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BREEDING STATUS OF THE TRICOLORED BLACKBIRD, 1969–1972[1]

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During 1969–1972, 164 breeding colonies of tricolored blackbirds were found in California and southern Oregon. The location of the colonies, their sizes (including acreage, number of birds, and number of nests), and nesting habitats are given and comparisons made with previously reported data. The tricolor's general range and major breeding areas have remained unchanged during the past 35 years, but in the Central Valley, population size has declined, perhaps by more than 50%. Possible causes for the decline are given, and other aspects of the tricolor's breeding ecology are discussed.

INTRODUCTION

Since 1967 we have studied blackbird damage to rice in California. Our first step in defining this problem was to investigate the population status of the various species involved in depredations, with particular emphasis on the tricolored blackbird (*Agelaius tricolor*) because of its endemic distribution. Neff's (1937; 1942) studies provide the basis for much current knowledge about the tricolor, but because his data were gathered more than 30 years ago and because more recent workers (Orians 1961*a*, 1961*b*; Orians and Collier 1963; Payne 1965; and Collier 1968) have not provided data on the tricolor's general distribution and numbers, its present status was uncertain. We therefore studied the tricolor during four breeding seasons during 1969–1972. This paper presents our findings on the size and distribution of the tricolor breeding population, and compares them with earlier findings.

METHODS

Each spring (April–June) different portions of the tricolor's range were surveyed by auto for breeding colonies. In 1969 and 1970, the survey was concentrated in the Central Valley (combined Sacramento Valley: Tehama, Butte, Glenn, Colusa, Sutter, Yuba, Yolo, Solano, and Sacramento counties; and San Joaquin Valley: NW Kern, Kings, Tulare, Fresno, Madera, Merced, Stanislaus, and San Joaquin counties). In 1971 we attempted to survey the entire breeding range (excluding Baja California) by driving more than 8,000 miles and visiting most of the reported breeding areas (Table 1) from San Diego through southern Oregon. In 1972 our search was conducted from the northern San Joaquin Valley through southern Oregon. Some of the tabular data also include four colonies we found during brief explorations in

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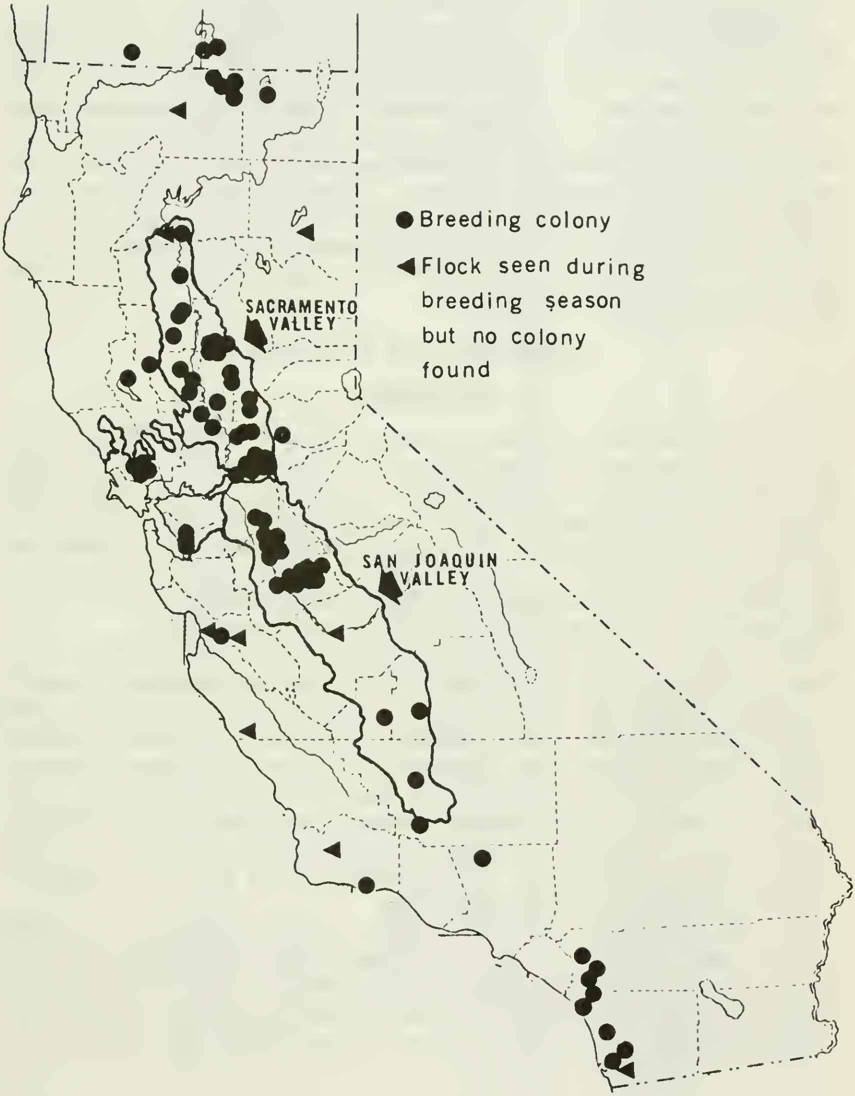

FIGURE 1. Location of tricolored blackbird breeding colonies 1968–1972. (Some of the locations represent more than one colony.)

the Sacramento Valley in 1968. During each of the survey years, records of several additional colonies were provided by amateur and professional ornithologists. However, because we could not thoroughly investigate all colonies and because many of our cooperators' reports were incomplete, all data are not available for each colony.

Estimates of different population segments were made by counts and by projections based on the findings of Payne (1965), Lack and Emlen (1939), and Lack (1968) who indicated that each tricolor female attends only one active nest and that the male: female ratio averages about 1:2. If a colony was located early in the nesting cycle when both males and females were present, the breeding population was directly estimated by counts, and the number of active nests to be built was projected. During later nesting stages, such as incubation when the males are absent, or the nestling stage when both sexes may be away from the colony in search of food, the nests were counted and the breeding population was projected.

DISTRIBUTION OF COLONIES

Geographic

Including the four colonies in 1968, we found 168 breeding colonies at 113 locations, each at least 1.6 km (1 mile) apart (Table 1; Figure 1). About 78% (131) of the colonies were in the Central Valley, with 48% (80) in Sacramento Valley, and 30% (51) in the San Joaquin Valley. The remaining 22% (37) were in other parts of California and in southern Oregon. The counties (all in the Central Valley) where the most colonies were found in a single season were Sacramento (11), Merced (10), Stanislaus (7), Glenn (7), and Colusa (4).

Neff (1933; 1937) reported tricolor colonies in 26 counties in California and one county in Oregon; but he believed occasional breeding was likely in at least 15 additional counties. Later, breeding records were published for five more counties in California (Lassen, Alameda, Santa Clara, Ventura, and Riverside) and one in Oregon (Jackson) (Table 1). And in our survey, we found tricolors breeding in four additional counties in California: Sonoma (near Petaluma), El Dorado (near Salmon Falls Road), Modoc (at Clear Lake National Wildlife Refuge), and Siskiyou (at Lower Klamath and Tule Lake National Wildlife Refuges) (Table 1; Figure 1).

We did not find tricolors breeding in four California counties (Marin, Solano, Santa Cruz, and Fresno) where Neff (1937) reported them, but this does not necessarily mean that breeding has declined in these areas. The colonies he found were relatively small (6 to 500 nests), and our searches were limited to one or two quick drives through each county by road.

TABLE 1. Number and Size of Tricolored Blackbird Breeding Colonies Reported Since 1933 and Found During 1968–1972, by Year and County

County	Year(s)	Colonies (range during years) Number	Size	Source
		Sacramento Valley, California		
Sacramento	32–36	1–3	1,000–121,000 nests	Neff 1937
	60	2	30,500 nests	Orians 1961a
	69–72	6–11	15,850– 50,915 birds	Present study
Yolo	31–36	1–3	2,000– 38,000 nests	Neff 1937
	39	1	2,000 birds	Lack and Emlen 1939
	60	1	70,000 nests	Orians 1961a
	69–72	2	5,000– 31,000 birds	Present study
Placer	33, 36	1	1,000– 1,500 nests	Neff 1937
	71	1	?	Present study
Sutter	32–36	1–3	1,000– 13,000 nests	Neff 1937
	68	1	25,000 birds	Present study
Lake	36	1	20 nests	Neff 1937
	72	1	2,500 birds	Present study
Colusa	32–34, 36	2–11	3,000– 37,000 nests	Neff 1937
	59*	1*	19,500 nests	Orians 1960
	59–60	3–4	104,650–156,500 nests	Orians 1961a
	61*	1*	4,000 nests	Payne 1965
	63	?	?	Payne 1965
	69–72	1–4	1,000– 57,000 birds	Present study
El Dorado	71	1	800 birds	Present study
Yuba	31–36	2–9	2,000–113,000 nests	Neff 1937
	39	4	60,000+ birds	Lack and Emlen 1939
	40	2	22,000 nests	Emlen 1941
	59*	1*	2,150 nests	Orians 1960
	59–60	2–3	17,300– 55,000 nests	Orians 1961a
	62–63	?	?	Payne 1965
	60–64*	1–2*	100– 400 nests	Payne 1965
	69–70	1–2	1,000– 5,250 birds	Present study
Butte	32–36	2–13	3,000–106,000 nests	Neff 1937
	60	1	35,000 nests	Orians 1961a
	61, 64*	1*	100– 150 nests	Payne 1965
	69–72	1–3	500– 25,000 birds	Present study
Glenn	32–36	3–7	4,000–282,000 nests	Neff 1937
	63*	1*	20 nests	Payne 1965
	63–64	?	?	Payne 1965
	69–72	1–3	2,000– 18,500 birds	Present study
	72*	1*	1,000 nests	Present study
Tehama	36	1	75 nests	Neff 1937
	69–70, 72	1	1,500– 2,000 birds	Present study
		San Joaquin Valley, California		
San Joaquin	35–36	1–4	100– 3,750 nests	Neff 1937
	69–72	1–2	500– 5,050 birds	Present study
Stanislaus	32, 35–36	2–6	8,000– 12,500 nests	Neff 1937
	69–72	2–7	4,200– 25,300 birds	Present study
Merced	32–36	1–19	2,000– 58,000 nests	Neff 1937
	69–72	3–10	12,500– 26,000 birds	Present study
Fresno	36	1	100 nests	Neff 1937
	56	1	10,000 birds	AFN† 10(4):362, 1956
	62, 64	?	?	Payne 1965
	63*	2*	101 nests	Payne 1965
Kings	32	1	2,000 nests	Neff 1937
	71	1	25,000 birds	Present study
Tulare	35	1	2,000 nests	Neff 1937
	71	1	1,500 birds	Present study
Kern	35–36	1–2	500– 2,000 nests	Neff 1937
	53	1	1,000 nests	AFN 7(4):292, 1953
	56, 58–60	1–2	200– 2,000 nests	Collier 1968
	58	1	?	Orians 1961a
	59	1	600 birds	AFN 13(4):402, 1959
	71–72	1	2,000– 3,000 birds	Present study

TABLE 1. **Number and Size of Tricolored Blackbird Breeding Colonies Reported Since 1933 and Found During 1968–1972, by Year and County—Continued**

County	Year(s)	Colonies (range during years) Number	Size	Source
		Northern California—southern Oregon		
Shasta (Ca.)	32–33	2–4	1,000– 18,000 nests	Neff 1937
	72	1	5,000 birds	Present study
Lassen (Ca.)	62	1	?	AFN 16(4):445, 1962
Modoc (Ca.)	70–71	1	125– 250 birds	Present study
Siskiyou (Ca.)	69–72	1–3	250– 10,200 birds	Present study
Klamath (Or.)	33	1	50 nests	Neff 1933
	71	2	180 nests	Present study
Jackson (Or.)	58	1	1,000 nests	AFN 12(4):379, 1958
	60	1	1,800 birds	Richardson 1961
	63	3	40 birds	AFN 17(5):479, 1963
	65	?	100+ birds	AFN 19(5):573, 1965
	70	2	?	Present study
		Coastal and southern California		
Marin	33	1	?	Neff 1937
Sonoma	71	4	150– 3,000 birds	Present study
Solano	32	1	6 nests	Neff 1937
Alameda	66	1	4,000 birds	AFN 20(4):545, 1966
	71	3	11,200 birds	Present study
Santa Clara	51	1	?	AFN 5(4):276, 1951
Santa Cruz	32	1	500 nests	Neff 1937
Monterey	32, 36	1–3	2,000– 4,000 nests	Neff 1937
	59	1	400 birds	AFN 13(4):398, 1959
	71	1	5,000 birds	Present study
Santa Barbara	36	1	3,000 nests	Neff 1937
	71	1	1,200 birds	Present study
Ventura	57–59	2–3	175– 1,800 nests	Collier 1968
Los Angeles	36	1	500 nests	Neff 1937
	59–60	1	300– 600 nests	Collier 1968
	71	1	2,500 birds	Present study
Riverside	43, 51	1	2,000 birds	AFN 5(5):309, 1951
	69–71	1–3	5,000– 15,750 birds	Present study
Orange	36	1	250 nests	Neff 1937
San Diego	32, 35–36	1–4	100– 3,000 nests	Neff 1937
	62	1	2,000 birds	AFN 16(4):448, 1962
	64	?	?	Payne 1965
	70–72	1–3	5,000– 9,000 birds	Present study

* Fall breeding colonies.
† AFN = Audubon Field Notes.

In several other areas, we saw flocks of tricolors during the breeding season without finding colonies (Figure 1). At Honey Lake (Lassen County), for example, about 20 males were seen singing in a tree. About 60 tricolors were sighted in a field near Yreka (Siskiyou County), and flocks of 100 to about 1,000 were seen near Chula Vista and near Otay Reservoir (San Diego County); near Los Alamos (Santa Barbara County); near Redding (Shasta County); near Moss Landing and on Hunter Liggett Military Reservation (Monterey County); and in the San Benito River Valley (San Benito County). Published records (Table 1) report tricolor breeding in all of these counties except San Benito.

Geographically, the breeding range of the tricolor has changed little during the past 30 years. Colonies are still found from southern Oregon south through Shasta County, California, and along the coast of California from Sonoma County to the Baja California border. Sporadic breeding also occurs in the plateau region of northeastern California and in the northwestern extremity of the Mojave Desert, but by far the majority of tricolors still breed within the Central Valley.

General Habitat

Within the Central Valley, breeding colonies were generally found in two major agricultural types—the rice lands of the Sacramento Valley and the pasturelands of the lower Sacramento Valley and San Joaquin Valley. In the rice lands, the annually flooded rice is the dominant crop, but small grains, hay, safflower, sugar beets, corn and beans are also grown. The pasturelands consist largely of irrigated fields of introduced grasses, alfalfa (grown for seed), hay, and small grains. In both areas, insects in flooded fields probably provide the primary food for breeding tricolors (Crase and DeHaven, manuscript in prep.).

Colonies outside the Central Valley were in several different habitat types. For example, at East Park Reservoir (Colusa County) and near Alberhill (Riverside County), breeding areas were surrounded by chaparral covered hills extending for several miles in all directions. A colony near Fallbrook (San Diego County) was surrounded by several hundred acres of orange and avocado groves interspersed with grass-covered hills a few acres in size. Two colonies in Alameda County were adjacent to the salt-marsh habitat of San Francisco Bay. At Clear Lake National Wildlife Refuge and at the Lava Beds National Monument (Siskiyou County) colonies were in sagebrush-grasslands.

Two southern California colonies probably best illustrate the tricolor's ability to breed under widely varying environmental conditions. A colony of about 2,500 adults was nesting in a small agricultural area near Del Sur (Los Angeles County), which is on the western edge of the Mojave Desert, and a group of several small colonies was found within the city limits of Santa Barbara (Santa Barbara County), about 274 m (300 yards) from the Pacific Ocean. Of the two sites, the desert breeding is probably more unusual, since the tricolor has apparently not invaded the man-made agricultural environment in the desert of the Coachella Valley (Riverside County), although less than 121 km (75 miles) of semi-desert separates the area from other breeding sites.

Nesting Substrate

The vegetation in which nests were built was recorded for 156 colonies (Table 2). Of these, 108(69%) had nests built in some kind of marsh vegetation—cattails (*Typha* sp.), bulrushes (*Scirpus* sp.), willows (*Salix* sp.), or some combination of these, and 76 (49%) were in cattails only. Other workers have also reported marsh vegetation as the major nesting substrate. In particular, of 256 colonies Neff (1937) found, 246 (96%) were in cattails, willows, and bulrushes. Orians (1961*a*) reported that 16 (64%) of the 25 colonies in the Sacramento Valley were in cattails and other emergents. And Collier (1968) found 27 (84%) of 32 southern California colonies in marshes or riparian willows.

The size, configuration, and plant density of the marshes used for nesting were extremely variable. Near Red Bluff (Tehama County), a 1,500-bird colony nested for 2 consecutive years in a burned-over cattail marsh where the vegetation was less than 0.9 m (3 ft) tall and nearly too sparse to support the nests (which were often only a few inches above the water); near Modesto (Stanislaus County) a colony of more than 1,000 birds nested in a strip of cattails only 3 m (10 ft) wide and 22.9 m (75 ft) long; near Arbuckle (Colusa County) adults nested in 3.7 m (12 ft) tall bulrush and cattail that was too thick for a man on foot to penetrate. In general, we observed no preference for a particular shape of marsh such as the broad circles or irregular polygons that Collier (1968) thought tricolors preferred.

We also found tricolors nesting in blackberry (*Rubus* sp.), mustard (*Brassica campestris*), thistle (*Centaurea* sp.), nettle (*Urtica* sp.), safflower (*Carthamus tinctorius*), and giant reed (*Arundo donax*) (Table 2). We know of no previous report of nesting in giant reed, although tricolors nested in this at least three times during our study (near Manteca, San Joaquin County, where 3,000 birds nested in 1971 and 1972, and near Del Sur where the 2,500-bird colony mentioned earlier nested near the desert).

TABLE 2. Number of Tricolored Blackbird Breeding Colonies by Nesting Substrate, 1968–1972

Nesting substrate	Number of breeding colonies found					Total (%)
	1968	1969	1970	1971	1972	
Cattail	2	13	20	28	13	76 (48.7)
Cattail, bulrush	1	2	7	8	5	23 (14.7)
Blackberries	--	6	4	11	4	25 (16.0)
Willows	--	1	1	3	--	5 (3.2)
Bulrush	1	1	1	2	2	7 (4.5)
Mustard, thistle	--	1	1	3	--	5 (3.2)
Thistle	--	--	--	2	--	2 (1.3)
Giant reed	--	--	--	2	1	3 (1.9)
Mustard	--	1	1	--	1	3 (1.9)
Nettles	--	1	--	1	--	2 (1.3)
Cattail, bulrush, willows	--	--	--	2	--	2 (1.3)
Mustard, safflower	--	--	--	1	--	1 (0.6)
Nettles, willows, blackberries	--	--	1	1	--	2 (1.3)
Total	4	26	36	64	26	156 (99.9)

Altitudinal Dispersion

Neff (1937) found colonies from sea level near San Diego and Santa Cruz to about 1,280 m (4,200 ft) on Klamath Lake. More recently, Collier (1968) reported a colony near Tehachapi (Kern County) at 1,158 m (3,800 ft) and Audubon Field Notes (16: 445, 1962) reported a colony near Susanville (Lassen County) at slightly over 1,219 m (4,000 ft). We found a similar altitudinal dispersion, with colonies ranging from sea level in Santa Barbara and near Alameda (Alameda

County) to 1,362 m (4,469 ft) at Clear Lake National Wildlife Refuge. However, altitudes in the Central Valley, where most colonies are located, are only about 6.1 to 121.9 m (20 to 400 ft) and those in the high-density tricolor breeding areas in Merced, Stanislaus and Sacramento counties (Figure 1) are only about 18.3 to 30.5 m (60 to 100 ft).

Fall Breeding

Although we were aware of possible fall breeding by tricolors in the Sacramento Valley (Orians 1960; Payne 1965), and in fact searched for colonies several times, we found only one instance of fall breeding. This was a colony of about 1,000 nests apparently all unsuccessful, in a cattail pond on the Sacramento National Wildlife Refuge (Glenn County) during November 1972. We do not know if fall breeding occurred in other parts of the species' range.

SIZE OF COLONIES

Numbers of Birds

We estimated the number of breeding birds at 157 colonies (Table 3). Of these, about 25% had fewer than 1,000 birds, about 62% had from 1,000 to 10,000 birds, and 13% had more than 10,000 birds.

TABLE 3. **Number of Tricolored Blackbird Breeding Colonies by Size Classes, 1968–1972**

Size class (number of breeding birds)	Year					Total (%)
	1968	1969	1970	1971	1972	
Fewer than 1,000	--	1	11	20	8	40 (25.5)
1,000 to 9,999	2	17	25	36	17	97 (61.8)
10,000 to 25,000	2	8	--	7	2	19 (12.1)
More than 25,000	--	--	--	--	1	1 (0.6)
Total	4	26	36	63	28	157 (100.0)

The smallest colony, 15 birds, was observed in 1971 near Folsom (Sacramento County). All large colonies were in the Central Valley. The largest, about 30,000 birds, was observed in 1972 near Knights Landing (Yolo County). Others, each containing about 20,000–25,000 birds, were: near Tudor (Sutter County) in 1968; near Colusa in 1969 and 1971 and near Dunnigan in 1969 (Colusa County); near Clay and near Galt in 1971 (Sacramento County); near Corcoran (Kings County) in 1971; and near Knights Landing in 1969.

The colonies outside the Central Valley all contained fewer than 10,000 tricolors. West of the valley, for example, the three largest colonies were in the San Francisco Bay area (Alameda County), and each had about 5,000 breeding birds. North of the valley, the largest colony had about 1,250 birds at Tule Lake National Wildlife Refuge.

TABLE 4. **Nesting Densities of Tricolored Blackbirds in Breeding Colonies by Nesting Substrate, 1968–1972**

Nesting substrate	Number of colonies	Area occupied by nests (acres)		Number of birds per acre*		Number of active nests per acre*	
		Range	Average	Range	Average	Range	Average
Giant reed	2	0.01– 0.25	0.17	12,000–200,000	106,000	8,004–133,340	70,670
Blackberries	15	0.02– 1.25	0.41	750–100,000	24,532	500– 66,670	16,355
Mustard	2	0.25– 0.33	0.29	700– 1,000	8,500	467– 667	5,667
Mustard, thistle	6	0.05–10.00	1.80	400– 30,000	7,240	267– 20,000	4,827
Willow trees	5	1.00– 2.33	1.67	1,000– 20,000	6,550	667– 13,340	4,367
Cattails and/or bulrush	77	0.05–10.00	1.62	400– 30,000	5,024	267– 20,010	3,350
Thistle	1	--	1.25	--	3,000	--	2,000
Mustard, safflower	1	--	0.04	--	313	--	209
Total	109						

* Some bird census figures were estimated from nest counts and some nest density figures from bird counts; these estimates were based on a male:female ratio of 1:2 and a female:active nest ratio of 1:1.

(About 10,000 tricolors were reported there early in the spring of 1969, but the birds apparently did not all nest in one colony.) South of the valley, the largest colony was about 2,500 birds in San Diego County. A cooperator reported that a colony of about 10,000 birds nested near Temecula (Riverside County), but we did not confirm this estimate.

Nesting Area and Density

The number of birds or nests and the area they occupied were estimated for 109 colonies (Table 4). Nesting areas varied widely with the size of the colony and the type and size of the local nesting substrate, but generally nests were built in only a fraction of the total area available. Also, areas occupied by more or less continuous nesting were smaller in upland habitats than in marshes. Continuous nesting areas in blackberries averaged .17 ha (0.41 acre); in all other upland types they averaged .33 ha (0.82 acre). In contrast, nesting areas in marshes averaged .65 ha (1.62 acres). In several marshes, nesting was nearly continuous on at least 1.6 ha (4 acres) of the available habitat. The largest areas of continuous nesting recorded were on about 4.1 ha (10 acres) of mustard and thistle in Alameda County where 5,000 birds nested, and on 10 acres of cattails (part of a 10.1 ha (25-acre) marsh) in Colusa County where more than 20,000 birds nested.

The greatest nesting density was at the Del Sur colony, where 2,500 tricolors built nests in an area of giant reed only about 12.8 x 3.9 m (42 x 13 ft) (1/80 acre); this is equivalent to about 200,000 birds, or 133,340 nests, per acre. Two sites with extremely sparse nesting densities were a 15-bird colony at Folsom (in blackberries), and a 50-bird colony at Tule Lake National Wildlife Refuge (in mustard and thistle), where densities were only about 750 birds per acre. Overall, nesting was densest in giant reed and blackberries; intermediate in mustard, mustard-thistle, and willow; and sparsest in cattails, bulrush, and combinations of these (Table 4).

POPULATION SHIFTS

Seasonal

Colony abandonment provided evidence of population shifts during the nesting seasons. During the survey, we made repeated visits to about one-third of all the colonies found, and of these, about 10% to 50% were partially or completely abandoned each year. The observed abandonment occurred throughout each nesting season, although, like Neff (1937), we observed it more often early in the year. In April 1970, for instance, we found about 10,000 tricolors at four breeding colonies in southeastern Sacramento County. The birds were building nests or incubating eggs. Within a few days, all four had been abandoned, and there was no later breeding in the area that year. Abandonment likely is related to insufficient food supplies for the breeding birds and their young (Lack 1954; Orians 1960, 1961*a*).

Yearly

We also observed substantial yearly variation in the centers of breeding abundance. In several counties in the Central Valley where man-days spent searching was fairly constant each year from 1969 through

1972, the number of colonies and breeding birds usually differed greatly between years (Tables 1 and 5). For example, in 1969 at least 57,000 tricolors nested in Colusa County, but in 1970 there were only about 2,000. Similar fluctuations occurred elswhere in the Central Valley.

Neff (1937), Orians (1961*b*), and Orians and Collier (1963) also reported that the breeding distribution of the tricolor was somewhat unpredictable from year to year. Orians (1960; 1961*a*), however, stated that the tricolor's center of breeding abundance and the largest colonies were in the rice-growing area of the Sacramento Valley. Our data show that this is not true for all years. Only 5 of the 10 largest colonies of our study were in the major rice district. Furthermore, in 1969 and 1972 about 58% and 59% of all the breeding tricolors were in five major rice-growing counties, but in 1970 and 1971 only about 32% and 29% were (Table 5). In 1971 we found only 49,000 tricolors nesting in the five major rice counties, compared to the largest breeding population (about 51,000 birds) which nested within a few square miles in the pasturelands of southeastern Sacramento County.

These yearly shifts, which are likely related to insect supplies and other, unknown, breeding requirements, may operate as follows: During winter, many tricolors leave the Sacramento Valley rice areas. Probable major wintering areas are the San Francisco Bay-Delta area and the northern San Joaquin Valley (Neff 1937, 1942; Orians 1961*a*; Payne 1965; and DeHaven et al., manuscript in prep.). When spring arrives, tricolors disperse from these wintering areas to search out sites with the proper requirements for breeding, of which an abundance of insects is probably most critical (Orians 1961*a*; Orians and Collier 1963; Payne 1965; and Lack 1954). Movement is probably mainly northward from wintering locations because areas with acceptable nesting substrates are relatively scarce in the arid southern San Joaquin Valley.

Although population shifts occurred each year, there were a few local areas, such as the pasturelands in Merced County near Gustine and Los Banos and in Stanislaus County along the San Joaquin River, where breeding was somewhat regular and predictable. Neff (1937) also found regular breeding in the Merced County area which, judging from his descriptions, seems to have changed little. However, probably the most consistently used area during our study was the pasturelands in southern Sacramento County, where we found 6, 8, 11, and 4 colonies during the years 1969–1972.

A few specific breeding sites outside of the Central Valley were regularly used. A cooperator reported that near Temecula a colony was active during 1967–1971. Colonies at Tule Lake and Lower Klamath National Wildlife Refuges were active during all years of the study. A land owner reported that one of the colonies we found near Santa Barbara had been active for at least 25 years, and according to Bent (1965), Nuttall first described the species from this or a nearby area in 1836, and listed it as common in April.

TABLE 5. Number of Tricolored Blackbirds Breeding in Major Rice-Growing Counties of the Sacramento Valley, California, 1969–1972

Year	Number of breeding birds found							Percent total found in major rice counties
	In all counties	In major rice counties*						
		Colusa	Butte	Glenn	Yolo	Yuba	Total	
1969	181,000	57,000	20,000	2,000	25,000	1,000	105,000	58.0
1970	84,850	2,000	1,500	18,500	5,000	5,250	32,250	38.0
1971	167,540	26,000	2,500	5,500	15,150	--	49,150	29.3
1972	97,850	25,000	500	1,000	31,000	--	57,500	58.8
Total	532,040	110,000	24,500	27,000	76,150	6,250	243,900	45.8

* No colonies were found in Sutter County, a major rice-growing area, during 1969–1972.

LONG-TERM POPULATION CHANGES

The findings of our survey were similar in many respects to those of Neff (1937) who first studied tricolor populations some 35 years earlier. There were, however, several striking differences:

1) We found fewer colonies than Neff (1937). During 6 years of study (1931–1936), he devoted an average of about 31 man-days a year to specific searches for tricolor colonies, and listed a total of more than 256. (His listing, like ours, included a few records supplied by cooperators.) Even with our better transportation, more roads providing access to colonies, and about 45 man-days a year specifically devoted to searches, in 4 years we found only 164 colonies.

2) We saw fewer non-breeding tricolors than Neff (1937). He estimated that "unattached bands observed during the [6 years of] field work totaled considerably more than 50,000 birds." During 4 years, we observed fewer than 15,000.

3) We did not find any nesting areas approaching the size of some Neff (1937) reported. For example, he described a large colony in Glenn County where the birds were "active [in nest building] over an area roughly 6.4 km (4 miles) east and west by 9.6 km (6 miles) north and south." He estimated that another colony in Glenn County contained at least 260,000 nests and covered virtually 24.3 ha (60 acres). Our most extensive colonies had continuous nesting over only about 4 ha (10 acres). (One large colony of about 25,000 birds was found in a 32.3-ha (80-acre) safflower field, but we do not know if nesting was continuous throughout the field. The colony was abandoned during egg-laying.)

4) Our largest colonies apparently contained far fewer birds than Neff's (1937). He listed five colonies with at least 75,000 nests (equivalent to about 112 500 birds). Our largest colony contained only about 30,000 birds, and fewer than 20,000 of these actually completed their nesting cycle. In attempting to estimate the population of his largest colony (in Glenn County), Neff "gave up in despair with the thought that an estimate of 250,000 adults was ridiculously low." This figure is considerably larger than the highest yearly total we recorded for all colonies (181,800 birds), in 1969.

5) We found fewer total tricolors than Neff (1937). During his 6 years of study, he found more than 1.5 million nests, equivalent to more than 2.2 million breeding birds, or more than 375,000 a year. During 1969–1972, we found about 532,000 breeding birds, or about 133,000 a year. The difference was especially obvious in the major rice-growing counties (Butte, Colusa, Glenn, Sutter, Yolo and Yuba) of the Sacramento Valley where Neff (1937) found all of his very large colonies, and an average of about 161,000 nests, or more than 241,000 breeding birds a year. In comparison, our 4-year total for the major rice-growing counties was about 244,000 birds (Table 5).

Tricolors have apparently not benefited from increasing rice culture in the Central Valley as suggested by Neff (1937) and Orians (1961*a*, 1961*b*). Rice acreages have increased nearly fourfold during the last 30 years, from about 50,625 ha (125,000 acres) during the 1940's to nearly 202,500 ha (500,000 acres) in 1954, then down to 91,530 ha

(226,000 acres) in 1957, and finally to 174,960 ha (432,000) acres in 1968 (Johnston and Dean 1969). Thus, if rice culture is beneficial to the tricolor, then this benefit must have been offset by one or more detrimental factors. Perhaps the increase in land use and intensified pesticide use in recent years have limited the food supplies essential for tricolor breeding.

There is no question that suitable nesting habitat for tricolors has been lost in some local areas. For example, Neff (1937) and later Lack and Emlen (1939) studied colonies near Davis (Yolo County), but little or no nesting habitat exists there now and we found no breeding. There is now no nesting habitat near Riego Road in Sacramento County where Orians (1961*a*) found several colonies. South of the Central Valley, Collier (1963) studied colonies at Cache Creek (Kern County), which has since been covered by a freeway, and at San Fernando Reservoir (Los Angeles County), which has been drained for housing development. Nevertheless, we doubt that local losses of habitat have contributed significantly to any overall population decline. In fact, like Neff (1937), we found that tricolors in most areas, including the Sacramento Valley, leave many marshes and other apparently suitable nesting sites unused each year. Clearly, further research on the requirements for tricolor breeding is needed to help isolate a possible cause for the species' apparent decline.

Also important are the questions of when the decline began and whether it is continuing. Unfortunately, none of the studies conducted between Neff's (1937) and ours are complete enough to draw conclusions about total population size in even a portion of the tricolors' range. However, if significant observer differences can be ruled out, the fact that Orians (1961*a*) found three colonies with 50,000 to 100,000 nests in the Central Valley as recently as the early 1960's could indicate that the decline is relatively recent. Further research is needed to determine whether this downward trend, which may have reduced the Central Valley population by more than 50%, is continuing, and whether it has yet reached the point of concern.

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For advice during the study and during preparation of the manuscript, we thank Joseph L. Guarino, Willis C. Royall, Jr., Jerome F. Besser and Ann H. Jones of the Denver Wildlife Research Center. For data on one or more tricolor breeding colonies we thank Lee R. Baker, Dell O. Clark, Alice E. Fries, Gary Nielsen, Bruce R. Norwitt, Randy Parsons, Edward J. O'Neill, Donald S. Pine, Gene A. Sipe, Otis Swisher, Robert C. Watsin, Robert L. Van Wormer, Joseph M. Welch, Shirley Wells, Jack Wilburn, Vernal L. Yadon, and Jack M. Yardley.

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THE AGE AND GROWTH OF THE PACIFIC BONITO, *SARDA CHILIENSIS*, IN THE EASTERN NORTH PACIFIC[1]

by

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An age and growth study of the Pacific bonito, *Sarda chiliensis*, was conducted between 1968 and 1973. Otoliths were used to establish the ages of over 3,000 bonito, and the results verified by length frequency samples, a tag and recapture experiment, and back-calculation of mean length at each age. The results show that bonito grow rapidly during their first 3 years of life, with much slower growth from 3 to 6 years old. The mean length of each age group in the fishery is: age I—51.5 cm (20.3 inches), age II—63.3 cm (24.9 inches), age III—69.5 cm (27.4 inches), age IV—72.9 cm (28.7 inches), age V—74.8 cm (29.4 inches), and age VI—75.7 cm (29.8 inches).

INTRODUCTION

The Pacific bonito is an epipelagic schooling fish found along the Pacific coast of both North and South America. This tuna-like species is discontinuously distributed from Chile to the Gulf of Alaska, being absent from the central coast of Mexico south into Panama. In the North Pacific the species is most economically productive from Magdalena Bay in southern Baja California to Point Conception, California. The growing importance of this species after 1957 in the California sport and commercial catch has emphasized the need for information on which to base management decisions.

During the early years, commercial fishermen using purse seines and trolling gear averaged about 2,000 metric tons per year (Heimann and Carlisle 1970). Commercial landings increased dramatically after 1966, reaching 13,900 metric tons (MT) (15,400 short tons) in 1973 (Oliphant 1974), and averaging about 8,800 MT per year (9,700 short tons), primarily because of increased demand for the canned product.

During the decade between 1947 and 1956 sport anglers using rod and reel caught an average of 46,000 bonito per year. The bonito sportcatch started on the upswing with the onset of anomalous warm water years in the California Current system in 1957 (Radovich 1961). For unknown reasons, when the ocean waters off California returned to cooler temperatures after 1960, the catch of bonito remained high. In the years between 1960 and 1972 the sport catch averaged about 1 million fish per year and reached a record of about 2.5 million fish in 1964 (Thayer 1973). By 1968 bonito were ranked as the fourth most important species to the partyboat industry (Young 1969). The peak sportcatch of bonito occurs during August and September, however, it gains exceptional recognition during the winter months when the young

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bonito abound in the warm water discharges of coastal power plants. The peak commercial catch occurs during September through November when the larger fish are quite abundant near the northern Channel Islands off southern California and are readily available to trolling and purse seine gear.

A research program to ascertain the age, growth and migration of Pacific bonito in the eastern North Pacific was begun by the Department in 1968. The program consisted of two parts, a tag and recapture experiment and an age and growth study. This paper covers the results of the age and growth studies. The migration of bonito as determined by the tag and recapture experiment will be reported in another paper.

METHODS

Most fish age determination methods rely on the interpretation of rings on scales, otoliths, or other bony structures of the fish. In the course of this study, otoliths, scales and vertebrae were examined to determine if they were suitable for age determination. Bonito scales proved to be unreliable due to the high percentage of regeneration and irregularity of the circuli. Vertebrae were potentially useful but were more difficult to process and less legible than otoliths. Otoliths appeared to be the most promising material and we decided to use them as our principal age determination material. Otoliths have also been successfully used by Department of Fish and Game management programs on Pacific mackerel, *Scomber japonicus*, a closely related species (Fitch 1951), as well as northern anchovy, *Engraulis mordax* (Collins and Spratt 1969), and jack mackerel, *Trachurus symmetricus* (Knaggs and Sunada 1974).

SAMPLING

Material for this study was obtained through routine sampling of the Pacific bonito landings at the canneries in San Pedro, California. Commercial catches landed here originate between central Baja California and Point Conception, California.

The details of the plan under which the samples were collected were modified several times during the period of the age and growth study, but basically involved the random selection of a boat load to be sampled and the selection of a random subsample of either a fixed weight of fish (1970–72), or a fixed number of fish (1968–69 and 1973–74), from each load.

Samplers recorded the fork length (FL) in millimeters, the weight to the nearest ounce, determined the sex and collected the head from each fish sampled. The head was brought back to the laboratory for removal of the otoliths.

Extraction of Otoliths

The otoliths are located in cavities in the posterior portion of the skull. They were exposed by making a diagonal slice through the skull anterodorsal to the eye on a plane which cuts midway through the operculum. The largest pair of otoliths, the sagittae, were carefully extracted with a pair of fine pointed forceps. After removal of the enveloping tissue sac, the sacculus, the pair was placed in labeled gelatin capsules which were stored in numbered coin envelopes.

Age Determination

Otoliths were submerged in about 6 mm ($\frac{1}{4}$ inch) of water in a small glass dish with a black plexiglass bottom. They were examined under a binocular microscope with the aid of a narrow beam of light directed toward the otolith at a low angle. With a magnification of 10$\times$ and the proper reflected light, the alternating white (opaque) and dark appearing (hyaline) zones could be counted (Figure 1). The number of annuli, the legibility of each pair of otoliths, and condition (opaque or hyaline) of the margin of each otolith were noted using the standard terminology of Jensen (1965).

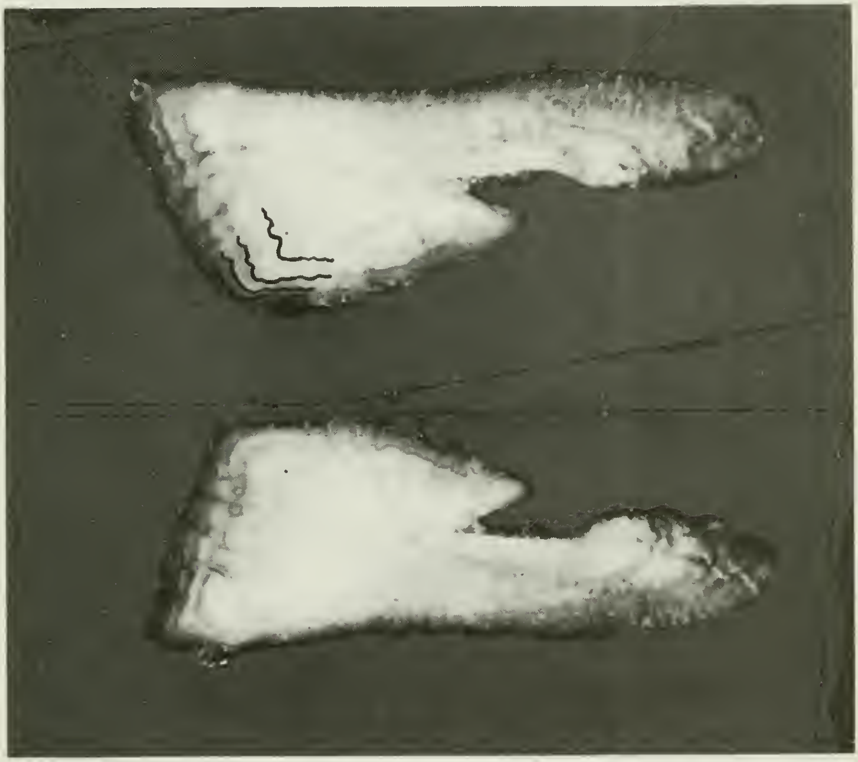

FIGURE 1. Pacific bonito otolith pair. Note alternating opaque and translucent (hyaline) zones. The locations of annuli are marked on the lower left corner of the top otolith. *Photograph by Jack W. Schott.*

The difference in transparency between the opaque and hyaline zones is apparently due to their content of organic matter (Fitch 1951). Calcium carbonate and organic matter are added to the otolith during the bonito's period of rapid growth each summer. During the winter however, the growth is slow and the zone contains much less organic matter. The summer zone appears white and opaque in reflected light because of the scattering of light by the organic matter while the winter zone appears dark and translucent.

Our criteria for interpreting otolith rings were based on Department of Fish and Game studies of Pacific mackerel (Fitch 1951) and northern anchovy (Collins and Spratt 1969). For the purpose of this study, we defined one year of growth as consisting of an inner opaque zone (summer growth) and an outer hyaline zone (winter growth). Since many otolith margins were difficult to interpret until a significant portion of a zone had been formed, we established the criterion that a year of growth was not complete until an opaque margin was evident on at least 50% of the outer rim of the otolith. This convention helped to establish consistency among the otolith readers. Some degree of unmeasureable error existed in the reading procedure, particularly in dealing with the older age groups. The otoliths from animals up to 4 years old are highly legible (Figures 2, 3), but those from fish 4 years and older tend to be heavily calcified and thickened and to produce two or more narrow opaque bands during summer growth. These bands are quite narrow relative to the others and often are not complete around the otolith; we termed them "fractured annuli". In our attempts to interpret these fractured annuli we eliminated some and consolidated others. An age was assigned to the fish by counting the correct bands and noting the condition of the margin. No reference was made to fish lengths when readers were establishing ages. The distance between the focus of the otolith and the midpoint of each opaque zone was measured using a micrometer eyepiece and a back-calculation of the fish's length at each year in its life was made. Although both otoliths were examined, only the best of the pair was measured. A few of the otoliths were either deformed or too thickly calcified and opaque to be read. Whenever this occurred, one of the pair of otoliths was legible and an age was assigned.

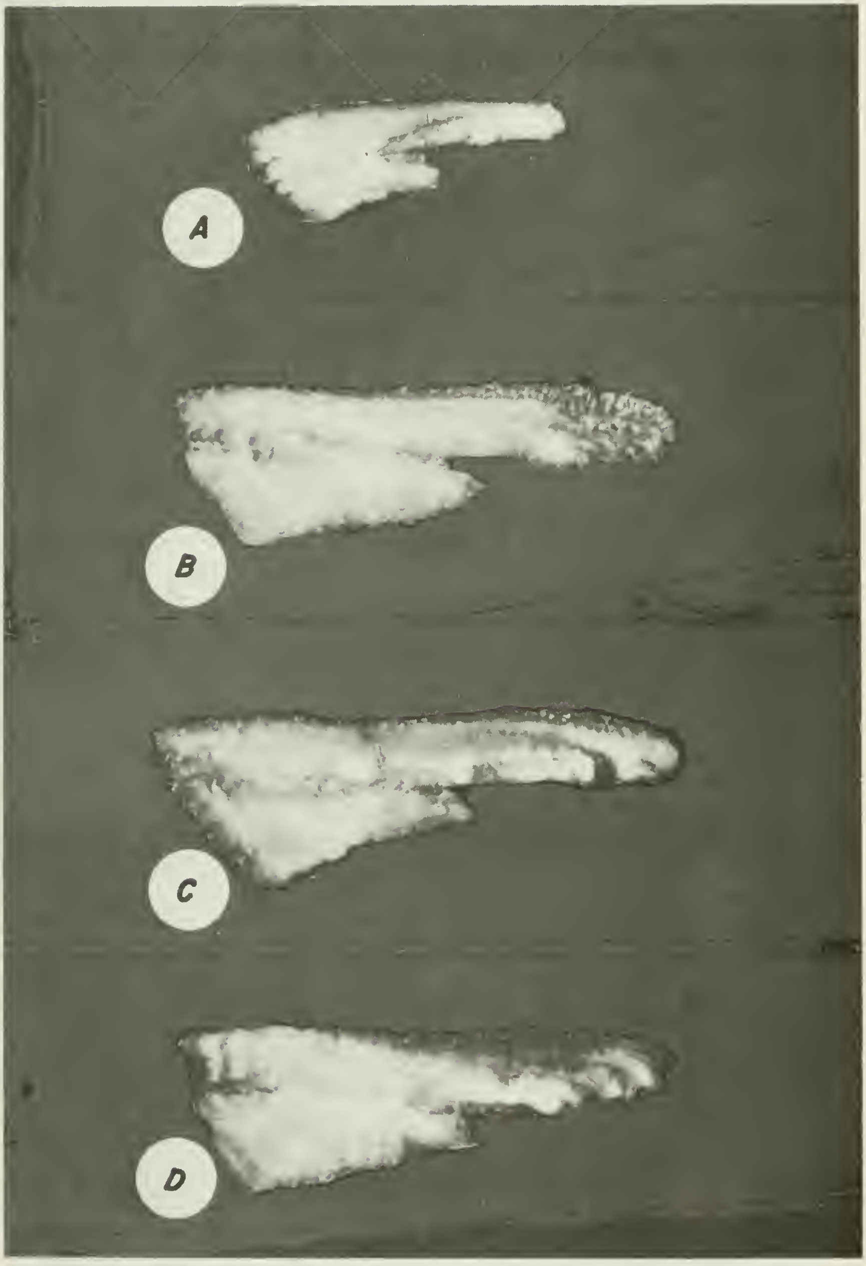

FIGURE 2. Examples of otoliths from: A—37.3 cm female, age O; B—57.9 cm male, age I; C—64.2 cm male, age II; and D—67.1 cm male, age III. *Photographs by Jack W. Schott.*

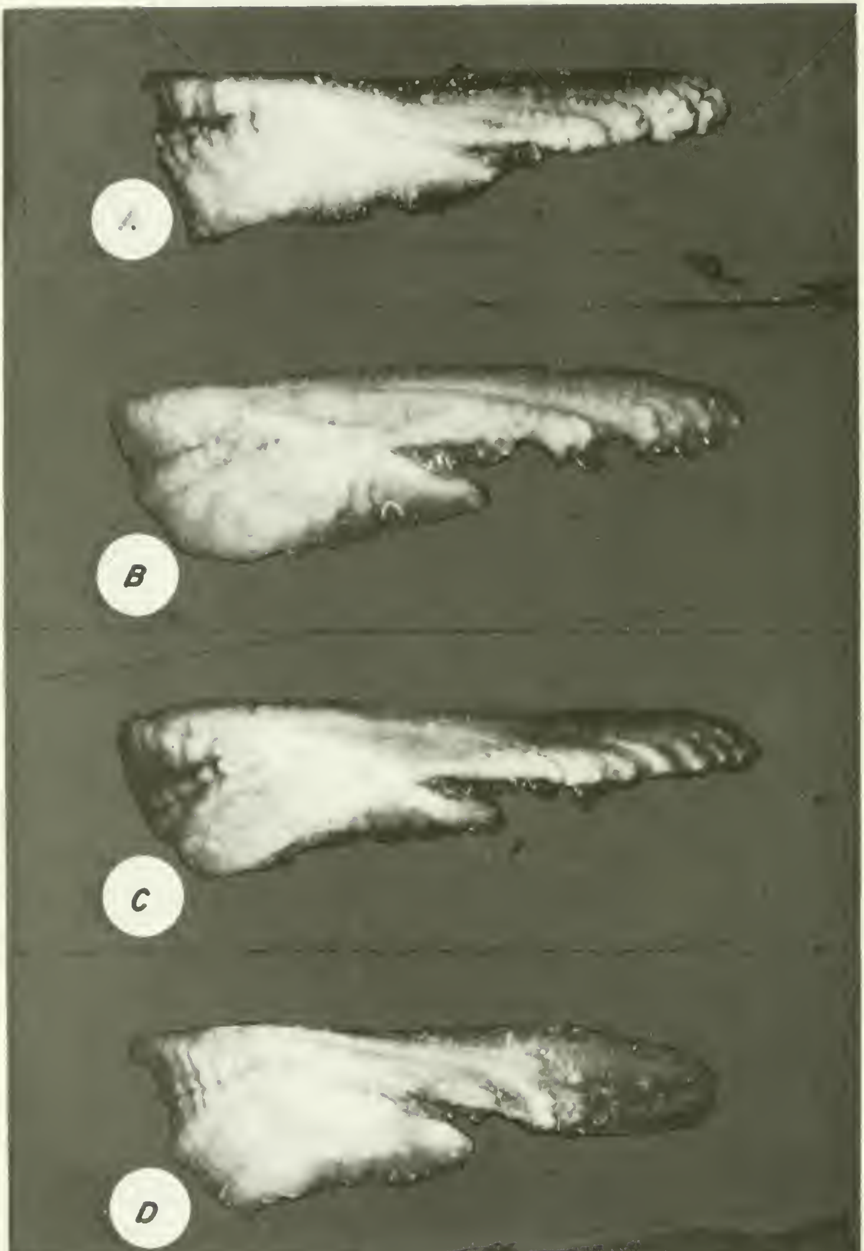

FIGURE 3. Otoliths from: A—71.5 cm female, age IV; B—72.4 cm female, age V; C—72.2 cm male, age V; and D—73.6 cm female, age VI. *Photographs by Jack W. Schott.*

RESULTS

Otolith Readings

Ages were assigned to all 3,139 bonito examined. These fish ranged from less than 1 to over 6 years, and in size from 23 to 79 cm (9 to 31 inches) FL.

The lengths and ages from these fish were used to generate the constants for a von Bertalanffy growth equation (Beverton and Holt, 1967).

$$l_t = 76.87\,[1 - e^{-0.6215(t-0.410)}]$$

The curve was fitted to the data using a least squares computer program (Abramson 1971, Tomlinson and Abramson 1961). The equation gives the length (FL) at each age as; age I—44.9 cm, II—67.6 cm, III—67.6 cm, IV—71.9 cm, V—74.2 cm, and V—75.4 cm. Growth is rapid during the first 3 years, tapering off to a relatively low rate during the last 3 years.

To compare the growth predicted by this equation with the mean length and range of the fish sampled from the fishery we calculated the length of each age group at the mid-point of the fishing season by adding 3 month's growth to the length at the time of annulus formation ($t + 0.375$). The mean length (FL) of each age group in the fishery then is; age group I—51.5 cm, II—63.3 cm, III—69.5 cm, IV—72.9 cm, V—74.8 cm, and VI—75.7 cm.

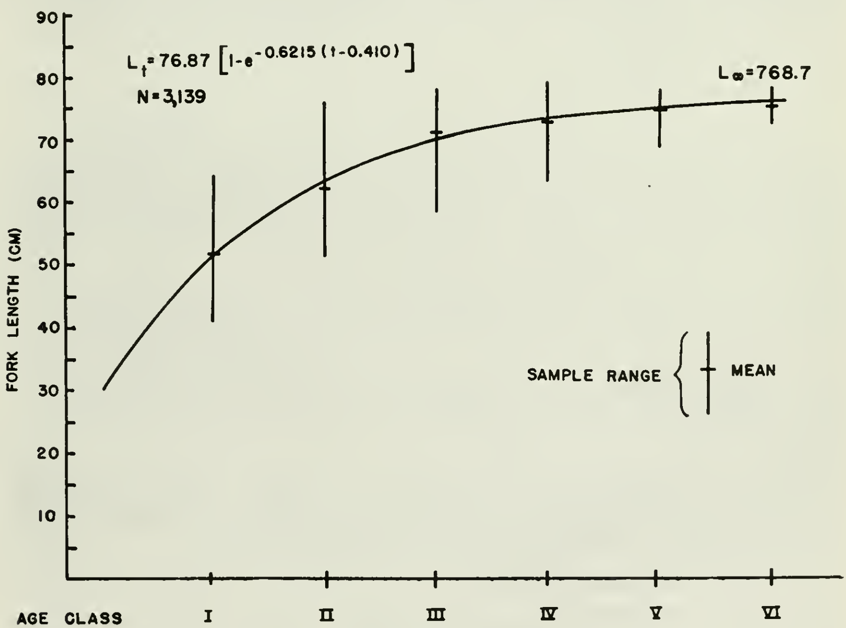

FIGURE 4. Von Bertalanffy growth curve for Pacific bonito. For comparison the range and mean lengths of each age group in the sample are plotted on the curve.

The L_∞ predicted by this equation is less than has been observed by us in the catch, and is much less than the 102 cm (40-inch) fish recorded by Roedel (1948). This may be due in part to the lack of fish larger than 79 cm (31 inches) in the sample which was used to calculate the growth curve. The 40-inch fish reported by Roedel (1948) is so far from our growth curve that Fitch (Pers. Comm.) speculates that it may have been an abnormally large unreproductive "giant" such as reported by Fitch and Lavenberg (1971) for Pacific mackerel (*Scomber japonicus*). Fish up to 82 cm (32 inches) FL were observed in the catch, but unfortunately no otoliths could be obtained from them.

Consistency of Otolith Readings

In order to test the consistency and reliability of the otolith reading technique, a total of 2,076 otoliths was read independently by the two readers. The frequency of agreement on the first reading varied between 61 and 87%. The two readers agreed on the age of better than 80% of the otoliths in 3 out of the 4 years of samples. Where differences in ring count occurred, a second examination was made by both readers simultaneously. The frequency of agreement during the second reading varied between 96 and 99.66%. The major discrepancy was due to differences in interpretation of the condition of the margin on otoliths from older fish. The relatively high degree of agreement indicates that age determination of bonito from otoliths is consistent and reliable.

Validation of Age Determination from Otoliths

We chose to validate the otolith method of age determination in four ways: i) Observation of the change in the character of the otolith margin over a year's time; ii) Back-calculation of length at each age by proportion to otolith length; iii) Observation of the progression of monthly length-frequency modes and; iv) Direct observation of the growth of tagged fish.

Changes in the Otolith Margin

The first hurdle in any age and growth study is to prove that the zones which are being counted on the scales, otoliths, vertebrae, etc. are formed annually. We noted the condition, opaque or translucent, of the margin of every otolith examined and used the otoliths with less than three annuli to graph the percent with either opaque or translucent margins each month, for one year (Figure 5).

In July, 100% of the fish sampled had otoliths with opaque margins, while between July and March this percentage decreased steadily to a low of 19% in March. Between March and July there was a steady increase in the percent of otoliths having opaque margins. This cyclic change indicates that a new opaque zone is begun each year between March and July and that a single opaque-hyaline zone pair is formed each year.

These data along with what spawning information is available (Pinkas 1961, Klawe 1961) indicate that a birthdate of July 1 would be appropriate for establishing year-class memberships.

Back-Calculation of Length at Age

To further validate the annual nature of the zones, we back-calculated the theoretical length of the fish at each age before it was caught and compared these to lengths from the Von Bertalanffy equation and to the age-length frequency obtained from sampled fish. This method is based on the direct proportion between otolith size and fish length and uses the formula $L = L_c O_r / O_m$ where $L =$ length at time of annulus formation, $L_c =$ length at time of capture, $O_r =$ dis-

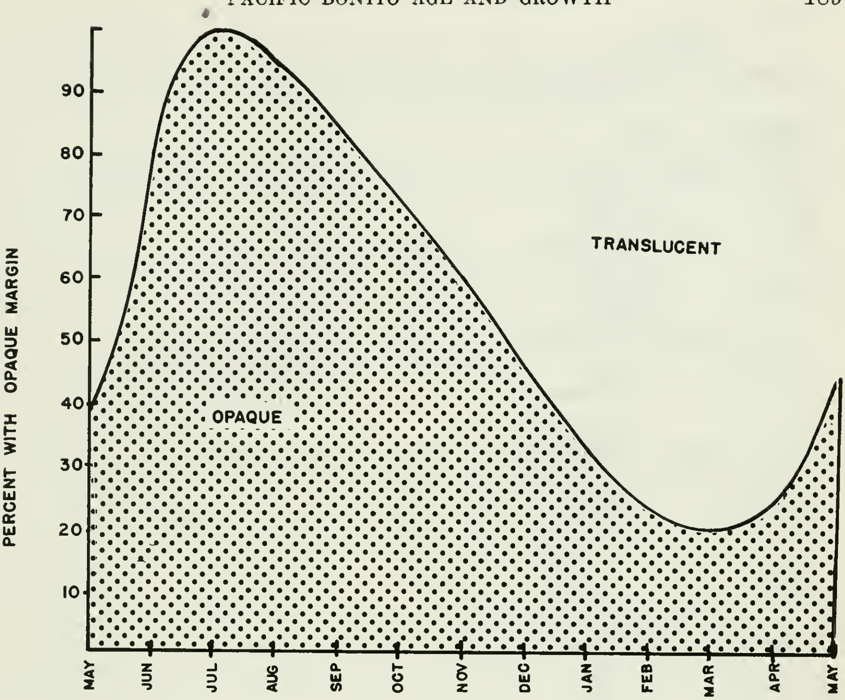

FIGURE 5. Percent of bonito otoliths showing opaque and hyaline margins for each month of the year.

tance from the otolith focus to the midpoint of the opaque zone in question, and $O_m =$ the distance from the focus to the posterior margin. In order to use this method there must be a direct relationship between otolith size and the length of the fish. Otolith length O_l (cm) was plotted against the fork length of the fish (cm) for 516 fish, and the relationship appeared linear. A regression analysis yielded the equation: $O_l = 10^{-3}(69.69 + 3.22 \text{ FL})$, with a standard error of 23.97 and a correlation coefficient of 0.85.

The otoliths from 918 bonito were used to back-calculate lengths and their means for each age group. These calculated mean lengths (FL) were 47.9 cm for formation of the first annulus, 58.0 cm for the second annulus, 64.3 cm for the third, 68.4 cm for the fourth, and 70.7 cm for the fifth (Table 1). When these lengths were compared to the length-frequency data, they matched the modes quite well (Figure 6). The relationship of the calculated lengths to the observed lengths exhibited a good correspondence and further validated the annual nature of the zones.

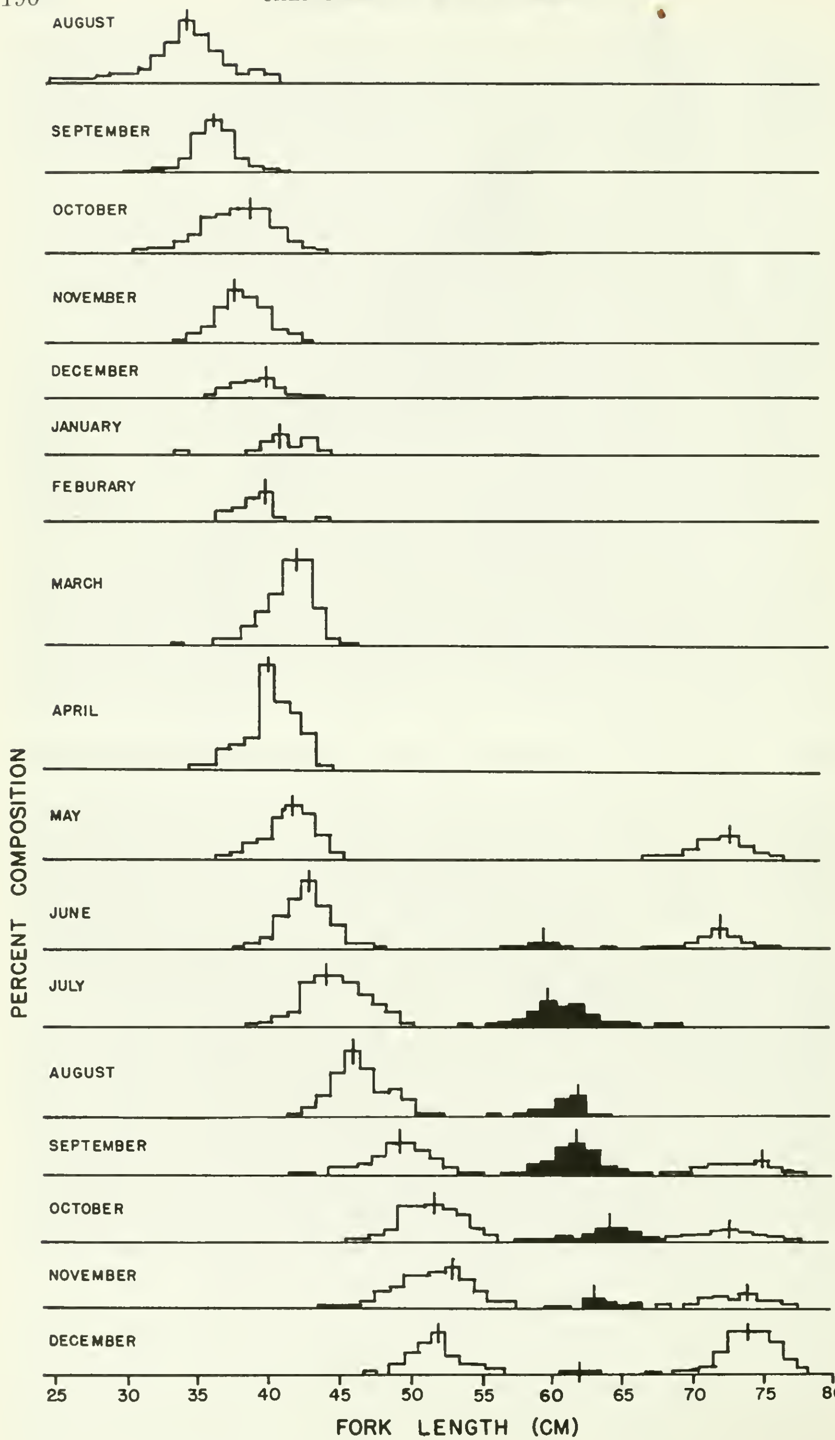

FIGURE 6. Monthly length frequencies of bonito caught off southern California 1972–73. The modes are marked.

TABLE 1. **Back-Calculated lengths at each age for Pacific Bonito**

Age group	Back-calculated lengths (cm FL)*					Number of samples
	l_1	l_2	l_3	l_4	l_5	
I	46.0					422
II	49.5	59.0				102
III	48.4	57.5	66.6			248
IV	48.4	57.5	64.1	70.1		124
V	47.1	58.1	62.1	66.7	70.7	22
Average	47.9	58.0	64.3	68.4	70.7	Total 918

* Lengths correspond to length of fish in early to mid summer.

Modal Progression

In order to compare growth estimates from the growth equation to field observations of growth, monthly length-frequency polygons were constructed from data collected from all segments of the fishery during 1972 and 1973 (Figure 6). The first mode, which we designated the 1972 year-class, was followed for more than a year, during which the change in the modal length matched the growth rate obtained from the otoliths of 0 and I age group fish. The modal progression indicated very rapid growth from about May or June until October, and almost no growth from January through April. During periods of rapid growth, fish in the first modal group gained about 2 cm per month, while the second mode fish grew 1 cm per month or less. Fish three years and older (third mode) could not be separated into distinct age groups, but it was evident that they grew very slowly. The modal lengths were plotted on the von Bertalanffy growth curve graph (Figure 7) in order to compare observed growth to estimates obtained from otoliths. The two curves fit quite well, lending further support to the otolith method.

Growth of Tagged Fish

Direct observations of growth can be obtained from a tag and recapture experiment when length measurements are taken from fish at both release and recapture. These measurements can then be compared to the calculated growth estimates derived from other methods. A tagging project was launched in 1968, in conjunction with the start of the age and growth study on bonito. To date, over 13,000 tagged fish have been released from research vessels, partyboats and bait receivers, and over 1,000 have been returned by sport and commercial fishermen. About 13% of the tag returns, or 140 fish, provided good, reliable (verified length at time of capture) growth data (Table 2). This growth matched that predicited by the von Bertalanffy growth curve quite well (Figure 8). The most interesting recovery was of a fish at liberty 848 days (over 2 years) which grew from 40 cm (15.7 inches) at the time of release to almost 68 cm (26.8 inches) when recaptured. This growth matched that predicted by the growth equation almost exactly. The growth of the 0 age group fish at liberty for short periods also agreed well with our predictions from growth curve data.

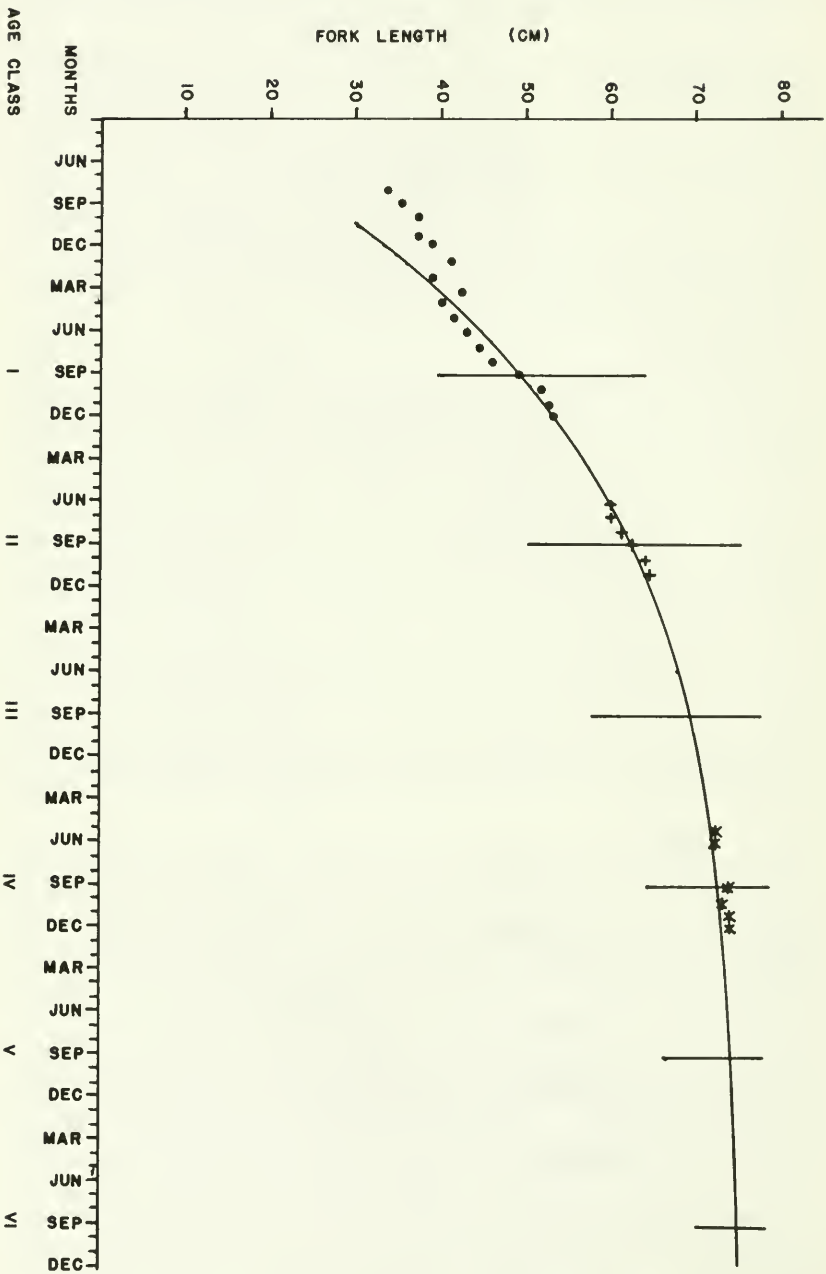

FIGURE 7. Monthly modal lengths from figure 6 plotted against the von Bertalanffy growth curve. ● = mode 1, + = mode 2, * = mode 3.

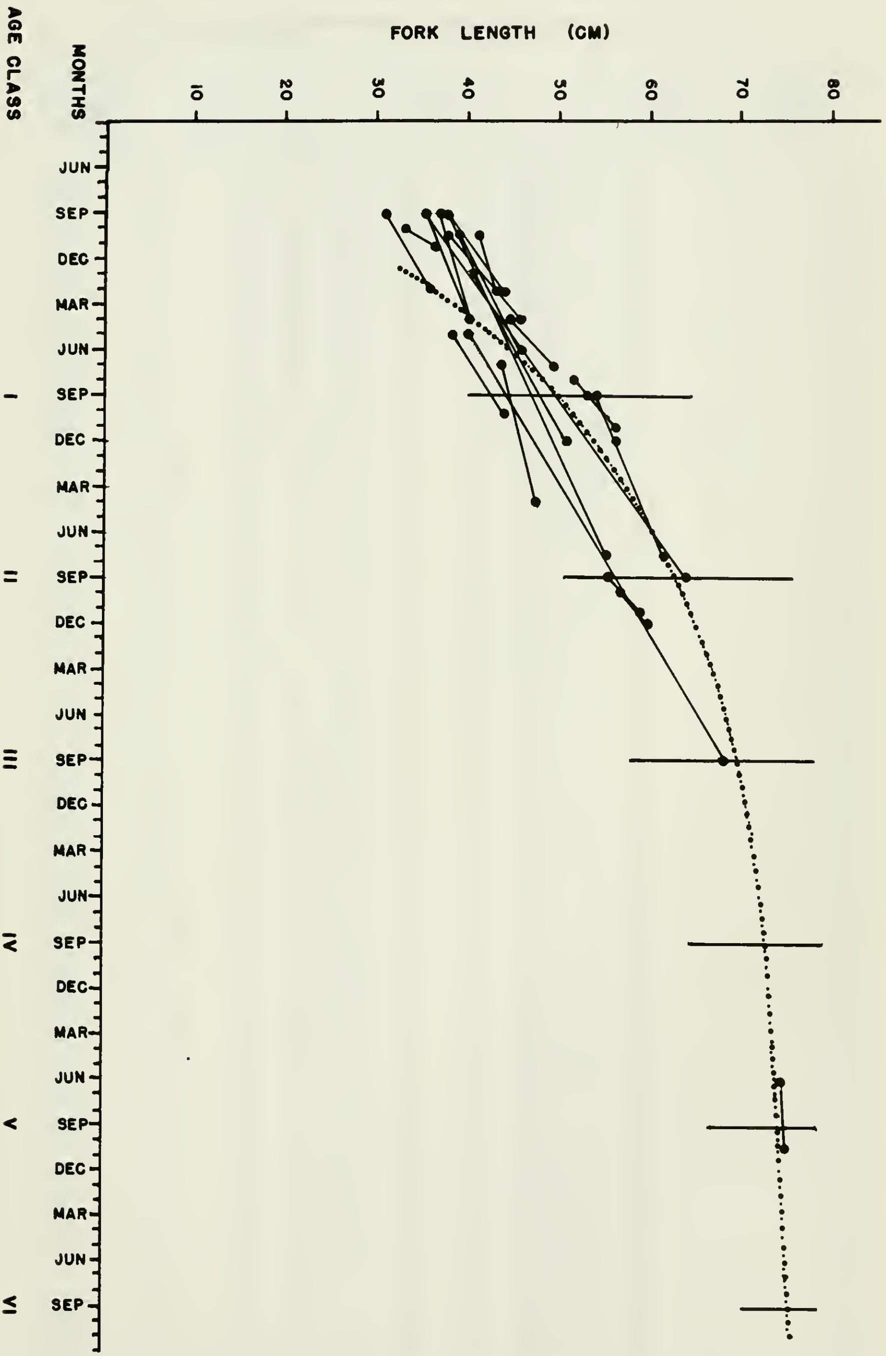

FIGURE 8. The growth of selected tagged fish against the van Bertalanffy growth curve. Fish at liberty less than 2 months have been omitted.

TABLE 2. **Growth Data from Recovered Tagged Bonito**

Date of release*	Length at release (mm FL)	Date of recovery*	Length at recovery (mm FL)	Days at liberty	Growth (mm)	Calculated length one year after release (mm)
115/69	455	185/69	492	71	37	645
122/69	430	127/69	432	6	2	552
122/69	450	140/69	438	25	−12	--
133/69	430	144/69	430	12	0	--
133/69	400	144/69	400	12	0	--
133/69	405	190/69	416	58	11	474
136/69	395	149/69	395	14	0	--
157/69	425	182/69	426	26	1	439
164/69	420	191/69	428	28	8	524
164/69	440	209/69	444	46	4	472
189/69	440	99/70	483	276	43	497
233/70	570	234/70	553	2	−17	--
237/70	570	250/70	574	14	4	674
247/70	320	279/70	338	33	18	519
247/70	310	55/71	362	174	52	419
248/70	580	265/70	567	18	−13	--
248/70	330	272/70	347	25	17	578
248/70	330	265/70	325	18	−5	--
252/70	520	271/70	516	20	−4	--
70/71	430	114/71	419	45	−11	--
25/72	570	64/72	567	40	−3	--
154/72	505	177/72	495	24	−10	--
162/72	745	277/72	752	116	7	767
248/72	570	287/72	551	40	−19	--
249/72	363	256/72	355	8	−8	--
249/72	575	257/72	560	9	−15	--
249/72	541	287/72	545	39	4	578
250/72	564	272/72	559	23	−5	--
250/72	598	267/72	599	18	1	618
250/72	560	265/72	559	16	−1	--
250/72	544	264/72	535	15	−9	--
250/72	351	263/72	355	14	4	455
348/72	401	208/73	457	225	56	489
251/72	545	201/73	618	315	74	633
271/72	380	104/73	457	198	77	427
279/72	585	353/72	605	75	20	682
282/72	700	332/72	692	51	−8	--
306/72	380	29/73	391	90	11	425
269/72	382	34/73	432	132	50	520
269/72	360	118/73	406	216	46	438
306/72	395	15/73	406	76	11	448
116/73	380	119/73	380	4	0	--
76/73	415	104/73	419	29	4	465
312/72	390	108/73	402	163	12	417
271/72	380	104/73	405	200	25	426
279/72	390	105/73	432	253	42	451
289/73	425	201/73	445	113	20	490
280/72	385	198/73	438	285	53	453
276/72	356	288/72	349	13	7	553
276/72	370	294/72	363	19	−7	--
281/72	395	21/73	443	107	50	566
282/72	595	306/72	584	25	−11	--
283/72	720	302/72	720	20	0	--
289/72	390	304/72	390	21	0	--
292/72	380	302/72	368	11	−12	--
300/72	380	309/72	378	10	−2	--
303/72	435	316/72	414	14	−21	--
306/72	370	326/72	363	21	−7	--
307/72	380	325/72	367	19	−13	--
76/73	436	131/73	427	56	−9	--
279/72	405	157/73	446	243	40	465
136/73	394	164/73	395	29	1	435
269/72	367	330/72	387	62	20	485
94/68	440	143/68	440	50	0	--

TABLE 2. **Growth Data from Recovered Tagged Bonito—Continued**

Date of release*	Length at release (mm FL)	Date of recovery*	Length at recovery (mm FL)	Days at liberty	Growth (mm)	Calculated length one year after release (mm)
131/68	438	140/68	430	10	−8	--
131/68	476	142/68	470	12	−6	--
145/68	420	145/68	410	1	−10	--
145/68	455	147/68	455	3	0	--
145/68	405	147/68	405	3	0	--
145/68	440	158/68	442	14	2	492
145/68	450	201/68	455	57	5	482
263/68	490	272/68	480	10	−10	--
263/68	510	275/68	510	13	0	--
271/68	410	309/68	407	39	−3	--
296/68	560	30/69	565	101	5	578
108/69	440	109/69	425	2	−15	--
184/73	455	190/73	457	7	2	663
129/69	400	247/71	686	848	286	523
201/73	485	277/73	520	77	35	651
271/72	390	228/73	413	322	23	416
187/73	445	240/73	460	53	15	548
278/72	395	249/73	457	336	62	462
282/72	410	251/73	432	334	22	434
173/73	405	289/73	442	117	37	520
213/73	472	282/73	520	70	48	722
228/73	468	360/73	507	133	39	575
258/72	365	245/73	481	353	116	485
230/73	515	315/73	557	86	42	694
89/73	405	96/73	406	8	1	451
280/72	370	91/73	395	177	25	422
76/73	415	104/73	419	29	4	465
89/73	460	108/73	470	20	10	643
261/72	380	99/73	415	203	35	443
271/72	370	100/73	394	195	24	415
187/73	420	194/73	422	8	2	511
170/73	418	216/73	420	47	2	589
250/72	534	291/72	559	42	25	751
251/72	545	287/72	547	37	2	565
251/72	560	266/72	552	16	−8	--
256/72	367	280/72	370	25	3	455
256/72	352	327/72	364	72	12	413
258/72	355	279/72	370	22	15	604
258/72	350	309/72	370	52	20	490
261/72	360	288/72	363	28	3	399
261/72	370	305/72	378	45	8	435
264/72	560	285/72	572	22	12	759
269/72	331	285/72	338	17	7	481
269/72	370	292/72	389	24	19	598
269/72	348	283/72	351	15	3	421
269/72	377	313/72	377	45	0	--
271/72	380	283/72	386	13	6	548
271/72	370	289/72	370	19	0	--
271/72	375	311/72	380	41	5	420
276/72	363	283/72	366	8	3	500
276/72	377	291/72	381	16	4	468
276/72	383	288/72	381	13	−2	--
276/72	407	301/72	399	26	−8	--
276/72	356	306/72	362	31	6	427
258/72	365	329/72	373	72	8	406
306/72	370	334/72	360	29	−10	--
247/70	320	298/70	343	52	23	481
273/70	360	26/71	381	119	21	424
68/71	415	87/71	413	20	−2	--
68/71	395	78/71	400	11	5	561
70/71	370	80/71	368	11	−2	--
152/72	450	183/73	552	396	102	544
258/72	336	201/73	457	311	121	478
145/68	430	291/68	448	147	18	475

TABLE 2. **Growth Data from Recovered Tagged Bonito—Continued**

Date of release*	Length at release (mm FL)	Date of recovery*	Length at recovery (mm FL)	Days at liberty	Growth (mm)	Calculated length one year after release (mm)
115/69	420	228/69	445	114	25	500
129/69	435	229/69	480	101	45	598
133/69	390	192/69	410	60	20	512
133/69	380	247/69	414	115	34	488
157/69	405	245/69	430	89	25	508
157/69	400	257/69	438	101	38	537
248/72	345	329/72	369	82	24	452
250/72	566	306/72	597	57	31	765
251/72	540	336/72	559	86	19	621
251/72	360	6/73	404	122	44	492
281/72	405	48/73	432	134	27	479
292/72	330	361/72	368	70	38	528

* Julian Date i.e. 361/72 is the 361st day of 1972 or December 26th, 1972.

In addition, we plotted growth of the tagged fish (cm) against days at liberty and compared the results with the predicted length changes from the growth curve. The resulting scatter diagram from the tagging data appeared linear, so a linear regression analysis was performed. The equation of best fit was $Y = -0.605 + 0.27X$ with a correlation coefficient of 0.89 and a standard error of 1.553 (Figure 9). The diagram indicated that the growth rate of the tagged fish was slightly less

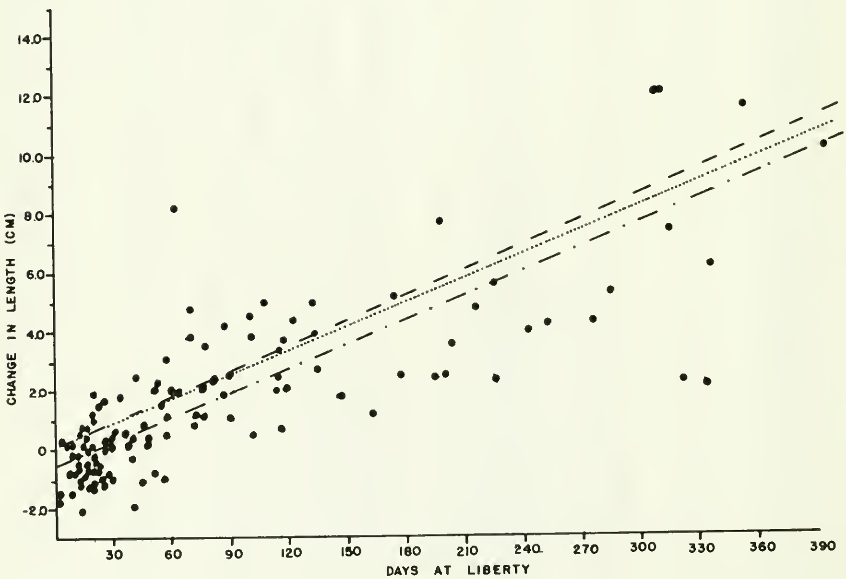

FIGURE 9. Scatter diagram of length changes of tagged fish. Dot-dash line is straight line of regression. Dashed line is straight line of regression forced through the origin. Dotted line is expected length changes derived from von Bertalanffy growth equation.

than the predicted values but still was in good agreement. A fish with a tag may not grow at a normal rate (Jensen 1967). Subnormal growth rates are commonly observed in tagging studies. The high degree of variation about the line was most likely due to the lack of accuracy in measuring a live, active fish.

Weight-Length Relationship

A weight-length relationship was determined for bonito based on a sample of 2,824 fish landed at the canneries at Terminal Island, California during 1969 through 1973. These fish ranged in weight from 200 to 7657 gms (0.4 to 16.9 lbs) and in length from 29 to 77 cm (11 to 30 inches). The least squares method was used to calculate the regression of weight (grams) on length (millimeters) for each sex. The equation of best fit for the males was $W = 7.26083 \times 10^{-6} L^{3.09749}$ and for the females $W = 7.93187 \times 10^{-6} L^{3.08338}$. The composite length-weight equation was $W = 7.62728 \times 10^{-6} L^{3.08962}$ with a standard error of 0.757 and a correlation coefficient of 0.99. The 95% upper confidence limit of the exponent was set at 3.10588 and lower limit set at 3.07335 (Figure 10).

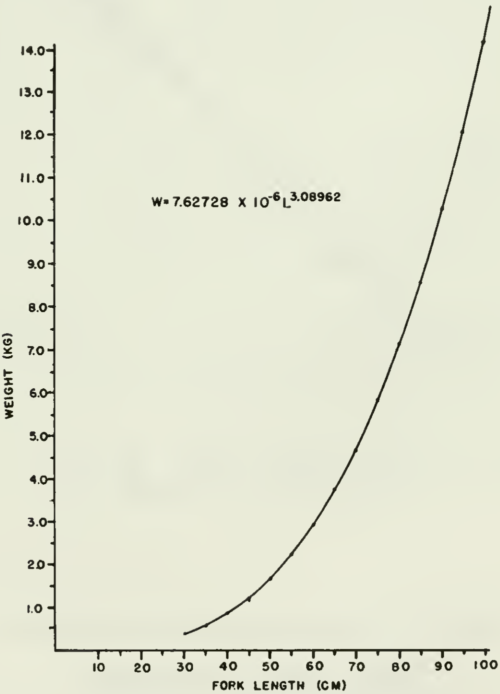

FIGURE 10. Length-weight relationship.

Length Conversions

Since project personnel use fork length in measuring bonito and fishermen often use total lengths, a conversion factor was derived based on 273 fish sampled from sportboats and canneries. Mean fork length for each 0.5 cm (0.2 inch) interval was plotted against its corresponding mean total length. The resulting graph indicated that the relationship was linear, so a linear regression equation was computed: Total length $= 4.05 + 1.02$ fork length with a standard error of 1.113 and a correlation coefficient of 0.99 (Figure 11).

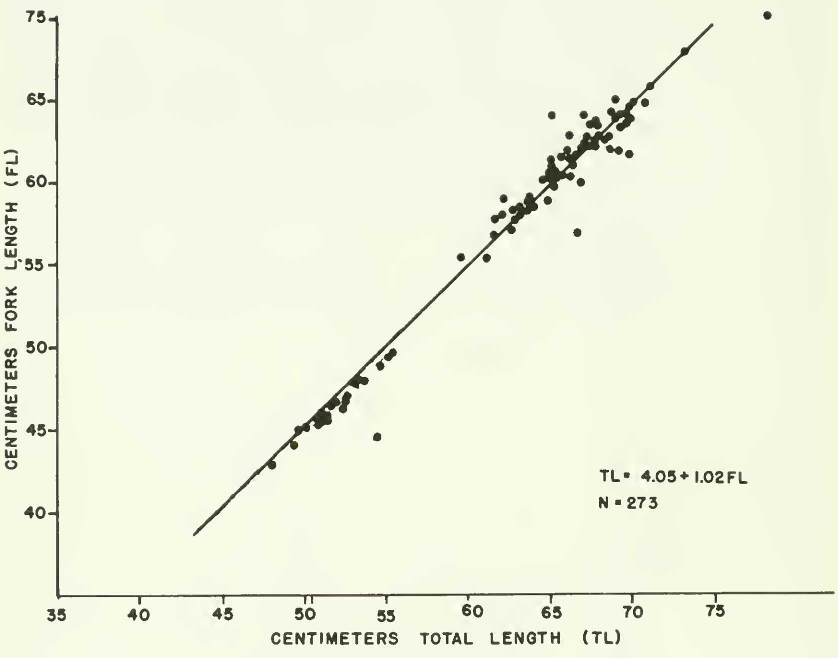

FIGURE 11. Relationship between fork and total length.

SUMMARY AND CONCLUSIONS

An age and growth study of Pacific bonito was undertaken by the California Department of Fish and Game to provide information for ultimate management of this rapidly expanding fishery.

Otoliths obtained from fish landed by the commercial fleet at San Pedro, California, from 1968 to 1973 were used to establish ages for more than 3,000 bonito. These otoliths were read and used to construct an age-length frequency and to obtain the constants for a von Bertalanffy growth curve.

The age determination method (otoliths) was validated by several techniques. The annual nature of the zones on the otoliths was demonstrated by the cyclic character of the otolith margin throughout the year and by the comparison of back-calculated fish lengths. Observed growth rates from length-frequency modes and tagging data correlated well with the growth rates from otolith reading. Two readers examined the otoliths independently and then simultaneously. The relatively high degree of agreement attained both times indicated good consistency in the method.

A weight-length equation was derived based on nearly 3,000 fish, and an equation was computed for converting total length to fork length.

Otoliths are deemed reliable for determining the age of bonito, and we recommend that they be used in any future management program.

ACKNOWLEDGEMENTS

Many Department personnel have contributed substantially to this study since its inception in 1968. Foremost among those deserving special mention is Kevin Farnum, who spent many hours learning the otolith reading technique. John Geibel and Brian Thayer coordinated the sampling and tagging projects until their transfers in 1969 and 1973, respectively. John Seapin carried out the waterfront sampling from 1970 through 1973.

Seasonal employees Harvey Pearson, Kenneth Bolding, Robert Dantas, Rodney Brashear, Donald Schultze, Darlene Osborne, and Dennis Henley all were involved in measuring, taking otoliths, and tagging fish. Other seasonal and permanent employees, too numerous to mention, participated in our tag and release experiment.

The captains and crews of the *N. B. SCOFIELD* and *KELP BASS* assisted immeasurably in the work at sea.

Harold B. Clemens and John E. Fitch gave valuable advice and counsel during the study, and Eric Knaggs reviewed the manuscript.

We sincerely offer our thanks to all these persons whose contributions were an integral part of the success of this study.

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PARASITES OF FISHES FROM THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA[1]

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Between June of 1972 and June of 1973, 545 fishes representing 28 species were examined, revealing the presence of the following parasites:

Protozoa: *Myxobolus koi* Kudo, 1920 from *Cyprinus carpio*.

Trematoda: *Dactylogyrus extensus* Mueller and Van Cleave, 1932 from *Cyprinus carpio; Cleidodiscus pricei* Mueller, 1936 from *Ictalurus catus, I. melas, Morone saxatilis,* and *Chaenobryttus gulosus; Posthodiplostomum minimum centrarchi* (MacCallum, 1921; Dubois, 1936) Hoffman, 1958 from *Chaenobryttus gulosus* and *Lepomis macrochirus; Clinostomum marginatum* (Rudolphi, 1819) from *Chaenobryttus gulosus;* and *Alloglossidium corti* (Lamont, 1921) Mueller, 1930 from *Ictalurus catus, I. nebulosus,* and *I. punctatus*.

Cestoda: *Atractolytocestus huronensis* Anthony, 1958 from *Cyprinus carpio; Khawia iowensis* Calentine and Ulmer, 1961 from *Cyprinus carpio; Corallobothrium giganteum* Essex, 1927 from *Ictalurus catus, I. punctatus,* and *I. melas; Corallobothrium fimbriatum* Essex, 1927 from *Ictalurus catus, I. punctatus,* and *I. melas; Bothriocephalus claviceps* (Goeze, 1782) Rudolphi, 1810 from *Lepomis macrochirus; Pelichnibothrium speciosum* Monticelli, 1889 from *Alosa sapidissima;* and *Lacistorhynchus* sp. from *Morone saxatilis*.

Nematoda: *Philometra carassii* (Ishii, 1934) from *Carassius auratus; Capillaria catenata* Mueller and Van Cleave, 1932 from *Cyprinus carpio; Contracaecum brachyurum* (Ward and Magath, 1917) from *Ictalurus catus, Morone saxatilis, Pomoxis nigromaculatus,* and *Alosa sapidissima; Contracaecum spiculigerum* (Rudolphi, 1809) from *Ictalurus nebulosus; Raphidascaris* sp. from *Alosa sapidissima; Metabronema salvelini* (Fujita, 1922) from *Pogonichthys macrolepidotus;* and *Spiroxys* sp. from *Morone saxatilis*.

Hirudinea: *Illinobdella moorei* (Meyer, 1940) Meyer, 1946 from *Ictalurus catus*.

Crustacea: *Lernaea cyprinacaea* Linnaeus, 1761 from *Ictalurus catus, Mylopharodon concocephalus, Orthodon microlepidotus, Pogonichthys macrolepidotus,* and *Ptychocheilus grandis*.

New geographic distributions include: *Myxobolus koi* Kudo, 1920 (Protozoa); *Atractolytocestus huronensis* Anthony, 1958; *Khawia iowensis* Calentine and Ulmer, 1961; and *Bothriocephalus claviceps* (Goeze, 1782) Rudolphi, 1810, (Cestoda); *Philometra carassii* (ishii, 1934); *Capillaria catenata* Mueller and Van Cleave, 1932; and *Contracaecum brachyurum* (Ward and Magath, 1917), (Nematoda); *Illinobdella moorei* (Meyer, 1940) Meyer, 1946 (Hirudinea).

A list of fishes negative for parasites is included.

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INTRODUCTION

There have been three major studies concerned with parasites of freshwater fishes of California. Haderlie (1953) summarized research up to 1953 and conducted a general survey of the parasites of fishes of northern California. From 2,010 fishes representing 36 species examined from 1947 to 1950, he obtained a total of 59 species of helminth, copepod, and hirudinian parasites. Along with the taxonomic study, Haderlie attempted to correlate relative occurrence of the parasites with various ecological habitats.

Haderlie examined a few fish from the San Pablo Reservoir, Lake Temescal, Lake Hinman, and the Napa River, about 80 km (50 miles) west of the Sacramento-San Joaquin Delta. There is no indication in his paper as to the type of parasites encountered or the frequency of parasitism in these regions.

Edwards and Nahhas (1968) investigated the parasites of fishes of the Sacramento-San Joaquin Delta and compared their findings with those of Haderlie. During 1966 and 1967, 236 fishes representing 26 species were examined resulting in the recovery of 12 parasites of which six were digenea, five cestodes, and one acanthocephalan.

Miller, Olson, and Miller (1973) reported the results of an investigation in which 480 fishes representing 13 species were collected from 13 reservoirs in southern California. Four digeneans, seven monogeans, five cestodes, one nematode, one acanthocephalan, and one hirudinean are reported.

Less extensive work has been done by Wagner (1953), Wales (1958), Colley and Olsen (1963), Miller, L. W. (1967), Miller, R. L. (1967), and Heckman (1974). The protozoan parasites of California fishes have been studied by several authors in separate articles: Jameson (1931), Noble (1943, 1950), Davis (1947), Wales and Wolf (1955), Leitritz (1960), Becker (1964), Becker and Katz (1965), and Yasutake (1970).

In the central region of the Sacramento-San Joaquin Valley, the monogenetic fauna was investigated extensively by Mizelle and coworkers: Mizelle and Arcadi (1945); Mizelle et al, (1956); Mizelle, Toth, and Wolf (1961); Mizelle (1962); Mizelle and Crane (1964); Mizelle and Price (1964); Price and Mizelle (1964); Mizelle and Kritsky (1967*a*, 1967*b*); Crane and Mizelle (1968); Kritsky and Mizelle (1968); and Mizelle and McDougal (1970).

A report from Van Cleave and Haderlie (1950) deals with acanthocephalans found in California.

Crustaceans and molluscans from California have been described by Wilson (1908) and Murphy (1942).

The purpose of the present study, which was conducted between June 1972 and June 1973, was to extend previous parasitological investigations of the San Joaquin area fishes, with emphasis on their helminthic fauna. One protozoan, found in large numbers, is however included. A brief discussion is given for all parasites encountered for the first time in California.

SAMPLING AND EXAMINATION OF FISH

The major site of collection was the Fish Screen, Bureau of Reclamation, Department of the Interior at Tracy, California. A small number of fish were taken from various sloughs in the Stockton area. In all, 545 fishes were examined. Positive specimens resulted in the recovery of one protozoan, two monogeneans, three digeneans, seven cestodes, seven nematodes, one hirudinean, and one copepod. No parasites were found in 46 fishes belonging to 9 genera.

Fish were obtained by hook and line, dip net, seine, and by hand. After collection, the fish were brought alive to the laboratory, segregated into groups, killed, and immediately examined to minimize migration or loss of parasites.

Before removing the internal organs, each fish was examined for external parasites. The internal organs were removed from the host, separated, and placed in 0.7% saline solution. The heart, liver, gall bladder, urinary bladder, caeca, and mesenteries were examined by teasing the tissues apart with dissecting needles under a dissecting microscope. The stomach and intestine were cut longitudinally to expose the lumen and its contents.

After removal from the host, the parasites were processed according to standard methods. Measurements are in millimeters unless otherwise noted. New host records are indicated by an asterisk. The numbers in parentheses following host name represent the number of individuals that harbored that particular parasite (numerator) and total number of fish examined (denominator).

PARASITES AND FISHES ENCOUNTERED

PROTOZOA

Myxobolus koi Kudo, 1920

Host: *Cyprinus carpio* Linnaeus (1/50)
Site: Encysted on gills

Description based on hundreds of spores, measurements on twenty: Cyst white in color in live material 0.35–0.80 mm in diameter; spores pyriform, 12–15 μ long by 7–10 μ wide; posterior processes and shell striations absent. Polar capsules two, pyriform with coiled filament, equal or somewhat subequal in size, each 7–10 μ long by 2–3 μ wide. Sporoplasm finely granular with an iodinophilous vacuole; sporoplasmic nuclei indistinct.

At least 70 species have been described in the genus *Myxobolus* Bütschli 1881. Most of the species are histozoic parasites of freshwater fish; few are marine; one is parasitic in an annelid, and one in an amphibian. The chief criteria in classification include host and tissue specificity in addition to size and shape of the spore, and number of polar capsules. Infected tissues include brain, spinal cord, intestine, liver, gall bladder, kidneys, spleen, connective tissues, body cavity, cutaneous and subcutaneous tissues, muscle, eye, fins, and gills.

Cyprinus carpio is known to harbor 16 species of *Myxobolus*, four of which are from the gills: *M. cyprinicola* Reuss, 1906 from various localities in Europe, *M. ellipsoides* Thélohan, 1892 from Russia, *M. koi* Kudo, 1920 and *M. toyamai* Kudo, 1915 from Japan and Russia, respectively. Although several species have been reported from North American carp, none were recovered from the gills of *Cyprinus carpio*.

The present specimens agree with the description of *M. koi* Kudo, 1920 in size, shape of spores, and characteristics of the capsules. The only difference noted is the size of the cyst given by Kudo (1920) as 230 μ in maximum diameter, whereas in the present study cysts were larger, ranging in size from 350 to 800 μ. As far as can be determined, this is the first record of this parasite outside Japan.

MONOGENEA

Dactylogyrus extensus Mueller and Van Cleave, 1932

Host: *Cyprinus carpio* Linnaeus (9/50)
Site: Gills

Cleidodiscus pricei Mueller, 1936

Hosts: *Ictalurus catus* (Linnaeus) (6/137)
**Ictalurus melas* (Rafinesque) (7/33)
**Morone saxatilis* (Walbaum) (1/81)
**Chaenobryttus gulosus* (Cuvier) (1/7)
Site: Gills

DIGENEA

Posthodiplostomum minimum centrarchi (MacCallum, 1921; Dubois, 1936) Hoffman, 1958

Hosts: *Chaenobryttus gulosus* Cuvier (3/7)
Lepomis macrochirus Rafinesque (9/33)
Site: Encysted on the heart and liver

Clinostomum marginatum (Rudolphi, 1819)

Host: *Chaenobryttus gulosus* (Cuvier) (1/7)
Site: Encysted on heart

Alloglossidium corti (Lamont, 1921) Mueller, 1930

Hosts: *Ictalurus catus* Linnaeus (7/137)
Ictalurus nebulosus (LeSueur) (4/9)
Ictalurus punctatus Rafinesque (1/9)
Site: Intestine

CESTODA

Atractolytocestus huronensis Anthony, 1958

Host: *Cyprinus carpio*, Linnaeus (1/50)
Site: Intestine

This species, first described from the same host in Michigan, was also found in Oklahoma. Its recovery from *Cyprinus carpio* in California confirms Mackiewicz's belief of its wide geographic distribution (J. S. Mackiewicz, State University of New York, pers. comm.).

Khawia iowensis Calentine and Ulmer, 1961

Host: *Cyprinus carpio*, Linnaeus (3/50)

Site: Intestine

Khawia iowensis, a common parasite of *Cyprinus carpio,* is known from Iowa, Wisconsin, and Oklahoma. It is here reported for the first time from California. Its identification, and that of *Atractolytocestus huronensis,* was confirmed by Dr. Mackiewicz.

Corallobothrium giganteum Essex, 1927

Hosts: *Ictalurus catus* (Linnaeus) (13/137)
Ictalurus punctatus Rafinesque (1/9)
**Ictalurus melas* (Rafinesque) (1/33)
Site: Intestine

Corallobothrium fimbriatum Essex, 1927

Hosts: *Ictalurus catus* (Linnaeus) (55/137)
Ictalurus punctatus Rafinesque (5/9)
Ictalurus melas (Rafinesque) (1/33)
Site: Intestine and stomach

Bothriocephalus claviceps (Goeze, 1782) Rudolphi, 1810

Host: *Lepomis macrochirus* Rafinesque (2/33)
Site: Intestine

Haderlie (1953) found larval forms of this genus in *Lepomis macrochirus* and *L. cyanellus.* The present material, represented by 2 mature specimens, is the first record of the adult form in California.

Pelichnibothrium speciosum Monticelli, 1889

Host: **Alosa sapidissima* (Wilson) (1/17)
Site: Intestine

Lacistorhynchus sp.

Host: *Morone saxatilis* (Walbaum) (1/81)
Site: Encysted in muscle

NEMATODA

Philometra carassii (Ishii, 1934)

Host: *Carassius auratus* (Linnaeus) (10/20)
Site: Between caudal fin rays

At least forty-nine species have been described in the genus *Philometra* Costa, 1845, five of which are known from the United States. The unique site of infection and the host suggest *P. carassii* from Japan, *P. sanguinea* from Europe, or *P. trilabiata* from Russia. The Russian species was not available for study, and a comparison of the present material with the other two species suggests *P. carassii.* This species was originally reported from Japan by Ishii (1934), being found between the caudal fin rays of *Carassius auratus.* The only other report of this species is from Ohio. The present report establishes a new geographic distribution.

Capillaria catenata Van Cleave and Mueller, 1932

Host: **Cyprinus carpio* (Linnaeus) (3/50)
Site: Intestine

This species, originally described from Oneida Lake fishes, is also known from Idaho and Wyoming. The present report establishes a new geographic distribution and host record.

Contracaecum brachyurum (Ward and Magath, 1917)

Hosts: **Ictalurus catus* (Linnaeus) (6/137)
**Morone saxatilis* (Walbaum) (2/81)
**Pomoxis nigromaculatus* (LeSueur) (1/44)
**Alosa sapidissima* (Wilson) (1/17)
Sites: Intestine and caeca

Twenty-two specimens in various degrees of maturity were collected from the above four hosts. This report establishes a new geographic distribution record.

Contracaecum spiculigerum (Rudolphi, 1809)

Host: *Ictalurus nebulosus* (LeSueur) (1/9)
Site: Encysted in mesentery

Raphidascaris sp.

Host: *Alosa sapidissima* (Wilson) (7/17)
Site: Coelom and mesentery

Metabronema salvelini (Fujita, 1922)

Host: **Pogonichthys macrolepidotus* (Ayres) (3/21)
Site: Intestine

Spiroxys sp.

Host: *Morone saxatilis* (Walbaum) (13/81)
Sites: Intestine, stomach, caeca, and mesentery

HIRUDINEA

Illinobdella moorei (Meyer, 1940) Meyer, 1946

Host: *Ictalurus catus* (Linnaeus) (24/137)
Site: Skin, gills, and fins

Four of the five known species in the genus *Illinobdella* are American: *I. alba* Meyer, 1940; *I. elongata* Meyer, 1940; *I. moorei* (Meyer, 1940) Meyer, 1946; and *I. richardsoni* (Meyer, 1940) Meyer, 1946. Haderlie (1953) has recorded *Illinobdella* sp. from *Ictalurus catus* and *I. nebulosus* in California.

CRUSTACEA

Lernaea cyprinacaea Linnaeus, 1761

Hosts: *Ictalurus catus* (Linnaeus) (21/137)
Mylopharodon conocephalus (Baird and Girard) (4/12)
Orthodon microlepidotus (Ayres) (1/9)
**Pogonichthys macrolepidotus* (Ayres) (1/21)
Ptychocheilus grandis (Ayres) (1/1)
Sites: Skin, gills, fins, mouth, eyes

LIST OF FISHES NEGATIVE FOR PARASITES

(Number of fish examined indicated in parentheses)

Acipenseridae
Acipenser medirostris Ayres, Green sturgeon (1)
Clupeidae
Dorosoma petenense (Gunther), Threadfin shad (9)
Cottidae
Cottus gulosus (Girard), Riffle sculpin (1)

Cyprinidae

Lavinia exilicauda exilicauda Baird and Girard, Sacramento hitch (2)
Notemigonus crysoleucas (Mitchill), Golden shiner (3)

Embiotocidae

Hysterocarpus traskii Gibbons, Tule perch (1)

Pleuronectidae

Platichthys stellatus (Pallas), Starry flounder (2)

Salmonidae

Oncorhynchus tshawytscha (Walbaum), King salmon (3)
Salmo gairdneri Richardson, Rainbow trout (24)

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FISH TRAPPING: A NEW METHOD OF EVALUATING FISH SPECIES COMPOSITION IN LIMNETIC AREAS OF RESERVOIRS[1]

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Lighted fish traps were suspended in limnetic waters of Las Vegas Bay, Lake Mead, Nevada to evaluate the fish species components of a dense scattering layer. Preliminary results suggested that the scattering layer was composed primarily of young-of-the-year threadfin shad. The lighted traps appear to be an inexpensive, effective means of sampling shad in a scattering layer.

INTRODUCTION

Echo sounding results from Las Vegas Bay, Lake Mead, Nevada revealed a dense scattering layer in limnetic waters. We suspected that threadfin shad, *Dorosoma petenense* (Günther), comprised a majority of the scattering layer since they are well established in Las Vegas Bay (Deacon, Paulson and Minckley 1970), and a series of Clarke-Bumpus plankton tows through the scattering layer failed to reveal zooplankton concentrations dense enough to account for the scattering layer (Deacon and Tew 1973). Netsch, Kersh, Houser, and Kilambi (1971) identified a similar scattering layer as threadfin and gizzard shad (*Dorosoma cepedianum* LeSueur) and described their horizontal and vertical distribution in Beaver Reservoir, Arkansas by utilizing echo sounding and a variety of conventional sampling gear. Since we did not possess elaborate trawling gear we developed an alternative method of evaluating the scattering layer.

This paper describes a simple and inexpensive method to evaluate and identify the shad components of sonic scattering layers in limnetic areas of reservoirs by utilizing lighted fish traps.

DESIGN AND METHODS

Minnow traps have been used successfully in springs, pools, streams, and ponds (Hedges and Ball 1953; Deacon and Wilson 1967; Hubbs, Baird and Gerald 1967). Extensive trapping in lakes and reservoirs, however, is not a common practice. Usually "hoop nets" or other entrapment gear are more successful (Bennett 1971). We designed our traps as a combination of the minnow trap and hoop net (Figure 1). Each trap was constructed with two circular steel support rods each 3.2 mm (0.13 inch) in diameter enclosed with 6.3 mm (0.25 inch galvanized wire mesh. The traps were 0.9 m (35 inches) long and 1.57 m (61.8 inches) in circumference with 10 cm (3.9 inches) funnel open-

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ings at each end of the trap. Each funnel was 0.3 m (11.8 inches) long. An access hole was cut in the top of each trap to permit removal of captured fish. The traps were suspended to desired depths by nylon rope secured to permanently moored, fiberglass buoys.

Since threadfin shad are positively phototactic (Johnson 1970), we included a light source inside each trap to attract the shad. A light package, consisting of two 6-volt, dry cell batteries and a single 6-volt light bulb, was placed inside a 3.8 liter (1 gal) glass jar. Each jar was

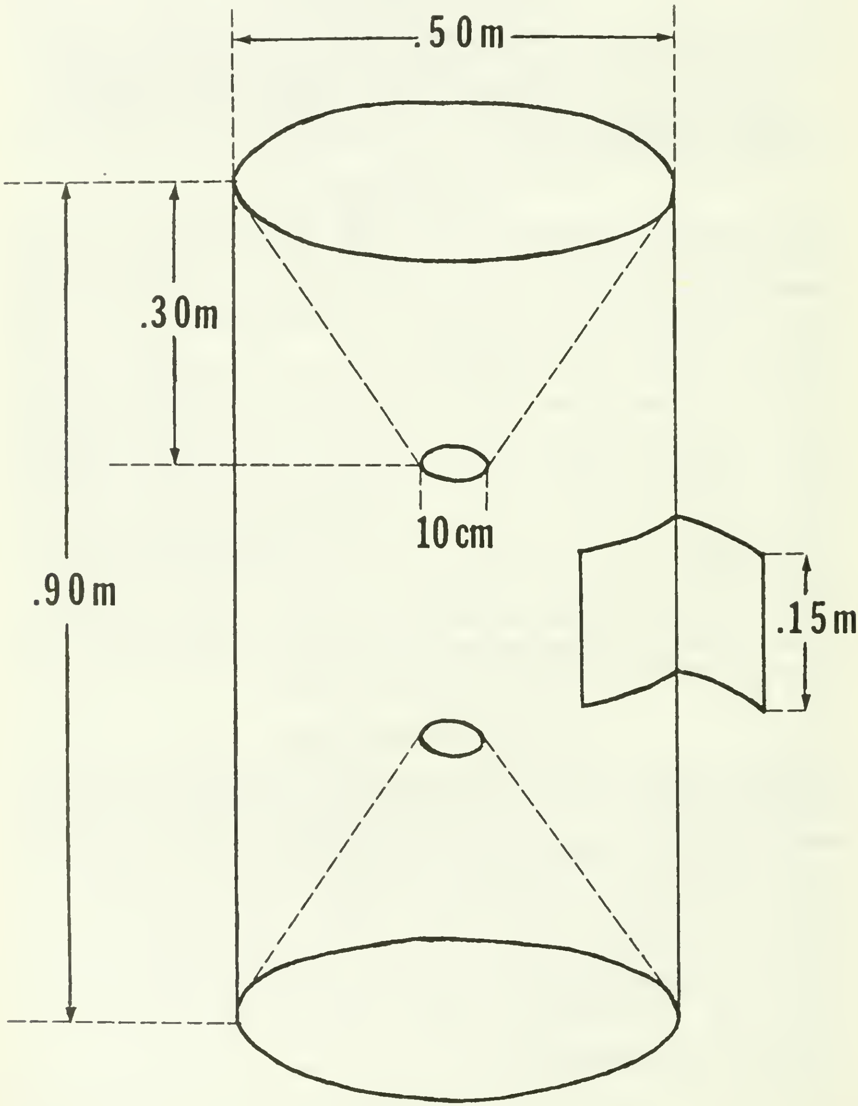

FIGURE 1. Cylindrical wire fish trap used to evaluate threadfin shad populations in sonic scattering layers.

waterproofed by lining the lid with a rubber seal coated with high vacuum stopcock grease. This light source provided an estimated 3 m (9.8 ft) sphere of illumination in Las Vegas Bay water. The jars were able to sustain water pressures at our deepest sampling depth of 20 m (65.6 ft). The total cost of materials and labor was $10.00 per lighted trap.

Test trapping was done to determine: (i) if fish could be captured, (ii) if differences existed between day and night sets, (iii) if lights were necessary, and (iv) if a relationship existed between trapping results and the intensity of sonic recordings. A 48-hour trapping period was conducted in a limnetic area 61 m (200 ft) deep (Station A). A single trap was set without lights for 24 hours and with lights for another 24 hours. The trap was checked at 12-hour intervals. During the day the trap was set at 15 m (49.2 ft); at night it was raised to 10 m (32.8 ft). The trapping depth was determined after observing echograms made just prior to the placement of the trap. The trap was set at the depth where the echogram indicated a distinct and intense sonic scattering layer. Echo sounding was done with a Furuno model FM22-D Echosounder (Konel Corporation).

This trapping period was followed by two more night sets: a single, lighted trap set at 10 m (32.8 ft) in a limnetic area 90 m (295.3 ft) deep (Station B), and a vertical series of three lighted traps set at 5, 10, and 20 m (16.4, 32.8, 65.6 ft) at Station A.

Captured fish were immediately preserved in 10% formalin. Total length (mm) and weight (g) were recorded for each fish and means computed for each catch.

RESULTS AND DISCUSSION

The trap catches consisted entirely of threadfin shad, except at Station A, where six black crappie, (*Pomoxis nigromaculatus* LeSueur), were captured at a depth of 20 m (65.6 ft) on 16 and 17 September (Table 1). Threadfin shad can be captured in limnetic areas, but only at night, with lighted traps. Day sets were unsuccessful with or without lights. Netsch et al. (1971) found substantial differences between day and night midwater trawl captures of shad. They attributed this difference primarily to a more dense, uniform distribution at night as opposed to scattered schools during the day. Our echograms revealed a somewhat similar pattern of night distribution (Figure 2-1A); however, several schools were observed during the day (Figure 2-1C), and a decrease in population density was not apparent. Apparently trap avoidance was the main reason for unsuccessful daytime captures. This is the major drawback of trapping; only night collections are successful. Costly sampling gear such as a midwater trawl would have to be used if information on daytime distribution was required.

The catch results from the vertical trap series at Station A on September 16 and 17 indicate that shad population densities are sharply stratified. This stratified catch pattern corresponds satisfactorily with the intensity of the scattering layer at the 5 and 10 m (16.4 and 32.8 ft) depths. However, the relationship at the 20 m (65.6 ft) depth is not evident. The echogram (Figure 2-1B) revealed that a secondary layer of fish was present at 15 and 20 m (49.2 and 65.6 ft) yet only 26

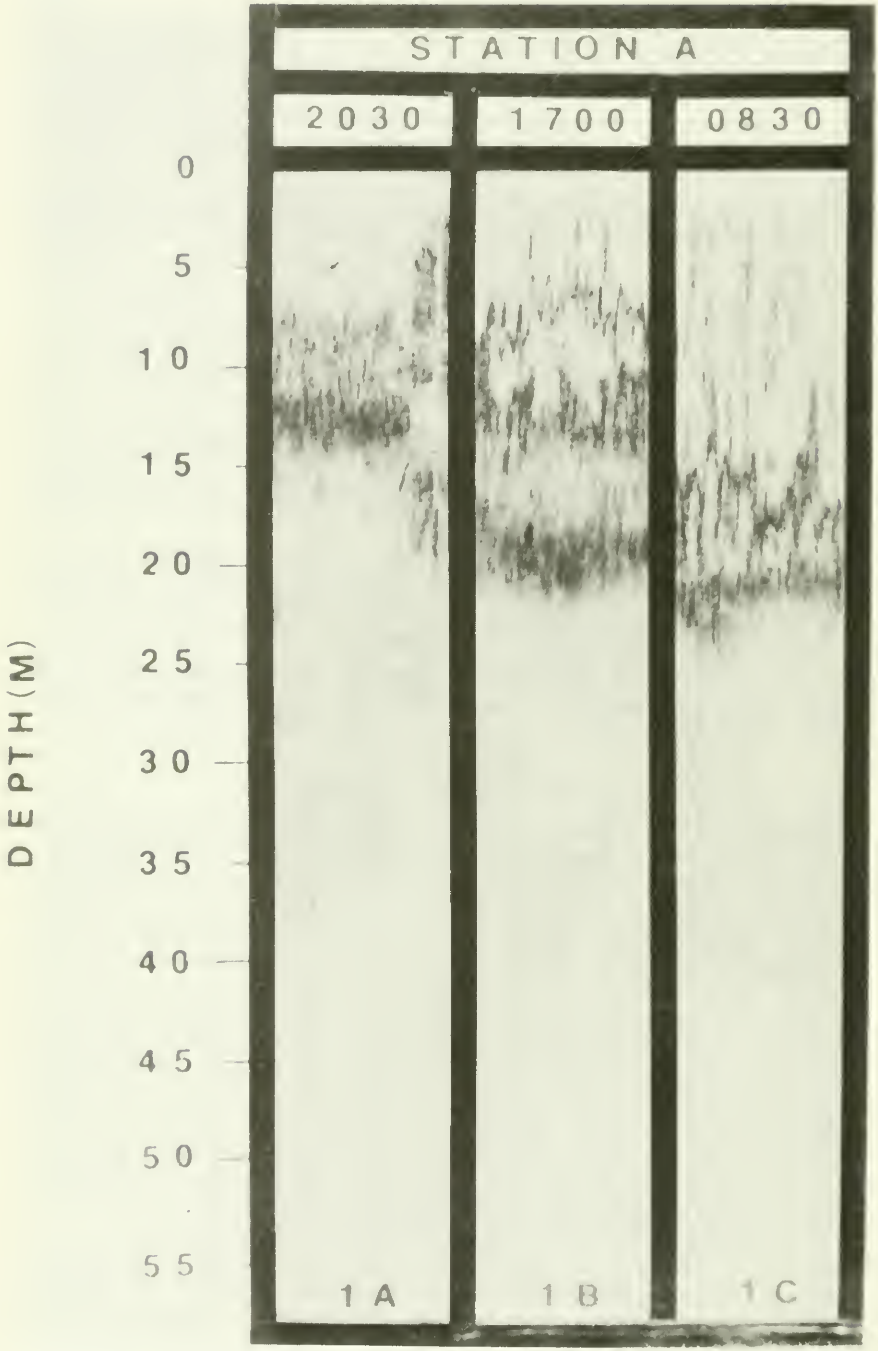

FIGURE 2. Representative Sonar echograms taken at Station A, Las Vegas Bay, Lake Mead, Nevada on September 4 and 5 (1A and 1C) and September 16 and 17, 1972 (1B), showing the typical scattering layer encountered during various hours of the day. Column heads indicate the beginning of the 12-hour sampling period.

TABLE 1. **Results of a Series of 12-Hour Fish Trapping Periods at Station A and B**

Station	Date	Time	Lights	Depth (mm)	Number of fish captured	Mean length of shad (mm)	Mean weight of shad (gm)
A 3–4	Sept. 1972	2000–0800	no	10	0	----	----
A 4	Sept. 1972	0800–2000	no	15	0	----	----
A 4–5	Sept. 1972	2030–0830	yes	10	111	35.3	.40
A 5	Sept. 1972	0830–1930	yes	15	0	----	----
B 5–6	Sept. 1972	2000–0800	yes	10	76	39.5	.57
A 16–17	Sept. 1972	1900–0700	yes	5	24	40.0	.90
A 16–17	Sept. 1972	1900–0700	yes	10	377	41.0	.70
A 16–17	Sept. 1972	1900–0700	yes	20	32*	39.3	1.10

* 26 shad and 6 black crappie.

shad were captured. Shad in Las Vegas Bay undergo a diurnal, vertical migration (Deacon and Tew 1973). After sunset they began to ascend, and at total darkness the majority of the shad occupy waters between 10 and 15 m (32.8 and 49.2 ft). During the early morning they form schools and most descend to depths of 15 and 20 m (49.2 and 65.6 ft). Since the echogram for the trap period was recorded at 1700 hours, just prior to darkness and completion of the shad migration, we suspect the shad were not exposed to the traps long enough to capture substantial numbers.

Evaluation of mean lengths and weights showed that all captured shad were young-of-the-year (Table 1). It is difficult to judge the effectiveness of the traps for capturing larger shad and other fish species. Obviously, the 10 cm (3.9 inch) funnel openings in the traps would limit the capture of larger species if they were present in the scattering layer. Vertical gill nets set at Station A 2 weeks prior to the trapping failed to capture predatory species or larger shad within the scattering layer (Deacon and Tew 1973). This suggests that the traps were effectively sampling the scattering layer. Adult shad may avoid the traps, or they may not be present in limnetic areas. Johnson (1970) noted diurnal and seasonal segregation between young and adult shad. Summer midwater trawl collections in Lake Mead revealed that young-of-the-year shad predominated in limnetic areas, whereas electrofishing in littoral areas resulted in capture of adult shad. (Deacon et al. 1970). We therefore assumed that the traps were sampling a representative portion of the limnetic shad population.

Despite the very limited sampling, the trapping method appears to have some merit in evaluating the shad components of sonic scattering layers in the limnetic areas of reservoirs. With further research the trapping could perhaps be utilized in estimating relative abundance and investigating distributional patterns of threadfin shad.

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ASPECTS OF THE LIFE HISTORY OF *TRESUS NUTTALLII* IN ELKHORN SLOUGH[1]

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A 2-year study of the reproductive cycle and growth rate of the gaper clam, *Tresus nuttallii*, in Elkhorn Slough indicated that the primary spawning time is from February to April, but that some reproduction probably occurs during every month of the year. Based on remeasurement of individually marked clams, a growth curve for clams up to 55 mm (2.2 inches) in shell lengths was also established.

INTRODUCTION

In Elkhorn Slough the gaper clam *Tresus* (= *Schizothacrus*) *nuttallii* (Conrad), is an important sport species that is fished heavily during periods of spring tides. Detailed knowledge of the reproductive cycle and growth rate of the gaper clam are presently lacking, and it is the purpose of this paper to report the results of a 2-year study of the reproductive cycle and growth rate of *T. nuttallii* in Elkhorn Slough.

Previous studies concerning the reproductive cycle in the genus *Tresus* have concerned *Tresus capax* (Gould), a more northern species, with the majority of its populations found above Humboldt Bay, California (Swan and Finueane 1952). Winter spawning of *T. capax* has been reported by Swan and Finucane (1952) for the populations on the coast along the San Juan Archipelago, by Reid (1969) for those on the coast of British Columbia, Canada, and by Machell and De Martini (1971) for the population in Humboldt Bay, California. As yet nothing has been published concerning the growth rate of either *T. nuttallii* or *T. capax.*

MacGinitie (1935) warned that the heavy clamming pressure endured by the many species of game clams in Elkhorn Slough might lead to the local extinction of these game species. We found that three of the bivalve species that MacGinitie counted as common or abundant (*Protothaca staminea, Saxidomus nuttallii* and *Clinocardimum nattalli*) can no longer be considered common.

METHODS AND MATERIALS

Spawning Cycle Study

A minimum of 10 and a maximum of 24 *Tresus nuttallii* above 90 mm (3.5 inches) in length (greatest posterior-anterior dimension) were collected during each series of daylight tides lower than —0.7 ft (—0.2 m) from a mudflat in Elkhorn Slough (lat 36°48′36″N; long 121°47′6″W). Collecting was done by shovel. The clams were brought into the laboratory where their lengths and widths (greatest lateral dimension) were measured to the nearest mm with vernier calipers. The

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soft parts were preserved in 10% buffered formalin. Gonadal blocks were dissected from the dorso-posterior area of the fixed body, dehydrated and infiltrated by the dioxane-paraffin method of Galigher and Kozloff (1964), embedded in paraffin, sectioned at 7μ intervals, and stained with standard hematoxylin and eosin procedures (Humason 1967).

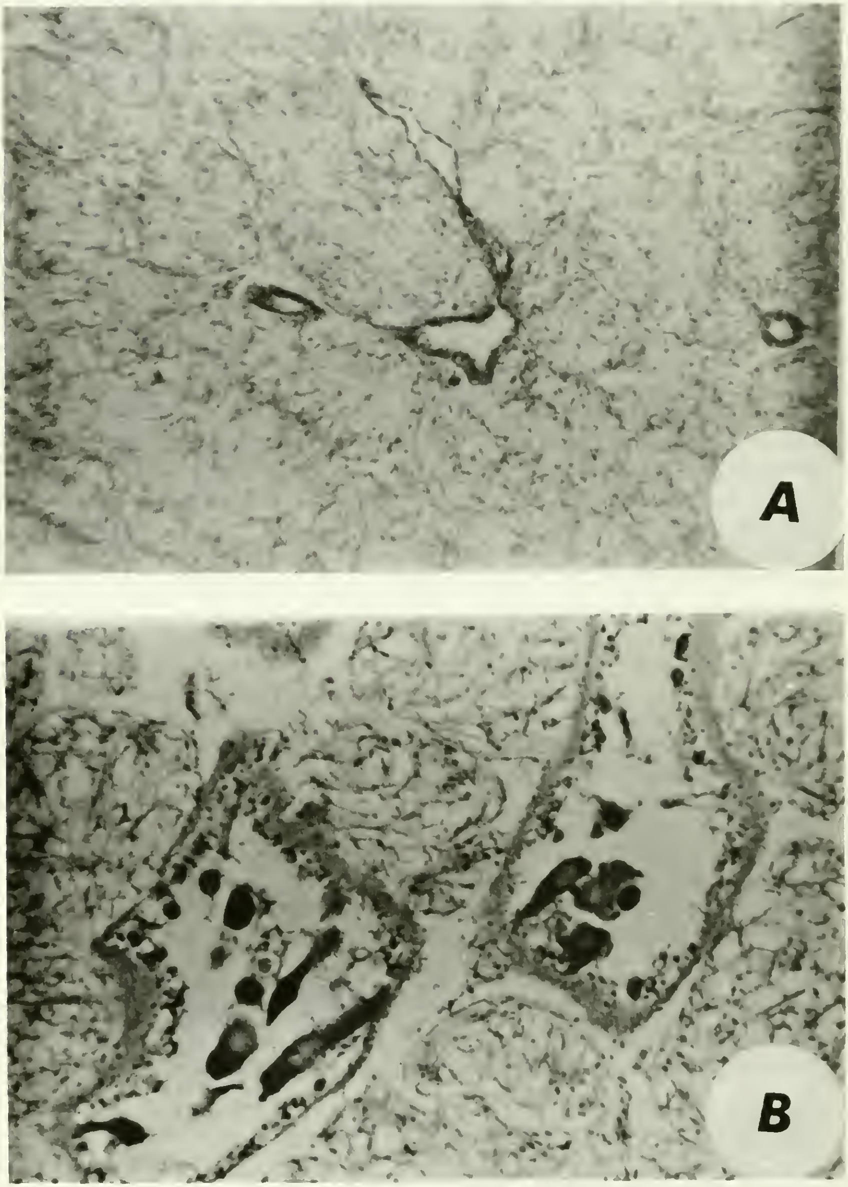

FIGURE 1. Sections of gonad tissue of female *Tresus nuttallii*. A, inactive phase (4×); B, early active phase of oogenesis (10×). Photographs by Pat Clark.

Upon examination of the gonadal preparations, each individual adult female sampled was placed into one of the five developmental categories established by Ropes and Stickney (1965) in their study of *Mya arenaria:* i) inactive; ii) active; iii) ripe; iv) partially spawned; and v) spent. The inactive phase was characterized by col-

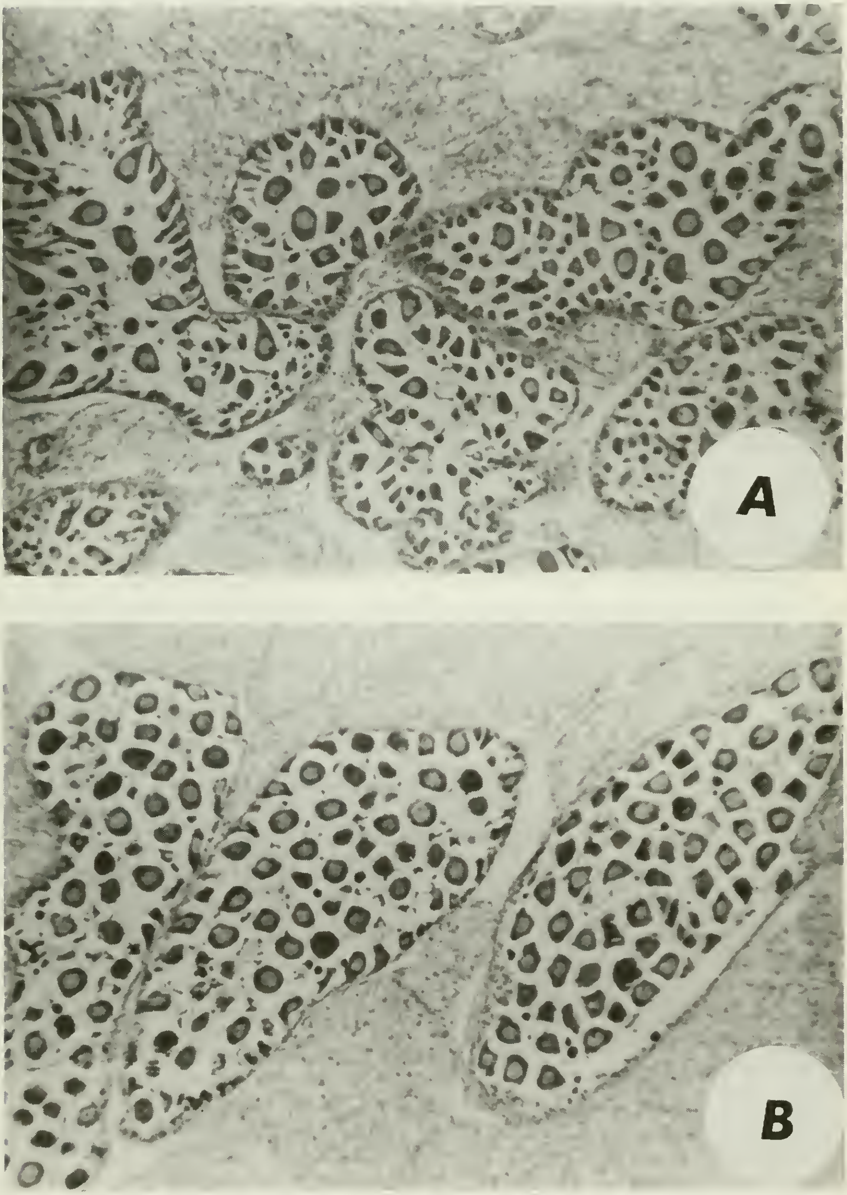

FIGURE 2. Sections of gonad tissue of female *Tresus nuttallii.* A, late active phase (4×); B, ripe phase of oogenesis (4×). Photographs by Pat Clark.

lapsed follicles with few to no oogonia present (Figure 1A). In the early active phase the follicle wall began to thicken with the follicle cells beginning to form oogonia (Figure 1B). In the late active phase the alveolar wall was thin, the oogonia elongate, at which time they were considered primary oocytes, and the oocytes were attached to the alveolar wall by means of stalks (Figure 2A). When there were more

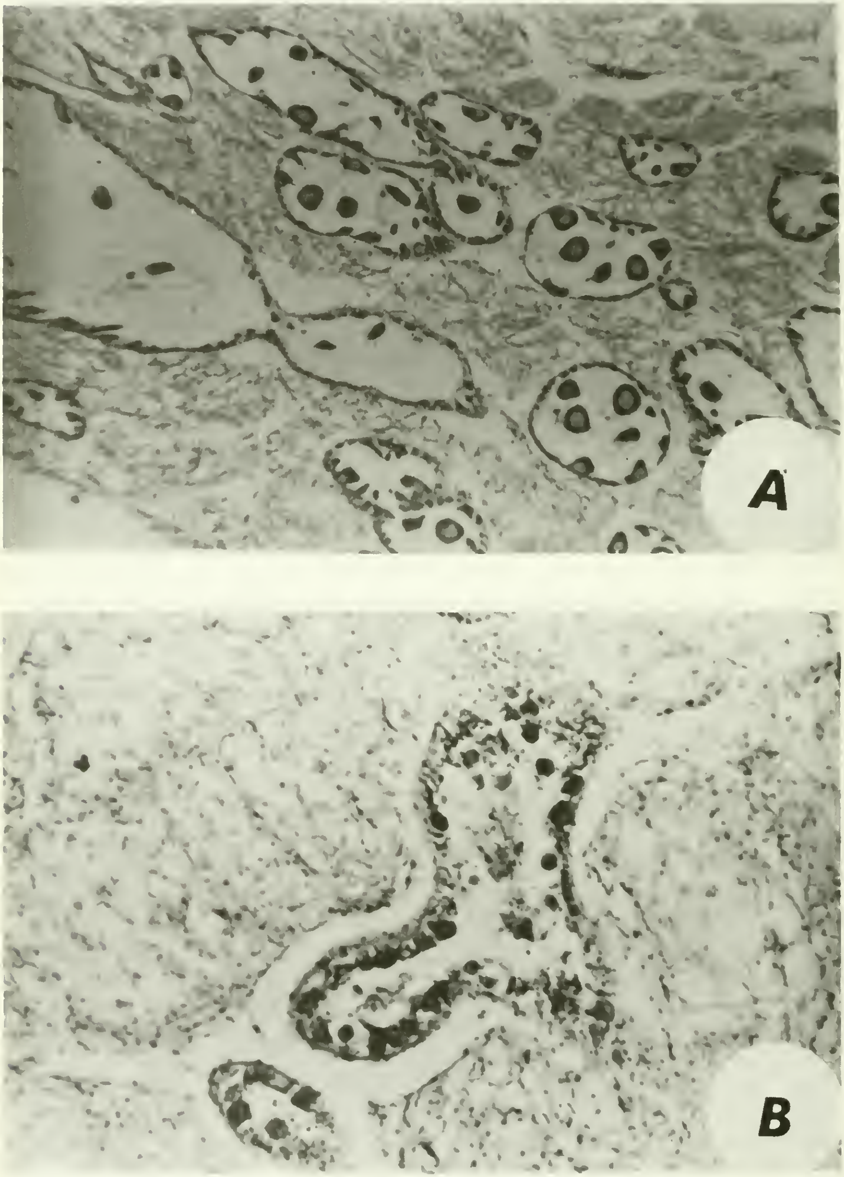

FIGURE 3. Section of gonad tissue of female *Tresus nuttallii*. A, partially spawned phase (4×); B, spent phase of aogenesis (10×). Photographs by Pat Clark.

oocytes lying freely within the lumen than were attached to the alveolar wall, the ovary was considered to be in the ripe phase of development (Figure 2B). In the partially spawned phase, the alveoli were partially empty and the follicle wall was slightly thickened (Figure 3A). The spent phase was characterized by inflated follicles with degenerating residual oocytes and debris (Figure 3B).

Since it is impossible to distinguish inactive females from inactive males, the number of specimens in the inactive state were divided in half and the resulting quotient was used as the number of inactive clams. Laurent (1971) found that within his samples the ratio of males to females was 1:1 ($P = .95$, Chi Square Test). This ratio was assumed to exist in the samples obtained for this study.

The population density of juvenile clams less than 75 mm (3 inches) in length was measured during each series of daylight tides lower than —0.7 ft (—0.2m) in the five sites of the mudflat sampled for adults. Densities were determined to test for correlations between the number of juveniles settling and the gonadal condition of the mature population. From each of five sites on the mudflat a sample of 0.15 m^2 (1.6 ft^2) was chosen and excavated to a depth of 12 cm (4.7 inches). The substrate within the samples was sieved through a 2-mm (0.08-inch) mesh sieve. The residue was then taken to the laboratory where all the live *Tresus* were removed, measured with vernier calipers to the nearest 0.1 mm (0.004 inch) and a frequency distribution and histogram constructed.

Growth Rate Study

There are at least two possible methods of determining growth in bivalves: i) by following a size class through time; or 2) by repetitive measurements of an individually marked population. Laurent (1971) attempted the former method and was not successful in estimating growth; nearly continuous recruitment prevented the following of one size class through time. The latter method was started by us in February 1971 on an experimental basis.

Initially, we took juveniles collected from the juvenile population study, measured them to the nearest 0.1 mm (0.004 inch) and planted them in two plastic buckets located subtidally in Elkhorn Slough. We retrieved the buckets 50 days later on March 2, 1971. Since we had not marked the juveniles, we were unable to determine anything but mean growth in each bucket. These juveniles were then individually marked with printed numbers attached to the right valve and the numbers were covered with Dekaphane. The buckets with their marked juveniles were returned to their racks on March 25, 1971. They were then retrieved May 18, June 12, September 15, and November 3, 1971. Three more plastic containers were placed subtidally in the slough on June 14, 1971 to make a total of five containers with marked, premeasured juveniles. When the containers were retrieved the clams were remeasured and those that had died were replaced with freshly collected juveniles. The containers were returned to their subtidal racks. Sometime in December, 1971, all of the containers were overturned and the contents lost. In March 1972, two racks of much sturdier construction were placed in the slough (Figure 4).

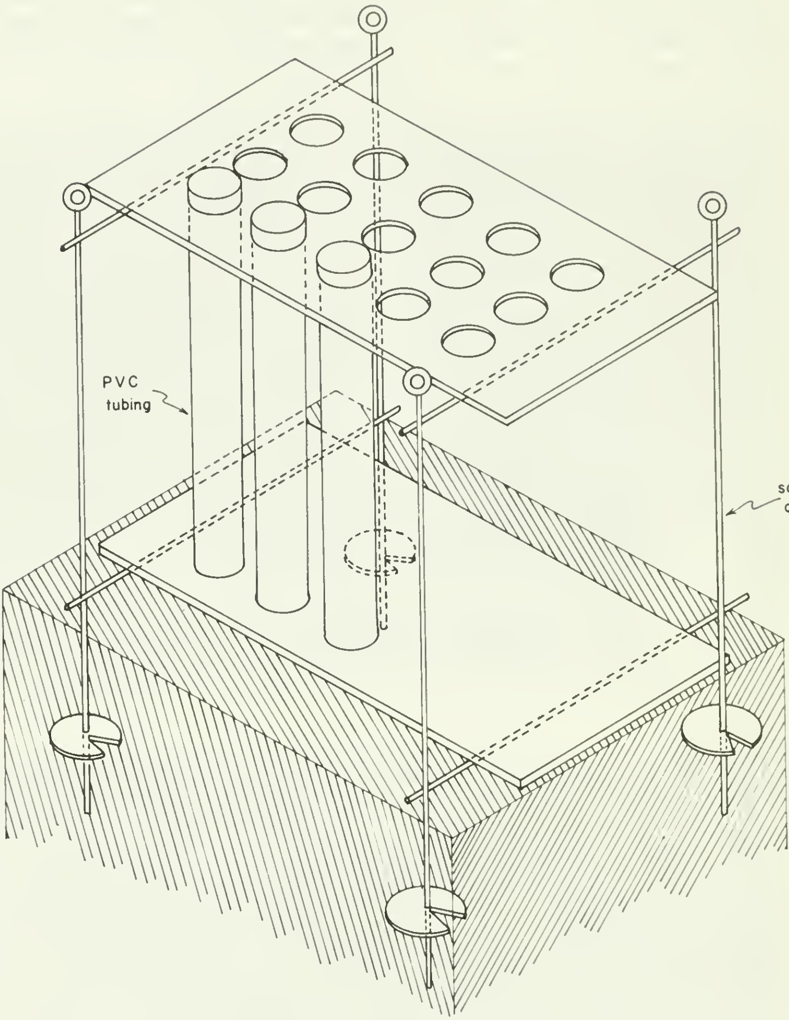

FIGURE 4. Subtidal rack for growth studies of *Tresus nuttallii.*

The new subtidal growth racks utilized four 1.8-m (6-ft) fence anchors buried into the slough bottom approximately 0.6 m (2 ft). To these fence anchors were attached two 0.9-m x 1.2-m (3-ft x 4-ft) sheets of plywood which were sealed with finishing resin. The uppermost sheet of plywood contained fifteen 12.7-cm (5-inch) diameter holes through which were placed 10.2-cm (4-inch) diameter PVC (polyvinyl chloride) pipes 0.9 m (3 ft) in length. One end of each PVC pipe was sealed by means of a sheet of rubber and a hose clamp. The pipes were filled with sediment which was obtained either from beach sand that had been sieved to remove most of the organic debris or from the slough bottom. At least one gaper clam was placed in each pipe, and the juveniles were placed in smaller diameter PVC pipes that then were placed within the larger pipe.

Each clam was removed from the rack at intervals depending on the clam's size: i) those less than 10 mm (0.4 inch) were measured at 1-week intervals; ii) those between 10 and 50 mm (0.4 and 2.0 inches) were measured at 1-month intervals; and iii) those greater than 50 mm (2.0 inches) were measured at 3-month intervals. A graph of length versus time in days was constructed for each clam. This line was then resolved into points with each point representing 1 day along the growth line. Size classes were then chosen with the class interval being 5.0 mm (0.2 inch). All the points that fell within each size class were combined. A regression analysis was conducted on the points within each size class to obtain a line for each size class. These lines were then connected end to end in a progressive order of size starting from the smallest measured individual and progressing to the largest measured individual. From this procedure a non-smooth growth curve was obtained. The curve was then analyzed by means of a curvilinear regression analysis to obtain a smooth curve (Figure 5). All the computations were done on a Wang 700 Series Advanced Programming Calculator.

RESULTS

Gonadal sections of adult *Tresus nuttallii* have been examined from specimens collected during the period from February 1970 to June 1972. Measurements on those specimens obtained between February 1970 and December 1970 were data obtained from Laurent (1971).

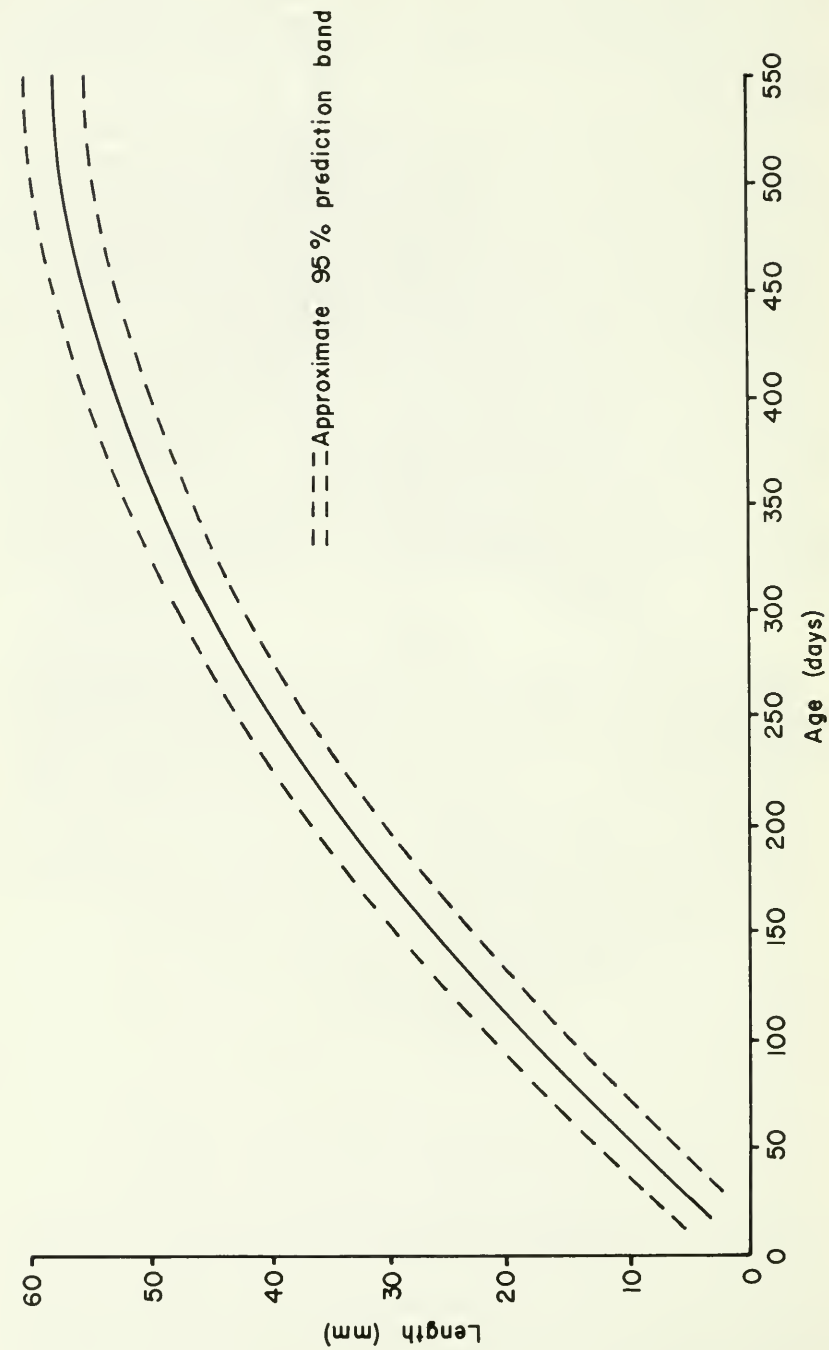

FIGURE 5. Growth curve for *Tresus nuttallii* from Elkhorn Slough, California.

Only females were considered in this study. Males were not considered due to the difficulty of determining their state of gonadal development. Samples were not taken during the months of September 1970 and September and October 1971 because there were no tides below –0.7 ft. (–0.2 m) during daylight hours. Juveniles and adults were collected during the months of February and March 1972 for the growth rate study. Since these specimens were to be kept alive no spawning cycle data were obtained.

The gonadal condition of female clams sampled between February 1970 and June 1972 indicated that the primary time of spawning in 1970 was the winter and spring (Figure 6). In 1971, clams were found spawned out again in February but also in June (Figure 7). In 1972, spawned clams were found in all months checked (Figure 8). One problem with these data is that for many sampling months the sample size is too small to warrant making definitive statements.

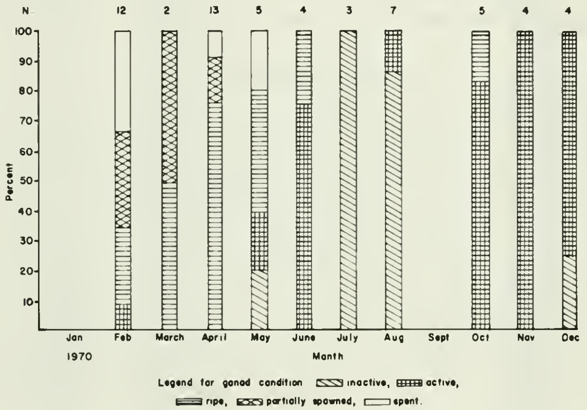

FIGURE 6. Gonad condition of female gaper clams collected from Elkhorn Slough in 1970. The length of each shaped area represents the percentage of clams in each gonadal condition. N = number of females sampled.

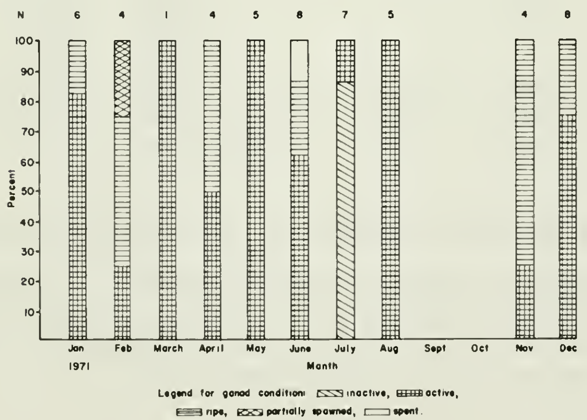

FIGURE 7. Gonad condition of female gaper clams collected from Elkhorn Slough in 1971. The length of each shaded area represents the percentage of clams in each gonadal condition. N = number of females sampled.

Those data available on the density of juveniles suggest that some settling occurred during every month in the sampling period from April 1971 to June 1972. Very definite peaks were noted during May 1971 and April 1972 (Figure 9).

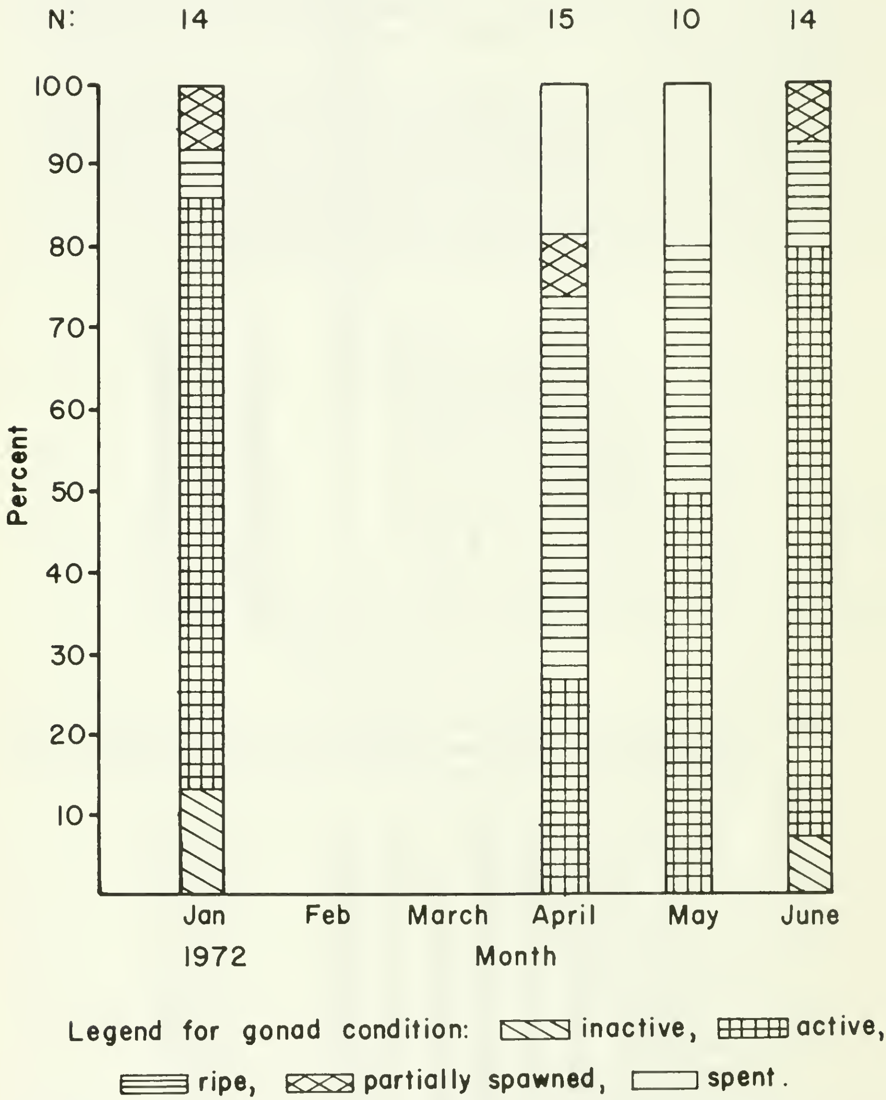

FIGURE 8. Gonad condition of female gaper clams collected from Elkhorn Slough in 1972. The length of each shaded area represents the percentage of clams in each gonadal condition. N = number of females sampled.

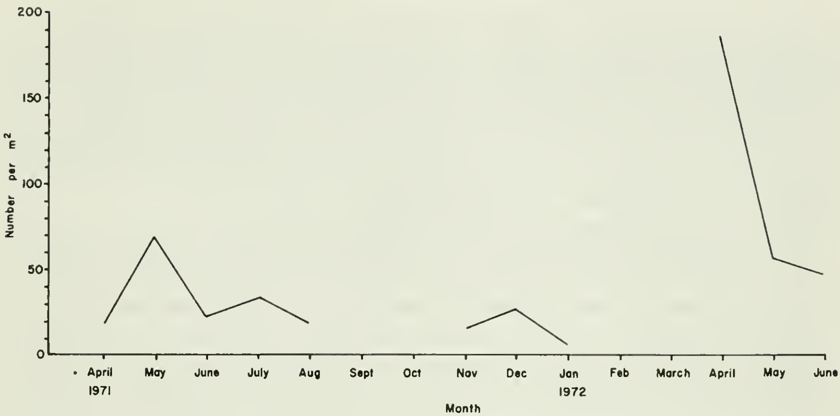

FIGURE 9. Total number of juveniles 2 to 4.9 mm collected each month per m ^{2}.

Growth Rate Study

The gaper clams placed in the subtidal growth racks ranged in size from 2.2 to 143 mm (0.07 to 5.6 inches) in length. A growth curve was compiled for those claims between 2.2 and 55 mm (0.07 and 2.2 inches). When this curve was smoothed by means of a curvilinear regression analysis, it fit the equation: Length (mm) $=$ 0.0027 $+$ 0.2043 (age in days) — 0.0002 (age in days)^2, (Standard Error $=$ 0.41) (Figure 5).

Those clams greater than 55 mm (2.2 inches) in length were not in the subtidal racks long enough to provide enough data to extend the curve. It is apparent from this study that adult gaper clams, greater than 75 mm (3 inches) in length, should remain in racks for at least a year to obtain a complete growth curve.

DISCUSSION

The gonad sections for the period from February 1970 to June 1972 suggest that the primary spawning period for gaper clams in Elkhorn Slough is from February through April. This is inferred from the high fraction of females that are ripe, partially spawned, or spent at this time. The juvenile density study indicates high numbers per m^2 of newly settled gaper clams 2 to 4.9 mm (0.08 to 0.2 inch) during May 1971 and April 1972. There appears to be approximately a 1-month lag between spawning as determined from the gonad sections and the appearance of a high peak of newly settled juveniles in the samples. Fifty percent of the adult females sampled in April 1971 were in a ripe condition and all the females sampled in May 1971 were in an active condition (Figure 7). This change in gonadal condition indicates that spawning occurred between the two sampling dates. The juvenile density data indicate that there was a peak in juvenile settling in May 1971 and a decline in June 1971 (Figure 9).

The point of intersection of the abscissa and ordinate of the growth curve (Figure 5) is that point where the veliger begins forming a calcium carbonate shell and settles. Since the actual data begin at 2.2 mm (0.08 inch), the growth curve was extrapolated back to zero using the growth equation. This procedure indicates that it takes approximately

10 days from settling in order to grow to a size of 2 mm (0.08 inch) and 25 days in order to grow to a size of 5 mm (0.2 inch). Loosanoff (1963) states that most temperate bivalves have a maximum larval life of 30 days. If this is true for the gaper clam in Elkhorn Slough, then spawning would have occurred from 40 to 45 days prior to the observed peaks. Judging from the dates at which the two above mentioned samples were collected, we would predict a larval life of 21 to 30 days for the gaper clam in Elkhorn Slough.

The work done by Machell and De Martini (1971) on *Tresus capax* in South Humboldt Bay closely parallels this study. We both determined that the primary spawning period is in the late winter, from January to April for *Tresus capax,* and from February to April for *T. nuttallii* Machell and De Martini found that the active phase was associated with the highest temperature and salinity measurements and spawning with the seasonal low values for these parameters. We believe that the active phase is associated with the initial lowering of the water temperature, and spawning with the seasonal low temperature (Figures 6 and 7). Machell and De Martini found spat only during the spring, whereas we found spat throughout the whole year.

The reasons for the observed differences are probably many, not the least of which is that we are dealing with different species. One possible clue as to the differences in spat settling times could be the large ranges of water temperatures found each day in Elkhorn Slough. For example, on February 27, 1971 the water temperature varied over a 24-hr period from 9.6 to 13.4 C (42.9 to 56.1 F) and during August 16, 1971 it varied from 13.2 to 19.2 C (55.8 to 66.6 F). The temperature range for August 16 is noteworthy since it falls within the range of daily water temperatures recorded during the spawning season. Perhaps, the wide daily fluctuations in water temperature in Elkhorn Slough explain the presence of ripe females and newly settled spat in the population throughout the year; temperatures sufficiently low to trigger spawning may occur during a number of seasons in Elkhorn Slough. If the daily temperature ranges in Humboldt Bay are smaller. the difference in spawning behavior between the two *Tresus* populations might be accounted for.

The growth curve (Figure 5) can be used to estimate clam length at a given age. A gaper clam 1 year old will be 49.5 to 50.3 mm (1.95 to 1.98 inches) in length 95% of the time, at least in Elkhorn Slough. Gonadal sections demonstrate that female gaper clams greater than 70 mm (2.8 inches) have mature ova. The growth curve indicates that age at maturity for a female gaper clam or age of a 70-mm (2.8-inch) individual is at least 2 years.

The method used to determine growth rate of the gaper clam in Elkhorn Slough has not been previously reported. Until now there have been two options for determining growth: i) a growth model, i.e. standard exponential curve; or ii) a number of specimens observed from birth over a long time period. With the method described in this paper it is possible to obtain an accurate growth curve for an average individual of a population in 2 years, the only requirement being that the animal add length, width or height with age.

The present study also provides some data on year to year fluctuations in recruitment. The population density study (Figure 9) indicates that recruitment during 1972 was more than twice as great as the recruitment during 1971. If there are no catastrophic occurrences on the mudflats of Elkhorn Slough, 1975 should be a good year for harvesting gaper clams.

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NOTES ON THE EXTERNAL PARASITES OF CALIFORNIA INSHORE SHARKS

INTRODUCTION

Specimens and data collected since 1970 from over 900 sharks captured in San Francisco and Tomales Bays indicate that at least two species of pandarid copepods, *Pandaris bicolor* (Figure 1) and *Perissopus oblongatus* (Figure 2), occur frequently. Both of these parasites occur regularly on leopard sharks, *Triakis semifasciata*, and brown smoothhounds, *Mustelus henlei*. Between October 1973 and April 1974, 30.0% of the 206 leopard sharks collected hosted either one or both of these parasitic copepods.

The percentage of Leopard sharks hosting these copepods varies drastically from catch to catch, season to season and between populations. Of the 31 leopard sharks examined in October 1973, 61.3% hosted one or both of these parasites. In April 1974, only 7.5% of the 67 sharks examined hosted these copepods.

While we have not yet found *Perissopus oblongatus* on other inshore sharks, we have found *Pandaris bicolor* on soupfin, *Galeorhinus zyopterus*, sevengill, *Notorhynchus maculatus*, and spiny dogfish, *Squalus acanthias*. We have not examined enough soupfin, spiny dogfish and sevengill sharks to determine whether these parasites occur as regularly as they do on leopard sharks. *Pandaris bicolor* is approximately 1 cm (0.4 inch) in length, while *Perissopus oblongatus* is about 5 mm (0.2 inch in length.

FIGURE 1. Three female *Pandaris bicolor* (1 cm body length) with elongated egg sacs seen on the left pectoral fin of a leopard shark. Photo by author.

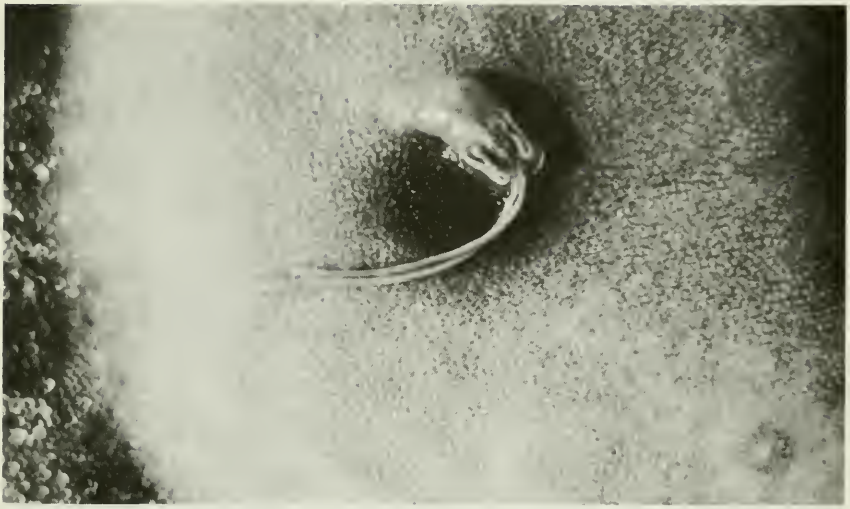

FIGURE 2. A female Perissopus oblongatus (5 mm body length) with elongated egg sacs seen on the left pectoral fin of a leopard shark. Photo by author.

Prior to 1967, *Pandaris bicolor* had been reported only on spiny dogfish from European waters (Cressey 1967). Subsequent to this report, specimens of this species were collected from California waters, but data on these collections were not published (Cressey pers. comm.). The report of *Pandaris bicolor* and *Perissopus oblongatus* on the sharks mentioned represents a new host-parasite record.

Both of these pandarid copepods are normally found attached to the fins and dorsal surface of the fish's body. They occur most often above the gill openings, around the head, and on the trailing edges of fins. They occasionally occur in small numbers away from the edges of the pectoral and pelvic fins. The frayed edges of the dorsal fins often support large numbers of either or both of these parasites. On October 19, 1972, we found 31 *Perissopus oblongatus* attached on opposite sides of the first dorsal fin of a 109-cm (43-inch) female leopard shark.

A third pandarid copepod, *Echthrogaleus coleoptratus,* has been reported from a large variety of pelagic sharks including blue sharks, *Prionace glauca.* It occurs on the body and fins of leopard sharks but is less noticeable than either of the other two pandarid copepods. *Echthrogaleus coleoptratus* is approximately 1 cm (0.4 inch) total length.

A fourth copepod, *Lerneopoda scylicola* (Lerneopididae) (Figure 3), was found during our investigations on a single leopard shark and a single skate, *Raja binoculata.* It was previously known to occur only on sharks of the genus *Scyllium* (Cressey pers. comm.), which has since been divided into several new genera. This parasite is apparently rare, since we have encountered it only on these two occasions. In each case, they occurred in large numbers about the head region.

We have not yet found any parasitic copepods in the buccal cavity or on the gills probably because our examinations of these organs has been superficial. Other species of copepods might exist in these areas on estuarine sharks.

FIGURE 3. A female *Lerneopoda scylicola* (4 mm body length) with oblong egg sacs. Photo by Don Wilson, East Bay Regional Park District.

While there are several marine leeches that are known to occur on fishes, only one appears to be common on the elasmobranchs of Tomales and San Francisco Bays. This leech, *Branchellion lobata* (Piscicolidae) (Figure 4), was originally described by Moore (1952). At that time it was reported from big skates, brown smoothhounds, spiny dogfish, and Pacific angel sharks, *Squatina californica*. It was reported that a few specimens were taken from the gills of a spiny dogfish, but this was the only reference to point of attachment (Moore 1952).

We have collected *Branchellion lobata* from the claspers, buccal cavities and fins of leopard, brown smoothhound, dogfish, sevengill and soupfin sharks. On five occasions *Branchellion lobata* was found attached directly to the surface of the eyes of spiny dogfish. In each case, the area above the eye was abraded and inflamed. What connection there is between the condition of the eyelid and the presence of the leech on the eye itself is not known. They often occur in numbers of a dozen or more on the claspers of host sharks. Of the 206 leopard sharks collected between October 1973 and April 1974, 10.6% hosted this leech.

However, like the copepods, the percentage of leopard sharks hosting *Branchellion* leeches varies from catch to catch and season to season and probably among different groups of leopard sharks. Of the 31 leopard sharks examined in October of 1973, 3.2% hosted this leech. In January of 1974, 24.4% of the 45 leopard sharks examined hosted this leech. *Branchellion lobata* reaches lengths of 3–4 cm (1.5 inches). Young leeches are quite prevalent during the summer months. The report of this leech on leopard, sevengill and soupfin sharks represents a new host-parasite record.

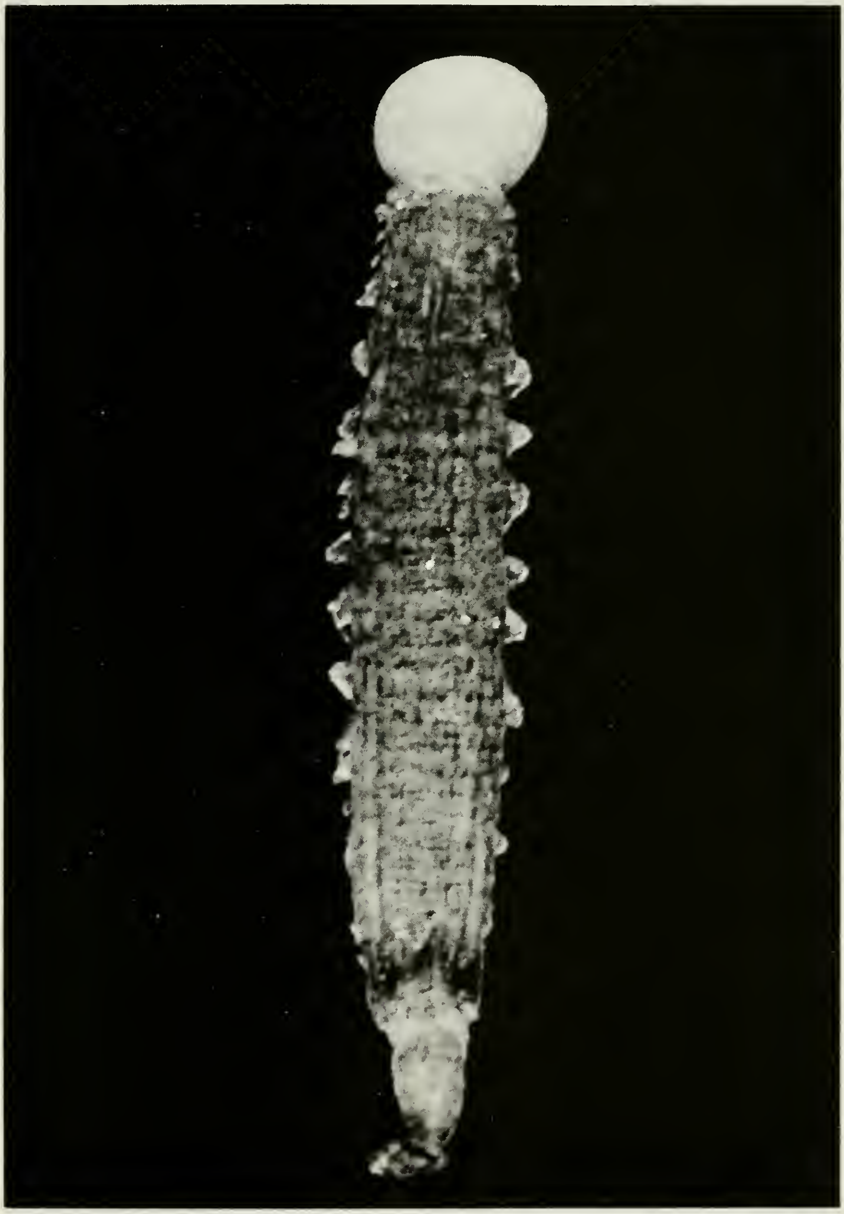

FIGURE 4. *Branchellion lobata* (3 cm total length). Photo by Don Wilson, East Bay Regional Park District.

Questions concerning the length of time of attachment to the host, seasonality of occurrence, effect on sperm injection into the female shark when attached to claspers, and the general biology of this leech are largely unknown.

On one occasion we found circular scars or depressions of approximately 3–4 mm (0.2 inch) on the belly of a leopard shark. Whether or not these were previous points of attachment for leeches or copepods is not clear. However, because the leopard shark frequently rests on the bottom, the belly would be a difficult area to maintain a hold for any external parasite.

ACKNOWLEDGEMENTS

I am indebted to Roger Cressey of the National Museum of Natural History for his generous assistance in identifying the copepods and providing me with taxonomic information, and to Eugene M. Burreson of Oregon State University for his assistance in the identification of the leeches.

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—*Ronald A. Russo, Resident Naturalist, East Bay Regional Park District, 11500 Skyline Blvd., Oakland, California 94619.* *Accepted March 1975.*

AN EXTRAUTERINE FETUS IN THE STELLER SEA LION, *EUMETOPIAS JUBATA*

On 27 June 1972, we discovered a dead female Steller sea lion on the beach 2.4 km (1.5 miles) south of Moss Landing Harbor, Monterey Bay, California. The carcass contained one fetus in utero and one extrauterine fetus in the abdominal cavity. This anomalous condition has not been previously reported in a Steller sea lion and as well as we can determine this is the first record of an extrauterine fetus in the order Pinnipedia.

The fetus in utero measured 740 mm (29.1 inches) from nose to tip of tail and weighed 12.5 kg (27.5 lb). The extrauterine fetus measured 900 mm (35.5 inches) and weighed 16.0 kg (35.2 lb). Both fetuses were males and appeared to have full-term development. However, they were smaller than 22 newborn Steller pups measured by Mathisen et al. (1962) that ranged between 889 mm (35 inches) and 1219 mm (48 inches) from nose to tip of tail and weighed between 19.0 kg (42 lb) and 21.8 kg (48 lb).

The female's uterus was not ruptured, indicating that the extrauterine fetus probably arose from an ovum that became fertilized in the peritoneal cavity. It was not possible to determine the exact site of implantation of the zygote. At the time of examination the placenta was not attached to the female but the ventral surfaces of the gastrohepatic ligament, duodenum, and lesser curvature of the stomach were highly vascularized and probably were sites of placental attachment. Sea lions have a zonary type of placenta that typically forms a band around a fetus' abdomen and judging from the extrauterine fetus' position in the female's abdominal cavity, it is probable that the placenta was also attached to the female's abdominal wall.

The extrauterine fetus was lying stretched out longitudinally in the abdominal cavity between the female's viscera and abdominal wall. The fetus' back was against the female's parietal peritoneum while its head was pressed deeply into the diaphragm and its hind feet were lying against the fetus in utero. The embryonic membranes of the extrauterine fetus were ruptured and the zonary placenta was not around the fetus in the typical position but was wrapped around its feet, free of maternal attachment. The placenta may have been torn loose from its attachment by fetal movements or possibly by pounding of the surf on the carcass.

The cause of death of the female could not be determined. She showed no signs of injury and appeared to have been in good physical condition prior to death. Death may have resulted as a consequence of the extrauterine fetus although in some mammals extrauterine fetuses apparently can be carried indefinitely as mummified carcasses (Williams 1950; Evans and Griffith 1972).

Año Nuevo Island, approximately 64 km (40 miles) north of Moss Landing, is the nearest Steller sea lion breeding site. Because most pups are born in June and early July on Año Nuevo Island (Orr and Poulter 1967; Gentry 1970), the female may have died at sea while enroute to the rookery and was carried ashore by the wind and currents.

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ANOMALOUS OTOLITHS FROM THE NORTHERN ANCHOVY, *ENGRAULIS MORDAX*

The Fish and Game Commission authorized taking anchovies for reduction to fish meal in 1965. The Department has sampled the reduction fishery landings for both age and size composition of catch. By the end of the 1971–72 season, over 22,000 otoliths had been collected for determining age composition of the catch. There has been a number of anomalous otoliths observed in these collections. Collins and Spratt (1969) described opaque and translucent otoliths, two of the more frequently occurring anomalies. These types have been present throughout the fishery and make up an estimated 5% of all otoliths taken.

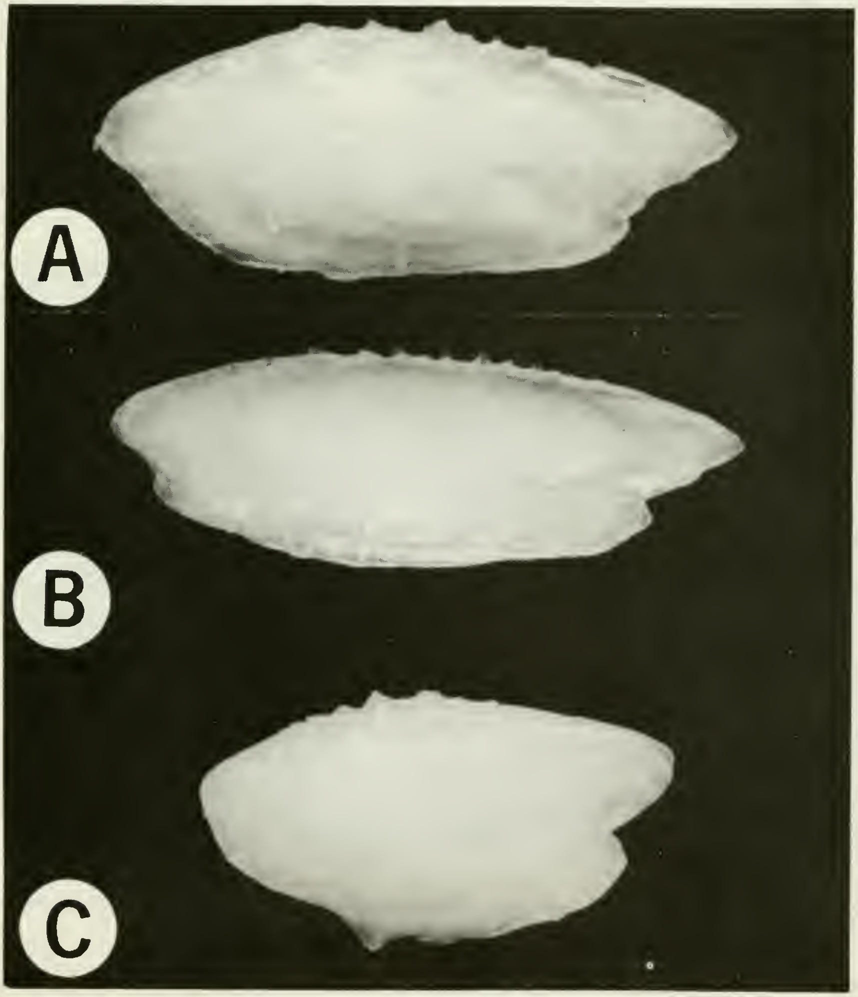

FIGURE 1. Otolith types from one year old anchovies: A. normal, B. narrow, C. oval. Photograph by Jack W. Schott.

During the 1971–72 anchovy reduction season, two more anomalous anchovy otoliths were collected. On January 13, 1972, an otolith narrow on the dorso-ventral axis (Figure 1B) was collected from a female anchovy caught in the San Pedro Channel. A typical otolith with one annual ring measures 3.8 mm (0.15 inch) long and 1.7 mm (0.07 inch) wide. The length of this one-ring otolith is normal, but its width is only 1.3 mm (0.05 inch) or three-fourths the width of an average otolith. Otoliths of this type are rare, only a few have been observed in the 22,000 otoliths examined.

On January 17, 1972, an oval shaped otolith (Figure 1C) was collected from another female anchovy caught in the San Pedro Channel. This one-ring otolith measured 1.7 mm (0.07 inch) wide and 3.0 mm (0.12 inch) long. The width is normal, but the length is much shorter than average. To my knowledge this is the only anchovy otolith with these characteristics that has been reported.

The age, length, weight and sex of the three anchovies from which the otoliths were taken are similar (Table 1).

TABLE 1

Age, Length, Weight, and Sex of Anchovies From Which Otoliths Were Taken

	Anchovy with typical otolith	Anchovy with narrow otolith	Anchovy with oval otolith
Age	1	1	1
Length (mm SL)	128	120	129
Weight (g)	21.0	17.3	21.1
Sex	female	female	female

The different shaped otoliths probably reflect a genetic trait because of their limited occurrence. Completely calcified otoliths and transparent otoliths occur much more frequently and could reflect an environmental factor which affects the formation of calcified body parts.

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—*Jerome D. Spratt, Operations Research Branch, California Department of Fish and Game.* *Accepted March 1975.*

THE STEWART MODIFIED CORRAL TRAP

In conjunction with the North Kings Deer Management Project (Bertram 1973), deer were trapped for marking and radio collaring to establish migration routes, delay areas, and to aid studies on fawn production and survival. Winter range deer trapping provided information on deer movement to various sections of the summer range; however, some gaps occurred regarding movements to and from certain sections of the summer range. In order to fill in these gaps it was decided to trap deer on the summer range at selected locations. Attempts with snares (Ashcraft and Reese 1957) and baited Clover traps (Clover 1956) in the summer of 1971 were unsuccessful.

In the summer of 1972, trapping on the summer range was attempted using a corral trap consisting of five 2.1 m x 2.1 m (7 ft x 7 ft) panels and a slightly modified gate from an "Oregon Panel" trap (Anon., 1962). Three does were subsequently caught. One escaped during handling, one killed itself when it hit the gate attempting to escape and the third broke the gate and escaped.

Bill Stewart, Department of Fish and Game Fresno Unit Wildlife Manager, suggested attaching a Clover Trap to the corral trap to alleviate injury and handling problems. The idea was that a deer after

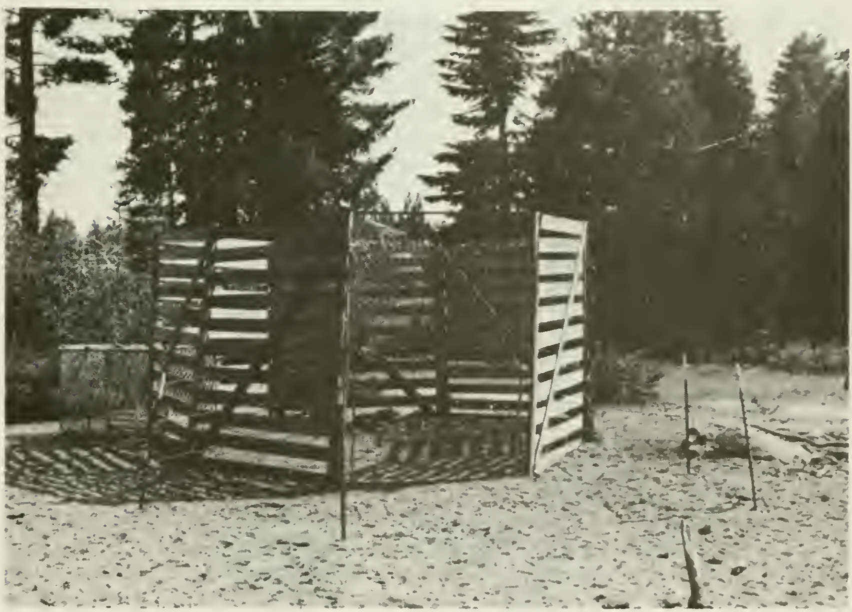

FIGURE 1. A Stewart Modified Corral Trap in place. The main gate, front, is a large version of a Clover trap gate. One of the Clover traps is visible at the left rear. Photo by R. Bertram.

getting trapped in the corral would enter the Clover trap while trying to escape and be held there, minimizing the chances of the deer injuring themselves. In the summers of 1973 and 1974 the Stewart Modified Corral Trap was field tested.

METHODS AND MATERIALS

The basic corral trap consists of 7 panels, each 2.4 m x 2.4 m (8 ft x 8 ft) constructed of 2.5 cm x 15.2 cm (1 inch x 6 inch) boards (13 per panel). The panels are then arranged in an octagonal shape (Figure 1). Heavy wire is used top and bottom to attach adjacent panels together at the corners. The eighth side is comprised of the main gate. Holes are cut into two of the panels to accommodate the gate ends of the Clover trap. The Clover traps are inserted into these holes so that the gate end is flush with the inside of the panel. The Clover traps are held in place by anchoring the middle of each side and the rear to rocks buried in the ground and by wiring (heavy wire) each side of the inserted end of the Clover trap to the corral panel.

The main gate mechanism is essentially a larger scale of that used on a Clover trap. The trigger mechanism for the corral trap is also essentially the same as used on the Clover trap except that horizontal trip strings were utilized.

RESULTS AND DISCUSSION

Nine deer (plus a recapture) were trapped and marked at one trap site. It is of interest that all deer entered and were trapped in the Clover traps while attempting to escape. In fact the first deer entered the Clover trap and was caught even though the main corral gate failed to drop because of improper setting.

The deer trap was constructed to encircle a cattle salting area that has historically shown heavy deer use. Deer visited the salt lick normally at night although several were observed around it during the day. The period when deer seem to seek out salt most at this elevation 1,829 m (6,000 ft) is during June and July.

Cattle became a problem, getting caught in, and breaking boards on the corral, so a three-strand barbed wire fence was put in a half circle in front of the main gate. The fence was dropped when the trap was not in operation. Also, the main gate was securely tied up so both cattle and deer could use the salt lick.

The Stewart Modified Corral Trap has numerous advantages over other types of traps.

1) Deer are not as prone to injury when held in a Clover trap; injuries are relatively common when using a corral trap.
2) The described trap can be placed around an established salt lick or water and no additional bait is needed.
3) The trap can be set in the evening and checked in the morning whereas snares must be closely monitored.
4) The gate can be tied up for any period of time allowing free movement to and from the salt lick for both cattle and deer.

ACKNOWLEDGEMENTS

Bill Stewart of The Department of Fish and Game should be credited with the idea for the trapping apparatus and Hal Salwasser, University of California, Berkeley, helped with early stages of development and trapping operations.

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—*Ronald D. Rempel and Ronald C. Bertram, Wildlife Management Branch, California Department of Fish and Game.* *Accepted November 1974.*

THE STATUS OF ROCKY MOUNTAIN ELK IN KERN COUNTY, 1974

HISTORY

On December 6, 1966, Department of Fish and Game issued a permit to Mr. Rex C. Ellsworth for the importation of 300 Rocky Mountain elk (*Cervus c. canadensis*) from Yellowstone National Park to be released into a fenced compound on his ranch in southern Kern County, California (Figure 1). The Ellsworth Ranch is on Cummings Mountain, approximately 16 km (10 miles) southwest of the town of Tehachapi.

By April 24, 1967, 290 elk had been shipped from Yellowstone, but due to the stress of transport and possibly other causes, only 277 survived to be released inside the ranch enclosure.

Many elk died within the enclosure. In mid-1967 wildlife pathologist Oscar Brunetti (California Department of Fish and Game) reported that animals were dying from several disease entities brought on by stress induced by confinement and a new and different diet. At that time, losses had just about ended. Elk began escaping by about the middle of 1967 because of lack of fence maintenance. In early 1968 Department of Fish and Game personnel reported that approximately 15 elk were outside the enclosure and were scattered on Tejon Ranch lands to the south and west and on Cummings Valley and Bear Mountain to the north. Another 1968 report indicates that 24 animals re-entered the enclosure and were trapped. Eight animals were outside and near the enclosure at that time. This same report estimated 12 animals on Tejon Ranch and 12 on Cummings Ranch. It is not known exactly how many animals escaped to the wild.

FIGURE 1. Rocky Mountain elk in the Ellsworth Ranch enclosure. Photo taken by W. Macgregor, 1967.

PRESENT STATUS

Field surveys and interviews were conducted during August and September, 1974, to update data on the Tehachapi elk herd. Fresh and recent elk sign were found in several areas; the Peckerwood Basin-Cottonwood Creek area of the Tejon Ranch (especially Sections 8, 9, and 10, T 10 N, R 16 W S.B.B.M.) contained sign of at least three bands of eight to fourteen animals each. The Lopez Flats area and surrounding ridges on the Tejon Ranch showed sign of 10 to 20 animals. Two areas (Section 13, T 10 N, R 17 W, and Sections 19, 20 and 30, T 10 N, R 16 W), contain the most sign and probably provide habitat for two separate populations, though some movement and inter-mingling probably occurs. Both of these areas have grassy slopes and willow-lined drainages with abundant water. Elk browse on willows and wallow in mudholes in the creeks during the summer months.

Current information indicates these two areas are probably the most densely populated with elk. Field surveys revealed that small numbers of elk are scattered over wide areas of the Tehachapi Mountains and probably wander over large areas of range.

Tejon Canyon and the Brush Spring Tributary provide suitable elk habitat, although heavy livestock use in the area probably masks elk sign.

Some areas of Cummings Mountain and nearby Cedar Creek have habitat suitable for elk, for at least a portion of the year.

The southeast-facing slope of the Tehachapi Range, facing Antelope Valley, is indented with numerous drainages, most with abundant water, and many with grassy, willow-lined stream courses suitable for elk.

Several areas on the north end of the Tehachapis show elk usage. An estimated four to eight elk are regularly inhabiting the area near Sycamore Canyon. Other reports suggest widespread usage by elk in and around Bear and Cummings Valleys. Bear Mountain has islands of suitable elk habitat and bulls, cows, and calves have been reported there. Intensive development of Bear Mountain is drastically reducing wildlife values there, however.

Large areas in and near Horse Thief Flat and Oak Flat may support elk, especially when acorns provide ample feed there.

Elk have been reported at very low elevations in Tejon Canyon and at the mouth of El Paso Creek.

Nearly 100 elk may now be living in the Tehachapi Mountains, Table 1.

TABLE 1. Estimates of Elk Numbers by Area

Area	Estimate of minimum number	Estimate of maximum number
Peckerwood Basin-Cottonwood Creek	25	40
Lopez Flats	10	20
Tejon Canyon	8	12
Cummings Mountain-Cedar Canyon	4	8
Sycamore Canyon-Bear Valley	6	12
Bear Mountain	3	5
Totals	56	97

DISCUSSION

Since evidence of reproduction has been noted in each of the past 4 years, it is apparent that the elk have adapted to their new range. Distinct bands are occupying islands of suitable habitat and are moving seasonally from one area of suitable feed to others. In addition, small bands or individuals seem to wander over wide areas of range.

Riparian habitat is preferred during summer months when succulent grasses, forbs, and willows provide the bulk of the animals' diet. During the fall, elk disperse to oak groves and higher slopes to feed on acorns and browse. After winter rains begin, and into the spring months, grasses are abundant over most of the Tehachapi range.

It seems likely that elk numbers are reaching a balance with the average carrying capacity of these islands of suitable habitat. Pressures of livestock grazing will influence this carrying capacity. In addition, deer numbers are increasing dramatically on some portions of the Tejon Ranch and are presenting a negative impact on elk, deer, and livestock habitat and on the range in general.

No damage by elk has been reported, and all landowners and other persons interviewed expressed desire to preserve the herd.

—*Ronald D. Thomas, Wildlife Management Branch, California Department of Fish and Game. Accepted for publication November 1974.*

MODIFICATION OF THE CLOVER DEER TRAP

The Clover (1954, 1956) deer trap, consisting of a metal pipe frame covered by heavy nylon mesh, has many advantages related to its light weight and ease of movement. It has the disadvantage that a trapped animal can see the approaching trap crew, and usually hurls itself excitedly about inside the trap. Injuries are likely if the animal is not restrained quickly.

In my experience with the white-tailed deer (*Odocoileus virginianus*) on the George Reserve in Michigan the catch-net design of Clover (1954) is quite inefficient. It takes time to set correctly, and despite my best efforts, a fair number of animals elude the net. Redesign of the catch-net to use both ends of the purse string to close the purse instead of just one, which closes the purse in half the time, resulted in improved efficiency of capture. Still, a number of animals escaped.

Use of the catch-net also involves hazards to the trapping crew. Safely handling our large deer—large males weigh well over 90 kg (200 pounds)—involves a crew of at least three men.

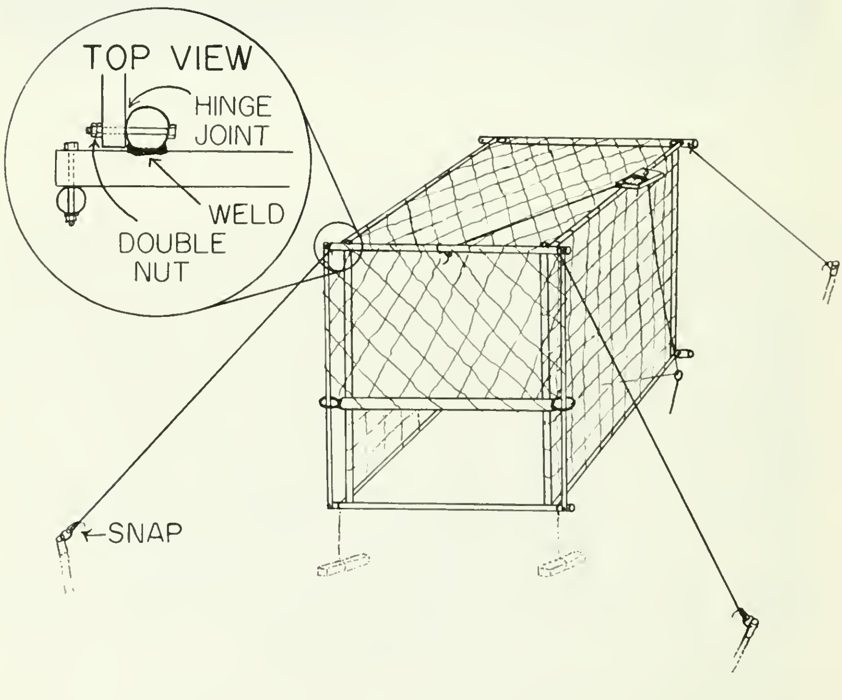

FIGURE 1. Diagram of the collapsible deer trap, showing general construction and set-up of the trap. The inset shows detailed construction of the corners. Both pipe frame end pieces are constructed identically for complete interchangeability; however, drop bar guides are bolted only to the drop gate end.

The Clover trap construction details were modified to allow rapid collapse of the trap to restrain the animal (Figure 1). This collapsing design is less cumbersome than that of Sparrowe and Springer (1970) and allows rapid collapse and re-resetting. Furthermore, the trap can be collapsed for transport without unlacing netting as is required in the Clover (1954) design.

The collapsible design shown in Figure 1 could be applied to any pipe-frame, net covered trap. I am including the specific design details of the traps used on the George Reserve since many problems of economy, ease of construction, and maintenance have been solved, and the same trap would be useful on any deer-sized animal.

Dimension of the pipe frame in the traps are 106.7 cm (42 inches) for all of the end pieces and 167.6 cm (66 inches) for the long sides. The sides and drop-gate guides, 1.27 cm ($\frac{1}{2}$ inch) black pipe, are bolted onto the rigidly welded end-frame, 1.9 cm ($\frac{3}{4}$ inch) pipe, members. The sides of the end frame are welded solidly to the tops and bottoms, 7.6 cm (3 inches) in from their ends. The drop-gate guides are bolted flush with the end of the top and bottom end frame pieces. The drop-gate is 3.2 cm ($1\frac{1}{4}$ inch) black pipe, 95.3 cm (37.5 inches) long, with 7.6 cm (3 inch) diameter rings welded to each end.

The mesh covering the trap is knotless netting of No. 84 nylon twine 145.2 kg (230^{+} pounds) test, with 10.2 cm (4 inch) square mesh (available from Nichols Net and Twine, East St. Louis, Illinois) treated with net set. Side pieces of mesh must be put on in a square pattern for the trap to collapse. With the trap made with dimensions given above, each side consists of a piece 10 squares by 15 squares. Tops and bottoms of the side piece can be looped over the unbolted side pipes, but the ends must be lashed with nylon rope. The top and closed end should be in a single piece using the diamond pattern and measuring 17 diamonds long by 7 diamonds wide, lashed on with nylon rope. The drop-gate should be a separate piece because it wears out most quickly and should be easily replaced. Furthermore, if it is made continuous with the top and closed end, the hitting of the closed end by the trapped animal tends to slide the netting in that direction with a consequent lifting of the drop-gate and possible escape. The drop-gate is cut in diamond patterns (7 diamonds high by 8 diamonds wide), looped over the drop bar and unbolted drop bar guides and lashed at the top. No netting is required on the bottom of the trap. The trigger mechanism is a rat trap similar to that described by Clover (1956).

In the field, the trap is held in place by deadmen or heavy stakes at each bottom corner, and guylines from each top corner leading at a 45°–50° angle downward to secure stakes. The guylines at the rear are fastened permanently, but the two at the front are attached by quick detachable snaps.

When an animal is captured, the two guylines at the front are unsnapped, and the trap collapsed on the animal. The animal can be restrained by a single handler by tying the collapsed top side pipe to the bottom side pipe.

The animal can be released easily by tying the drop-gate open, going to the rear of the trap, and lifting the trap to its upright position. The deer can pass out the open door away from the handler.

With this trap a single worker can handle antlered, rutting bucks weighing over 200 pounds with ease and safety. The traps have proven to be sturdy, flexible, and easy to maintain.

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—*Dale R. McCullough, School of Natural Resources, Univ. of Michigan, Ann Arbor 48104.* *Accepted for publication December 1974. Supported by NSF Grant GB-6171.*

BLOOD AND SERUM ANALYSES OF ADULT STRIPED BASS, *MORONE SAXATILIS*, CAPTURED IN THE SACRAMENTO RIVER

Fisheries hematological literature has been primarily concerned with the establishment of blood parameters for salmonids. The lack of basic hematological data for other species presents problems when attempting to assess their physiological state. Additional problems of interpretation arise from the diverse and varied techniques and reporting formats used. Blaxhall (1972) suggested several standard techniques which were previously applied only to higher vertebrates. This would provide for better repeatibility, and allow for a comparison of results among fish groups. The purpose of this project was to provide basic blood and serum data for *Morone saxatilus* (Walbaum) using established techniques.

During early fall of 1972, several migrating striped bass, *M. saxatilis*, were captured in fyke traps on the Sacramento River near Freeport, California. Lengths were recorded for each fish, a blood sample (3.0 ml) was obtained via heart puncture and the fish returned to the river.

The blood samples were immediately mixed with heparin and iced until analyses could be performed. The samples were analyzed for hematocrit and hemoglobin content [1] using standard techniques (Blaxhall 1972). The remainder of the blood was centrifuged, the serum pipetted and frozen until processed on an SMA micro 12 serum analyzer.

The results of all analyses are presented in Table 1. This is the first report of blood parameters for this species captured from a freshwater environment.

TABLE 1. Results of Adult Striped Bass Blood and Serum Parameters Collected on September 19, 1972, Water Temperature 19°C.

	Fish number					
	1	2	3	4	5	6
Length (cm)	40	40	43	65	103	108
Hct (%)	58	52	45	60	--	51
Hb (gm/100 ml)	8.0	10.3	9.0	7.6	--	12.1
Na^+ (meq/L)	125	160	160	120	157	160
K^+ (meq/L)	5.10	3.73	3.35	3.70	3.70	2.65
Cholesterol (mg %)	285	410	345	365	480	350
Ca^{++} (mg%)	9.5	13.5	10.0	11.0	10.9	15.0
Inorganic Phosphate (mg % P)	9.5	10.0	6.7	6.9	5.9	10.0
Glucose (mg %)	440	105	115	525	123	105
BUN (mg %)	6.0	2.3	3.0	5.0	2.0	2.5
Uric Acid (mg %)	5.45	1.00	0.30	4.10	0.15	0.40
Total Protein T.P. (gm %)	4.2	5.8	4.7	4.3	5.1	5.3
Alkaline Phosphate (mU./ml)	5	10	25	13	70	13
SGOT/340 (mU./ml)	580	25	--	137	--	43

[1] The Unopette System (Becton-Dickinson, No. 5857) was used for hemoglobin analyses. This is a modification of the Standard Cyanomethmoglobin procedure (Cannan, 1958).

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—Louis A. Courtois, Environmental Services Branch, Water Pollution Control Laboratory, Rancho Cordova, California 95670. *Accepted March 1975*

MEASURING SALMON, AN OLD AND UNFAMILIAR METHOD

While working with salmon data collected off northern California from 1948 into the early 1950's I had occasion to compare some weights and lengths with similar data from 1919 and 1920 published in California Department of Fish and Game Fish Bulletin No. 34, "The Salmon of the Klamath River", by John O. Snyder. The differences led me to the inescapable conclusion that Snyder's fish and mine had not been measured the same way. How had Snyder's been measured? The old fisheries pioneer had died, and his bulletin gave no hint that I could find.

Ever since the Department of Fish and Game re-started its sampling of the commercial salmon catch in the 1940's the measurement used for scientific studies has been the caudal fork length, though frequently the total length was also taken. Snyder had used a measurement that appeared to be greater than the fork length, less than the total. This, of course, ruled out standard length which is less than fork.

After stewing over the problem I relegated it to the back of my mind where it remained for some time. Then a visitor dropped by my office. It was W. L. Scofield, then retired, since deceased. Scofield had had a long career with the Division of Fish and Game. After we had chatted awhile I had a thought and asked him if he knew how Snyder's salmon measurements had been taken. He was highly amused and said he was only too familiar with it, having measured several thousand salmon for Snyder. He went on to explain that the salmon were usually spread out on a cannery or fish house floor and to measure them Snyder placed the end of a flexible steel tape against the tip of the snout and passed the tape over the curve of the body to the tip of the central caudal rays. Because of the curve of the body this gave a measurement somewhat longer than the fork length as used today, but less than the total length. Scofield went on to say that the method did have the advantage of speed because the fish could be measured without moving them, but that he had argued against its use and had been over-ruled.

The presently used measurement can be obtained by sliding the fish onto a measuring board which has a ruler set into the bottom and a perpendicular stop at one end. The salmon's snout is held against the perpendicular end and the measurement is to the central rays of the caudal fin.

Snyder makes no mention of whether his fish were weighed dressed or round. I believe anyone wishing to use Snyder's data would be safe in assuming that all were measured round. Gill net catches landed in California were round until the fisheries were abolished by law. Ocean-caught salmon taken south of Eureka were still being landed round in the 1950's.

—*Donald H. Fry, Jr., Anadromous Fisheries Branch, California Department of Fish and Game (Retired).* *Accepted November 1974.*

FURTHER RECORD OF LITTLE KERN GOLDEN TROUT, *SALMO AGUABONITA WHITEI*, IN THE LITTLE KERN RIVER BASIN, CALIFORNIA

In a recent study of phenetic variation among six populations of golden trout, *Salmo aguabonita* Jordan, collected in 1973 from the Sierra Nevada, California, we reported the presence of at least two significantly distinct phenetic groups of golden-like trout resident within the upper Little Kern River basin (Gold and Gall 1975*a*). The first was represented by two samples, one from the Little Kern River near Peck's Canyon Creek, and the other from lower Soda Springs Creek near its confluence with the Little Kern River. Subsequently, Gold (1975) reported that this group occupied a cluster point in phenetic hyperspace approximately halfway between that occupied by rainbow trout (*Salmo gairdneri* Richardson) and that by *S. aguabonita aguabonita*—the golden trout subspecies from the South Fork of the Kern River and Golden Trout Creek.

The second phenetic group was represented by a single sample from upper Soda Springs Creek, above a series of natural barriers which prevent the upstream migration of trout from lower Soda Springs Creek and the Little Kern River. Phenetically, this group was found to be much more closely related to the geographically distant populations of *S. a. aguabonita* than to the samples from lower Soda Springs Creek and Little Kern River situated only 10–11 km (6–7 miles) downstream (Gold and Gall 1975*a*). This evidence, plus some differences in chromosome karyotype (Gold and Gall 1975*b*), and a remarkable similarity in morphology between the upper Soda Springs Creek trout and Evermann's (1905) first description of the Little Kern golden trout, led us to hypothesize that the upper Soda Springs Creek trout represented a "pure" population of the endemic, and now threatened (Miller 1972; Fisk 1972), Little Kern golden trout, *S. a. whitei* Evermann.

Subsequently, a search was undertaken for additional populations that might represent "pure" Little Kern golden trout. In June 1974, 20 specimens were removed by angling from Deadman Creek, a northern tributary of Soda Springs Creek, and tested for phenetic similarity with the upper Soda Springs Creek population. Trout were caught at random sites along the creek, but always upstream from a series of natural barriers which prevent any upward migration of trout from below.

Ten meristic characters were examined on all specimens in the same manner as described in Gold and Gall (1975*a*). All data were subjected initially to frequency distribution analysis using the mean, variance, and Fisher's third and fourth moment statistics (Sokal and Rohlf 1969). Evaluation of the distributions revealed that all ten characters were distributed approximately normally. Slight deviations from normality were invariably leptokurtotic and were considered as being due to small sample size.

The means of the ten characters for both populations were compared by "t" tests, with each test having 111 degress of freedom.

Means of 8 of the 10 characters were found not to differ significantly at the 5% probability level (Table 1). Of the two means which differed significantly between the two samples, one (scales above the lateral line) differed at the 5% probability level but not at the 2% level. The reduced number of vertebrae in the Deadman Creek trout was highly significant ($P < 0.01$), and was the only clear cut difference between the two samples.

TABLE 1

Observed Means and Standard Errors of 10 Characters for 20 Deadman Creek and 93 Upper Soda Springs Creek Trout, and the Results of "t" Test Comparisons Between Means

Character	Mean ± S.E.		Pooled‡ standard error	"t"
	Deadman Creek	Upper Soda† Springs Creek		
Pyloric caeca	30.6 ± 0.4	32.2 ± 0.4	0.884	1.753
Fin rays				
Pelvic	9.6 ± 0.1	9.5 ± 0.1	0.197	0.761
Dorsal	12.2 ± 0.1	11.9 ± 0.1	0.241	1.245
Anal	11.5 ± 0.1	11.5 ± 0.1	0.230	0.217
Pectoral	15.4 ± 0.1	15.5 ± 0.1	0.192	0.260
Branchiostegal rays	11.1 ± 0.1	11.3 ± 0.1	0.202	0.990
No. vertebrae	59.9 ± 0.1	60.8 ± 0.1	0.209	4.067**
Gill rakers	17.8 ± 0.2	18.2 ± 0.1	0.326	1.227
Scales along lateral line	181.0 ± 1.2	181.8 ± 0.9	2.112	0.379
Scales above lateral line	35.2 ± 0.3	36.6 ± 0.3	0.684	2.050*

† From Gold and Gall (1975a).
‡ The pooled standard error for the "t" tests was computed after Sokal and Rohlf (1969) using a weighted analysis for unequal sample size.
* $P < 0.05$.
** $P < 0.01$.

The high degree of similarity (8 of 10 means) strongly indicates taxonomic identity between the two populations. The differences between them may be the result of environmental variation. This could be true for the different vertebral numbers observed, since relatively slight alterations in environmental variables (specifically temperature) are known to modify this character in salmonids (Tåning 1952; Garside 1966). Also, slight population divergence by chance alone might be expected since these two populations may have been isolated from each other for some time.

Since both the Deadman Creek and upper Soda Springs Creek populations are sufficiently isolated from each other, and from the trout populations of lower Soda Springs Creek and the Little Kern River, the two populations, although isolated, very probably represent a single form of golden trout long resident in the upper Little Kern basin. This would appear to support our earlier finding that relatively "pure" populations of Little Kern golden trout still reside in waters of the Little Kern River basin. Furthermore, the finding of a second population, closely related phenetically to the upper Soda Springs Creek population and hence by inference distantly related to the lower Soda Springs and Little Kern River populations, reinforces our earlier contention that the trout of lower Soda Springs Creek and the Little Kern

River are not the endemic golden trout of the region, but rather remnants of golden × rainbow hybridization (as suggested by Dill 1945, 1950). This contention was supported by the fact that the lower Soda Springs Creek and Little Kern River trout were phenetically intermediate between *S. gairdneri* and *S. a. aguabonita* (Gold 1975), and by the close phenetic relationship observed between *S. a. aguabonita* and the upper Soda Springs Creek golden trout (Gold and Gall 1975*a*).

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POECILIOPSIS GRACILIS (HECKEL), A NEWLY INTRODUCED POECILIID FISH IN CALIFORNIA

On 27 July 1974, four specimens of a poeciliid previously unreported in California were collected with a minnow seine in an irrigation canal at the junction of U.S. Highway 111 and Johnson Avenue, near Mecca, Riverside County, California. The specimens were identified by Dr. Carl L. Hubbs (Scripps Institution of Oceanography) as *Poeciliopsis gracilis* (Heckel), 1848 (Rosen and Bailey 1966).

Poeciliopsis gracilis is native to freshwater streams on both the Pacific and Atlantic slopes of southern Mexico and Guatemala (Rosen and Bailey 1966). Males reach 30 mm TL and females 50 mm (1.17 and 1.95 inches, respectively). Their preferred water temperature is 22–24 C (71.6–75.2 F) (Sterba 1962). Observations in the field and in aquaria suggest that *P. gracilis* prefers moderately fast-moving water and is active throughout the water column.

P. gracilis resembles the mosquitofish, (*Gambusia affinis*), but is readily distinguished in the field by a longitudinal row of four to eight large, jet-black spots; the males have an extremely long anal fin (gonopodium), extending almost to the caudal fin when depressed. Rosen and Bailey (1966) have reviewed the nomenclature of this species of which *Heterandia pleurospilus* (Jordan and Evermann 1896) and *Poecilistes pleurospilus* (Sterba 1962) are among the synonyms. The common name "porthole live bearer" is suggested, as a modification of "porthole fish" used by Sterba (1962).

P. gracilis should not be confused with the Gila topminnow, *P. occidentalis,* which was formerly abundant in the Gila River system of Arizona (Minckley and Deacon 1968; Minckley 1973; Carl L. Hubbs, pers. comm.). The specimens I collected, one immature male (21 mm SL) (0.82 inch) and three half-grown females (14–20 mm) (0.55–0.78 inch) were readily distinguished from other resident stream poeciliids by the four to five very distinct, jet-black spots on each side of their translucent tan body.

Twelve additional specimens, ranging in size from 8 mm (0.31 inch) juveniles to a 43 mm (1.69 inches) female, were collected on 17 November 1974 at the same site (Table 1). At least a dozen more were observed schooling with young of shortfin molly, *P. mexicana* and red shiners, *Notropis lutrensis.* The appearance of recently born young, the wide range of sizes, and the persistence of the fish for at least a 4-month period, suggest that *P. gracilis* is a reproducing resident of this canal.

The species was not represented in collections I have previously made at this site, nor have I obtained *P. gracilis* in samples from other nearby Coachella Valley canals and waterways sampled periodically since 1964 (i.e., canals at Avenues 81, 82, and 83 near Highway 86 as described by St. Amant and Sharp (1971) and the Whitewater River, Riverside County). Thus, the introduction appears to be recent, possibly early in 1974. Possible sources of introduction were not investigated but presumably were by direct release by aquarists or escapements from a nearby tropical fish farm.

Eight additional species, representing a total of four families, were recorded from the Johnson Avenue canal in 1974 (Table 1). The assemblage was dominated by sailfin mollies (*Poecilia latipinna*) and shortfin mollies and by red shiners. *Poeciliopsis gracilis*, mosquitofish, and desert pupfish (*Cyprinodon macularius*) were common but not abundant. One small "green wag" variety of the green swordtail, *Xiphophorus helleri*, was also collected on 27 July 1974 (juvenile, 22 mm) (0.87 inch). It is also known to have been released in a drainage canal at Avenue 82 near Highway 86 in the Coachella Valley; although this stock did not survive (St. Amant, Calif. Dept. Fish and Game, pers. comm.) it may have been the source of this specimen. However, the variated platy, *Xiphophorus variatus*, also previously described from the Avenue 82 site (St. Amant and Sharp 1971), was not found here.

TABLE 1

Fishes Collected and Observed in an Irrigation Canal at U.S. Highway 111 and Johnson Avenue, 1 mile south of Mecca, Riverside County, California

Species	Number collected (+ = observed only)			
	20 January 1974	27 July 1974	17 November 1974	Total
Cyprinidae				
Cyprinus carpio	2	1	+	3
Notropis lutrensis	+	3	22	25+
Cyprinodontidae				
Cyprinodon macularius	0	32	+	32+
Poeciliidae				
Gambusia affinis	+	12	5	17+
Poecilia latipinna	+	130	78	208+
P. mexicana	+	15	84	99+
Poeciliopsis gracilis	0	4	15	19
Xiphophorus helleri	0	1	0	1
Cichlidae				
Tilapia sp.	1	+	+	1+
Total species	6	9	8	9
Time of day	Midday	Late afternoon	Morning	
Air temperature, C	21	43	17	
Water temperature, C	20	26	23	
pH	7.8	--	7.8	

Finally, carp (*Cyprinus carpio*), ranging in size from 7 to 28 cm (2.8 to 11.0 inches) and a number of tilapia (*Tilapia* sp.) were observed and captured in deeper portions of the canal. The identification of the species of *Tilapia* has not been confirmed, but it does not appear to be *T. mossambica* (as previously reported from Imperial County by Hoover and St. Amant 1970).

P. gracilis does not now threaten sport fish populations, but it does represent one of many recent introductions which may compete with remaining native fishes such as the desert pupfish. Studies on food habits and behavior are warranted. Likewise, ecological studies of the present irrigation canal assemblages are warranted since the canals may serve as reservoirs for further invasions.

ACKNOWLEDGEMENTS

I thank Rick D. Cardwell, Dow Foreman, M. James Allen, James A. St. Amant, and especially Carl L. Hubbs. Specimens from the 27 July 1974 collection are deposited in the fish collection of Scripps Institution of Oceanography (51074-126).

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—*Alan J. Mearns. Southern California Coastal Water Research Project. 1500 East Imperial Highway, El Segundo, California, 90245.* *Accepted February 1975.*

POLYMORPHISM IN POPULATIONS OF *SCELOPORUS OCCIDENTALIS* IN SANTA BARBARA COUNTY, CALIFORNIA

There exists in the literature two taxonomic schools of thought with respect to the subspeciation of the western fence lizard, *Sceloporus occidentalis*. Stebbins (1966) has recognized four subspecies, with two of these, *S. o. occidentalis* and *S. o. biseriatus*, possibly occurring in Santa Barbara County. Other authors (Bell 1954; Cochran and Goin 1970) have recognized a total of six subspecies, with three of these, *S. o. bocourti*, *S. o. biseriatus*, and *S. o. longipes* also possibly occurring in Santa Barbara County. A criterion used by both schools of thought for subspecific differentiation has been the pattern of the blue gular throat patch—whether or not there exists a single patch, a partially divided patch, or two completely separate patches. Both schools agree that the patch (or patches) may be absent in adult females and juveniles of either sex.

Concurrent with a study of five natural populations of *S. occidentalis* in Santa Barbara County, California, it was observed that 39% ($N = 97$) of the adult males taken from these five populations during 1970 and 1971 were totally devoid of any throat patch. The remaining 61% possessed the expected variations in patch patterns as noted above. These populations were geographically separated along an approximate north-south transect through the county between the Goleta Valley on the south and the Cuyama Valley on the north. No gradation in patch patterns or patchlessness was observed. Unless one were cognizant of the fact that males of this species have enlarged postanal scales (Stebbins *op. cit.*; Davis 1967), the patchless forms might be mistaken for females. Prior to this study it was found through dissection that all animals taken from the study areas, which had enlarged postanal scales, were in fact males. Of particular note is the fact that the patchless form fits neither of the current taxonomic schemes nor the possible *bocourti* × *longipes* intergrades suggested by Bell (*op. cit.*)

However, it is felt that these populations should not be considered as a separate taxonomic unit but rather they should serve as an additional example of the highly polymorphic nature of this wide ranging species.

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BOOK REVIEWS

Freshwater Ecology

By T. T. Macan, John Wiley & Sons, Inc., New York, Second Edition, 1974; viii + 341 p. illus.

The material in the second edition of *Freshwater Ecology* varied only slightly from that of the original book which was published in 1963. The new edition was revised slightly to omit obsolete information, and some recent material was added.

The author subscribes to the belief that the reason species are present in some places and absent from others is because of the interaction of limiting factors. To support his convictions, Dr. Macan presents material on physical and chemical properties of water, communities, transport, behavior, interrelationships, physical factors, oxygen, salinity, calcium, other chemical factors, production and study methods.

I could not relate very well to examples the author used to sell his points because most of the material described aquatic insects and other invertebrates. The role of fish in the aquatic habitat was seldom covered.

A failure of this book is the use of names of animals. The author took great pains to be comprehensible to all in using generic and specific names. In fact a list of alternative names followed each chapter; however, common or vernacular names would often be more descriptive and less disruptive to a reader who isn't well versed in the scientific names of invertebrates.—*Larry K. Puckett.*

The Carnivores

By R. F. Ewer; Cornell University Press, Ithaca, New York, 1973. xv + 494 p., illustrated. $21.50.

This volume, the product of the author's lifelong interest in and study of carnivores, is a pleasure to read. It is well written and presents an excellent review of many aspects of the biology of the Carnivora. Not only does this work deserve a place in the professional biologist's library, it also will be of interest to laymen and amateur naturalists interested in carnivore biology.

The text begins with a succinct introduction to the Carnivora, including a brief taxonomy and some characteristics and habits of each family. Chapter 2, "The Skeleton", is a somewhat detailed analysis of the skeletal anatomy of the seven families, including discussions of the post-cranial skeleton, the skull, and the dentition. Of particular interest are the summaries of dental formulae and eruption sequences.

Chapter 3, "Anatomy of the Soft Parts", is presented in somewhat less detail than is skeletal anatomy. Included are discussions of the pelage, skin glands, rhinarium, ears, paws, and a very cursory treatment of the viscera. Chapter 4, "The Special Senses", concerns vision, hearing, smell, taste, tactile senses, and their relationships to carnivore biology.

Chapter 5, "Food and Food Finding", discusses feeding behavior and food habits for many taxa of carnivores. Not only does the author provide data at the family level, in many instances she supplies detailed accounts at the species level.

A discussion of signals and social organization (Chapter 6) logically precedes a chapter on social organization and living space (Chapter 7). Together these chapters provide an interesting account of the social life and behavior of the Carnivora. These chapters, like most of the others, present the material in a comparative manner, a technique particularly appreciated by the reviewer. In Chapter 8, reproduction is broken down into general biology, courtship and mating, and development and rearing of the young. In each category, the author again discusses the different aspects at the family level as well as at the generic or specific level when data are sufficient to allow it.

Chapter 9, "Fossil Relatives", briefly discusses the early relatives of the present day Carnivora, and presents data on the origins and relationships of the living families. Included is a necessarily brief treatment of the biochemical relationships of the living families as well as a discussion of some karyological data and their implications regarding the evolution of the present day Carnivora. A useful table detailing the diploid chromosome numbers of many genera and species, representative of all extant families, is included.

Chapter 10, "Classification and Distribution of the Living Species", is a systematic and zoogeographic review of the extant Carnivora. The author points out many of the taxonomic problems inherent in a group as large and diverse as the Carnivora and includes, at pertinent points, her own opinions. Of particular interest is Ewer's treatment of the Felidae; however, she is in agreement with Leyhausen (Bull. Zool. Nomencl. 25:130, 1969), that a satisfactory classification will be possible only after each and every species of cat has been thoroughly studied.

This work cannot be considered complete in its treatment of carnivore biology. It is particularly weak in its treament of physiology and population dynamics, subjects which are scarcely mentioned. *The Carnivores* is, however, a useful, well-written and intriguing account of many of the aspects of carnivore biology, and will be a welcome addition to the libraries of interested biologists and naturalists. Although some obvious errors and omissions occur, the author has presented in one volume a usable, readable compilation of pertinent facts and opinions. It is unfortunate that the publisher has seen fit to place such an exorbitant price on this volume.—*Vernon C. Bleich.*

Fly Casting with Lefty Kreh

By Lefty Kreh; J. B. Lippincott Company, Philadelphia and New York, 1974, illustrated. $8.95.

Fly casting has often been a major obstacle which discourages people and keeps them from taking up the sport of fly fishing. Instead, they look for an easier and less complicated method and fall back on the spinning rod. I don't look for this new book on casting by Lefty Kreh, however, to make great inroads into the problem. The old Chinese philosopher who once said "one picture is worth a thousand words" must never have attempted to teach a tyro fly caster the art of forming a neat, tight, wind-cutting loop with 30 feet of fly line. Photographs, diagrams, or silhouettes can never convey the idea of timing and rhythm.

This book uses a series of sequence photos of Lefty in various positions of casting and creates an artful approach to solving the problem. By carefully using light and shade in his photos, photographer Irv Swope has made Lefty's rod and fly line glow as though lighted with electricity. The reader can follow the sequences through and gain an idea of Lefty's movements during casting. While the casting style is fairly basic, it does differ somewhat from traditional form. The author has incorporated several tricks developed by West Coast fly fishermen for big, windy steelhead rivers.

In conclusion, while *Fly Casting with Lefty Kreh* is not intended to turn every fly caster into another Steve Rayjeff (World Champion Fly Caster), it does approach a difficult problem in a manner easily understood by the beginner. —*Dennis P. Lee.*

How to Tie Freshwater Flies

By Kenneth E. Bay; Winchester Press, N.Y., 1974; vii + 152 p. color and black-and-white photos. $10.00.

It's always fun to watch a fly tier at work and reading Ken Bay's book "How to Tie Freshwater Flies" is just like sitting next to an experienced tier and watching him tie.

This is a book for the beginner and by far the best book available for someone who has never tied before and wants to teach himself. There are initial brief chapters on fly tying tools, hooks, and materials. While the chapters are brief, they do present the basic information needed by a beginner and present it in a clear, straight-forward style. The remainder of the book is the "how to" part, detailing first the basic techniques of tying the thread on the hook, tying in tails and various wing materials, and, finally, the whip finish. Each step of each process is clearly illustrated in large, black-and-white photos by Matthew Vinciguerra. The final four chapters photographically lead the reader through the steps of tying 14 different patterns, including 2 streamers, 2 wet flies, 7 dry flies, and 3 nymphs. Each pattern was obviously chosen to illustrate the techniques required for different materials, but each pattern is a good, fishable pattern. One brief appendix provides a selected bibliography and a list of sources of fly tying materials.

The book has few, if any, shortcomings. I would have included photos of hackling both wet and dry flies in the chapter on basic techniques, and I think the book could have been further improved by a bit more explanation of *why* a technique was used —Why are spent wings tied spent? Why do you tie in materials under the shank of the hook? A more detailed explanation of proportions and position of wings, tails, etc. would have also added to the text.

The photos are excellent and the inclusion of 4 color plates of materials and the finished fly patterns really improve the book. It's well worth the $10 price tag. —*K. A. Hashagen, Jr.*

Return to the River

By Roderick Haig-Brown; Crown Publishers, Inc., N.Y., 1974; 248 p. black-and-white illustrations. $7.50.

Long out of print, "Return to the River" has finally been reprinted, to the delight of many angler/readers familiar with Haig-Brown's work and for the enjoyment of those who have yet to discover Haig-Brown.

The subtitle of the book is "The Classic Story of the Chinook Run and of the Men Who Fish It". The book describes the life history of a Chinook salmon, "Spring" from the time of egg deposition to her eventual spawning and death. There is a huge mass of authentic, accurate life history information presented in a very enjoyable, fictionalized manner. The author obviously knows his salmon and has read the technical fisheries literature extensively. No aspect of the life cycle of a salmon in the great Columbia River system is missed — spawning, predators, prey, pollution, logging, dams, offshore migrations, commercial and sport fishermen, hatcheries.

The book *is* a classic and I highly recommend it to any one interested in fishing and the literature of fishing. The price is $7.50. —*K. A. Hashagen, Jr.*

Trout Magic

By Robert Traver; Crown Publishers, Inc., New York, 1974; 216 p., black-and-white illustrations. $7.50.

Crown Publishers continues to turn out top quality fishing books — this one is a book of short stories by Robert Traver, author of "Trout Madness" and several other books. Over half of the 17 stories have appeared elsewhere but they're all worth reading or rereading. I spent a couple of very pleasant evenings reading "Trout Magic". The illustrations by Milton Weiler are very nicely done and add a lot to the book.—*K. A. Hashagen, Jr.*

Wilderness Fishing for Salmon and Steelhead

By Roy A. McInturff; A. S. Barnes and Co., New Jersey, 1974; 197 p., illustrated. $8.95.

Roy McInturff, the author of "Wilderness Fishing for Salmon and Steelhead" has been enthusiastically fishing the Klamath and Trinity rivers in California each fall for the last 20 years. Unfortunately, he felt it was necessary to write a book about his experiences. While you have to admire his love of these rivers and his enthusiasm for salmon and steelhead fishing, you wonder how anyone could put together a book like this one. There is a fair amount of misinformation on movements of fish and the life history information, there are numerous typographic errors, which detract from the text, and one photo is used three times, once on the cover and twice in the book itself. Although fishermen rarely agree on tackle or techniques, most will agree that night crawlers are not a "new" bait for steelhead, and that monofilament can be used successfully for shooting line on fly rod; the author has to be the only person I know who has been fishing for any length of time who uses a spear point barbed eyelet to attach his leader to his fly line. His views on conservation are stated roughly as follows "Keep all you catch—if you can't use 'em you can always give 'em away" and "A few small 'trout' taken on a small fly make a good breakfast if you can't catch a steelhead". Sorry, I just can't recommend this one.—*K. A. Hashagen, Jr.*

The Trout and the Stream

By Charles E. Brooks; Crown Publishers, Inc., N.Y., 1974; viii + 216 p., illustrated. $7.95.

For anglers who make the pilgrimage to the rivers and streams of Idaho, southwestern Montana and northeastern Wyoming this book will have far more value than to those unfamiliar with these waters. Mr. Brooks tells about habitat, fish, fishing techniques, tackle, and conservation using as examples the Gallatin, the Madison, the Firehole, the Yellowstone, and Henry's Fork of the Snake.

The first chapter "Life in Running Water" is a semidisaster, describing the interrelationships and interactions of algae, phyto- and zooplankton, and other food organisms as well as temperature, oxygen, and the chemical composition of the water. The presentation of the material is awkward and often confusing. Mr. Brooks has spent a great deal of time collecting, observing, and formulating theories, many of which, he says, he was happy to find confirmed by professionals like Birge and Juday, Needham, Ruttner, and Hynes. I feel there is far more in this section than the average fisherman wants or needs to know and insufficient detail for the student or professional.

The remainder of the book is far better. Mr. Brooks is predominantly a nymph fisherman and as such has spent many years collecting, identifying, observing both above and below the water's surface, thinking, and experimenting. He puts it all together very nicely—rods, lines, tippet size, retrieves, patterns, water types. It makes interesting reading, and even if you don't agree with all of it I think most fishermen will find something new to experiment with or at least think about.

There is the usual chapter on fly patterns and how to tie them, which would be of value to anyone planning to fish the Yellowstone area waters. There is also a chapter on conservation, which must be required by law in all recently published fishing books—the release your fish, get involved, don't litter philosophy.

All in all "The Trout and The Stream" is an interesting, entertaining book. The price ($7.95) is reasonable and the illustrations by Dave Whitlock are good.—*K. A. Hashagen, Jr.*

A River Never Sleeps

By Roderick L. Haig-Brown; Crown Publishers, Inc., N.Y., 1974; 352 p., illustrated. $7.50.

It has been a long time since I have enjoyed a fishing book as much as I enjoyed "A River Never Sleeps" by Roderick Haig-Brown—probably not since I read an earlier edition of this same book. Crown Publishers has done fishermen/readers a great service by reprinting this long out of print classic. It is a book to be read slowly and savored thoroughly.

"A River Never Sleeps" was written "simply to define and pass on some of the pleasures I (Haig-Brown) have had from fishing". Basically, it is a book about rivers and changes in the rivers and fish throughout the course of a year. However, that is putting it far too basically and bluntly. The river is any river—from English rivers from the author's boyhood to the Campbell on Vancouver Island. It isn't all about rivers, though; there is also mention of lakes, estuaries, and the salt water. The fish are salmon, steelhead, cutthroat and brown trout, pike, and chubs. There are stories of hunting, of family, and of the out of doors. Stories of fishing in British Columbia cover the span of time, roughly from 1925 to 1945. There are wonderful glimpses of the abundance of fish and wildlife of that period. No mention is made of vast numbers of competing anglers. In discussing the life and death of salmon, the author mentions the many species of birds and mammals utilizing the dead and dying fish. He counted 200 bald eagles in a 2-mile stretch of river—I wonder what it would be today.

This book I can highly recommend. The price is reasonable and the writing excellent. Haig-Brown is a far better observer of his surroundings than the average fisherman and, fortunately, is an extremely articulate writer.—*K. A. Hashagen, Jr.*

The Shore Fishes of Hawaii

By D. S. Jordon and B. W. Evermann; Charles E. Tuttle Co., Rutlond, Vermont, 1973; 392 p., illustrated. $8.50 paper.

In a chapter entitled "Introduction to the new edition," the reader is informed that "This classic study of Hawaiian shore fishes was first printed in Washington in 1905 . . . [and] is an abridgment into handbook form, now newly titled *The Shore Fishes of Hawaii*." Further, "In condensing this *magnum opus* of Hawaiian ichthyology the editors have omitted only those parts of little reference value today to the fisherman, scuba divers, fish fanciers, or other readers who are likely to use the book. The deleted parts relate mainly to nineteenth-century literature, historical background, and other data of scant contemporary interest."

An examination of the 574-page 1905 edition, shows that 28 pages of historical review and bibliography have been omitted, as well as 7 pages on introduction of additional species (to Hawaii) and 1 page of addenda. In my opinion the editors showed extremely poor judgement in failing to reproduce Jordan and Evermann's *The Shore Fishes* in its entirety. Contrary to their belief that this information is "of scant contemporary interest," I feel that a great void was created by failing to include these relatively short but extremely pertinent sections.

The original pagination has not been retained in the present abridgment and the 138 plates (73 color and 65 black and white) which were scattered throughout the 1905 edition are now condensed onto 32 pages at the back of the book. Typescript and black-and-white figures have reproduced beautifully, but the color reproductions leave much to be desired. It is unfortunate that the editors did not include an addendum listing the currently accepted scientific names for the included taxa, especially generic and specific names. It seems to me that those who supposedly are to benefit from the present abridgment (i.e., fishermen, scuba divers, fish fanciers, and lovers of nature in general) truly would have benefited with up-to-date nomenclature. One can't fault the price, however.—*John E. Fitch.*

Marine Molluscan Genera of Western North America: An Illustrated Key (second edition).

By A. Myra Keen and Eugene Coan; Stanford University Press, Stanford, Calif.; 1974, vi + 208 p. $8.75.

When the first edition appeared in 1963, it was so well done that I thought it would be two or three decades before it could be improved upon substantially, yet here in just 11 years is a greatly improved version. Text and keys have been completely revised and reset, and the page size has been reduced "to make the book more portable."

An expanded "introduction" briefly explains the logic involved in classifying and identifying living organisms, and fits mollusks into the orderly world of marine invertebrates. The history behind, and layout of, the present book are also explained. The four figures illustrating gastropod topography and terminology now appear on a single page which faces a page showing the 11 basic shell forms. An idea as to the expanded coverage can be obtained by looking at the first couplet in the gastropod key: in the first edition the opposing characters in this couplet referred the user to couplets 2 and 36; in the present edition, one is referred to couplets 2 and 43. In both editions, *Cryptogemma* is the last gastropod genus keyed-out; however, in the first edition it is with couplet 235, while in this edition it is with couplet 262. Similar expanded coverage is found in all keys except that for cephalopods, and a key to families of Aplacophora is presented.

An innovation with this edition is a chapter entitled "Identification of figures" which gives generic and specific names, and authorities and dates for the shells figured in the keys.

Surely now we have an edition that is so meticulously prepared, and so complete that I do not see how it can be improved upon in this century, at least.—*John E. Fitch.*

Seashore Life of Puget Sound, the Strait of Georgia, and the San Juan Archipelago.

By Eugene N. Kozloff, University of Washington Press. 310 pp. 28 color plates, 223 drawings and black and white plates. Cloth—$15.00; paper—$6.95.

Although Dr. Kozloff, an outstanding marine ecologist, designed this book specifically around the inner Pacific Northwest region, about 90% of the plants and animals discussed are commonly found in the temperate nearshore waters as far south as Point Conception.

The book is written primarily for amateur and student naturalists and the first 47 pages are dedicated to what the author calls "instant zoology and botany" where tides, the metric system, and taxonomy are explained. A much needed "plea for conservation" with 10 rules of seashore etiquette is also offered. A bonus to the novice is a 105 entry glossary of common marine biological terms. However, because of its many plates and up-to-date taxonomy, the book also makes a handy, although limited, secondary reference for working field biologists.

The material is divided into three habitat types: Floating docks and piers, rocky shores, and sandy beaches and quiet bays—another feature geared to the needs of beginning and amateur biologists. The great strengths of the book are the large amount of natural history it contains and, refreshingly, that the plates of plants and animals usually appear on the pages where they are discussed.

The book is not without flaws and my major criticism is that the glued softback binding of the paperback version appears inadequate for a lot of field use. Hopefully, the cloth back is better suited for this purpose. Although most of the plates are excellent, a few of them (in my copy) reproduced very poorly and some could have been better chosen. Despite these criticisms, this is an excellent book which belongs in the collection of anyone interested in marine natural history.—*Lawrence L. Laurent.*

The Blackbass in America and Overseas

By William H. Robbins and Hugh R. MacCrimmon; Publications Division, Biomanagement and Research Enterprises, Sault Ste. Marie, Ontario, Canada, 1974; 196 p., $12.95 (hardcover) $7.95 (softcover).

The authors have condensed a tremendous amount of information into 196 pages. It must have been a labor of love to compile the information gleaned from several hundred sources into so compact a form.

A brief account is given of the discovery and scientific description of the six species of blackbass that are currently recognized. Taxonomic descriptions and a key to the six species are provided.

Each species is covered in a separate chapter, all following the same outline: a review of its biology, its native and naturalized (if any) range and its status as a sport and food fish. This similarity in format makes it easier to compare different aspects of the various species.

Space is allotted each species roughly in relation to its native range, with the largemouth and smallmouth bass getting top billing, since they are the most widely distributed and well known. The restricted range of the Guadalupe and especially the Suwanee bass has kept them from the eye of the public and scientists until quit recently, which no doubt accounts for the limited space allotted to them. The authors cite only three references for the Suwanee bass.

A brief history is presented of the culture of the blackbass in North America, as well as present North American and world culture.

The chapter on the habitat requirements of the six species of bass neatly summarizes their requirements for a quick reference for the fishery manager who is on the lookout for a game fish to fill a particular biological niche.

The chapter on angling for blackbass is not a "how to" guide, as the title may imply, but a very brief "where to" for the Americas, Eurasia and Africa.

One of the most valuable chapters in the book is the bibliography, which lists 504 references, 144 personal communications that are cited in the text, plus 61 additional personal communications that were not cited.

I may be picky, but the only fault I could find with the book is in the illustrations. I particularly found the distribution maps to be difficult to comprehend, primarily due to too much detail. The quality of the photographic illustrations is generally quite good, even though I personally am not fond of the montage-like presentation of many of them.

All in all, this is a handy reference book that any fishery biologist who is working with blackbass should find valuable.—*D. A. La Faunce.*

Fisherman's Spring

By Roderick L. Haig-Brown; Crown Publishers, Inc., N.Y., 1975; 222 p., illustrated. $7.50.

Crown Publishers, Inc. continues to do anglers/readers a great service by reprinting another Haig-Brown angling book. *Fisherman's Spring*, first published in 1951, is the first book of a four-book series chronicling the four angling seasons of the year.

Written in Haig-Brown's usual rambling, philosophical style, *Fisherman's Spring* discusses early season angling, starting with the opening of British Columbian trout season. The book doesn't just talk about fish and fishing, but the whole fishing experience—gear, canoes, wading, flies, family, and birds. Throughout the book there is a strong conservation message. The books being published today beat the drum loudly for conservation; Haig-Brown saw the need for gear and bag restrictions over 20 years ago. He discusses the role of forests and the need for sensible logging practices.

Although not a trained biologist, the author is a very observant fisherman and a thinking fisherman. Above all he is an excellent writer. I highly recommend *Fisherman's Spring*, as I have all Haig-Brown's other works.—*K. A. Hashagen, Jr.*

ERRATA

Crane, Jules M., Larry G. Allen and Connie Eisemann. Growth rate, distribution, and population density of the northern quahog *Mercenaria mercenaria* in Long Beach, California. 61 (2) : 68–94. 1975.

Tables 1, 2 and 4: replace x with $\bar{x}$.

Table 3: units are in mm.

Table 4: Cage 3, size class 61–80 should read 5.0.

Figure 4, replace scale: 1 cm = 31 m.

Page 79, paragraph 6, line 2: delete since.

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AUTHORS

SCIENTIFIC NAMES

SUBJECT

△88038—800 6-75 4,500 LDA

FISH AND GAME COMMISSION
NOTICE OF MEETINGS

Notice is hereby given that the Fish and Game Commission shall meet on October 3, 1975 at 9:00 a.m. in Room 1138, New State Building, 107 South Broadway, Los Angeles, California, to receive recommendations from its own officers and employees, from the department and other public agencies, from organizations of private citizens, and from any interested groups as to what, if any, regulations should be made relating to fish, amphibia and reptiles, or any species or subspecies thereof.

Notice is hereby given that the Fish and Game Commission shall meet on November 7, 1975 at 9:00 a.m. in the Auditorium of the San Diego Gas and Electric Company, 101 Ash Street, San Diego, California, for public discussion of and presentation of objections to, the proposals presented to the commission on October 3, 1975, and after considering such discussion and objections, the commission, at this meeting, shall announce the regulations which it proposes to make relating to fish, amphibia and reptiles.

Notice is hereby given that the Fish and Game Commission shall meet on December 5, 1975 at 9:00 a.m. in the Auditorium, Resources Building, 1416 Ninth Street, Sacramento, California, to hear and consider any objections to its determinations or proposed orders in relation to fish, amphibia and reptiles or any species or subspecies thereof for the 1976 sport fishing season; such determinations and orders resulting from the hearings held on October 3, 1975 and November 7, 1975.

FISH AND GAME COMMISSION

Leslie F. Edgerton
Executive Secretary

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