak more or less coincident with gestation and lactation, the time of greatest nutritional demand on the ewes (Maynard and Loosli 1969). Without additional data, however, we can not eliminate the possibility that other causes, such as the presence of high concentrations of secondary compounds (e.g. phenolics) and low digestibility (Mould and Robbins 1981, 1982), are responsible for the elevation of fecal nitrogen output.

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REFUTATION OF LENGTHS OF 11.3, 9.0, AND 6.4 M ATTRIBUTED TO THE WHITE SHARK, *CARCHARODON CARCHARIAS* [1]

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The 36.5-foot (11.1 m) length attributed to an Australian specimen of the white shark, *Carcharodon carcharias,* in 1870 is an error. The length determined from the jaws and teeth of this shark in the British Museum (Natural History) is about 17.7 feet (5.4 m). Wood (1982) presented a photograph of a white shark taken in the Azores which he claimed was 29.5 feet (9 m) in length. He also attempted to lend authenticity to a report of a 37-foot (11.3 m) white shark from New Brunswick, Canada, recorded by Vladykov and McKenzie (1935). Evidence is presented herein to refute both of these lengths. The 21-foot (6.4 m) length given for a white shark caught off Cuba in 1945 is also erroneous. From a photograph of the shark, the 44-mm enamel height of an upper jaw tooth, and a vertebral centrum 80 mm in diameter, its length is estimated as about 16 feet (5 m). The largest white shark reliably measured appears to be one from Ledge Point, Western Australia, which was 19 feet, 6 inches (6 m) long. Although it is probable that *C. carcharias* exceeds a length of 20 feet (6.1 m), irrefutable evidence of such a length has yet to be presented.

Few marine animals have had as much written about them as the white shark, *Carcharodon carcharias* (Linnaeus), justifiably the most feared creature of the sea. Paradoxically, very little is known of the habits and biology of this shark. For example, there is no verifiable record of the capture of a female bearing young.[2] We know nothing of the breeding habits, development, number of young in a litter, etc. Also, not all that has been published on this species has been correct. Even something as straight-forward as the total length of specimens has at times been misrepresented in the literature.

Randall (1973) examined the jaws of a white shark from Port Fairy, Victoria, Australia, in the British Museum (Natural History) (Figure 1) which Günther (1870) reported as 36½ feet (11.1 m) in length. Suspecting an error in the length, Randall measured the perimeter of the upper jaw and the vertical height of the enamel of the largest upper tooth (from the tip perpendicular to a line connecting the most ventral extension of enamel on either side). From comparable measurements of jaws and teeth of white sharks at various museums for which authentic total lengths had been obtained, he plotted two graphs: perimeter of the upper jaw against total length and vertical height of the enamel of the largest upper tooth against total length. He then entered the measurements of the British Museum jaw and upper tooth into these graphs and concluded that the true total length of the Port Fairy shark approximated 17 feet, 8 inches (5.4 m). Perry W. Gilbert had also examined the jaws in the British Museum (Natural History) and suggested that there might have been a printer's error, 36½ feet instead of 16½ feet (Gilbert and Gilbert 1973). However, Günther (1880) wrote that the white shark can attain 40 feet (12.2 m); evidently he rounded off the 36½-feet.

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[2] See postscript

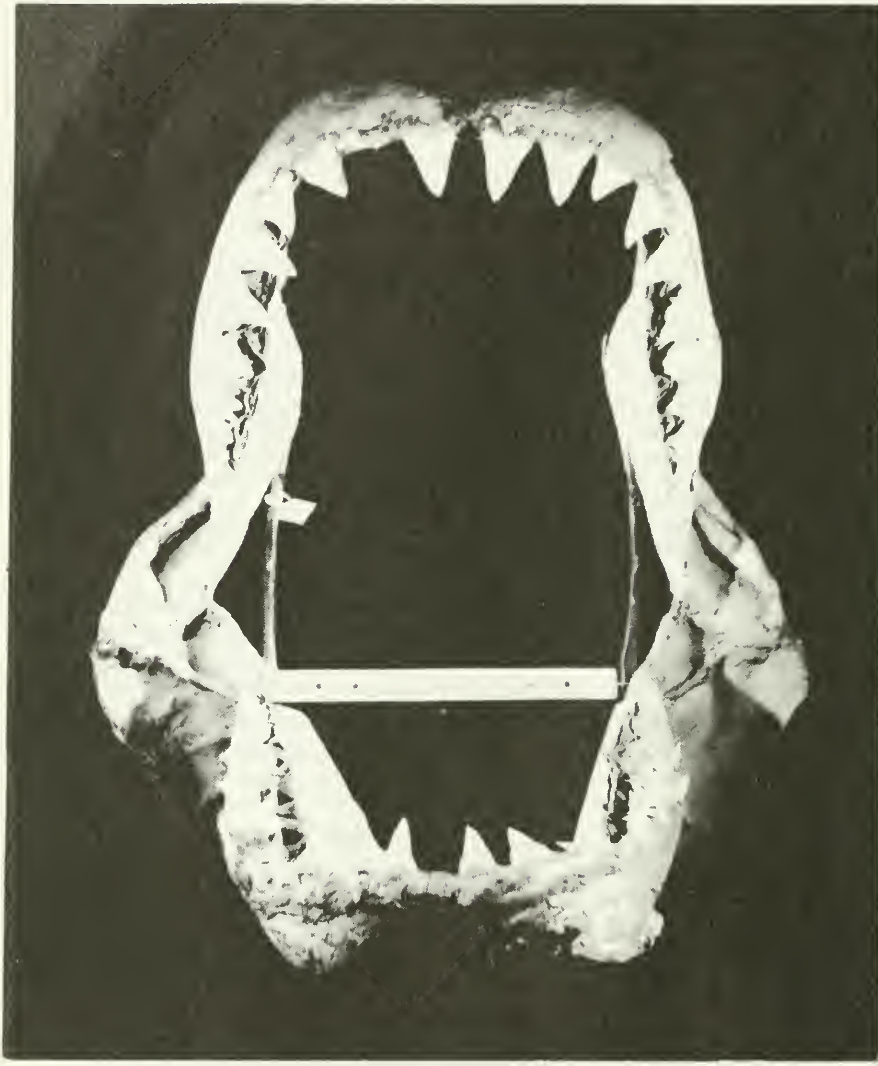

FIGURE 1. Jaws of a white shark from Port Fairy, Victoria, Australia in the British Museum (Natural History). The shark was reported by Günther (1870) to have been 36½ feet (11.1 m) in length, but comparison with other sets of jaws reveals the probable length at about 17 feet, 8 inches (5.4 m).

On 19 April 1974, a letter was received from Gerald L. Wood of Guinness Superlatives asking why the 37-foot (11.3 m) white shark taken in New Brunswick in 1930 (Vladykov and McKenzie 1935) and other records above 21 feet had not been accepted as valid by Randall (1973). I replied that these lengths were obtained from fishermen without verification. No evidence in the form of jaws or teeth or photographs that accurately depict the length of these alleged enormous sharks was given. Mr. Wood was asked to pass on proof he might have of any

C. carcharias in excess of 21 feet (6.4 m), the supposed authentic length given by Bigelow and Schroeder (1948) of a shark caught off Cuba in 1945.

On 24 September 1980, Mr. Wood wrote that he had received a photograph of a white shark caught off San Miguel, Azores, in 1978 "which measured an astonishing 27 feet in length." He included a xerox copy of the photograph. The shark is foreshortened in the photograph, with people standing immediately behind it. It is difficult to judge the length of the shark from the copy, but from the size of the bystanders it does not seem as large as 27 feet. A letter was written to Mr. Wood asking if a print of the photograph might be sent and to inquire if the jaws or teeth were saved. Wood replied that there was an error in the length of the Azores shark; he wrote, "I have since learned that the actual length was 29 feet 6 inches or 9 metres." He added "I will not be able to let you have a print until May 1982, when the 3rd edition of my compilation, *The Guinness Book of Animal Facts and Feats,* comes out. The teeth were purchased by a man living on Terceira, another island in the same group."

Knowing the importance of examining the teeth of this shark and being unable at that time to visit the Azores, I contacted John E. McCosker of the Steinhart Aquarium to see if he might make such a trip. He, in turn, suggested this to Richard Ellis, the author of *The Book of Sharks* (1975). Ellis went to the Azores and made a major effort to find evidence of the landing of a white shark of extraordinary size. Of his visit he wrote, "I had been to three islands in the Azores and had called several others. I had been to the museum (where there was a stuffed 16-foot specimen), the newspaper offices, the harbors, the docks, the bars, the houses. I had drawn pictures of teeth, tried to ask for them in Portuguese and even offered a cash reward to anyone who could produce a big tooth. I came back empty-handed. . . ." (Ellis 1983). Further negative evidence was provided by McCosker who had an announcement printed in the Ponta Delagada daily newspaper requesting information on large white sharks. No responses were received.

The third edition of the *The Guinness Book of Animal Facts and Feats* was published in 1982, and the photograph of the alleged 29.5-foot white shark from the Azores appears on pages 132–133 (reproduced herein as Figure 2). Attention is drawn to the legs and hands of the people standing just behind the shark, relative to the maximum height of the shark. Figure 3 is a photograph of a 16-foot 7-inch (5.1 m) white shark caught off Okinawa. Compare the height of this shark relative to the men standing beside it. It is obvious that the Azores shark could not have been $29\frac{1}{2}$ feet long—indeed probably not over 20 feet—since the Okinawa shark is 16-feet 7-inches long.

Wood (1982) discussed his attempt to authenticate the 37-foot length of a white shark caught in a herring weir at White Head Island, New Brunswick in June, 1930, which was reported by Vladykov and McKenzie (1935). He succeeded in contacting Mr. R. A. McKenzie who stated that Dr. Vadim Vladykov had supplied this record, but added that the shark had not been examined by him; his information had been secondhand. Wood wrote, "Would the Canadian ichthyologist [Vladykov], a man of high reputation, have included heresay data unless he was positive it was accurate?" Wood's attempts to contact Vladykov "proved fruitless." I also tried to communicate with Vladykov (who has since

FIGURE 2. White shark caught off the Azores reported as 29½ feet (9 m) in length by Wood (1982).

FIGURE 3. A 16-foot, 7-inch (5.1 m) white shark caught off Okinawa (Kyodo News Service Photo).

died), but failed; however, Dr. Don E. McAllister, National Museum of Natural Sciences, Ottawa, Canada, did so on my behalf and wrote (11 July 1984), "Vadim remembered the record. He did not see the specimen and said the fisherman had provided the length measurement. He did recall that the fisherman had given him two teeth and that he still had them." Only one tooth was supplied which Vladykov said was from the White Head Island specimen. On the back of the tooth is written "1936" which is not the date of collection although it is the date of publication. A xerox copy of the tooth was sent to me, along with its enamel height of 28 mm. From the size and shape of the tooth and its height relative to its width (width of enamel at base 1.2 in height of enamel in midline), one can ascertain that it is from the front of the lower jaw. Comparing this with lower front teeth in white shark jaws in the collection of the California Academy of Sciences, I conclude that it came from a shark of about 16 to 17 feet in length (5.0–5.3 m).

Therefore we again return to the 21-foot length given by Bigelow and Schroeder (1948) for the shark caught off Cojimar, Cuba, in 1945 as the largest reported in the scientific literature. However, even this length is incorrect. Guitart and Milera (1974) illustrated this shark with numerous people standing just behind it; one man is leaning over with the hands of his outstretched arms on the back of the shark just in front of the first dorsal fin. If one compares the relative height of these people and the Cuban shark to those standing by the Okinawa shark, the latter shark seems larger. An upper jaw tooth from the Cuban shark (presumably a large one from the front of the jaw) is figured beside a millimeter scale by Guitart and Milera; from this an enamel height of 44 mm may be determined. Such a tooth size is found in a shark of about 16 feet (4.9 m) in length. A vertebral centrum from the shark was also illustrated; it was measured as 80 mm in diameter and 37 mm in width. If this centrum was taken from under or anterior to the first dorsal fin, the regression of vertebral centra given in Cailliet et al. (1985) would indicate a shark length of 16 feet 4 inches (5 m). The weight of the liver of this shark was given as 1,005 pounds (456 kg). The total weight of the shark was estimated by fishermen at 7,000 pounds (3,175 kg). A shark of this size, however, would have had a liver much heavier than 1,005 pounds (John Hewitt, Steinhart Aquarium, pers. comm.).

Curiously, the point representing the 21-foot length and 7,000-pound weight of the Cuban shark fits well at the upper end of the length-weight curve for *C. carcharias* given by Tricas and McCosker (1984:224). It seems that the exaggerated length and the estimated weight were of the same order of magnitude.

Bigelow and Schroeder (1948) reported the second largest white shark (after the "21-footer") "actually measured" was 19 feet in length, but they gave no locality or other details on the shark. They added, "We should perhaps caution the reader that estimates of the size of the larger sharks are frequently much too high; e.g., an Australian specimen, reported in the local newspapers as 16 feet long, actually measured only eight feet six inches."

In recent years Dr. Gordon Hubbell of Key Biscayne, Florida has been keeping records of the length of large white sharks, the perimeter of their upper jaws and the perpendicular height of the enamel of the largest upper teeth. His largest record is a 19-foot 6-inch (6 m) female caught at Ledge Point, Western Australia on 22 March 1984. The perimeter of its upper jaw is 130 cm and the height of the enamel of the largest upper tooth 51 mm.

Undoubtedly *Carcharodon carcharias* exceeds 20 feet (6.1 m) in length, but as yet there is no authenticated record of such a size.

If a large white shark is captured, particularly if it is larger than 19 feet, 6 inches, every effort should be made to properly document its size. A horizontal measurement should be carefully taken from the tip of the snout to the end of the upper lobe of the caudal fin. This is the straight-line distance, not the curved measurement over the surface of the body. The girth might also be measured. A photograph should be taken with the shark perpendicular to the direction of the camera and something such as a meter stick or yard stick set on the back of the shark. The jaws with the teeth intact and some vertebrae should be saved and deposited in a major museum. The height of the enamel of the largest upper-jaw tooth and the perimeter of the upper jaw should be measured. The vertebrae should be taken from beneath or anterior to the first dorsal fin. If possible, the total weight of the shark should be accurately measured before it is cut open. It would be of interest to obtain the weight of the liver separately. Also any prey animals in the stomach should be weighed, and their weight subtracted from the total. If one wishes to make the many different measurements of the body and fins of a shark, see the diagrams of Compagno (1984).

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Postscript—In a symposium entitled "The Systematics, Ecology and Physiology of Elasmobranchs" held at the University of Tokyo, 17–18 March 1987, S. Uchida of the Okinawa Expo Aquarium reported on the capture on 2 April 1986 of a female of *C. carcharias* off Wakayama, Japan which was about 470 cm total length. It contained seven nearly full-term embryos about 100–110 cm total length. Unfortunately, neither the mother shark nor the embryos were retained. Uchida has prepared a manuscript on this discovery which will feature a photograph taken by I. Wakabayashi of the female and its embryos.

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REPRODUCTIVE RHYTHMICITY OF THE ATHERINID FISH, *COLPICHTHYS REGIS*, FROM ESTERO DEL SOLDADO, SONORA, MEXICO[1,2]

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ABSTRACT

The reproductive rhythmicity of the atherinid fish, *Colpichthys [c.f. Atherinops] regis* (Jenkins and Evermann 1889), was observed in the Estero del Soldado, Sonora, Mexico during October 1982 through January 1983. Spawning runs occurred at approximately two week intervals during daytime high tides. These high tides coincided with new and full moons. Spawning only occurred when predicted tidal heights were $\geq$0.73 m above MLW. Eggs were deposited in the upper intertidal zone in locations that appeared to provide protection from predators, thermal stress and desiccation.

INTRODUCTION

Fortnightly reproductive rhythms have been identified in several intertidally spawning atherinid fishes. The best known of these is the California grunion, *Leuresthes tenuis,* which is found along the Pacific Coast from Monterey Bay, California to Bahia Magdalena, Baja California Sur (Moffatt and Thomson 1978). Spawning runs of *L. tenuis* occur from February through August (Clark 1925; Walker 1952). Females deposit eggs in sand on nighttime high tides, just after the highest high tides during each semi-lunar period (Shepard and LaFond 1940; Middaugh, Kohl and Burnett 1983). The Gulf grunion, *Leuresthes sardina*, also has a fortnightly spawning periodicity and deposits its eggs in sand. Spawning occurs from January to May in the northern Gulf of California. Due to a shift in the time of high tides that occurs between January and May, the Gulf grunion spawns during nighttime in the early part of the reproductive season and in daytime towards the end of the season (Thomson and Muench 1976).

The Atlantic silverside, *Menidia menidia*, with a range from the Magdalen Islands, Quebec, Canada to northern Florida (Cox 1921; Johnson 1975), is a rhythmic spawner that deposits eggs on vegetation in the upper intertidal zone during daytime high tides from March through July (Middaugh, Scott and Dean 1981). Maximum intensity spawning runs occur on days just after new and full moons (Middaugh 1981).

The precise role of environmental variables in the observed spawning rhythms in these atherinid fishes is not fully understood, nevertheless, each exhibits a "lunar periodicity". Our study of the false grunion, *Colpichthys [c.f. Atherinops]*

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regis (Jenkins and Evermann 1889)*, an atherinid fish occurring in the northern Gulf of California, was conducted to determine if this species also demonstrates a reproductive rhythmicity and to elucidate the potential influence of environmental variables on the timing and location of spawning runs within a small estuary ("estero") on the coast of Sonora, México.

MATERIALS AND METHODS

Study Area

Observations were made at a site known locally as Estero del Soldado (Lat. 27° 57′ 31″ N, Long. 110° 59′ 00″ W), located between the city and port of Guaymas, and San Carlos, a small community ca. 19 km WNW of Guaymas, Sonora, México. The estero is in a crescent-shaped (horns pointing south) low-lying area whose northern boundary is an interrupted arc of hills and low mountains that extends from slightly west of San Carlos to the eastern side of the estero.

Two parallel and interdigitating zones of low-growth mangrove trees form a narrow fringing forest (Lugo and Snedaker 1974) around the estero from south to west. At the water's edge, the zone is composed of red mangroves, *Rhizophora mangle.* A band of black mangroves, *Avicennia germinans*, is generally located landward of the red mangroves. Shoreline substrate is composed of reddish-brown marine clays with abundant bryozoan remains and *Chione* shells backed by sand. As water depth increases, the substrate changes to brownish-black, foul-smelling silts and sands.

Observations on the reproductive habits of *C. regis* were made in the upper reaches of the westward most arm of the estero at two stations; the first in a small stand of red mangroves, the second in a nearby man-made pile of tile rubble slightly higher in the intertidal zone at the base of a small stand of black mangroves.

Environmental Measurements

All environmental measurements were taken daily between 0700 and 0900 hrs. During October 1982 through March 1983, salinity was measured to the nearest 0.2 ‰ for samples collected at station 1 (Strickland and Parsons 1968). Water temperature was determined with an immersion thermometer and dissolved oxygen was measured by the modified Winkler Procedure (American Public Health Association 1975).

Tidal predictions (times and heights in meters for Guaymas) used in our analyses were taken from Universidad Nacional Autónoma de México (UNAM), Instituto de Geofísica, "Tables de Predicción de Mareas, Puertos del Océano Pacífico" (1982, 1983).

Biological Observations

The reproductive periodicity of *C. regis* was determined by one of us (GAR) watching the spawning sites daily (0600–1100 h) from 18 October 1982 through 9 March 1983. Synoptic observations during October through April of 1979–1981 revealed that *C. regis* only spawned in the upper intertidal zone on

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**Note on the genus taxonomy*: The original describers of the species placed it in the genus *Atherinops* [Jenkins, O.P., and B.W. Evermann 1889., Proc. U.S. Natl. Mus., Vol. 11 (for 1888):138–139). C.L. Hubbs [Proc. Acad. Nat. Sci. Phila., 1918, Vol. 69 (for Oct.—Nov. 1917):67] thought the species distinctive enough to erect a new genus (*Colpichthys*) to contain it. Recent evidence on the biochemical systematics of the atherinids suggests that *regis* may belong in the genus *Atherinops*.

morning high tides. No reproductive activity was observed at other times or locations within the area of the stations. Because it was difficult to accurately assess the intensity of each run (number of fish involved), we scored daily observations as 0—no run observed; or 1—spawning observed. This conservative approach was used because Binkley (1973) has shown that loss of amplitude (in this case, the number of fish in a spawning run) has little effect on time series observations. When a spawning run was observed, the time that the run began was noted. The time when a run ended was also recorded on several occasions. For ease in analysis and reporting, clock times were converted to decimal hours (i.e. 0630 = 06.50 h). All statistical analyses were conducted using programs provided in the SAS Institute Inc. User's Guide (1982).

RESULTS AND DISCUSSION

Reproductive periodicity.—Spawning runs in *Colpichthys regis* occurred on daytime high tides between 07.08 and 10.13 hrs. The runs coincided with the fortnightly occurrence of tides of maximum height during the approximate time of new and full moons (Figure 1). During spawning runs, the mean water temperature was 13.7°C (range 10.5–16.5); salinity 36.2‰ (35.4–36.9) and dissolved oxygen 5.6 mg/L (4.1–6.0).

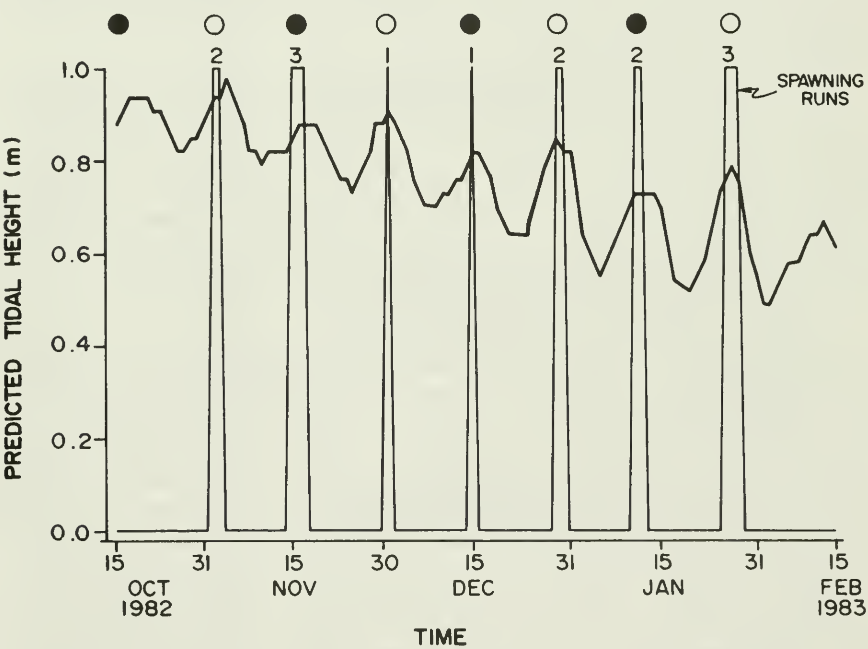

FIGURE 1. Reproductive periodicity in *Colpichthys regis*. Values above each peak in spawning runs indicate the number of days runs occurred. Predicted tidal heights (m) are for daytime high tides. Open circles = full moons, closed circles = new moons.

After observing several spawning runs, it became apparent that at least two factors influenced spawning by *C. regis*. The first was occurrence of tides of sufficient height to make the spawning substrates available. Spawning only occurred on days when predicted tidal heights were $\geq$ 0.73 m above mean low water (MLW) and when these high tides occurred between 07.08 and 10.13 h (Table 1). Secondly, an increase was noted in the delay between the predicted (for Guaymas) and observed (for Estero del Soldado) times of high tide with increased tidal heights (Table 1). A non-parametric Spearman rank correlation test was conducted to determine if a correlation existed between the predicted tidal height vs. the delay between predicted and observed times of high tide. There was a significant positive correlation ($r=0.63$, $P=0.015$) between tidal height and delay between predicted and observed times of high tide. We attribute this significant correlation to hydrological conditions at the mouth of the estero. Water must flood and ebb from the estero through a restricted channel that is only 76 m wide at the highest tide and 15 m wide at low tide. In contrast, the total surface area of the estero is 1.43 km^2. Tides at the estero entrance continue to flood for at least one hour after the predicted time of high tide for Guaymas and may ebb for up to two hours after the predicted time of low tide (UNAM, Instituto de Geofísica "Tablas de Prediccion de Mareas . . . ," 1982, 1983).

A paired comparison T-test for differences between predicted and observed times of high tide revealed a significant difference ($P=0.01$) for the two variables. However, a check of Table 1 shows that the observed times of high tide in the estero and observed onset of spawning runs are nearly identical. A paired comparison T-test of observed times for high tides and the time of spawning runs showed no significant difference ($P=0.15$).

The precise timing of spawning runs to coincide with high tide has been noted in other intertidally spawning atherinid fishes. Atlantic silversides, *Menidia menidia,* from the North Edisto River estuary in South Carolina spawn within a narrow range of intertidal elevations (1.4 to 2.4 m above MLW) and depend on tides of sufficient height to inundate intertidal spawning substrates (Middaugh and Takita 1983). In contrast, *M. menidia,* in Salem Harbor, Massachusetts generally spawned during ebb tides with spawning activity occasionally continuing for up to 2.5 hours after high tide. Spawning usually occurred in water 1 cm or less in depth (Conover and Kynard 1984).

Colpichthys regis always spawned in very shallow water. Indeed, individuals spawned at station 1 as long as their bodies could be exposed to the atmosphere while egg deposition and fertilization occurred. As the water level rose, spawning fish sometimes moved to station 2 (rubble pile) which was slightly higher in the intertidal zone. This behavior indicates that *C. regis* spawns as high as possible in the intertidal zone. The 3.0 mm diameter eggs were deposited in succulent vegetation growing at the base of black mangroves. Eggs deposited over the pile of loose rubble and broken ceramic tiles generally sank into cracks and crevices where they were apparently protected from desiccation and thermal stress.

On one occasion *C. regis* was observed spawning in the entrance of an apparently abandoned crab burrow at the water's edge. As the tide receded, fertilized eggs were found 2 to 3 cm deep in the crab burrow. The high tide on this day failed to reach the usual spawning substrates. It seems likely that the crab burrows would provide some protection from environmental stresses. Indeed, Middaugh et al. (1981) observed that another atherinid fish, *M. menidia,* utilized abandoned crab burrows along erosional scarps as a spawning substrate.

TABLE 1. Predicted tidal height in meters and time of high tide (HT) for Guaymas, Mexico taken from UNAM, Instituto de Geofísica—Tablas de Prediccion de Mareas (1982, 1983), and observed times of high tide and onset of spawning runs for *C. regis* at Estero del Soldado.

Date	*Predicted tidal height*	*Predicted time of HT*	*Observed time of HT*	*Delay (h)*	*Observed onset of run*	*Observed end of run*
11/3/82	0.94	08.60	10.13	+1.53	10.13	–
11/4/82	0.94	08.50	09.08	+0.58	09.08	–
11/16/82	0.85	07.88	09.32	+1.44	09.32	–
11/17/82	0.88	07.88	09.00	+1.12	08.50	–
11/18/82	0.88	08.10	08.57	+0.47	08.57	–
12/2/82	0.91	07.93	08.88	+0.95	08.55	–
12/16/82	0.82	07.60	08.70	+1.10	08.83	–
12/30/82	0.85	07.82	07.82	0.00	07.82	09.00
12/31/82	0.82	08.18	07.82	−0.36	07.08	08.70
1/12/83	0.73	07.10	07.20	+0.10	07.27	09.00
1/13/83	0.73	07.50	07.37	−0.13	07.27	07.56
1/27/83	0.76	07.50	07.67	+0.17	07.75	–
1/28/83	0.79	08.32	08.10	−0.22	07.68	09.00
1/29/83	0.76	09.00	09.28	+0.28	09.50	09.60

Colpichthys regis spawned on days when tides of maximum height occurred during new and full moons. The substrates where eggs were deposited are highly stable and exist in a low energy intertidal environment with little influence of wave action. In contrast, both *L. tenuis* and *L. sardina* spawn 3 to 4 days after new and full moons, and after the occurrence of maximum tidal heights. This delay in spawning helps to ensure that the decreasing tidal series deposits sand over incubating embryos (Shepard and LaFond 1940; Middaugh et al. 1983), thus providing protection from predation (Walker 1952), desiccation and thermal stress (Thompson and Thompson 1919; Middaugh et al. 1983). It also ensures that eggs will not be washed from substrates until the next series of high tides, 10 to 14 days after they are spawned (Walker 1952).

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COMPARISON OF MERISTIC AND MORPHOMETRIC CHARACTERS AMONG AND WITHIN SUBSPECIES OF THE SACRAMENTO SUCKER (*CATOSTOMUS OCCIDENTALIS* AYRES)[1, 2]

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ABSTRACT

Meristic and morphometric characters were analyzed to compare differences among and within Sacramento sucker (*Catostomus occidentalis*) subspecies: *C. o. occidentalis* (Sacramento sucker), *C. o. lacusanserinus* (Goose Lake sucker), *C. o. humboldtianus* (Humboldt sucker), and *C. o. mniotiltus* (Pajaro sucker). Meristic characters were compared by two cluster analysis techniques. Neither clustering technique distinguished between any of the subspecies. Separate analysis of scale counts showed that Pajaro suckers differed significantly from other populations. There were no significant differences among other populations. Based on comparison of morphometric characters, discriminant analysis grouped most Sacramento sucker specimens into their actual populations, separating even those of the same subspecies. Variability among and within Sacramento sucker populations was examined. In many cases, variation within subspecies was as great as that among subspecies, and therefore subspecific designation of most Sacramento sucker populations is not warranted. Only the Pajaro sucker may warrant subspecific status.

INTRODUCTION

The status of the Sacramento sucker (*Catostomus occidentalis* Ayres) and its subspecies has long been confused. The four currently recognized subspecies of *C. occidentalis* are: *C. o. occidentalis* Ayres, Sacramento sucker; *C. o. humboldtianus* Snyder, Humboldt sucker; *C. o. lacusanserinus* Fowler, Goose Lake sucker; and *C. o. mniotiltus* Snyder, Pajaro sucker. The common name Sacramento sucker is used herein for the *C. occidentalis* complex as recognized by Robins et al. (1980). This species constitutes a major portion of the catostomid fauna of central and northern California (Moyle 1976) (Figure 1). *C. occidentalis* was described by Ayres (1854) from San Francisco fish markets; Ayres' type was known as the Sacramento sucker. The Humboldt sucker was described as a new species, *C. humboldtianus,* by Snyder (1908). Fowler (1913) described the Goose Lake sucker from one specimen, and determined that it and the Humboldt sucker were two subspecies of the Sacramento sucker. The Pajaro sucker was described by Snyder (1913) as a new species, *C. mniotiltus.* It has since been relegated to subspecific status (Moyle 1976, Lee et al. 1980). Burns (1966) listed only the Sacramento and Goose Lake suckers as separate subspecies. Eddy (1969) reported many subspecies to be widespread throughout central Califor-

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nia. Lee et al. (1980) listed the four subspecies studied here, but described them as poorly defined with the validity of all subspecies questionable. Moyle (1976) recognized the four subspecies studied here, but cited the need for a thorough systematic review.

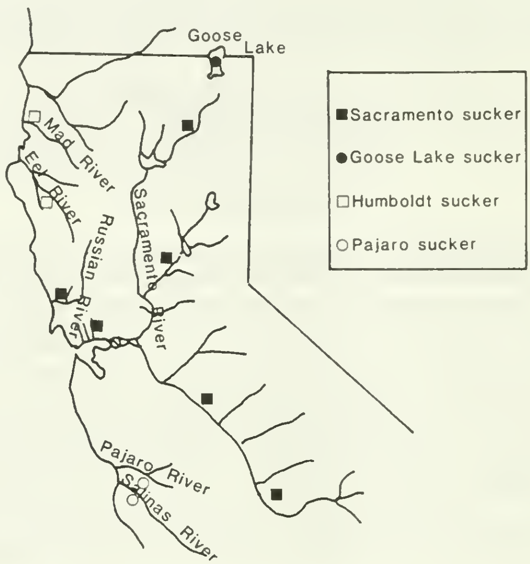

FIGURE 1. Map of northern California and southwestern Oregon showing distributions of *Catostomus occidentalis*. The river or lake system of each population studied is labeled.

The very use of the term subspecies as an evolutionary lineage has also been confused and controversial. A subspecies has been defined as "an aggregate of phenotypically similar populations of a species, inhabiting a geographic subdivision of the range of a species, and differing taxonomically from other populations of the species" (Mayr 1969). The degree of taxonomical difference used to delineate subspecies has varied. Wilson and Brown (1953) called for the abandonment of the subspecies trinomial and its replacement by a system of reference based on relevant geographical names.

This study involved analysis of adult and juvenile characters to identify and compare subspecies. Emphasis was placed on comparison of meristic characters because morphological features of suckers may differ between sexes. Cluster analysis, scale count comparisons and discriminant analysis were used to examine relationships within *C. occidentalis*. Relatively few taxonomic studies involving catostomids have used multivariate statistical techniques. Ferris and Whitt (1978) used cluster analysis based on phenetic similarities to determine relationships between 30 species of catostomids. Smith and Koehn (1971) did phenetic and cladistic studies on 16 species of catostomids. Fuiman (1978) described and compared five species of catostomid larvae, and used discriminant analysis to help create a taxonomic key. No studies using multivariate analysis to examine systematic relationships within a species have been published.

MATERIALS AND METHODS

Collection

Humboldt suckers were collected from the Eel and Mad Rivers, Sacramento suckers from the Sacramento and Russian River systems, and Pajaro suckers from the Pajaro and Salinas River systems. Goose Lake suckers are known to occur only in Goose Lake and its tributaries and were collected at Goose Lake. Humboldt suckers from the Eel River were collected in 1982 by seining. The remaining specimens were examined from collections housed at the California Academy of Sciences, San Francisco, California (CAS), and the Vertebrate Collection, Sacramento State University, Sacramento, California (SSU). Two populations of each fish type were studied when possible so that differences among subspecies could be compared to differences within each subspecies.

Specimens Examined

Catostomus occidentalis occidentalis: CAS 22873, 14 (125–321), Webber Creek, El Dorado Co.; CAS 22947, 19(189–344), American River, Sacramento Co.; CAS 26946, 1(135), Indian Creek, Plumas Co.; CAS 25452, 2(190–214), Feather River; CAS 14205, 14(160–376), Cache Creek, Yolo Co.; CAS 81426, 1(234), Russian River; CAS 21958, 2(165–287), Russian River; CAS 21127, 21(109–265), Russian River and Sulpher Creek; CAS 37013, 6(124–290), Dry Creek; CAS 21187, 1(305), Russian River; CAS 37014, 6(156–312), Russian River; CAS 21100, 2(210–234), Russian River; CAS 21118, 3(123–321), Russian River; CAS 21108, 2(176–189), Russian River; CAS 21192, 6(189–243), Russian River. *Catostomus occidentalis lacusanserinus:* CAS 48409, 4(154–290), Goose Lake; CAS 48410, 7(134–305), Goose Lake; CAS 37011, 11(176–275), Goose Lake; SSU 138-1, 4(134–211), Goose Lake; SSU 148-1, 14(42–205). *Catostomus occidentalis mniotiltus*: CAS(SU) 58372, 2(134–148), Pajaro River; CAS(SU) 24056, 1(150), Pajaro River; CAS(SU) 15125, 4(36–47), Pajaro River; CAS(SU) 37053, 28(54–87), Pajaro River; CAS(SU) 15151, 5(46–51), San Benito River; CAS(SU) 15107, 40(39–73), Arroyo Seco Creek. *Catostomus occidentalis humboldtianus*: HSU, 46(275–362), Eel River; CAS 18031, 1(68), Mad River; CAS 18036, 10(37–42), Mad River; CAS 18009, 7(36–44), Mad River.

Examination

Eleven meristic characters were enumerated for each specimen: lateral line scales (LLS), scales above the lateral line (SALL), scales below the lateral line (SBLL), scale rows before the dorsal (SRBD), papillae rows on the upper lip (ULP), papillae rows on the lower lip (LLP), papillae rows on the lower lip uninterrupted by the median cleft (UPR), and dorsal (D), anal (A), pectoral (P1), and pelvic fin rays (P2).

Morphometric characters were compared using data from specimens studied, data published by previous authors, or a combination of both. Morphometric characters included head length (HL), snout length (SNL), eye diameter (ED), interorbital width (IW), pre-dorsal length (PDL), dorsal base length (DBL), and anal base length (ABL). Measurements were given as a percentage of standard length (SL). All counts and measurements were made on the left side (where applicable) following the definitions given by Hubbs and Lagler (1958). Measurements greater than one millimeter were made with dial calipers and those less than one millimeter were made with a dissecting microscope equipped with an ocular micrometer.

Data Analysis

Meristic characters were analyzed using cluster analysis because they showed less variation within populations than morphometric characters (especially variation due to fish size and sex). They were also more easily and effectively measured. Meristic characters were compared by two cluster analysis techniques to ensure that resulting classifications were independent of technique bias. Each technique was divided into two parts: calculation of a matrix of distances between specimens, and a method to separate specimens into groups or clusters. The number of groups found by cluster analysis may vary with differing separation methods. The separation methods used here were Ward's method and single linkage clustering (Green 1978, Wishart 1979). In both cases the distance matrix was calculated using Euclidean distance (Green 1978). Data were standardized so that each character was weighted equally (Wishart 1979). Results from each technique were compared and displayed in a dendrogram. Populations were considered to exhibit subspecific differences if 84% of the specimens were grouped separately from all other specimens (Hubbs and Perlmutter 1942).

Scale counts of Sacramento sucker populations were also compared by the graphic methods of Hubbs and Perlmutter (1942) and Hubbs and Hubbs (1953). Each character was compared separately. Differences in scale counts were compared to differences that "are approximately of the order that may be utilized for subspecific separation" (84%) (Hubbs and Perlmutter 1942).

Least squares linear regression (Ott 1977) was used to determine if morphometric characters were correlated with SL. Morphometric characters that showed little or no correlation to SL ($|r| < 0.7$) were analyzed using discriminant analysis (Green 1978). The discriminant analysis procedure computed discriminant functions for classifying specimens into groups based on morphometric variables.

RESULTS

Most meristic and morphometric characters were extremely variable among and within Sacramento sucker populations (Tables 1 and 2). Neither clustering technique distinctly separated the populations based on meristic characters. Specimens from each population were distributed throughout the groupings formed by Ward's method (Figure 2). Although Pajaro and Salinas River specimens accounted for over 90% (36 of 41) of one of the groupings, these specimens accounted for less than 50% (36 of 74) of the total Pajaro and Salinas River specimens. Furthermore, this group was more similar to a group in which Pajaro and Salinas River specimens accounted for only 12% (six of 50) of the total than to a group in which they accounted for 76% (22 of 29). In no case did 84% of the specimens from a population or subspecies account for 84% of a grouping. Other than Pajaro suckers, there was no case in which even the majority of the specimens from one subspecies or population formed the majority of a grouping. Single linkage clustering placed most specimens into one group (Figure 3).

TABLE 1. Meristic Character Value Means of Western Sucker Populations. Ranges Given in Parentheses.

Character	*Sacramento River*	*Russian River*	*Goose Lake*	*Eel River*	*Mad River*	*Pajaro River*	*Salinas River*
	n=50	n=50	n=40	n=46	n=17	n=40	n=40
Lateral Line	69.3	68.1	68.6	66.1	67.6	62.4	61.6
Scales	[62-76]	[64-73]	[62-77]	[62-74]	[64-72]	[60-65]	[58-65]
Scales Above	14.1	14	13.9	13.2	13	12	12
Lateral Line	[13-17]	[13-15]	[12-16]	[12-14]	[12-14]	[11-13]	[11-13]
Scales Below	10.1	9.4	10	9.8	9.6	8.8	9
Lateral Line	[9-12]	[8-11]	[8-12]	[9-11]	[9-10]	[8-10]	[8-10]
Scale Rows	31.7	32.5	31	31.8	30.2	26.9	25.9
Before Dorsal	[27-36]	[31-35]	[27-36]	[28-36]	[28-32]	[24-29]	[24-29]
Dorsal Rays	12.2	12.2	11.8	11.8	12.1	12	11.8
	[11-13]	[12-13]	[11-13]	[11-13]	[11-13]	[11-14]	[11-13]
Anal Rays	7	7	7	7	7	7	7
Pectoral	17.4	17.2	17.2	17.4	17.7	17.6	17.4
Rays	[16-18]	[16-18]	[16-18]	[17-18]	[17-18]	[17-18]	[17-18]
Pelvic Rays	9.9	9.9	9.8	10	10.1	10.3	10.3
	[9-11]	[9-10]	[9-10]	[9-11]	[10-11]	[10-11]	[10-11]
Upper Lip	5.5	5.4	5.2	5.4	5.5	5.1	5.2
Papillae	[5-6]	[5-6]	[5-6]	[5-6]	[5-6]	[5-6]	[5-6]
Lower Lip	4.9	4.9	5	5	5	4.9	5
Papillae	[4-5]	[4-5]				[4-5]	
Uninterupted Papillae Rows	1	1	1	1	1	1	1

TABLE 2. Morphometric Character Value Means of Sacramento Sucker Populations, Given as Percentage of Standard Length. Ranges Given in Parentheses.

Character	Sacramento [a] *River*	*Russian* [a] *River*	*Goose Lake*	*Eel River*	*Mad River*	*Pajaro River*	*Salinas River*
	n=16	n=10	n=40	n=46	n=17	n=40	n=40
Head	23.9	25.1	24.1	23.9	26.9	26.9	27.4
Length	[23-25]	[24-27]	[22-26]	[22-26]	[24-29]	[22-29]	[25-29]
Snout [b]	11.6	11.9	9.6	11.2	9.8	9	8.7
Length	[10-13]	[11-13]	[8-13]	[9-13]	[8-11]	[6-11]	[7-10]
Eye [b]	4.3	4.9	4.7	3.3	6.7	5.5	6.5
Diameter	[4-5]	[4-6]	[4-7]	[3-4]	[6-8]	[4-8]	[5-8]
Interorbital	10	9.6	10.7	10.1	10.6	10.7	10.5
Width	[9-11]	[9-10]	[10-12]	[9-11]	[10-11]	[10-12]	[9-12]
Pre-dorsal	50.9	52.3	48.2	49.6	48.8	51	51.7
Length	[49-53]	[51-53]	[46-51]	[47-52]	[47-52]	[47-54]	[48-55]
Dorsal Base	16.7	18.4	16.5	14.5	17.5	16.3	16.2
Length	[15-19]	[17-20]	[15-18]	[12-16]	[16-19]	[14-19]	[14-18]
Anal Base [b]	7.9	8.4	7.9	7.3	6.6	7.8	6.9
Length	[7-9]	[7-9]	[6-10]	[6-8]	[5-8]	[6-11]	[6-8]

[a] From Snyder (1908)
[b] These characters showed strong correlation to standard length ($|r| > 0.7$) and were not analyzed further.

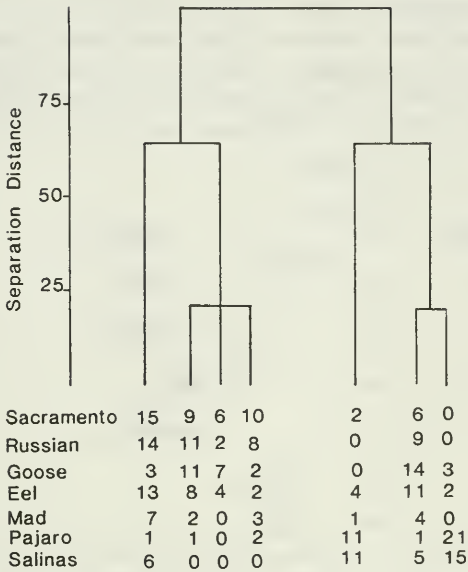

FIGURE 2. Dendrogram of cluster analysis using Ward's method and Euclidean distance to group *Catostomus occidentalis* specimens based on meristic characters. Separation distance is the percent of the Euclidean distance between least-alike specimens. Number of specimens per grouping from each population is listed.

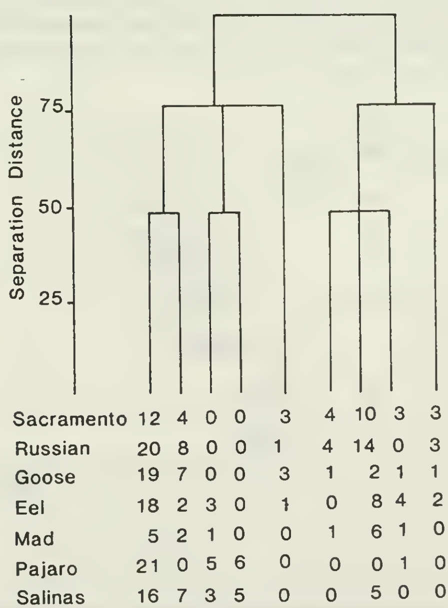

FIGURE 3. Dendrogram of cluster analysis using single linkage and Euclidean distance to group *Catostomus occidentalis* specimens based on meristic characters. Separation distance is the percent of the Euclidean distance between least-alike specimens. Number of specimens per grouping from each population is listed.

No differences were apparent among Goose Lake and Sacramento, Russian, Eel and Mad River populations for any scale counts compared (Figures 4–7). There was also little difference between Pajaro and Salinas populations. However, Pajaro and Salinas River populations differed from other populations in their values for LLS (Figure 4), SALL (Figure 5), and SRBD (Figure 7). There was slight overlap in LLS and SALL counts. No differences were shown in SBLL counts (Figure 6).

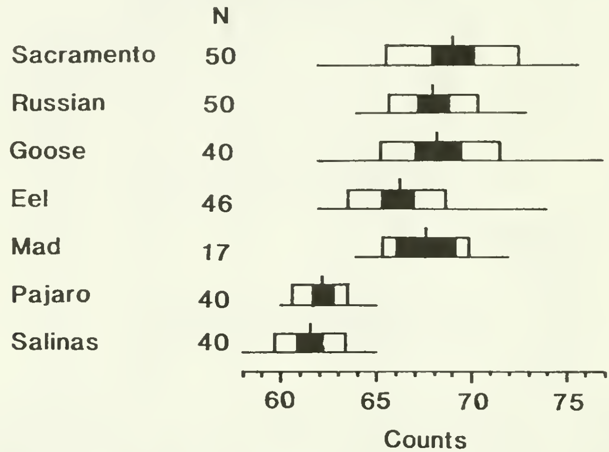

FIGURE 4. Variation in lateral line scale counts between Sacramento sucker populations. Included are range (horizontal line), mean (vertical line), one standard deviation on either side of the mean (light horizontal bars), and two standard errors on either side of the mean (dark horizontal bars).

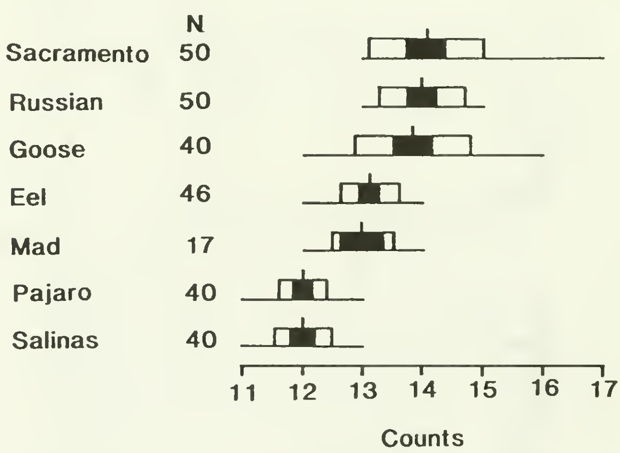

FIGURE 5. Variation in scales above lateral line counts between Sacramento sucker populations.

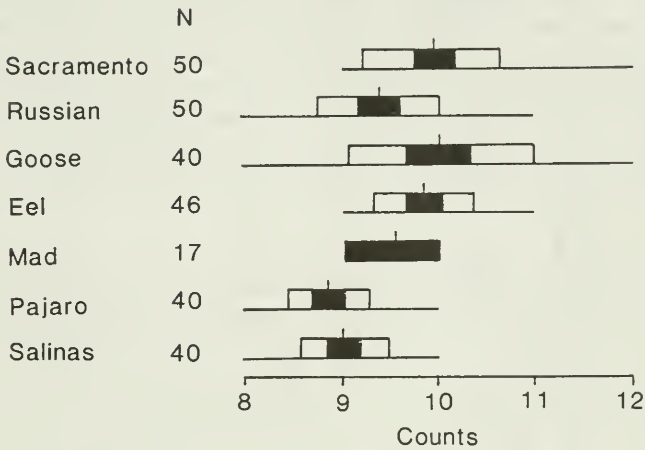

FIGURE 6. Variation in scales below lateral line counts between Sacramento sucker populations.

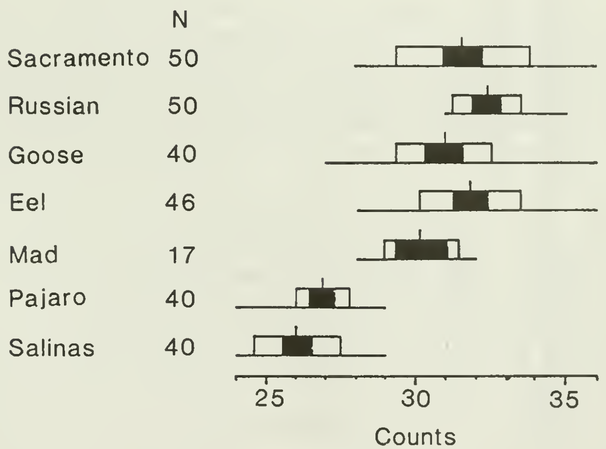

FIGURE 7. Variation in scale rows before the dorsal counts between Sacramento sucker populations.

Based on comparisons of morphometric characters, discriminant analysis grouped most Sacramento sucker specimens into their actual populations (Table 3). Slight overlap was observed between Goose Lake, Sacramento River, and Eel River populations. A number of Mad River, Pajaro River and Salinas River specimens were also misclassified. Eye diameter, SNL and ABL values were strongly correlated with SL for most populations (Table 2) so were not included in discriminant analysis.

TABLE 3. Classification of Sacramento Sucker Specimens by Discriminant Analysis Based on Morphometric Characters.

		Predicted Population Membership (%)						
Actual Population	*N*	*Sacramento* River	*Russian River*	*Goose Lake*	*Eel River*	*Mad River*	*Pajaro River*	*Salinas River*
Sacramento River	16	88	0	0	12	0	0	0
Russian River	10	0	100	0	0	0	0	0
Goose Lake	40	0	0	94	6	0	0	0
Eel River	46	0	0	6	94	0	0	0
Mad River	17	0	0	6	6	78	0	11
Pajaro River	40	0	0	5	0	8	58	30
Salinas River	40	0	0	0	0	10	15	75

DISCUSSION

Although specific results between the two clustering techniques varied, overall findings were similar; neither technique distinguished among populations of *C. occidentalis*. This disagrees with earlier findings (Snyder 1908, 1913, Fowler 1913), but supports recent authors questioning of subspecific status given to different Sacramento sucker populations (Moyle 1976, Lee *et al.* 1980). Analysis with Ward's method finds tight "minimum variance" clusters, whereas analysis with single linkage finds "natural" clusters which are not necessarily tight. When the two results coincide, a reliable classification has been obtained (Wishart 1979).

Results of other analyses varied with methodology. The graphic method of Hubbs and Hubbs (1953) showed no differences in scale counts among Sacramento sucker populations other than those from the Pajaro and Salinas Rivers. However, discriminant analysis of morphometric characters showed significant differences even within most subspecies (Table 3), but those specimens not classified into their true population were not necessarily classified with specimens from the other population of the same subspecies. Synder (1908) did not report differences between Russian and Sacramento basin populations, but discriminant analysis comparing morphometric character values from his study showed these populations to differ significantly. Snyder (1908) also reported no differences between Eel and Mad River populations. Discriminant analysis distinctly separated Eel and Mad River populations.

Sacramento sucker populations exhibit large variability in many of their morphometric and meristic characters. Rutter (1908) noted that specimens from certain localities have distinctly large or small heads. Specimens studied and compared here showed a wide range of HL's within each population (Table 2). Rutter also found that LLS counts ranged from 60–84 in suckers from the Sacramento-San Joaquin basin. This study found a range in LLS counts from 62–76 in fishes of just the Sacramento River basin. Snyder (1908) noted that "differences between the mouth and eye will usually serve to distinguish Humboldt specimens from Sacramento specimens at a glance." Rutter (1908) found that mouth and lip size vary greatly between specimens from different locations in the Sacramento basin. This great variability would seem to provide some difficulty in actually separating Humboldt and Sacramento specimens at a glance. Rutter (1908) also stated that there is no relation between lip size and the portion of the Sacramento-San Joaquin basin, i.e., there is no clinal variation due to location:

> There is no relationship between any particular variation and the division of the basin in which the specimens were taken. . . . Taken as a whole, the species is extremely variable. Specimens from one location often have a distinct physiogomy and can, as a whole, be readily distinguished. Pleasant Valley specimens are remarkable for big lips and fine scales, while North Yuba specimens have big lips and coarse scales. The Wolf Creek specimens have small heads, and so on.

Subspecific designation of Sacramento sucker populations requires consistency in methodology and criteria. Sacramento sucker populations have shown so much variation that consistency would demand designation of numerous subspecies if based on these slight morphometric and (or) meristic variations, and on some degree of geographic isolation. For example, populations in streams tributary to Tomales Bay show a slight difference in scale counts and morphometric characters from populations in the nearby Russian River system (Snyder 1914). Sacramento suckers from Tomales Bay tributaries could then be considered a separate subspecies depending on the criteria used. Upper Pit River specimens have also been found to have distinct scale and dorsal fin-ray counts (Martin 1967). Martin (1967) noted that subspecific designation of Pit River populations creates a problem, and that consistency requires placement of all populations from a distinct geographic area under one name. He found that some Pit River populations were not distinct, whereas others were. This is a typical occurence with Sacramento sucker populations (Rutter 1908). It is easier to be more consistent if variations within and among Sacramento sucker populations are considered as only variations within the species. If subspecific designations are to be used it would be necessary to examine and document variations among and within populations from virtually every stream and lake within the Sacramento sucker's range.

The findings of this study have shown that most Sacramento sucker populations do not exhibit subspecific differences. However, the Pajaro and Salinas River populations are distinctive in that they exhibit scale count differences exceeding those recommended by Hubbs and Perlmutter (1942) for subspecific separation. Although these findings are inconsistent with those from cluster analysis, Pajaro suckers may meet the subspecific definition of Mayr (1969) because they are the only populations that seem to be taxonomically distinct. Further study of the Pajaro and Salinas River populations is needed to determine their status. We recommend an electropheretic analysis to compare Pajaro and Salinas River populations to other populations for a final diagnosis. Prior to such a diagnosis, we feel it best to use the geographic vernacular designation (Wilson and Brown 1953) of Pajaro sucker to distinguish these populations. High variability among and within other populations precludes designating them as being subspecifically distinct.

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Calif. Fish and Game 73(3): 188–191 1987

EXTENT OF HUMAN-BEAR INTERACTIONS IN THE BACKCOUNTRY OF YOSEMITE NATIONAL PARK [1]

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A survey of human-bear interactions was conducted in 6 popular backcountry sites in Yosemite National Park during May–October 1979. Almost half of the 1647 parties interviewed noted bear activity (e.g. interactions, damages, or other evidence of bear presence) within the previous 24 hours, 41% directly interacted with bears, and over 12% sustained bear damage. Use of ranger patrols, advanced food storage techniques, and smaller party size appeared to reduce conflicts. Convenience for reporting bear incidents was found to be highly relevant to management estimates of bear-related conflicts. In addition, expensive losses were much more likely to be reported to the National Park Service than minor damages. Research and management recommendations are discussed.

INTRODUCTION

Conflicts between bears and national park users have received considerable attention in recent years. Although serious problems with grizzly bears, *Ursus arctos*, are often more publicized, interactions involving black bears, *Ursus americanus*, are more common. Herrero (1985) determined that at least 500 people were injured by black bears in North America from 1960 to 1980. Property damage can also be substantial. Although improvements in management strategies (e.g. relocation of problem bears combined with intensive enforcement of regulations and better education of visitors) reduced problems in many frontcountry areas, increased recreational use of the backcountry during the 1960's and 1970's led to more frequent human-bear conflicts. Similar problems increased in the backcountry of Yosemite National Park during the mid-1970's (Harms 1980). These problems led to an investigation of human-bear interactions and methods to separate the 2 species. Upon initiation of this project, it became apparent that no reliable information was available on the scale or extent of the problem in the backcountry. Thus, a portion of the study was directed to determining the proportion of backcountry parties directly affected by black bears. This paper analyzes the extent of the bear problem in several heavily used backcountry sites and makes relevant management recommendations.

METHODS

Informal interviews were conducted with overnight visitors at 6 popular backcountry sites during May through October 1979. These campgrounds were selected due to histories of human-bear interactions and applicability to other study objectives (see Hastings, Gilbert, and Turner 1981).

During interviews, data collectors wore normal backpacking clothes. They approached visitors mostly during mornings, introduced themselves as bear researchers and asked whether, within the previous 24 hours, anyone in the party had seen or heard a bear (interaction), sustained property damage from bears,

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or noticed any bear activity (which included interactions, damages, or any other evidence that a bear had been in their personal or camp vicinity). If they had received damage, they were asked to estimate the financial loss. Data were recorded on small, unobtrusive notepads and transferred daily to data sheets. Interviewers also recorded the size of each camping party; those with 8 or more persons per party were categorized as organized groups, usually consisting of 8 to 40 youths and a few adult leaders. In order to reduce bias when analyzing reporting rates, visitors were informed at the conclusion of each interview that they had not officially reported any damage and that they should do so.

All statistical comparisons were made with the Chi-Squared Test.

RESULTS AND DISCUSSION

A total of 1647 parties were interviewed (Table 1), which represented almost 90% of the 1841 groups camping at the study sites on days of interviews. One hundred and one of these parties consisted of 8 or more members.

TABLE 1. Summary of Interviews for All Sites Studied, Yosemite National Park, 1979.

Number of camps:	*Total*	*% of camps interviewed*	*No. of camps with < 8 visitors*	*% of camps interviewed*	*No. of camps with > 8 visitors*	*% of camps interviewed*
At sites	1841	–	1736	–	105	–
Interviewed	1647	100.0	1546	100.0	101	100.0
With activity	793	48.1	725	46.9	68	67.3
With interactions	675	41.0	611	39.5	64	63.4
With damages	208	12.6	171	11.1	37	36.6
Damage estimates	$2376		$1893		$483	

Bears and people came into close proximity far more often than had been anticipated. For data combined from all 6 study sites, almost half (48.1%) of the parties noted bear activity within the previous 24 hours, 41.0% experienced interactions with bears, and 12.6% sustained bear damage. Financial losses averaged $11.42 for each of the 208 parties experiencing damage. Although a single bear could occasionally be noticed by numerous campers at a congested site, most campgrounds were frequented by more than one bear, and each bear would often visit the site more than once a day. The reported levels of bear problems were not the result of one bear per campground visiting the area only once per day.

Almost two-thirds of the above data were collected in Little Yosemite Valley (LYV). LYV was previously known for its frequent and severe human-bear problems, and received the highest human use in Yosemite's backcountry during 1979 (NPS records). High overnight visitor use has been correlated with high probability of bear conflicts in several parks (Merrill 1978, Singer and Bratton 1980, Keay and van Wagtendonk 1983). However, bear problems occurred less frequently in LYV than in other study areas (Tables 2–3). Other sites had significantly more parties ($P < 0.001$) reporting bear activity, interactions, or damages than LYV. In addition, the average financial loss for a bear damage incident was almost half as expensive in LYV. Reduced bear problems in LYV were probably due to the frequent ranger patrols and the use of somewhat advanced food storage techniques, such as metal bear-proof food containers.

The major point is that a large percentage of backcountry users were interacting with bears and sustaining damages to food and equipment. Even LYV users were experiencing an unacceptable level of bear activity. The reader should be aware, however, that data collection was biased toward areas known for bear activity. This was offset somewhat by the clumping of visitors in certain areas, and the corresponding concentration of problem bears wherever there were concentrations of backcountry people (i.e. at the same backcountry sites where people tended to concentrate). During 1979, 60% of the backcountry visitors in Yosemite used only four trailheads (van Wagtendonk 1981). Thus, estimates from this study are probably reasonable for numerous sites in Yosemite, especially those with relatively heavy human use. However, sites with low human visitation may have been used less by problem bears.

TABLE 2. Summary of Interviews for Little Yosemite Valley, Yosemite National Park, 1979.

Number of camps:	*Total*	*% of camps interviewed*	*No. of camps with < 8 visitors*	*% of camps interviewed*	*No. of camps with > 8 visitors*	*% of camps interviewed*
At sites	1159	–	1102	–	57	–
Interviewed	1040	100.0	986	100.0	54	100.0
With activity	405	38.9	377	38.2	28	51.9
With interactions	308	29.6	283	28.7	25	46.3
With damages	62	6.0	53	5.4	9	16.7
Damage estimates	$436		$355		$81	

TABLE 3. Summary of Interviews for All Sites Studied Except Little Yosemite Valley, Yosemite National Park, 1979.

Number of camps:	*Total*	*% of camps interviewed*	*No. of camps with < 8 visitors*	*% of camps interviewed*	*No. of camps with > 8 visitors*	*% of camps interviewed*
At sites	682	–	634	–	48	–
Interviewed	607	100.0	560	100.0	47	100.0
With activity	388	63.9	348	62.1	40	85.1
With interactions	367	60.5	328	58.6	39	83.0
With damages	146	24.1	118	21.1	28	59.6
Damage estimates	$1940		$1538		$402	

Large visitor groups were more likely to note bear activity, experience interactions, and especially receive damages ($P < 0.001$) (Tables 1–3). This is partially due to more people being available to interact with and lose food to bears. However, organized groups rarely appeared to be truly "organized." These groups were well-known for storing food improperly (e.g. tying foodsacks to tree trunks) and for violating NPS regulations concerning maximum group size.

In order to better understand the extent of bear damages in the backcountry, data for LYV were again compared to sites without rangers. In LYV, 27.9% of the estimated number of parties experiencing damages reported those damages to the National Park Service, although 51.6% of the estimated financial losses in dollars was reported (i.e. more expensive damages were reported more often). For backcountry areas without rangers on duty, only 1.3% of the number of damages were reported while 2.8% of the financial losses were reported. Visitors appeared reluctant to report bear damage unless it was easy to do so; convenience for reporting bear conflicts has been described elsewhere as an important factor in improving reporting rates (Petko-Seus 1985). In addition, unwillingness to inform the National Park Service of bear damages may have been generated by a fear of receiving a citation for improper food storage. However, these tendencies decreased with more expensive damage as seen by the much higher percent of estimated dollar loss being reported. People who had large losses appeared to be more angry and more willing to risk a citation in hopes of being reimbursed by the Park Service for damages sustained.

CONCLUSIONS AND RECOMMENDATIONS

Large numbers of backcountry campers in 6 heavily used campgrounds in Yosemite National Park experienced interactions with black bears (41.0%) and sustained losses to food and equipment (12.6%). This does not mean that all interactions were unpleasant or inappropriate; seeing bears was obviously the most exciting feature of many visitors' trips. However, most visitors were not prepared for these situations. More parks should monitor the extent of bear problems and then relay those findings to visitors; if visitors recognized that one-fourth of the parties in certain areas receive bear damages, they might visit less heavily used areas or prepare better for dealing with bears.

The legal size of organized groups in black bear habitat should be enforced. Perhaps the optimal leader : member ratio should be evaluated and regulated in order to make these parties truly "organized."

Visitors using sites not patrolled regularly by backcountry rangers nor equipped with the most advanced food storage devices experienced more severe problems with bears. Obviously, the National Park Service cannot afford to place rangers and expensive equipment at many backcountry sites, but any increase in ranger/backpacker contact and improvements in bear-proofing techniques at sites known for bear problems could help. Convenience for reporting bear conflicts should be improved for backcountry users.

Additional research on this subject could provide information on the nature of human-bear relationships to many backcountry managers. Sampling might be altered in the future to include large numbers of sites while keeping costs reasonable by interviewing campers at trailheads. Projects can be designed to evaluate the extent of problems throughout a wilderness area or to test effectiveness of food protection or aversive conditioning techniques at specific sites. In addition, managers can use information obtained with this interviewing approach to establish indices for damages or other human-bear conflicts.

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Calif. Fish and Game 73(3): 192 1987

NOTES

FIRST OREGON RECORD FOR THE COWCOD, *SEBASTES LEVIS*

A cowcod, *Sebastes levis,* was recorded for the first time along the coast of Oregon on 19 April 1986, approximately 65 km west of Newport (lat 44°36.1'N, long 124°38.7'W). The specimen, an immature male, measuring 227 mm standard length and weighing 318 g, was captured in 256 m by the JUL-E (skippered by Wade E. Richardson) while trawling for rockfish with a 9.5 cm mesh otter trawl with roller gear. The specimen is deposited in the fish collection of the Department of Fisheries and Wildlife, Oregon State University, OS 11063. This collection extends the northern range of *Sebastes levis* into Oregon waters some 534 km from Usal, California, which was recorded as the northern limit by Odemar (1964).

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