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A BLACK BEAR POPULATION STUDY IN NORTHERN CALIFORNIA[1]

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Forty-three wild bears were culvert trapped, immobilized, and tagged in a limited area in Trinity County, California, during the summer and fall of 1972. Eleven depredation bears were trapped and tagged throughout the county. Sex and age distribution and physical characteristics of these 54 animals are summarized.

Summer movements and home ranges of the marked bears were small. Average known maximum summer movement was 1.85 miles (2.97 km), increasing in fall to 6.1 miles (9.8 km). Adult females with cubs appeared to have smaller yearly ranges than other sex and age classes. Summer density of the bear population in the study area was approximately two bears per square mile (2.6 km^2). Thirty-six percent of the adult females were with cubs, the average litter 1.67. Summer food habits are reported, based on analysis of 106 scats.

INTRODUCTION

The black bear, *Ursus americanus*, is receiving increasing recognition as an integral part of our forest environment and as an important game species. Improved methods of handling and tagging large animals have facilitated black bear population studies in the last 2 decades. This paper reports the initial phase of a long term black bear population study in California. Emphasis in the first year of the project was on determining population composition and density, movements, food habits, and individual physical characteristics of black bears in a representative habitat in northern California.

STUDY AREA

A study area of approximately 115 square miles (298 km^2) was selected east and south of Clair Engle Lake, Trinity County (Figure 1). Most of the study area is contained within the Shasta-Trinity National Forest. This part of the national forest is in "checker board" ownership; alternate sections are privately owned. The study area supports a relatively high density of bears and is intersected by numerous logging roads providing easy access. Although major emphasis was given to the study area outlined, depredation bears (garbage dump, campground, and other nuisance bears) captured elsewhere in Trinity County are included in the analyses.

The study area lies at the south base of the Trinity Alps, one of the principal mountain ranges of this area. Elevations range from 1,800 ft (549 m) in the Lewiston area to 8,091 ft (2,468 m) at Granite Peak. The area consists almost entirely of timbered or brushy gulches divided

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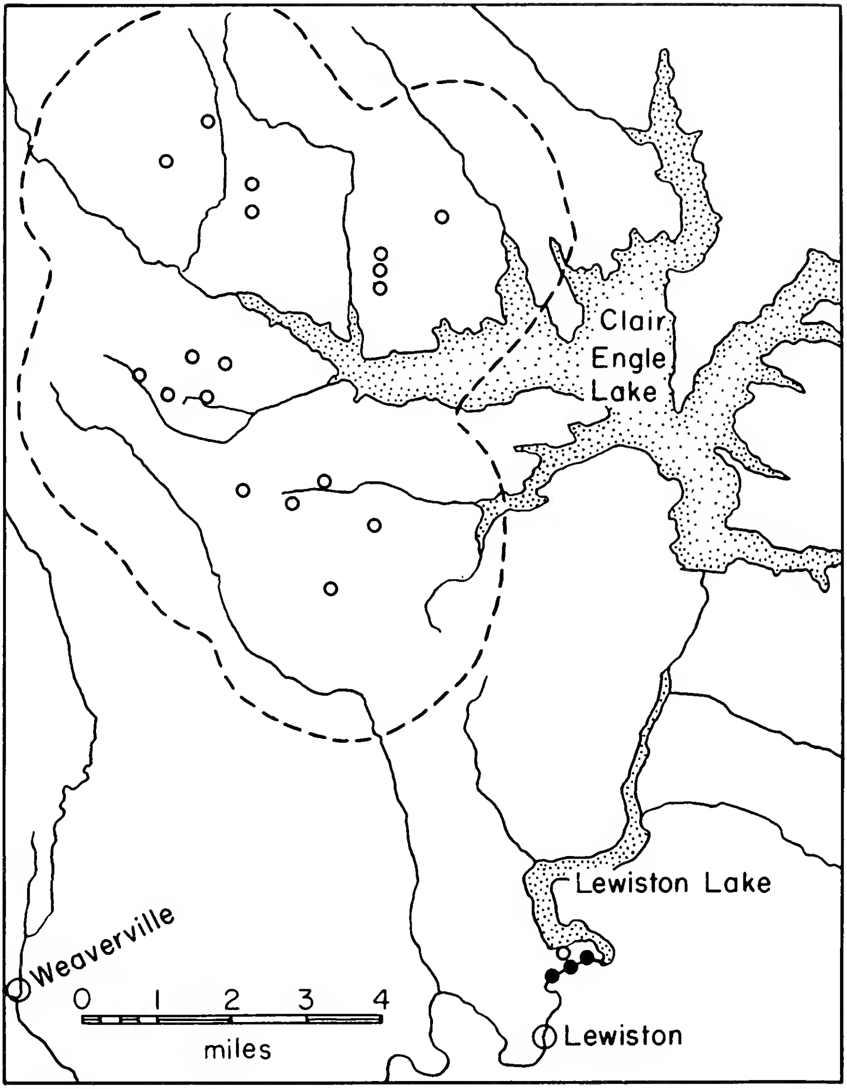

FIGURE 1. Principal bear study area west of Clair Engle Lake, Trinity County, California, showing summer trapping sites (o), and fall trapping sites (•) near Lewiston.

by sharp ridges, with local elevation changes of 1,000 (305 m) to 2,000 ft (610 m). At the immediate base of the Trinity Alps, precipitous local elevation changes approach 6,000 ft (1,830 m).

The climate of the area is typical of the Pacific Coast with local conditions influenced by elevation and exposure. Summers are dry and warm; winters are cool and wet. Snowfall may vary greatly from year to year with a range of 10 (25.4 cm) to 70 (177.8 cm) inches recorded at Weaverville. Higher elevations receive greater amounts of precipitation in the form of snow. The spring of 1972 was unusually dry and the fall months of 1972 were unusually wet.

Most of the study area is covered by a pine-fir forest; dominant species are Douglas fir (*Pseudotsuga menziesii*) and yellow pine (*Pinus ponderosa*) with lesser numbers of sugar pine (*P. lambertiana*) and incense cedar (*Libocedrus decurrens*) (Figure 2). Understory trees in the conifer forest include Pacific madrone (*Arbutus menziesii*), bigleaf maple (*Acer macrophyllus*) and Pacific dogwood (*Cornus nuttallii*). Oak woodland and manzanita communities are on some south facing slopes; principal species are Oregon white oak (*Quercus garryana*), California black oak (*Q. kelloggii*), interior live oak (*Q. wislizenii*), green leaf manzanita (*Arctostaphylos patula*), and white leaf manzanita (*A. viscida*). Some stands of digger pine (*P. sabiniana*) are at lower elevations. A few small wet meadows occur at higher elevations, about 4,000 ft (1,220 m). Scientific names of plants were taken from Munz and Keck (1959).

FIGURE 2. General view of part of the bear study area, showing intermixture of conifer timber and brush fields (largely manzanita).

Commercial logging plays a major role in the ecology of the study area. An estimated 40 to 50% of the study area has been at least partially logged since 1950. The completion of the Trinity and Lewiston dams in 1962 had an important effect on the physical aspects of the area. Clair Engle Lake, formed by the Trinity Dam, inundated much of the lowland watershed of the Trinity River and some of its major tributaries, which were previously winter deer range. The upstream spawning run of the king salmon (*Oncorhynchus tshawytscha*) was stopped at the breast of the Lewiston Dam.

Another recent impact on the study area is the great influx of summer recreationists. Within the study area there are 11 national forest campgrounds and one major private resort. However, there are few year-round residents in the study area.

METHODS

Trapping Methods

Trapping took place in two different time periods. A summer period, using 18 trapsites (Figure 1), extended from June 29 to September 6, 1972. Limited fall trapping was undertaken at a salmon spawning area near Lewiston between October 2 and October 13, 1972. Depredation bear trapping was done throughout the summer and into the fall.

Essentially all trapping was done with culvert traps. Emphasis was placed on capturing bears in natural settings in a defined local area. Traps were located on or near old logging roads. ''Call baits,'' consisting of fish (wrapped in burlap) or road killed deer hanging in trees, were used at these trapsites. Trapsites were chosen on the basis of bear sign in the area or the response to a test ''call bait'' placed in the area. Traps for nuisance bears were set when needed at campgrounds, private homes and resorts throughout the county. Trap bait consisted of canned fish base catfood, strawberry jam and marshmallows. Aldrich snare settings were tested as a trapping method the last two nights of the summer trapping period.

Trapping success was expressed in terms of bear captures per trap night. During the summer period 58 captures of 38 different bears were made in 156 culvert trap nights, for a 37% capture rate. During the fall period four captures of four different bears were made in 21 culvert trap nights, for a 19% capture rate. Fifteen depredation bear captures of 14 different bears were made in 94 culvert trap nights for a 16% capture rate. Eleven of the latter were immobilized, tagged, and transplanted. One bear was captured by a snare trap in six trap nights for a 17% capture rate.

FIGURE 3. Immobilized bear being processed outside of trap.

Immobilization, Handling and Tagging

Trapped bears were immobilized with Sernylan (phencyclidine hydrochloride) injected manually using a syringe with a 3 ft (0.9 m) fiberglass extension rod. Dosages were administered at the level of 1 mg of Sernylan per 3 (1.30 kg) to 4 lb. (1.81 kg) of estimated body weight. Once techniques were established, average time from first injection to immobilization was approximately 30 min with a range of 3 to 85 min. Average time from bear immobilization to bear arousal was approximately 60 min and ranged from 20 to 154 min. No lasting ill effects of the drug were noted, and the immobilization method was considered satisfactory.

Once a bear was immobilized biological data were recorded (Figure 3). All animals were then marked in each ear with metal ear tags with attached colored plastic streamers which identified each bear individually. Some bears were also tatooed in the ear. Retention of the metal ear tags and streamers was good; only one metal ear tag and four streamers were known lost. Six bears were also fitted with radio collars.

After marking, bears were given an injection of Procaine Penicillin G as a general prophylaxis.

INDIVIDUAL BLACK BEAR CHARACTERISTICS

Color

Of 54 bears handled and three cubs observed during the handling of their mothers, 33 (58%) were black or predominantly black with only small patches of another color, such as a white chest blaze. Twenty-one bears (37%) were predominantly a shade of brown (Figure 5). One bear was about equally brown and black. Two bears were predominantly blonde. In all, eight bears, three of the black phase and five of the brown phase, had white breast marks.

Color phases of the black bear vary from region to region. In the eastern United States most bears are of the black phase. Black (1958) reported that of 184 bears handled in New York all were black phase. In Pennsylvania the situation is similar with only a few cinnamon colored bears reported (Pennsylvania Game Commission 1952). In western North America there is a greater mixture of color phases. Records compiled from fur posts in British Columbia, Washington, Oregon and Idaho between 1825 and 1857 (Cowan 1938) indicated color phase ratios from 63% brown—37% black in Idaho to 100% black on Vancouver Island (Figure 4). In the Northwest Pacific area there was a pronounced increase in the proportion of black phase bears from south to north and also from east to west. In California, Grinnell et al. (1937) reported that bears in the Sierra Nevada were predominantly of the brown phase. The Trinity County ratio of 37% brown—58% black corresponds with the geographic trends in color reported by Cowan.

There was no correlation between color phase and sex in the Trinity study area. However, there did seem to be an unexplained correlation between color and age. Of five cubs handled or seen by the authors, all were black. Of six yearlings handled, five were black. Thus, of 11 cubs and yearlings 91% were black while of the total sampled population 58% were black, and of the sampled adult bears only 39% were black or predominantly black. If these samples are representative of the popu-

FIGURE 5. Sub-adult bear of brown phase recovering from immobilizing drug. Note ear markings.

lation, the question is raised whether a portion of the population changes with age from black to a lighter color phase. We have no proof that such change occurs.

Measurements

The following measurements were taken (in inches) from immobilized bears: body length, from nose tip to tail bone end; shoulder height, from top of shoulder to base of ankle; tail length, from base of tail to end of tail bone; neck girth; chest girth; head length; head width; head circumference; hind foot length; hind foot width; hind toe width; forefoot length; forefoot width; fore toe width, (see Figure 3 for illustration of foot measurements); ear height from notch; and ear height from crown. A summary of all measurements is given in the senior author's unpublished M. S. thesis, 1973, University of California, Berkeley.

Sexual dimorphism in size among the bears in the Trinity study area was pronounced. There was little overlap in any of the linear measurements of adult males and females, and where present was largely attributed to age differences. The average chest girth for adult male bears

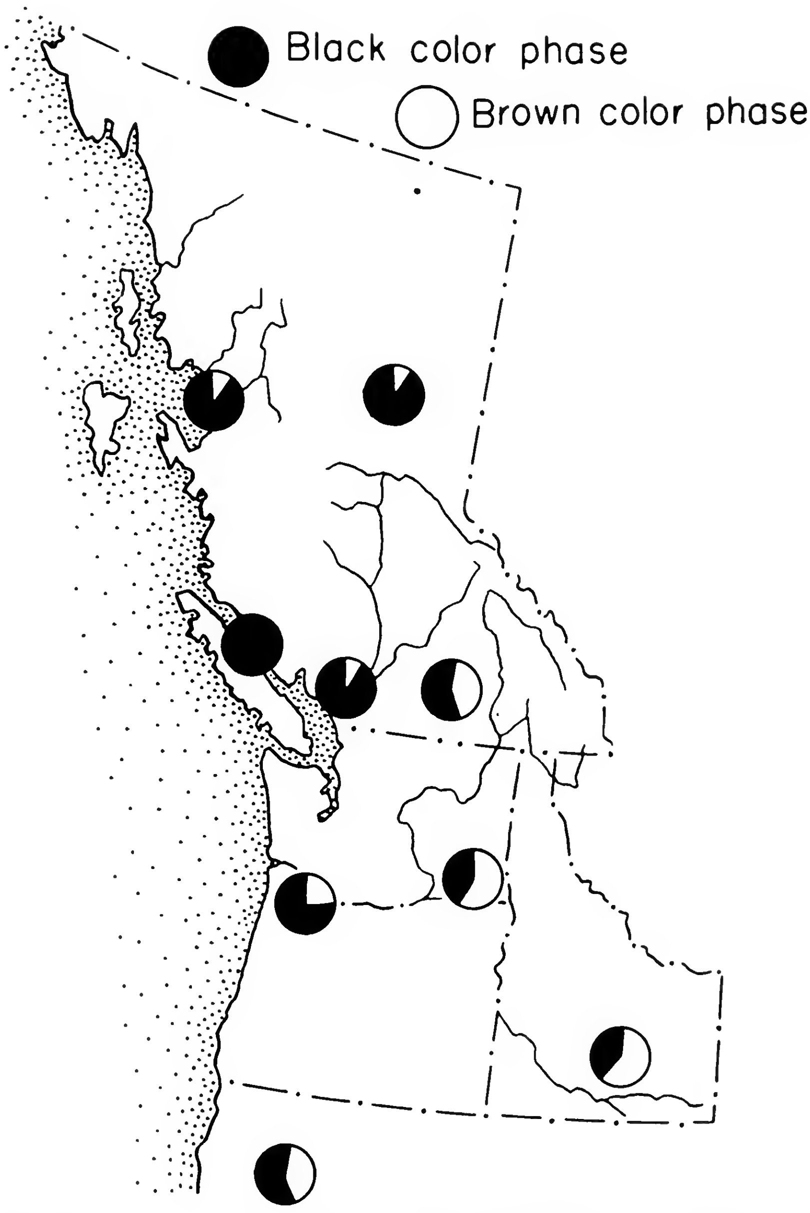

FIGURE 4. Color composition of black bear populations in the Pacific northwest. Data largely from Cowan, 1938.

was 41.7 (105.9 cm) inches compared to 34.5 (87.6 cm) inches for adult female bears. Size dimorphism apparently starts soon after birth, as yearlings exhibited a size difference between sexes.

Adult male depredation bears averaged larger than other adult male bears. A part of this average size difference was probably due to a larger percentage of older males in the depredation sample than in the wild bear sample.

A strong positive correlation was found between bear weight and composite foot measurements (Figures 6 and 7). The log-log form of plotting the data fit well to a straight line of the equation:

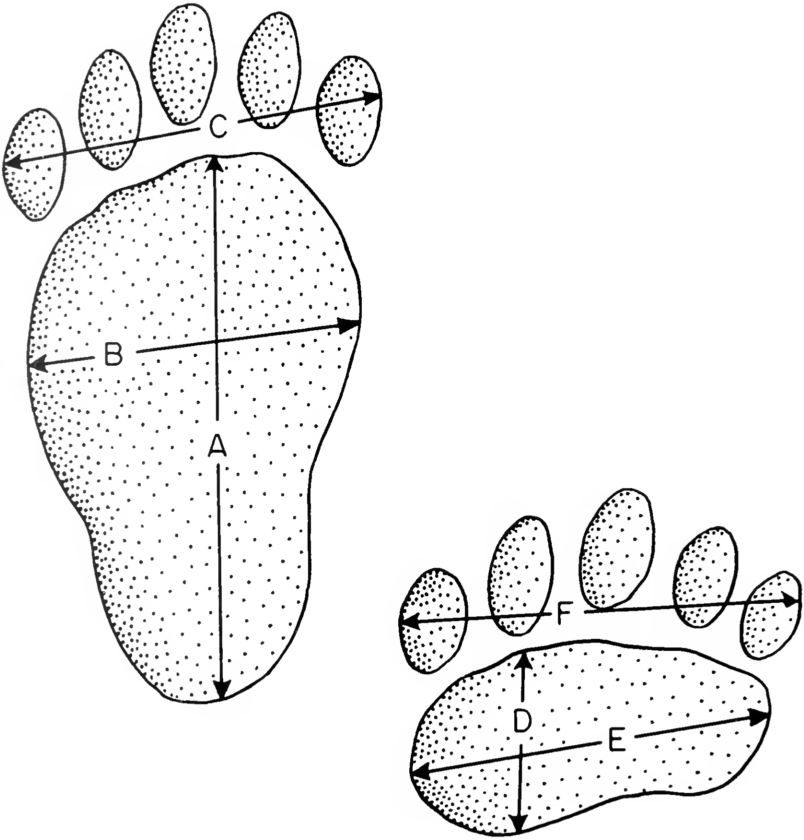

FIGURE 6. Foot measurements of black bears. A + B + C + D + E + F gives the sum of composite foot measurements plotted in Figure 7.

Log (weight) = — 2.73 + 3.5 log (sum of foot measurements). The correlation coefficient for this plot is 0.974.

Several field observations showed that a composite foot measurement sum obtained from a track in light dust was about 10% less than the true sum, obtained from the animal. Track measurements thus might be used to derive rough estimates of population composition.

Weights

The average weight of the adult male depredation bear is more than other wild males (Table 1). Bears captured in the fall appeared by

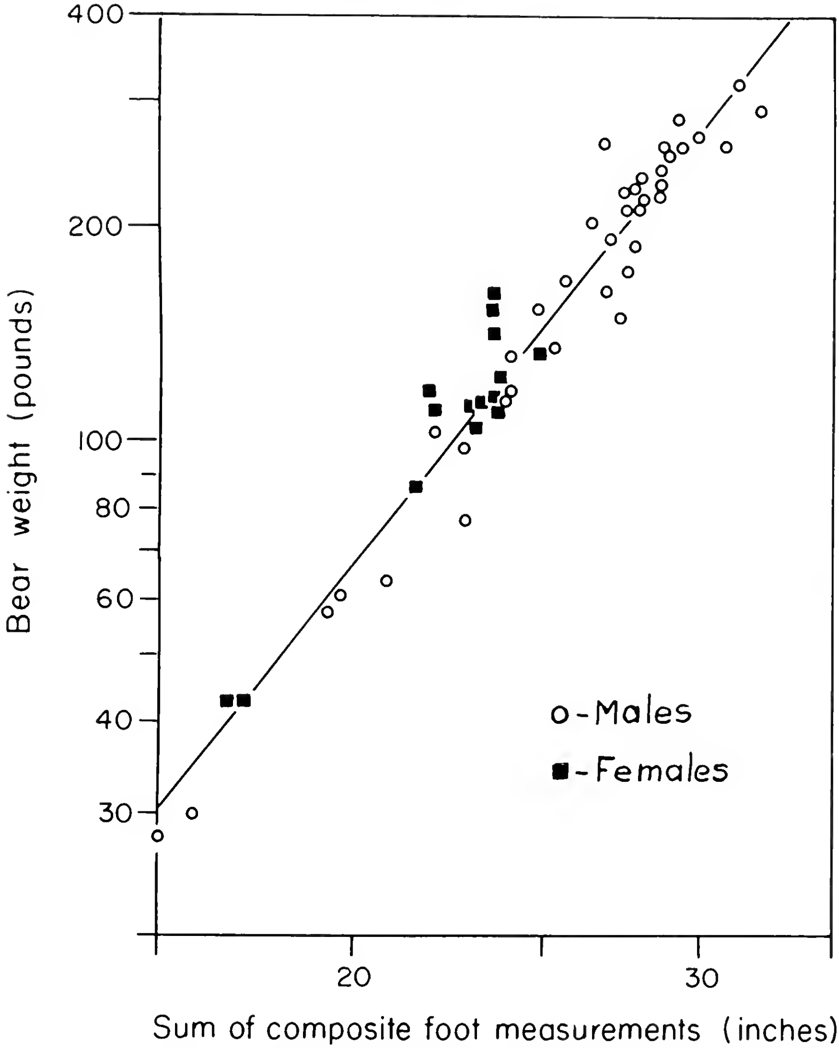

FIGURE 7. Correlation of body weight and composite foot measurements of Trinity County bears.

visual inspection to be fatter than summer captured bears. However, no bear captured in the summer was recaptured in the fall, so no actual weight gain could be determined.

Trinity County bears are similar in weight to those reported by Jonkel and Cowan (1971) in Montana, but are considerably lighter than those found in the eastern United States (Table 2). Because some of the weights given for the eastern states are probably late fall weights, it is difficult to make exact comparisons. Nevertheless, it seems apparent that Trinity County bears are smaller. Of 149 bears that Black (1958) handled in one summer, six male bears exceeded 400 lb. (181.6 kg) with the largest two weighing 562 (255.1 kg) and 599 lb. (271.9 kg). His maximum weight for a female was 361 lb. (163.9 kg). None of the Trinity bears approach these figures. The largest male, weighed 324 lb. (147.1 kg) and the largest female 162 lb. (73.5 kg).

TABLE 1.—Average Weights (pounds) of Trinity County Black Bears, 1972

Class	No.	Range	$\overline{X}$	SD
All adult males	30	116–324	215.0	55.0
Depredation adult males	8	190–295	243.6	38.8
Adult females	11	112–162	127.6	18.0
Sub-adult males	2	99–104	101.5	--
Sub-adult females	1	87	87.0	--
Male yearlings	3	58-64	61.0	--
Female yearlings	2	43–44	43.5	--

TABLE 2.—Average Black Bear Weights from Several Different Localities

Source	Location	Average weights (pounds)			
		Adults		Yearlings	Cubs
		Males	Females		
Jonkel and Cowan (1971)	Montana	211	125	45	22
Harlow (1961)	Florida	304	189	--	--
Harlow (1961)	New Hampshire	324	200	--	--
Black (1958)	New York	276	196	94	38
This study	Trinity County	215	128	54	29

LIFE HISTORY

Summer Movements and Home Range

Recaptures and radio locations of 13 bears (6 males and 7 female) yielded data on summer movements. All movements were computed as minimum linear distances between known location points. The average movement shown by male bears was 1.7 miles (2.7 km), while for females the average was 2.0 miles (3.2 km). The overall average summer movement was 1.9 (3.1 km) miles, both sexes included. The maximum movement recorded by recapture was 2.8 miles (4.5 km). During summer, the maximum distances moved by three radio-collared bears were 2.2 (3.5 km), 3.0 (4.8 km) and 4.5 miles (7.2 km). The average maximum number of days between known locations for bears showing movement was 24.5 days.

Trapsites were not located in such a pattern or in adequate numbers that a reliable home range size could be plotted on the basis of recaptures alone. However, two radio-collared bears—number 10, an adult male, and number 61, an adult female with cubs—were located frequently enough to enable an accurate estimation of their summer home range (Figure 8). A third bear, number 14, an adult female, was located only a few times before losing her collar.

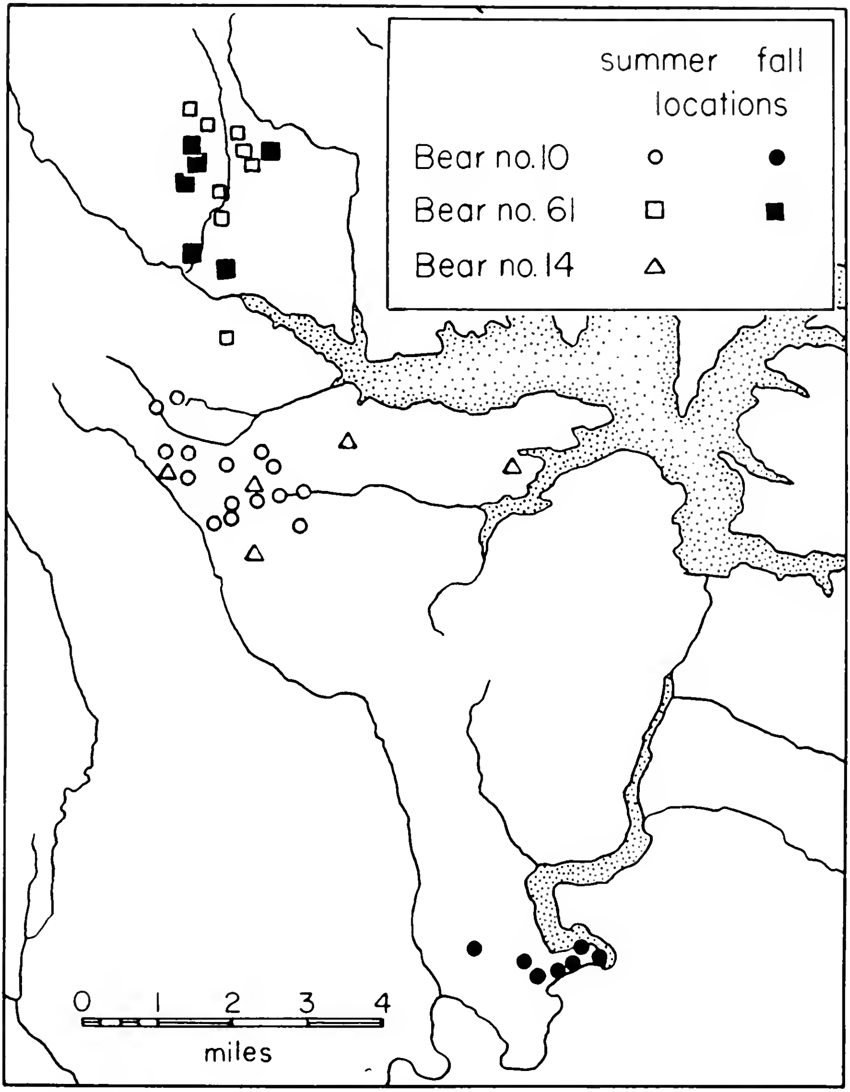

FIGURE 8. Movements of three Trinity County bears fitted with radio collars.

Bear number 10 was located 20 times over 56 days in an area of less than 5 square miles (12.9 km^2) before he moved a distance of approximately 7 miles (11.3 km) from his summer range. The latter movement was considered a seasonal migration. Bear number 61 was located six times over a period of 15 days in an area of less than 7 square miles

(18.1 km²). Bear number 14 was located four times in a period of 28 days in an area of less than 4 square miles (10.4 km²). Her collar was then recovered 23 days after the last known location approximately 3.5 miles (5.6 km) from the center of the area of her previously known locations.

From these data, summer home ranges were estimated to be fairly

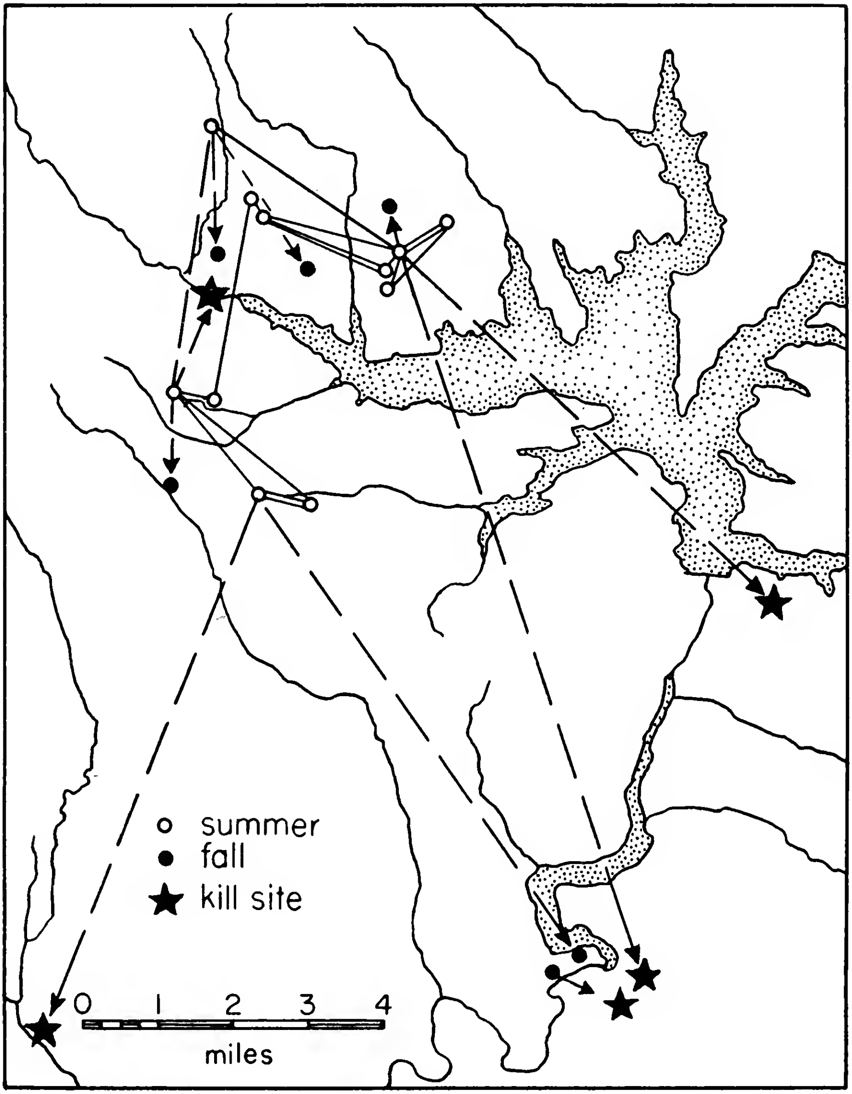

FIGURE 9. Seasonal movements of Trinity County bears as shown by recapture, sighting, and hunter kill. One kill site (SW corner) was actually 7 miles (11.3 km) farther to the Southwest, off the map.

small, most being approximately 5 (12.9 km^2) to 10 square miles (25.9 km^2) in size. Summer home range size did not appear to be differentiated by sex or age class.

Fall Movements

On the basis of radio collar locations, sightings, trapping, and hunter tag returns, fall movements of 10 bears were known (Figure 9). The average movement of nine bears trapped in the summer and located in the fall was 6.1 miles (9.8 km) from the original summer capture site. Movements fell into two distinct categories.

Four of the bears apparently had not, at the time of the fall location, left or moved far from their summer home range. Radio-collar bear number 61, a female with cubs, stayed in the area of her summer home range until she was shot on October 18. On October 17, an adult female with a cub was sighted 2.0 miles (3.2 km) from her capture site of September 1. On September 23, an adult male was shot illegally 1.5 miles (2.4 km) from his original summer (July 25) capture site.

On October 24, a yearling female was sighted 0.5 miles (.8 km) from her original summer (July 26) point of capture. It is not known if any of these bears would have moved or did move from their summer home ranges later in the fall.

The other five bears, captured in the summer and located in the fall, were found an average of 9.0 miles (14.5 km) from their original capture site. These fall locations were determined between September 11 and November 4. Radio-collared bear number 10 moved from his summer home range and then stayed on a small fall home range for at least 30 days (Figure 8). It is not known whether other bears located a relatively large distance from their original capture sites were staying in a newly defined home range or were wandering.

In summary, average fall movements were greater than average summer movements, but not all of the animals moved from their summer home ranges.

Comparison With Other Studies of Black Bear Mobility

Movement data from other reports (Table 3) show two important trends in bear movement habits. First, most studies report a larger average movement in the fall than in the summer. And second, male bears show larger average movement than females.

TABLE 3.—Average Movements of Black Bears According to Season and Sex

Location and source	Minimum average movement (miles)			
			All year	
	Summer	Fall	Males	Females
Michigan—Erickson and Petrides (1964)	2.1	6.7	5.4	1.4
Montana—Jonkel and Cowan (1971)	----	----	3.9	1.6
Virginia—Stickley (1961)	1.3	7.6	10.0	1.8
Trinity County (1972)	1.85	6.10	3.67	3.13

A greater average movement in the fall suggests an extension of the summer home range, or movement to a different fall home range, or possibly fall nomadism. Increased fall movement can be a result of bears taking advantage of local food abundance (Spencer 1955). In Montana, Jonkel and Cowan (1971) reported that throughout the year a small home range was used by all bears, except transient sub-adults. They believed that the large diversity of climate, topography and vegetation in a small area made it possible for bears in the Montana area to maintain small yearly home ranges.

In this study, bears seemed to have an extremely small summer home range, but part of the population moved in fall to new food supplies. By the latter half of September the supply of manzanita berries, the major summer food, had been exhausted in the summer trapping area. There appeared to be no mast crops, berry crops, or other easily available or plentiful food sources in the area to replace manzanita berries. There were plentiful food sources in the form of spawning salmon, acorn crops and manzanita berries in the areas to which bears were known to move.

Despite poor food conditions a segment of the study population did not move far from their summer home range, or possibly they moved later in the fall. That portion of the study population that stayed close to their summer home range was largely made up of sows with cubs or immature bears. Sows with cubs are generally expected to stay on small home ranges. Jonkel and Cowan (1971) reported that dispersal was pronounced in yearling bears in Montana. However, there was no evidence that this was the case with yearling bears in the Trinity study area.

Contrary to other reports, movement data from the Trinity study area were not clearly differentiated according to sex. The average maximum known summer movement of females was slightly greater than that of males. However, it appears that adult females with cubs make significantly shorter fall movements than either lone adult females or adult males.

Food Habits

Scats were collected from July through October of 1972. All scat samples were analyzed, most in the dry state, at the California Fish and Game laboratory.

Scat samples usually were not collected unless they could be dated to within approximately a week. During July and August most samples were collected along roads, around trapsites and bait stations, and from traps during regular trapping activities. Trap bait did not appear in scats taken from traps. All of the samples in July and August came from the summer trapping area. In September and October a system of trails and roads was checked periodically for scats. Part of this system was within the summer trapping area. The remainder was around Lewiston Lake, in an area with a high proportion of Manzanita thickets and oak woodland.

Table 4 summarizes the major food items found in 106 scat samples. Volumes of food items were estimated, but because volume composition in a scat is not necessarily indicative of the volume eaten, final data were expressed in terms of frequency of occurrence, with general volume trands noted. These data are presented only as a food index and a supplement to other data in the study.

Many of the September and October samples came from a king salmon (*Oncorhynchus tshawtscha*) spawning area on the Trinity River near the breast of Lewiston Dam. Although bears were seen feeding on salmon, scats dropped in the area contained mostly acorns and manzanita berries apparently eaten in the surrounding area.

Bears in the study area depended primarily on manzanita berries from July through August (Table 4). Thirty four of 35 scat samples contained manzanita berries, and a large majority of these samples were essentially 100% manzanita berries with other items in trace amounts. Grasses and forbs were the next most common food item in July and August, but they were a relatively small volume of the samples in which they occurred. Dogwood seed occurred in 14% of the August scats, usually as a major volume item.

In September and October manzanita berries remained a major food. By late September and into October acorns became a dominant food item in the Lewiston Lake area. Although acorns were found in 38% of the October scats, none occurred in any of the scats from the summer trapping area. Grasses and forbes continued to be found frequently but in small amounts.

Deer hair was found in 5 of 106 samples.

Reproduction

Of all adult female bears examined during the summer trapping period, two were in estrus. These bears were captured on July 17 and July 18. Of three adult female bears captured after July 18 that were believed to be without cubs, none were observed in heat. The beginning of the breeding season could not be estimated because trapping did not begin until the last week in June.

Four of the 11 adult females captured (36%) were known to have a litter of the year. Three of these litters were either handled or seen. The other litter was not observed during the handling of the mother, but was sighted with the mother several weeks later. Two other females unaccompanied by cubs during capture were lactating.

The average litter size in Trinity County was 1.67 cubs, based on six litters handled or seen.

The female black bear has seasonally constant estrus with ovulation induced following mating. The mating season can vary but usually occurs during June and July (Erickson and Nellor 1964). Grinnell et al. (1937) reported a pair of California black bears mating on June 25. Of eight females trapped by Stickley (1961) in Virginia in one summer, three were in heat in June, three in July and two in August. Jonkel and Cowan (1971) found in Montana that bears were in estrus as early as May 25 and as late as August 10, with a peak in June. Data indicated that most mating in Trinity County is over by mid-July.

Black bear litters seem to run slightly over two cubs in the eastern United States. Average litter size was reported as 2.4 in Maine (Spencer 1955), 2.2 in Florida (Harlow 1961) and 2.15 in Michigan (Erickson 1964). In the western United States reported average litter size is usually below two cubs. Average cubs per litter has been reported as

TABLE 4.—**Principal Food Components of 106 Bear Scats from Trinity County, 1972. (F indicates frequency of occurrence. F% indicates (F/number of scats for the month) × 100%. * Indicates ½ or more of the occurrences were more than trace amounts.)**

Food item	July (6)		Aug. (29)		Sept. (27)		Oct. (44)	
	F	F%	F	F%	F	F%	F	F%
Vegetative								
Manzanita berry, stem, seed, *Arctostaphylos* sp.	6	100.0*	28	96.6*	26	96.3*	40	91.0*
Grass stem & leaf (Gramineae)	4	66.7	10	34.5*	18	66.7	16	37.6
Forb stem & leafage	6	100.0	11	37.9*	10	37.0	10	25.0
Acorn fgmts., *Quercus* sp.	--	--	--	--	3	11.1*	16	37.6*
Dogwood seed, *Cornus* sp.	--	--	4	13.8*	2	7.4*	--	--
Plant fibers	--	--	1	3.4*	1	3.7	--	--
Thistle leaf	--	--	--	--	1	3.7*	--	--
Oak leafage, *Quercus* sp.	--	--	--	--	1	3.7*	--	--
Brome seed, *Bromus* sp.	3	50.0	--	--	2	7.4	1	2.3
Fescue seed, *Festuca* sp.	1	16.6	--	--	4	14.8	--	--
Animal								
Insect fgmts. and pupa	4	66.7	5	17.2	3	14.8	7	16.0
Insect larva	1	16.6	--	--	--	--	7	16.0
Deer hair, *Odocoileus* sp.	--	--	1	3.4*	2	7.4*	2	4.6
Bear hair, *Ursus* sp.	4	66.7	4	13.8	2	7.4*	3	6.8
Feathers, unidentified	2	33.3	--	--	--	--	--	--
Fish bone fgmts.	--	--	--	--	--	--	3	6.8

1.68 in Idaho (Rust 1946), 1.8 in Yellowstone National Park (Bray 1967) and 1.6 in Montana (Jonkel and Cowan 1971). Although the sample was small in Trinity County the average litter size of 1.67 compares closely with other areas in the West.

POPULATION CHARACTERISTICS

Density

Thirty-eight bears, which included two cubs, were trapped and tagged in the main part of the summer trapping area. In addition, four cubs were known to accompany three sows which were tagged. The average radius of movement for bears in the summer trapping area was 1.85 miles (2.9 km). If it is assumed that on the average bears were drawn a maximum of 1.85 miles from a trapsite, then the trapping covered an area of 44 square miles (113.9 km^2). If no emigration took place during the summer, the minimum density of the marked population in the main summer trapping area was 42 bears on 44 square miles or approximately one bear per square mile (2.6 km^2). This computation takes no cognizance of the unmarked portion of the population.

Three methods were used to estimate the total population, including marked and unmarked animals. Two utilized the Lincoln Index method with different types of sampling; the other fitted the frequencies of capture and recapture to a geometric model.

After the trapping period there were seven sightings of individual bears or family groups in the main summer trapping area. Three of these were marked. Using this as an estimate of the percentage of the total population marked in the area, it can be calculated that there were 84 individual bears and family groups in the area. If 14% of the population were cubs (see section on population structure) then the total population would be 98 bears.

If August 29 is arbitrarily chosen as the end of the marking period and the beginning of a sampling by capture period, the total population based on capture-recapture is estimated as 103 bears using a simple Lincoln Index.

The geometric model for the frequency of capture distribution (Edwards and Eberhardt 1967) uses as an estimator of total population the equation,

$$N = \frac{n}{1 - (n/t)}$$

where n = total number of individuals captured and
t = total number of captures.

Using this method we estimated the population to be 121 bears. Edwards and Eberhardt believed this computation gives estimates that are slightly high.

Comparing the results of these three methods of determining total population, we believe that a conservative estimate of the total population in the main trapping area during the summer of 1972 was between 80 and 90 bears. This would be a density of roughly two bears per square mile. It is thought that local densities in the trapping area may have been even higher. Of 42 known bears in the trapping area, 31 were known to be located in the northern half of the area.

Fall densities were not estimated for the main part of the summer trapping area or the total study area. From the decrease in bear sign in the main summer trapping area after mid-September and the data on fall movement patterns, it is postulated that the population density in the main summer trapping area decreased greatly in the fall.

Although five marked bears were reported shot during the 1972 bear season, no attempt was made to use the kill of marked and unmarked animals to estimate a fall population density. The relatively large dispersal movements shown by three of the marked hunter-killed bears would make it very difficult to determine over what area a Lincoln Index should be applied.

Spencer (1955) used a cruise line method to calculate a density for the total bear range in Maine of one bear per 5.56 square miles (14.5 km^2). In Virginia, Stickley (1957), cited by Bray and Barnes (1967), distributed questionnaires to game wardens and estimated the black bear density to be one per 3.9 square miles (10.1 km^2). In Michigan, Erickson and Petrides (1964) calculated, from marked-unmarked ratios among hunter-killed bears in their study area, a bear density of one per 3.4 square miles (8.8 km^2), although the researchers considered this calculated density to be low.

In the West, in that part of Yellowstone National Park studied by Bray (1967), the black bear density was estimated to be one per 5.2 square miles (13.5 km^2). In the best habitat of Bray's study the density was reported as one per 1.4 square miles (3.6 km^2). In Montana in the Bear Creek study area Jonkel and Cowan (1971), using tagging and observation data, estimated the bear density to be one per 0.8 square mile (2.1 km^2) in 1961. After increased hunting pressure in the area, they calculated the density to be one per 1.7 square miles (4.4 km^2) in 1966. In Alberta, Kemp (1972) reported the density of an unhunted bear population as one bear per 1.02 square miles (2.6 km^2).

The estimated summer bear density in the summer trapping area in Trinity County is about one bear per 0.5 square miles (1.3 km^2) which is almost twice that of any other reported in the literature. Even the absolute minimum density of one marked bear per square mile is close to the highest density given in the literature. We acknowledge that this may represent a seasonal concentration that could vary from year to year with shifting availability of food.

Sex and Age Structure

During the summer trapping period the sex ratio of trapped bears was 14 females to 25 males, or 36% females to 64% males. Statistically, this ratio was not significantly different at the 5% level from a one-to-one sex ratio. All four of the bears captured during the fall trapping period were males. Of 11 depredation bears tagged, 10 were males. Most previous studies have shown a preponderance of males in trapped samples, but Kemp (1972) suggests that this might derive from the higher mobility of males. The sex ratio of 88 hunter killed bears in Trinity County during the 1972–73 season was 42% females to 58% males. More data are needed to verify the actual sex ratio in the population.

The age was estimated by toothwear and body size. Cubs and yearlings were accurately classified. For analysis purposes, all other bears were placed in a combined subadult and adult classification. For the known population of 43 bears, the general age structure was as follows: six cubs; five yearlings; 32 subadults and adults. As suggested before, there may have been some cubs that were not seen that belong to this sample population.

Table 5 summarizes the age structure of other black bear populations, in comparison with that found in the Trinity study area. The age structure of the Trinity population was almost exactly that reported for a stable unhunted population in Alberta (Kemp 1972). It is also very similar to that of a slightly decreasing population in Montana (Jonkel and Cowan 1971). Bears in the Trinity study were not accurately aged by a tooth sectioning technique, so no calculation of mortality rate according to age class can be derived.

TABLE 5.—Age structures of Several Black Bear Populations

Location and source	Cubs		Yearlings		Older bears	
	No.	%	No.	%	No.	%
Colorado—Bray and Barnes (1967) citing Gilbert (1951)	44	19	53	23	133	58
Montana—Jonkel and Cowan (1971)	18	12	26	17	111	71
Virginia—Stickley (1961)	2	2	27	29	65	69
Michigan—Erickson and Petrides (1964)	42	36	27	23	48	41
Alberta—Kemp (1972)	21	15	18	13	104	72
Trinity County (1972)	6	14	5	12	32	74

Hunter Caused Mortality

Five of the 54 bears in the tagged populations were killed during the hunting season from October 14, 1972 to January 1, 1973. This is a 9% hunter caused mortality. However, if we exclude the tagged depredation bears, which were scattered throughout the county, and consider only the other tagged bears, the hunter caused mortality was five of 43 bears or almost 12%. It must be stressed that this is a minimum estimate since the hunting kill is not fully reported in Trinity County. The reported kill in the county was 88, which was close to the 5 year average of 91 bears, from 1967–68 to 1972–73.

Jonkel and Cowan (1971) reported a 3% hunter kill of tagged bears after the first year of trapping. This increased to 13% the following year when hunting was encouraged in the area. Erickson and Petrides (1964) in Michigan reported a minimum annual mortality rate by hunting of 19%. Stickley (1961) in Virginia found that hunters took 33% of his tagged bears the first fall after tagging. The Trinity County hunter kill percentage of 12% is relatively low compared to these reported figures, but as mentioned before the accuracy of this figure is in doubt.

DEPREDATION BEARS

Depredation bears are such a distinctive segment of the total bear population that a separate discussion is warranted. Of 11 depredation bears tagged, nine were adult males. One was a female subadult and one was a yearling male. It is not unusual that males comprise such a high percentage of the depredation bear sample. Black (1958) in New York found that of bears classified as dump bears, 75% were males. Similarly, Erickson and Petrides (1964) reported that 84% of 30 captured dump bears were males.

The average weight of adult male depredation bears (summer captured) was larger (243.6 lb. [110.6 kg]) than the average weight of summer captured wild bears (198.9 lb. [90.2 kg]) in the study. Most of the depredation adult males tagged were estimated to be 5 to 6 years old or older. Many of the wild adult male bears captured were estimated to be between 3 years and 6 years old. Black bears have been reported as not attaining full body growth until the sixth or seventh year (Gerstell 1939).

A subadult female depredation bear captured in a campground on July 6 was transplanted 14 miles (22.5 km) to the north. By late August this bear had moved 7 miles (11.3 km) southeast and has become a nuisance around a housing development and had to be removed. An adult male was captured at a private dump on June 27 and was transplanted approximately 25 miles (40.2 km) to the northeast. Two days later a tagged bear was reported seen about half way between the point of capture and point of release. On July 5 he was sighted and identified by us at the dump where he was originally captured.

In Michigan, of 19 bears transplanted an average of 39.7 miles (63.9 km) only two showed homing behavior (Erickson and Petrides 1964). However, in New York, Sauer et al. (1969) report that of 52 bears transferred from 8.2 (13.2 km) to 66.6 miles (107.2 km) from the capture site, 22 returned to the vicinity of capture. The longest distance from which a bear returned to its home range was 56 miles (90.1 km). Sauer et al. thought that this homing behavior was not due to a homing instinct but rather to the familiarity of many bears with a relatively large area around their home range.

The dense bear population in the summer trapping area coexisted with a high population of recreationists. Yet, in 1972 only two summer nuisance bears were reported in campgrounds although bear depredation in the county as a whole was high. Summer bear nuisances at the resort in the area were few and not troublesome. This situation might have been due to the concentration of the recreation activity along the main roads and around the lake shore, rather than being scattered throughout the area. However, field observations and radio collar locations showed that it was not unusual for bears to pass within a few hundred yards of campsites. Yet, few recreationists ever sighted a bear in the area. Some were surprised to learn that bears were common in the area.

The question of what causes a bear to become a nuisance is a complex one. It would be suspected that overcoming a fear of man is one of the major factors. Likewise, natural food conditions probably influence the incidence of nuisance behavior. Bear trouble in the Trinity area was low in the summer of 1972 when manzanita berries were plentiful. In the fall when bear food became scarce in the summer trapping area, bear nuisance reports increased for a time, even though human use of the area had greatly decreased and it was thought that bear density had greatly decreased. This leads one to postulate that natural food conditions in the area to which a depredation bear is transplanted may be a major factor in determining whether that bear becomes a nuisance bear again.

As human population density and recreational use increase in Trinity County, conflicts between bears and human interests will increase. More information on the factors which cause a bear to become a nuisance bear is needed. Also, methods of handling a troublesome bear will have to be improved so that the probability of nuisance recurrence by the bear will remain low.

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EARLY LARVAE OF THE DIAMOND TURBOT, *HYPSOPSETTA GUTTULATA*[1]

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A developmental series of larvae of *Hypsopsetta guttulata* collected in San Francisco Bay is described. These larvae are very similar to *Pleuronichthys* turbots and distinguishing characters which separate larval forms of *Hypsopsetta* from *Pleuronichthys* are discussed. Occurrences of *H. guttulata* eggs and larvae indicate an extended spawning period from early June through mid-October.

INTRODUCTION

The most abundant pleuronectid larva collected to date in a current study of the fish eggs and larvae of Richardson Bay, California, presented a problem. At first the larvae, especially the specimens with the yolk-sac absorbed, appeared to be one of the *Pleuronichthys* species, of which two (*P. decurrens* and *P. verticalis*) were known to be in the San Francisco Bay. Many identifying characters for *Pleuronichthys* spp. established by Budd (1940), however, did not agree with my specimens. The most obvious were the small size of yolk-sac larvae and the presence of oil globules in the yolk. The dilemma was presented to E. H. Ahlstrom of the NMFS Southwest Fisheries Center, who was able to identify the series of specimens as larvae of the diamond turbot, *Hypsopsetta guttulata*.

The diamond turbot is not tabulated separately in commercial landings but is included with turbots of the genus *Pleuronichthys*. Together they constitute a minor part of the commercial catch. The diamond turbot is often caught by coastal sport fishermen. This reflects the fish's habitat; it is commonly found in shallow bays and tidal flats and on muddy or sandy bottoms (Baxter 1960). This species ranges from Cape Mendocino to Cape San Lucas, Baja California, and in the Gulf of California. The larval specimens described herein are from the northern extent of the range of *H. guttulata* but early records (Jordan and Gilbert 1880) show that it has long been a resident of San Francisco Bay. Compared to the *Pleuronichthys* turbots, little is known of the life history of the diamond turbot, especially its reproductive habits.

Limbaugh (1955) stated that the pelagic eggs are released during summer and fall. Eggs from running ripe diamond turbots were taken by Limbaugh during the summer and similar eggs were taken repeatedly in plankton collections made off the Scripps Institution of Oceanography pier during the summer of 1952 (Orton and Limbaugh 1953).

The purpose of this paper is to describe the early life history stages of *H. guttulata* and to give characters that will readily separate it from the larvae of the two *Pleuronichthys* species whose adults occur in San Francisco Bay. The description is handicapped by the lack of a complete developmental series. There were no specimens obtained between 5.8 mm

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and 11.4 mm (0.23 and 0.45 inch). Therefore, the study concentrates on the younger larvae. Juvenile and adult specimens used in this study were obtained from field collections in San Francisco Bay and from the collection of the California Academy of Sciences.

METHODS

The larval specimens used for this description were collected in Richardson Bay, California, which is an approximate 11.0 km^2 (4.25 $mile^2$) shallow embayment located immediately to the north of the entrance to and within San Francisco Bay. Two methods were used to catch the diamond turbot. A standard 0.5 meter plankton net was towed at randomly selected stations throughout Richardson Bay, and two stationary channel nets, modified from a design of Lewis, et al (1970), were fished simultaneously. One channel net was positioned midway up the Bay and the other near the entrance to the Bay. All nets had a mesh aperture size of 333 micra.

A total of 135 specimens were examined in this study, 95 of which were larvae. The larvae were preserved in 5% buffered formalin, while the juvenile and adult fish were preserved in 40% isopropyl alcohol. Morphometric measurements followed those described by Ahlstrom and Ball (1954) and were made with an ocular micrometer. I selected the illustrated specimens to represent stages of development. The illustrations are literal, drawn by means of a camera lucida.

The meristic data were taken from either specimens stained with alizarin or from x-ray photographs.

The following description is organized by character according to the approach used by Ahlstrom and Ball (1954). Each character is followed through its development. Pigmentation is presented first followed by morphology and meristics.

PIGMENTATION

The discussion on pigmentation is limited to those melanophores visible in the preserved specimens. It is possible other body pigments are present in diamond turbot larvae but are lost in formalin preservation. The pigmentation varied within any given size class as might be expected for a species with heavy pigmentation. Throughout the entire series the larvae exhibited generally heavy body pigmentation on the anterior $\frac{3}{4}$'s of the body of yolk-sac larvae and extending $\frac{4}{5}$'s of the body length in 5 mm larvae. The most notable variation in pigment was the range of development of patches of scattered fine melanophores located along the dorsal and ventral midlines posterior to the anus. In younger forms, these patches ranged from barely detectable spots on the bases of the finfolds to occasionally a definite triangular patch in one or both finfolds. The older larvae did not exhibit any patches extending onto the finfold, but dark strips of fine spots were clearly visible.

Newly hatched larvae (Figure 1a) completely lacked eye pigment. The head and body were pigmented. The head melanophores were discrete stellate units while the body exhibited fine stippling at 50 x magnification. The yolk-sac was devoid of pigment except for approximately 10–15 stellate melanophores on the surface of the large oil globule.

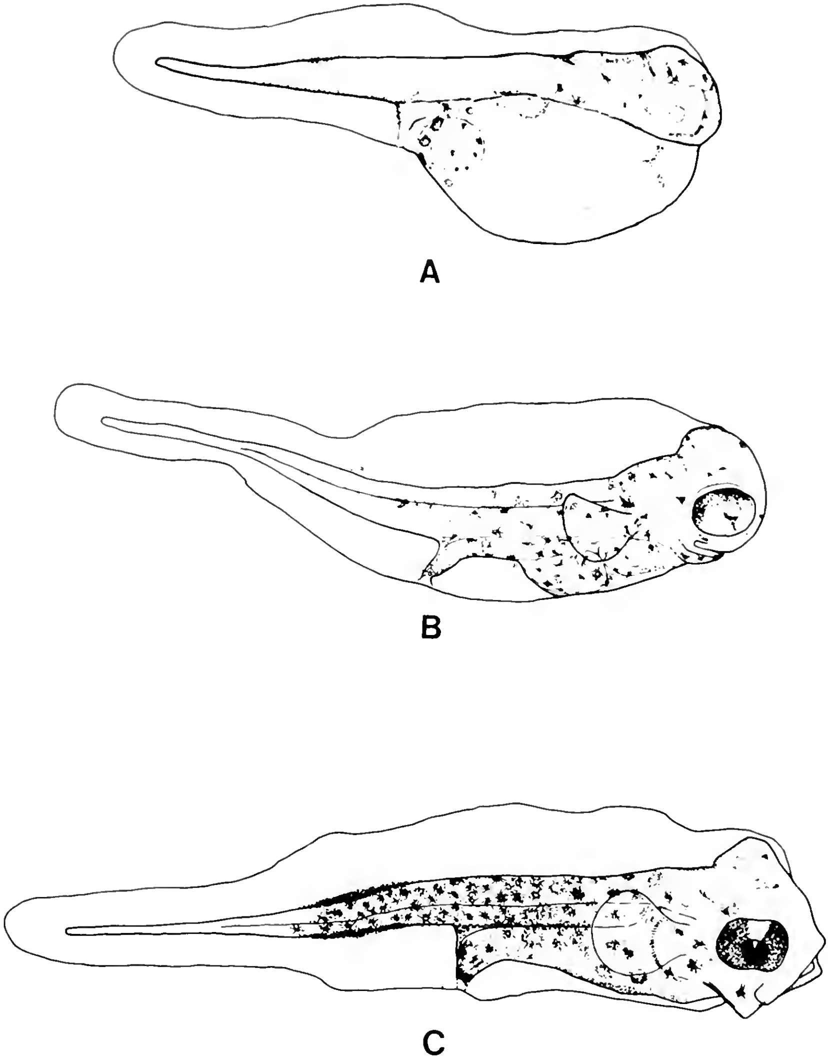

FIGURE 1. Diamond turbot. A, 1.7 mm; B, 212 mm; C, 216 mm.

As the yolk was absorbed and the gut became functional, the pigment spread ventrally over the yolk-sac. The hindgut enlarged and pigment was seen over its ventral flexion to the anus. Melanophores persisted on the oil globule. An interconnecting network of stellate melanophores was present over most of the anterior half of the body. The postanal patches on the dorsal and ventral midlines were now visible. In most specimens these were seen only as intensification of the fine pigment spots near the base of the finfold.

Eye pigmentation developed along the dorsal rim of the eye (Figure 1b). There was still some yolk visible at this stage and the mouth was well developed with up to 10 stellate melanophores along the margin of the dentary. The past-anal patches lessened in size in larger specimens and were routinely seen as concentrations of midline pigment (Figure 1c). The body became covered with discrete large stellate melanophores. Several spots were also visible in the isthmus. This general pattern continued into larger specimens (Figure 2a).

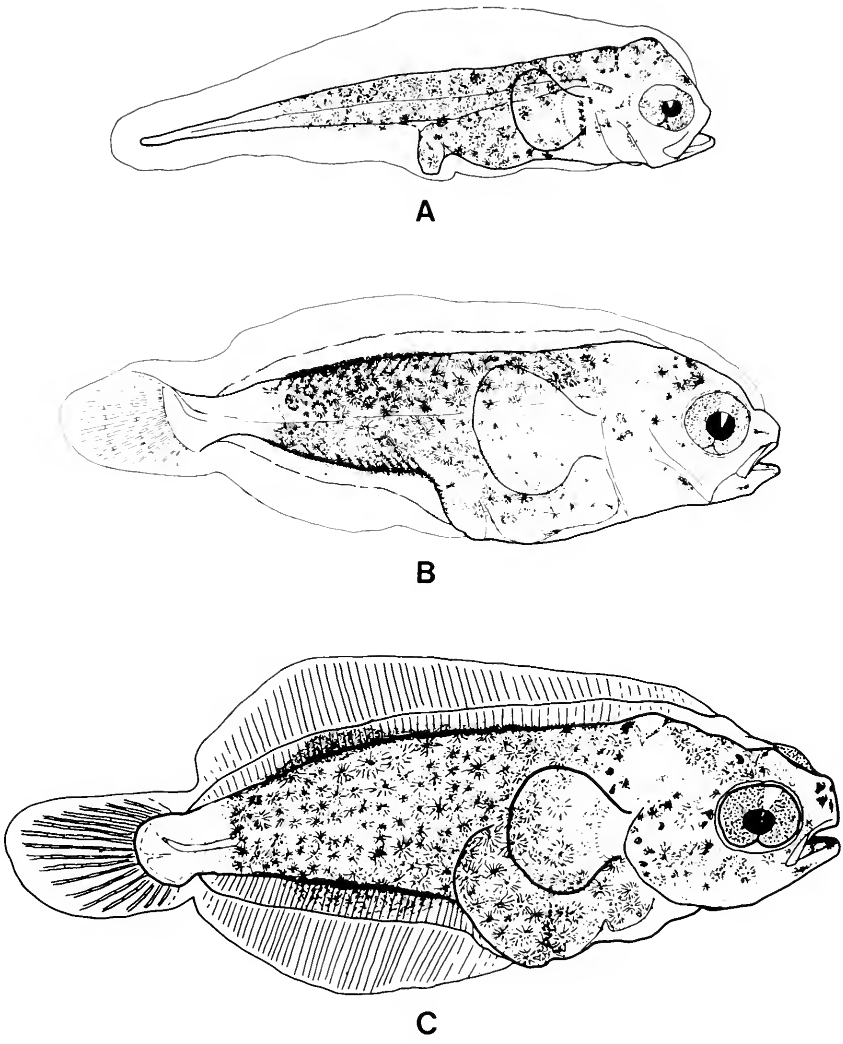

FIGURE 2. Diamond turbot larvae. A, 3.8 mm; B, 4.9 mm; C, 5.8 mm.

The more developed larvae around 4.0 to 4.9 mm were distinguished by the elongate patches which now were densely pigmented but still confined to the base of the developing vertical fin anlage. The head had less surface pigment spots but imbedded melanophores were visible, especially at the nape.

The metamorphosing larvae (Figure 2c) continued these pigment patterns. The median patches were more extensive, spreading onto the pterygiophore bases of the dorsal and anal fins. The specimens at this stage of development presented different appearances depending on the extent of expansion or contraction of the melanophores. Almost the entire body exclusive of the outer fin margins and the posterior portion of the body was covered with stellate melanophores.

Meristic characters easily distinguish metamorphosed juveniles. These characters are presented in Table 1. All juvenile specimens had a total of 35 vertebrae; 12 abdominal and 23 caudal. The dorsal fin averaged 71 rays and the anal fin 50 rays. The caudal fin averaged 19 rays. The eyed side was densely pigmented over the entire body. Dark spots were scattered on both sides and ended prior to the caudal pendunele. Pigment extended onto the vertical fins.

MORPHOMETRY AND MERISTICS

The newly hatched larvae averaged 1.6 mm (0.063 inch) standard length (S.L.) and appeared deep bodied because of the large yolk-sac. The oval shaped yolk-sac contained unsegmented yolk with numerous oil globules, the largest positioned to the rear of the yolk-sac. The single large oil globules averaged 0.14 mm (0.005 inch) in diameter. As the yolk was absorbed, the yolk-sac appeared more ovate and the head and hindgut more outlined. By approximately 2.2 mm (0.087 inch) S.L., the yolk was more than ½ absorbed. The oil globule now averaged around 0.06 mm (0.002 inch). Larvae ranging 2.3 to 2.4 mm (0.090 to 0.094 inch) had consumed nearly all their yolk.

As the yolk was consumed, the gut and mouth became more developed. Newly hatched larvae had no functional mouth and the hindgut leading to the anus appeared as a thin transparent tube extending ventrally through the finfold. Gut development was most evident in the bulging or enlargement proceeding ventrally to the anus, accompanied by heavy gut pigmentation. By 2.3–2.4 mm (0.090 to 0.094 inch) S.L., the gut was functional and food was seen in the intestine. In general, the gut length shortened relative to body length in the larvae; at metamorphosis the snout to anus length was approximately 35% S.L. (Figure 3).

Body shape became more fusiform as yolk absorption progressed. Some specimens slightly hunched over the yolk-sac, but this disappeared with yolk absorption. With the thickening of the gut, the development of the mouth and enlargement of the head, the body deepened in relation to its length (Figure 3). The specimens around 3.8 mm to 4.9 mm began to exhibit the compressed flatfish form. The illustrated larvae display the gradual rotation of the gut anteroventrally with a characteristic sag to the stomach. The metamorphic specimens had a rounded appearance to the gut. Their bodies were more compressed. Throughout the developmental series the myomeres were difficult to see mostly because of the intense pigmentation.

The head of the hatchling showed a midbrain bulge separated from forebrain and medulla which is typical of many pleuronectid larvae. By 2.4 mm, it appeared as a large dome which continued throughout the series. The fore and hindbrain sections could be seen also at these sizes. The head increased in overall relative size throughout development finally reaching approximately ⅓ of the body length, then it

TABLE 1.—Average Morphometrics and Meristics of Larval and Juvenile Diamond Turbot, *Hypsopsetta guttulata*

	Average Morphometrics (mm)						Average Meristics		
Standard length	Number examined	Standard length	Head length	Eye diam.	Depth at base of pectoral	Snout to anus	Vertebrae	Dorsal	Anal
1.0–1.4	3	1.4	.30	.17	ys*	.8			
1.5–1.9	36	1.7	.36	.19	.42	1.0			
2.0–2.4	44	2.2	.46	.20	.44	1.1			
2.5–2.9	1	2.5	.53	.22	.45	1.3			
3.0–3.4	2	3.2	.67	.30	.65	1.7			
3.5–3.9	3	3.6	.94	.35	.97	2.0			
4.0–4.4	------	------	------	------	------	------			
4.5–4.9	4	4.7	1.31	.46	1.33	2.5			
5.0–5.9	2	5.8	1.80	.56	1.80	2.7			

11.0–11.9	1	11.5	4.5	2.4	6.6	4.6	35	75	48
12.0–12.9	1	12.8	4.4	1.4	6.9	4.5	35	66	50
13.0–13.9	2	13.4	4.6	1.9	7.6	4.8	35	72	52
14.0–14.9	3	14.5	5.2	1.5	8.0	5.4	35	71	49
15.0–15.9	5	15.5	5.4	1.7	8.7	5.8	35	70	51
16.0–19.9	13	17.6	5.7	2.0	9.4	6.1	35	71	52
20.0–49.9	12	31.3	9.9	2.9	17.4	11.7	35	67	50
50.0	3	73.3	20.3	5.3	35.7	23.0	35	72	51

* Yolk-sac present

decreased slightly as the body deepened (Figure 2). The mouth was inferior in position until 3.5–3.9 mm when it became terminal. The larvae around 5.8 mm exhibited asymmetric growth, with the left eye

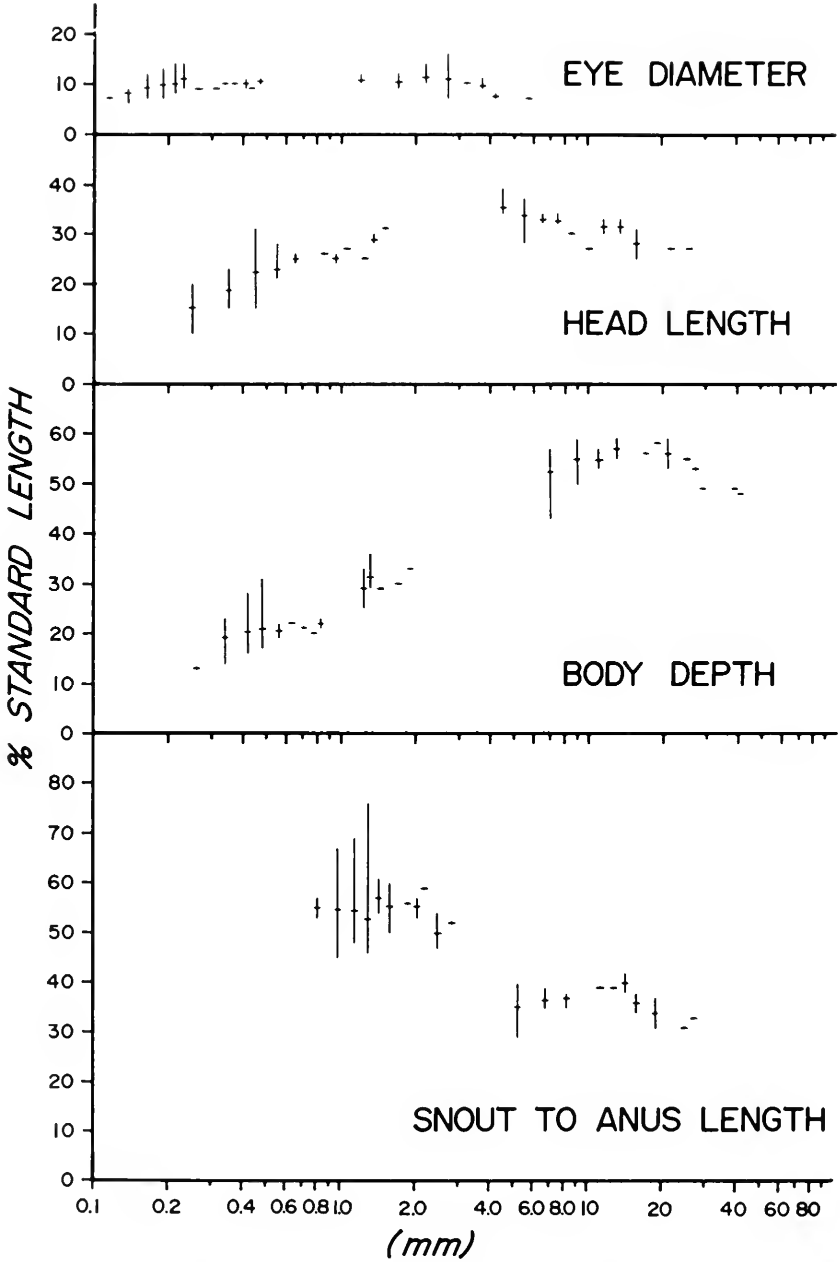

FIGURE 3. Morphometric proportions (in logorithmic scale) of the diamond turbot, plotted as percentages of standard length.

in the midst of migration to the right side. Eye diameters remained much the same in relation to body length throughout development (Figure 3).

The finfold began at the forehead and extended posteriorly around the tail and forward to the yolk-sac or gut. It remained complete and translucent throughout development until around 3.8 mm when the anlagen of the dorsal and anal fins and the caudal fin were seen forming. At hatching the pectoral fin bud was visible on the dorsal aspects of the yolk-sac. By approximately 2.4 mm, the pectoral fins appeared as small lateral projections.

The 4.9 mm larvae possessed nearly developed dorsal and anal fins but the fin ray counts were not complete. Likewise, the metamorphosing larvae did not have complete dorsal and anal fin development, but the rays were more discernible. The caudal fin developed simultaneously with the dorsal and anal fins. The upward flexion of the caudal notochord occurs at about 4.0 mm S.L. The hypural cartilages and the full complement of caudal rays were visible in the metamorphic specimens (Figure 2c). In these advanced larvae, the pterygiophore primordia appeared as longitudinal ridges along the bases of these fins. The smallest juvenile specimen (11.5 mm) did show complete vertical fin ray development.

DISCUSSION

From occurrences of the larvae, *Hypsopsetta guttulata* appeared to have an extended spawning period. Larvae, and what I believe to be the pelagic eggs of the diamond turbot, were collected from early June through mid-October.

These eggs averaged 0.80 mm in diameter with usually one large oil globule (average 0.14 mm diameter) and numerous other globules scattered throughout the yolk. They can easily be distinguished from *Pleuronichthys* eggs by the absence of the hexagonal pattern on the chorion and the presence of oil globules.

It is very easy to confuse *H. guttulata* larvae with *Pleuronichthys* larvae, especially with the similarity in pigmentation and morphology. There are no other known larvae in this geographical area which have such heavy pigmentation and which might be confused with turbot larvae. So differentiation needs to be made between the larvae of the different turbots which might occur in the San Francisco Bay area.

In general, the *Pleuronichthys* larvae are larger than *Hypsopsetta* larvae in the early stages of development. *P. verticalis* is the smallest at hatching being 3.16 mm (0.12 inch) long (Budd 1940). Even allowing for shrinkage during preservation, *Hypsopsetta* larvae would not exceed about 2.00 mm (0.08) at hatching. Yolk-sac larvae of *P. verticalis* have a notable crest not as pronounced in the diamond turbot. Another distinguishing characteristic for the young is the presence of oil globules in the yolk. The finfold pigment patches found in both *P. verticalis* and *P. decurrens* are not as developed or as consistently present in the diamond turbot. Only the very small *Hypsopsetta* larvae (2.4 mm) had finfold patches. The mottled turbot, *P. coenosus*, is separated most easily because it is very large at hatching (5.54 mm) and has heavy pigmentation throughout its finfold.

It can be seen that various turbot larvae are best separated by pigmentation (especially in the finfold), and relative size at which structures develop in post yolk-sac larvae.

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THE FOOD OF *NEOMYSIS MERCEDIS* HOLMES IN THE SACRAMENTO-SAN JOAQUIN ESTUARY

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ABSTRACT

Gut contents were determined in approximately 1500 opossum shrimp, *Neomysis mercedis* Holmes, from the Sacramento-San Joaquin Estuary. The shrimp, obtained from 12 stations over a 13-month period, were 2 to 17 mm (0.08 to 0.67 inch) long.

The most abundant items in the gut were detritus and diatoms. The percentage of detritus relative to diatoms was greater in winter than in summer, and increased with shrimp size.

Forty kinds of diatoms were found in the gut. Certain diatom genera predominated in shrimp from particular locations and in shrimp collected during particular times of the year.

Animal fragments and other items also encountered were much less abundant than detritus and diatoms.

Thus, the shrimp appears to eat a variety of food items.

INTRODUCTION

This study was initiated, along with others on the opossum shrimp, *Neomysis mercedis* Holmes, to improve understanding of environmental relationships in the Sacramento-San Joaquin Estuary which might be affected by water development projects. The present study is an important component of an extensive investigation into many aspects of the biology and ecology of *N. mercedis* and the striped bass, *Morone saxatilis.*

N. mercedis is an important component of the trophic structure of the Sacramento-San Joaquin Estuary. This shrimp is the major food item in the diet of young striped bass in all seasons of the year (Stevens 1966). This study involved the gut contents of approximately 1500 opossum shrimp collected from Suisun Bay and the Delta from March 1970 through March 1971. Very little previous information was available on the feeding habits of this shrimp.

MATERIALS AND METHODS

Sampling Stations

The opossum shrimp were collected by the California Department of Fish and Game, Bay-Delta Fishery Project, from 12 stations extending from Suisun Bay up the Sacramento River to Rio Vista, and up the San Joaquin River almost to Stockton (Figure 1). The station numbers used in this study are those of the California Department of Fish and Game.

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Sampling Procedure

Each month from March 1970 to March 1971 a sample was obtained from each of the 12 stations, for a total of 156 samples. Monthly sampling was conducted during three consecutive days between one-half hour before and one hour after high neap tide.

Samples were taken with a cone-shaped plankton net of silk bolting cloth with 23 meshes per inch. The net opening was 0.1 m^2 (1.07 ft^2). A diagonal tow was made from the bottom to the surface, and each tow took approximately 10 minutes.

Each sample was preserved with 5–10% formalin, along with enough Rose Bengal dye to stain the shrimp.

Five pair of shrimp were selected from each sample. The shrimp were selected to obtain a wide range of sizes (2–17 mm from the anterior

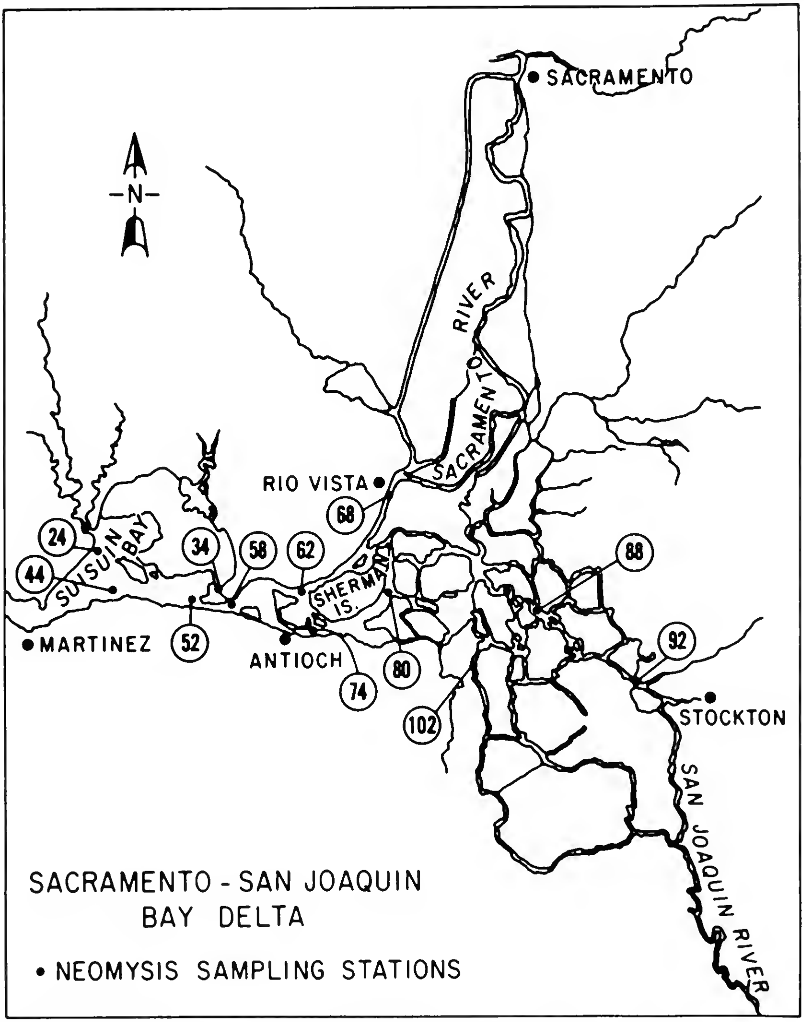

FIGURE 1. Sacramento-San Joaquin Bay-Delta Estuary System, Neomysis sampling stations.

end of the eyestalk to the base of the telson). The sex was determined for each organism 7 mm and longer. Shrimp shorter than 7 mm could not be sexed and were considered as juveniles. Shrimp of the same size and sex were chosen for each pair, and their gut contents were pooled.

Shrimp Dissection and Slide Preparation

The stomach and intestine were removed from each shrimp with two fine needles under a dissecting microscope. The full gut was located readily since it did not take up the stain. The thin exoskeleton was teased apart along the dorsal surface of the organism from the head to the base of the telson, and the gut was then carefully lifted out.

Each pair of pooled guts was placed on a glass microscope slide in a drop of water. The stomach and intestine were gently broken open with the needles, and the contents were dispersed and stirred in the water.

The slide was then air-dried, a drop of Permount mounting medium was applied, and a 1 cm^2 glass coverslip was placed on the slide. The preparation was dried overnight.

Enumeration of Gut Contents

Items present in the mounted gut contents were counted and identified with a compound microscope at 400×. Every item was enumerated except when more than 1000 algal cells were present on a slide. In such cases (about half of the total), enumeration was terminated at 1000 cells. According to Javornicky (1958) counting 1000 cells limits the expected error to ±6.3% (with a probability of 0.95).

TABLE 1.—Diatoms Encountered in *Neomysis* Gut Contents

Diatom	Total number counted	Diatom	Total number counted
Coscinodiscus sp.	196,633	*Rhopalodia* sp.	159
Melosira sp.	166,380	*Gomphonema* sp. No. 1	143
Cyclotella sp.	57,206	*Surirella* sp. No. 2	96
Nitzschia paradoxa	16,893	*Nitzschia* sp. No. 4	88
Tabellaria sp.	11,882	*Pinnularia* sp.	85
Diatoma sp.	7,173	*Stauroneis* sp.	45
Fragilaria sp. No. 1	6,450	*Eunotia* sp.	32
Stephanodiscus sp.	4,661	*Fragilaria* sp. No. 2	22
Synedra sp.	4,412	*Actinoptychus* sp.	18
Asterionella sp.	3,547	*Pleurosigma* sp.	15
Epithemia sp.	2,002	*Meridion* sp.	13
Navicula sp.	1,808	*Acnanthes* sp.	9
Triceratium sp.	1,182	*Gyrosigma* sp.	6
Cocconeis sp.	446	*Amphora* sp.	5
Cymbella sp.	414	*Fragilaria arcus*	5
Nitzschia sp. No. 2	288	*Skeletonema* sp.	4
Surirella sp. No. 1	285	*Lepidodiscus* sp.	3
Rhoicosphenia sp.	250	*Frustula* sp.	1
Nitzschia sp. No. 3	223	*Gomphonema* sp. No. 2	1
Diploneis sp.	174	*Nedium* sp.	1

Algae were identified to the generic level, but many animal fragments could not be identified and were included in the general category "animal fragments".

Detritus was enumerated by using a microscope ocular attachment which divided the field into 100 squares, 0.0258 mm on a side, at 400×. The quantity of detritus was approximated by counting the number of squares filled in each field examined. The portion of the field occupied by diatoms was also estimated, according to the detailed procedure described elsewhere (Baldo, 1972).

RESULTS

The most abundant of the materials found in the gut were detritus and diatoms. Each varied in importance with station, time of year, and size of shrimp. Of the identifiable material, a total of 40 diatoms were encountered (Table 1). In addition there were 2 genera of green algae, one dinoflagellate, rotifer loricas, tintinid loricas, crustacean fragments, sponge spicules, pollen grains, and (apparently) fragments of higher plants (Table 2).

TABLE 2.—Additional Items Encountered in *Neomysis* Gut Contents

Item	Total number counted
Green algae	
Scenedesmus	38
Pediastrum	20
Dinoflagellate	
Ceratium	1
Rotifer loricas	252
Tintined lociras	129
Crustacean fragments	739
Sponge spicules	129
Pollen grains	252
Higher-plant fragments	10

Detritus

The majority of the guts examined contained a significant amount of unidentifiable material. This unidentifiable material was classified as detritus. It was usually a gold-brown color. Some of this material appeared to be homogeneous, but it was generally mixed with particles or objects of different sizes and shapes of unknown origin. This material was probably either organic debris (e.g., peat or plant material) that the shrimp had ingested, or partially digested algal material. Its actual origin was not determined.

Comparison of the relative amounts of detritus and diatoms in the guts showed that detritus was more important during the winter (December to March), while diatoms were more important during the summer and early fall (Figure 2).

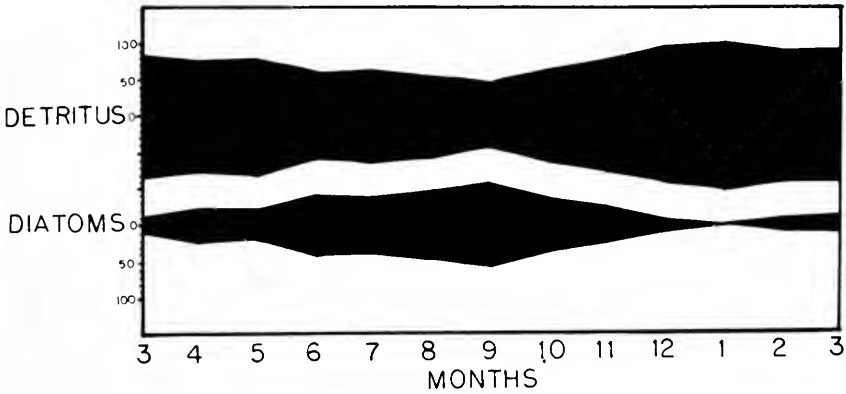

FIGURE 2. The percentage of total diatoms and detritus relative to each other. Gut contents from all 12 stations combined for each month from March 1970 through March 1971.

Over the shrimp size range evaluated, the relative amounts of detritus and diatoms differed markedly. Diatoms were more plentiful in small shrimp than in large ones. On the other hand, detritus was more abundant in the larger shrimp (Figure 3). Shrimp 16 to 17 mm long were excluded because only one of each was examined. Calculations for most of the other sizes were based on more than 80 individuals. The increase in percentage of detritus with size was rather uniform except for 2 mm shrimp (which included only 9 individuals).

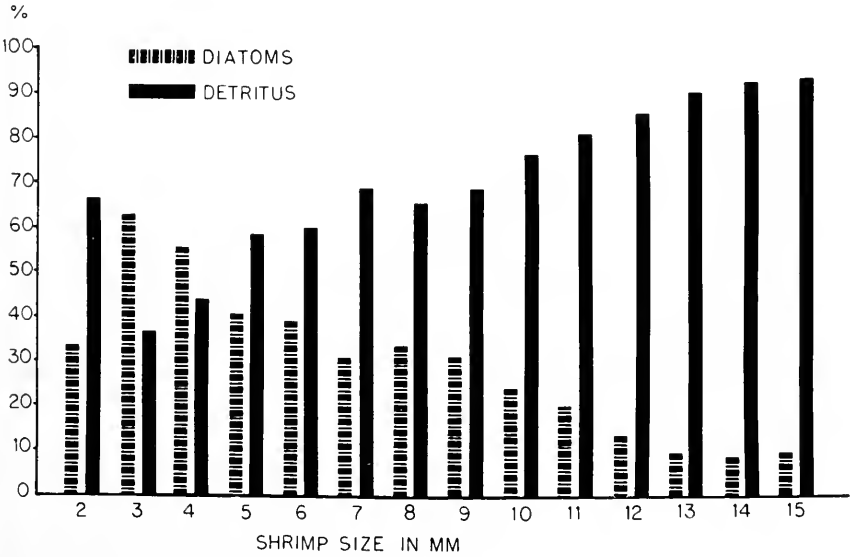

FIGURE 3. The percentage of total diatoms and detritus relative to each other in the gut of shrimp of different sizes (2 to 15 mm), all stations and months combined.

Diatoms

Of the 40 kinds of diatoms encountered in the guts of *N. mercedis*, certain genera predominated (Table 1). Two diatoms, *Coscinodiscus* and *Melosira*, were far more abundant than the rest. *Coscinodiscus* was

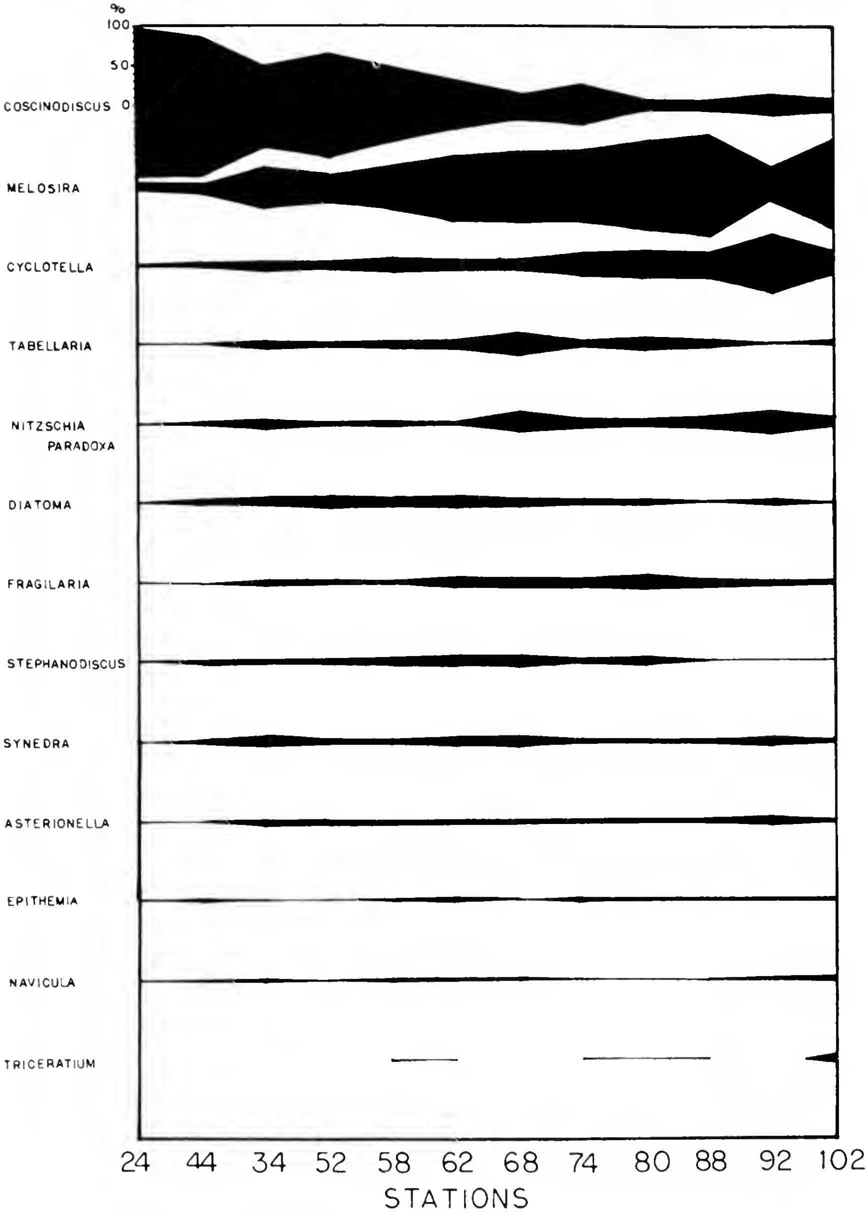

FIGURE 4. Variation in the 13 most common diatom genera encountered in the gut of shrimp from each of the 12 Bay-Delta stations, all months combined. Each genus is represented as its percent of total diatoms. Diatoms not included constituted less than 1% of the total.

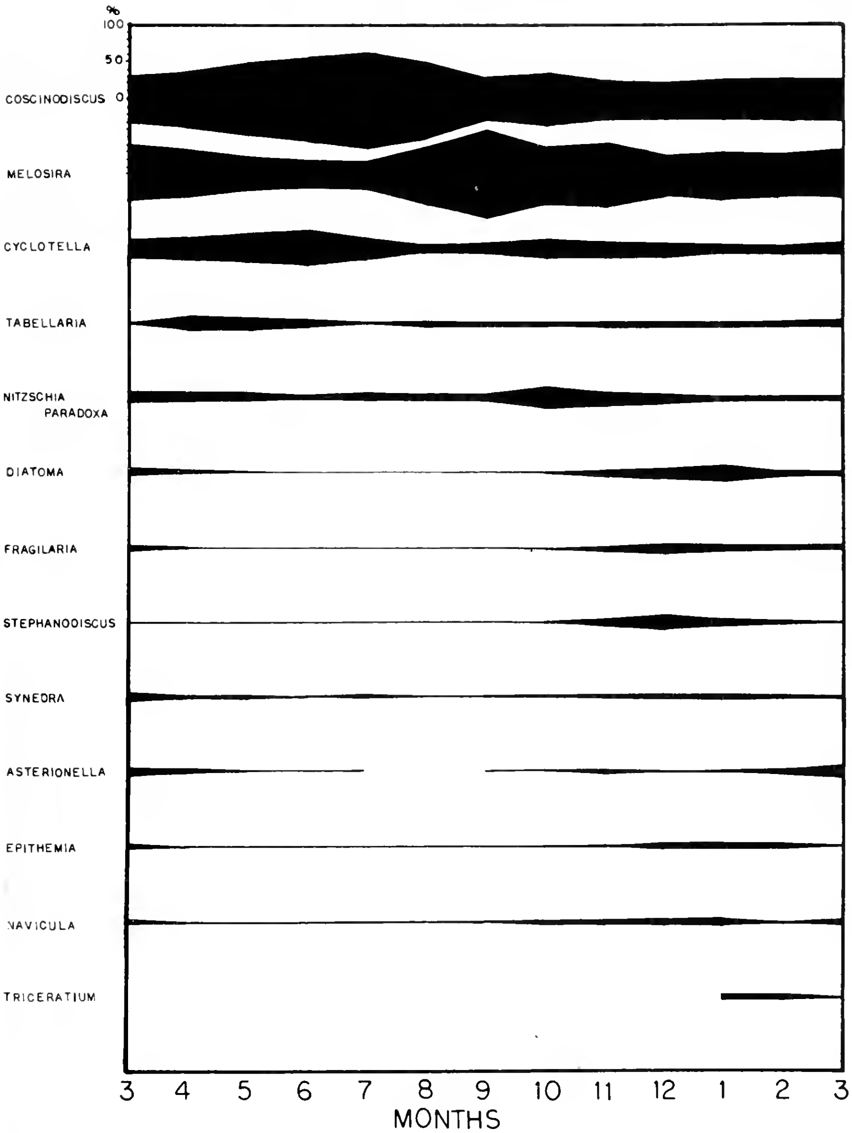

FIGURE 5. Variation in the 13 most common diatom genera encountered in the gut of shrimp from March 1970 through March 1971, all stations combined. Each genus is represented as its percent of the total diatoms.

the most important diatom in guts of shrimp from the lower Delta and Suisun Bay stations (Figure 4). At these downstream stations it often constituted 90 to 99% of the total diatoms. The diatom *Melosira* replaced *Coscinodiscus* as the most abundant diatom in shrimp from upper Delta stations during most of the year. *Cyclotella* was also important at eastern stations, especially at station 92, near Stockton. These geographical variations in the relative abundance of the various diatoms were greater than seasonal variations in relative abundance (Figure 5).

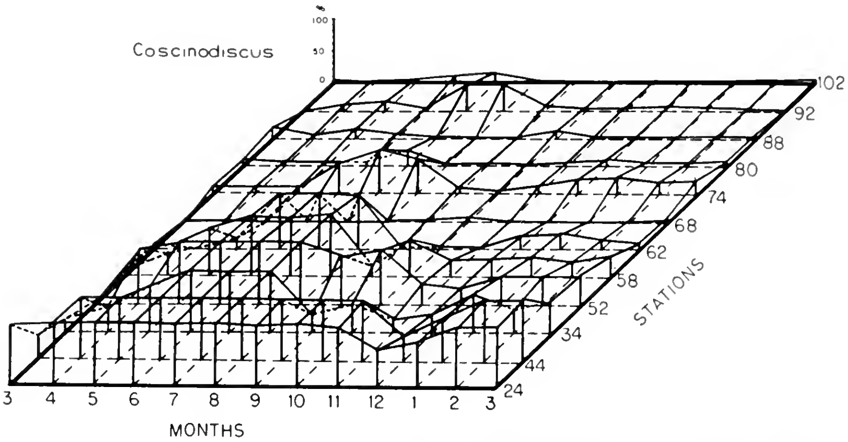

FIGURE 6. Variation in the diatom *Coscinodiscus* sp., represented as its percent of the total diatoms in the gut for each month from March 1970 through March 1971 at 12 Bay-Delta stations.

Figures 6, 7, and 8 are three-dimensional graphs showing the spatial and temporal distribution of the 3 most common diatoms. Each diatom is represented as its percent of the total diatoms in all the guts examined from each station and each month. It is again evident that *Coscinodiscus* was the most abundant diatom in the gut from the lower Delta. It was replaced by *Melosira* as the most common diatom in the upper Delta. The percentage of *Coscinodiscus* in shrimp from stations in the upper Delta is greater from June to August than during the

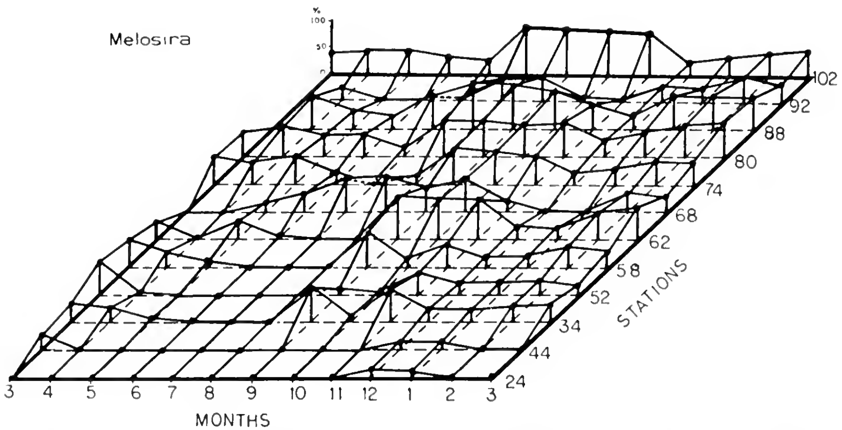

FIGURE 7. Variation in the diatom *Melosira* sp., represented as its percent of the total diatoms in the gut for each month from March 1970 through March 1971 at 12 Bay-Delta stations.

rest of the year (Figure 6). This increase appears to be related to the salinity, which increases upstream during the summer when the flow in the rivers is decreased (Figure 9).

Distribution of the remaining diatoms in the guts also varied geographically and seasonally. For example, *Triceratium* appeared predominantly at station 102 during most of the year whereas *Tabellaria* appeared at station 68 during the late spring and early summer. For a more complete description of the distribution of the less common diatoms, see Baldo (1972).

Animal Fragments and Other Gut Contents

Many guts contained fragments (mostly appendages) of unidentified crustaceans. A copepod was encountered which was nearly intact. The

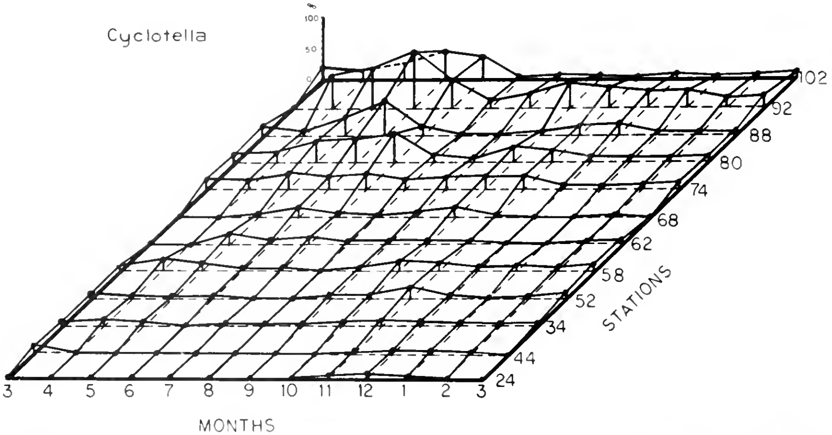

FIGURE 8. Variation in the diatom *Cyclotella* sp., represented as its percent of the total diatoms in the gut for each month from March 1970 through March 1971 at 12 Bay-Delta stations.

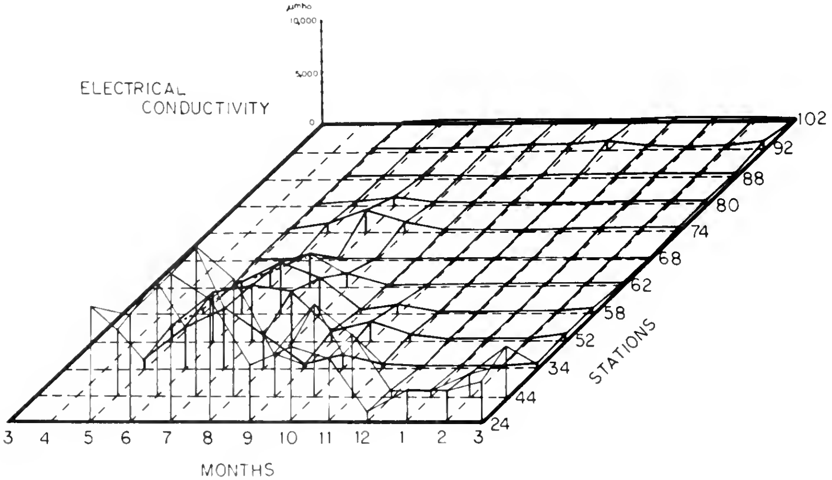

FIGURE 9. Variation in electrical conductivity in umhos of water at 12 Bay-Delta stations for each month from May 1970 through March 1971. Data are from Knight, Biggar, and Tanji, 1972.

crustacean fragments found increased in number with shrimp size, but so few crustaceans were found that the validity of this observation is questionable.

Rotifer loricas which appeared to be of the genus *Keratella* were found in a number of shrimp. Tintinid loricas were less common. The number of rotifers or tintinids present was not correlated with shrimp size.

At least two varieties of sponge spicules were present in the gut of a number of shrimp.

Two genera of green algae, *Scenedesmus* and *Pediastrum*, were encountered in very small numbers. A single dinoflagellate, *Ceratium*, was found in a shrimp from Suisun Bay.

Pollen grains were present in very small numbers at every station.

Fragments of higher plants were only minor contributions.

For more information on the spatial and temporal distribution of these items, see Baldo (1972).

DISCUSSION

Many investigators (e.g., Esterly 1916, Wilson 1951, Mecom and Cummins 1964, Hart 1934) have noted that recognizable items in the gut may not be the sole source of nutrition. In some cases the items may not even be a source of nutrition. The hard skeletons of items such as diatoms and crustaceans may be the main reason for their retention and recognition in the gut. Many kinds of algae such as greens and blue-greens would be less likely to retain their original structure after being eaten and partially or totally digested. Items such as bacteria, either free in the water or surrounding detritus particles, and other nanoplankters which would be difficult to identify in the guts, may or may not play a significant role in the nutrition of these shrimp.

Data were obtained from the Federal Bureau of Reclamation in Sacramento on the phytoplankton present at Delta stations during the same period. Many of the diatoms found in the shrimp guts were similar to those in the phytoplankton samples. A number of Chlorophyta, Cyanophyta, and Crytophyta, however, which were present in the phytoplankton samples were not in the shrimp guts. It was not possible to determine from the gut contents examined whether the shrimp ingested these green algae and other forms and digested them beyond identification, or whether they selected against these forms.

The seasonal changes in the relative occurrence of detritus and diatoms in the guts noted in this study presumably reflect changes in their relative availability. Diatoms are several times more abundant in the environment during the summer than in the winter (Delta Fish and Wildlife Protection Study, 1972). Conversely, detritus may be more abundant during the winter, when increased runoff likely carries greater amounts of organic debris into the Estuary. Both of these probable changes parallel the changes in relative abundance observed in the shrimp guts.

This study does indicate that *N. mercedis* is able to ingest a wide variety of foods. It is reasonable to assume that it utilizes whatever food is available at any particular place or time, whether it be detritus or one kind of diatom or another.

Mauchline (1967) indicated similar results for the mysid *Schistomysis spiritis*. That shrimp extracts suspended matter indiscriminately from the water and must therefore use a large variety of foods. In guts of *S. spiritis* he found fine particulate matter mixed with sand grains, various diatoms, dinoflagellates, filamentous algae, some leaf fragments, spores, and seeds of terrestrial origin. In addition, Mauchline (1971a, b) found that the mysid, *Paramysis arenosa* and *Neomysis integer* could utilize many food types when available, including plant and animal matter, detritus, and inorganic particles. Raymont et al (1964) stated that mysids take whatever food is more or less immediately available. They indicated that detritus is important in the nutrition of *N. integer*, especially in estuarine conditions where there is normally a constant supply of organic matter. They observed *Neomysis* stirring up detritus on the bottom with its appendages and ingesting it. Lasenby and Langford (1973) found that *Mysis relicta* in two Canadian lakes is potentially omnivorous.

Wilson (1951) examined the stomach contents of *Neomysis mercedis* Holmes in British Columbia, and found diatoms, dinoflagellates, blue-green algae, vascular plant material, and animal material consisting of mainly copepod and mysidacean remains.

Tattersall (1951) indicates that most mysidacea, including *N. integer*, filter-feed microscopic plants and animals and detritus. They are able to pounce on living copepods and ingest them and have been seen carrying around dead mysids and amphipods of their own size while eating them. *Acanthomysis sculpta* will readily eat injured or freshly killed members of its own species and anything else it can capture (Green 1970). *N. mercedis* has been seen in the lab eating dead or weak members of its own species.

It is probable that shifts in environmental quality would alter the food supply available to *N. mercedis*. Changes in water chemistry (salinity, pollutants, etc.) would favor certain forms of algae rather than others. Increased turbidity could inhibit algal growth. However, since *N. mercedis* appears to utilize a diversity of items, food will probably not be limiting to the shrimp as long as either detritus or some form of algae is present in sufficient quantity.

SUMMARY

1. Detritus and diatoms were the major food items found in the gut of *N. mercedis* from the Sacramento-San Joaquin Delta. Animal fragments and other items were less abundant.

2. The relative abundance of detritus and diatoms in the gut varied during the year. Diatoms increased in relative amounts in summer, and detritus increased in the winter months.

3. The relative importance of detritus increased in the gut of larger shrimp, and, conversely the relative importance of diatoms increased in the gut of smaller shrimp.

4. Previous reports indicate that mysid shrimp are capable of utilizing a wide variety of foods. The results of this study are consistent with those reports. The shrimp *N. mercedis* appears to be omnivorous.

ACKNOWLEDGEMENTS

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NOTE ON THE ECOLOGY OF THE RATFISH, *HYDROLAGUS COLLEI*, IN THE GULF OF CALIFORNIA[1]

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***Hydrolagus colliei*, the ratfish, has been taken frequently in the northern Gulf of California. This species shows a marked migratory pattern being relatively abundant and widely distributed in this area in February–March, and found at few stations and in low numbers in June and August. Males appear to grow more slowly than females and are less frequent in the catches. The breeding season must be several months before or after the period of spring abundance in the northern Gulf.**

***Hydrolagus colliei*, el pez llamado pez rata de California, ha sido capturado frecuentemente en el norte del Golfo de California. Esta especie demuestra un patrón migratorio; es relativamente abundante en esta zona en febrero y marzo y muy restringido en su distribución y en abundancias muy bajas en junio y en agosto. La estación de reproducción debe de estar varios meses antes a después del período de abundancias altas en el norte del Golfo de California.**

INTRODUCTION

Hydrolagus collei has been known to occur in eastern Pacific tropical waters from western Alaska to northern Baja California; Johnson and Horton (1972) have described some aspects of the ecology of this species. It is the object of this paper to present some of the results of the exploratory and prospective fishing cruises of the Alejandro de Humboldt, during which *Hydrolagus collei* was found to be fairly widespread although usually in low abundances, at certain times of the year in the northern Gulf of California. During a series of cruises conducted by the R/V Alejandro de Humboldt of the Instituto Nacional de Pesca of México, between June, 1971 and March, 1972, sufficient data were gathered for the bathymetric and geographic distributions of this species to be known in the area from Guaymas to Isla Tiburón and in the zone north of Isla Tiburón and Isla Ángel de la Guarda. During cruises conducted from April 1971 to December 1971, in other parts of the Gulf of California no ratfish were taken although on all cruises the same depths (100–600 m) (328–1,968 ft) were sampled.

METHODS

The Alejandro de Humboldt is a 42 m (138 foot), 450 gross ton stern trawler equipped as a research vessel. The usual sampling tool was an otter-trawl net, with a 41 m (136 feet) headline, and cod-ends with mesh sizes of 4.5 cm (1.8 inches) and 5.5 cm (2.2 inches). The smaller

[1] These views do not necessarily reflect those of FAO. Accepted for publication June 1974.

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mesh cod-end was employed only from July 1971 onwards, but is not thought to have increased the vulnerability of ratfish to the net during this period.

Specimens of ratfish were separated from the catch, and were usually measured (total body length in cm) and sexed.

RESULTS

Ratfish were taken from the mid-Gulf northward, but the area of greatest concentration was to the north of Isla Ángel de la Guarda.

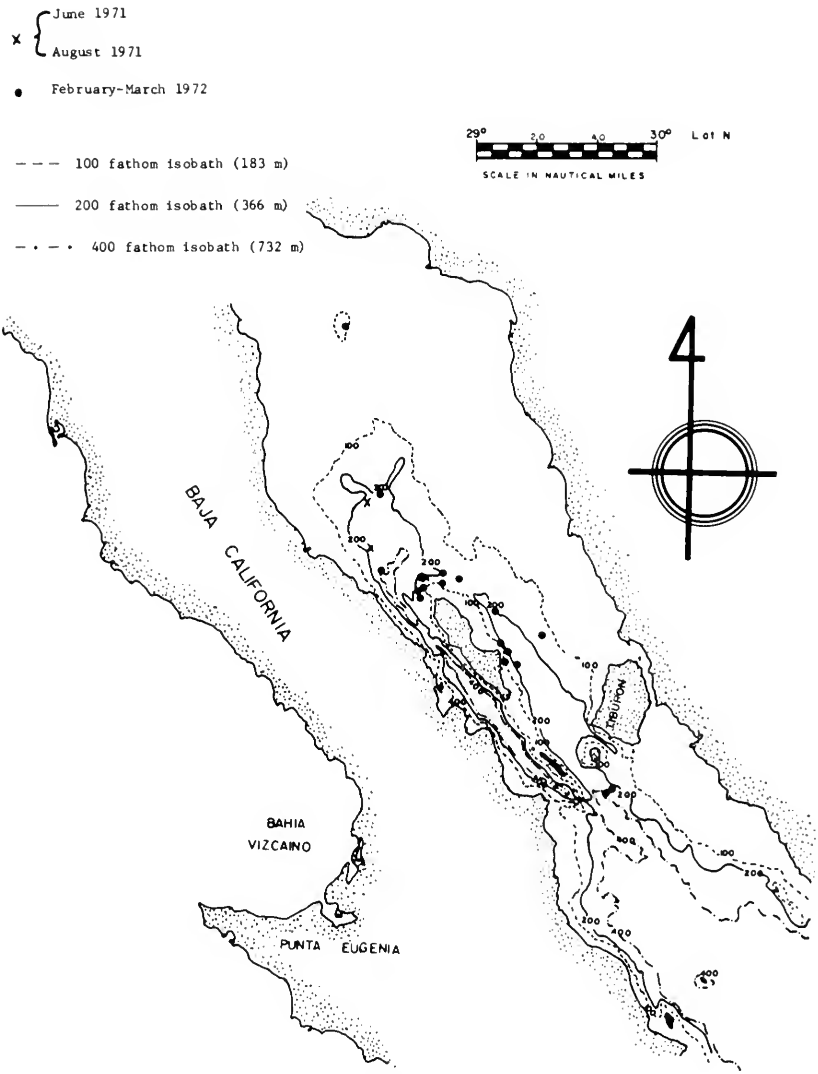

FIGURE 1. Distribution of *Hydrolagus collei* in the Northern Gulf of California.

TABLE 1.—**Stations at Which *Hydrolagus collei* was Captured by the "Alejandro de Humboldt"**

	Number of specimens	Total length in cms.	Depth (m)
Date 1971			
19 June	6	--	412–446
20 June	1	--	502–506
21 June	4	--	290–310
23 August	1	40	540–560
1 September	1	51	294–296
Date 1972			
23 February	4	--	196
23 February	3	42–49	304–307
23 February	23	38–55	390–394
23 February	33	33–50	309–312
24 February	3	40–42	192–220
25 February	11	25–51	366–415
28 February	112	26–49	288–292
28 February	75	36–45	304–332
28 February	17	38–50	250–298
28 February	4	39–51	201–226
29 February	4	--	300m
29 February	4	46–48	330
29 February	15	39–49	290
29 February	75	30–50	292–296
29 February	40–50	--	282–360
1 March	7	38–51	268–274
2 March	17	43–55	264–321
3 March	2	50–51	398–400
10 March	6	36–44	420–434
10 March	58	36–44	341–348

Rarely some specimens were found between Guaymas and Isla Tiburón.

Ratfish were far more abundant in February–March 1972 than in June or August 1971 (Figure 1, Table 1).

In interpreting these data, it is important to remember that in June and August–September 1971, approximately 50 hours of fishing were spent in the area in which ratfish were subsequently found in February-March 1972, when about 60 hours were fished. Therefore, the amount of fishing effort expended in the summer of 1971 and early spring, 1972 was approximately equal and the marked differences in abundance and distribution are not caused by differences in fishing effort expended. They are probably due to migratory movements of the fish themselves, either towards depths the Alejandre de Humboldt could not sample, or out of the Gulf of California.

Most stations (16 out of 19) at which ratfish were found were situated from 270–430 m deep.

Abundances, expressed in numbers of fish per hectare, varied from 0.1 fish/ha to 2.9 fish/ha (Figure 2).

These depths also contain all stations at which abundances exceeded two individuals per hectare. However, ratfish were found up to 196 m deep in low abundances (0.2 or less/ha).

The envelope curve for the stations at which ratfish were found in summer 1971, is based on only five occurrences, but three of these were

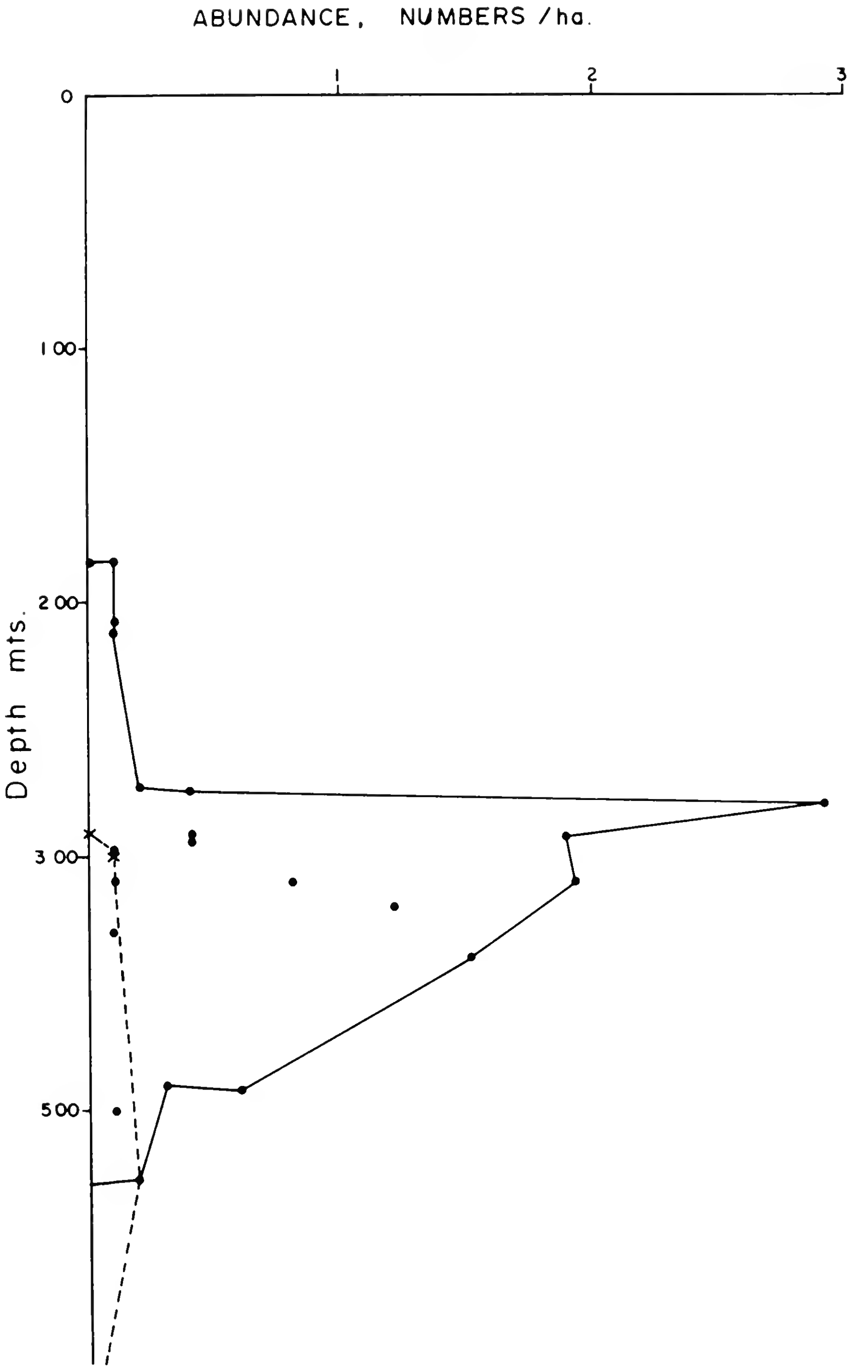

FIGURE 2. Bathymetric distribution and abundance of *Hydrolagus callei*.

in deeper waters than any of the spring 1972 occurrences (Table 1), and all five occurrences were in low abundances (0.1–0.4 fish/ha). This suggests that in summer (June–September) ratfish move out of the northern Gulf of California into deeper waters and return at the latest by the end of winter (February), probably earlier.

A total of 448 ratfish was measured and sexed on the Alejandre de Humboldt in February and March 1972 (Figure 3). Two modes are present, at 38–39 cm and at 47 cm, corresponding to the maximum occurrence of male and female fish. It is unlikely that there is any question of sex reversal in this species, so it may be concluded that females grow to a larger size than males. From 45–55 cm 10 fish were males and 168 females, giving a sex ratio of 94.4% females, with no males from 52–55 cm. On the other hand, from 35–44 cm, 131 males and 104 females were found, giving a sex ratio of 44.3% females. Females predominate in the catch, of which 67.2% were females and 42.8% males.

Twenty-seven females, all taken in spring 1971, from 36–55 cm in length, were opened and their gonads were examined. Two stages were recognized:

i) Ovaries moderately developed, include at least one clear yellow, yolky egg 2.0–2.5 cm in diameter; frequently other, smaller and similar bodies were present.

ii) Immature, when the ovaries are small and undeveloped (Table 2).

TABLE 2.—**Maturity in Female Ratfish**

Total body length (cm)	State of ovaries	Immature	With eggs
36–40	Three immature fish	3	0
41–45	One fish with eggs, one fish immature	1	1
46–50*	Five fish with eggs, six fish immature	6	5
51–55	Eleven fish with eggs	0	11

* Longest immature female: 47 cm.

These rather sparse data indicate that female ratfish mature at lengths between 41–47 cm, and that fish 51 cm and over are always mature.

It was not possible to distinguish any stages of maturation in the male gonads: these were inconspicuous and showed no signs of sperm.

The state of the female gonads, and especially the male gonads, suggests that reproduction takes place several months before or after the sampling period (February 1972). At any rate, no ripe animals were taken. Unfortunately, none of the fish taken in June or August 1972, were dissected.

An attempt to examine the stomach contents was made, but this species has no clearly defined stomach and the area which corresponds to the stomach in other fish was empty in the fish examined. The spiral valves of four were opened; while three of these were empty, the fourth contained what appeared to be some sand.

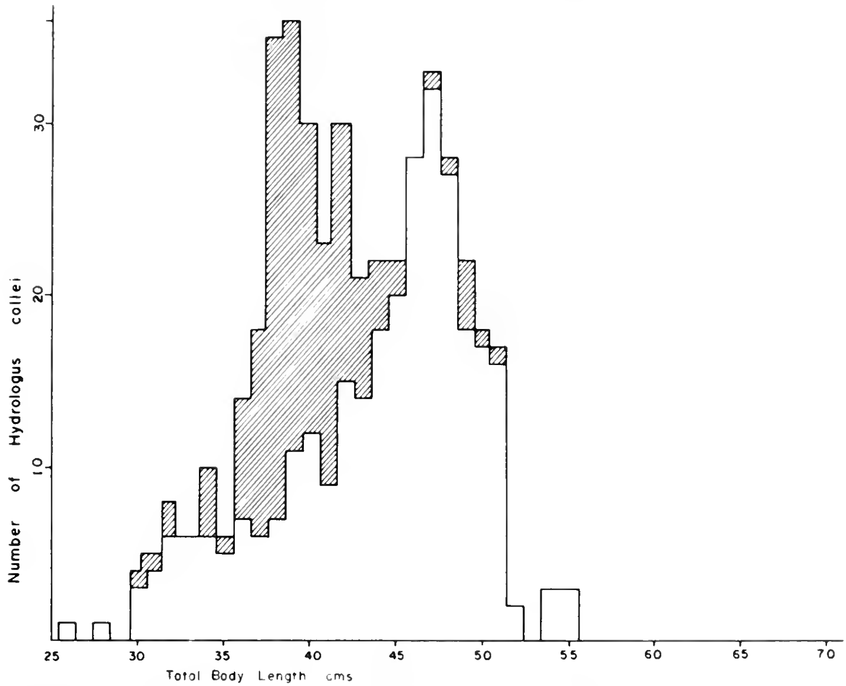

FIGURE 3. Size frequency distribution of the males and females of *Hydrologus collei*. SHADED BARS=MALES

DISCUSSION AND CONCLUSIONS

Ratfish show a distinct migratory movement, being more abundant and more widespread in the northern Gulf of California in February–March, than in June–September. They do not appear to reproduce during the period of peak abundance, but this requires further investigation. Females predominate in the catch and this could be because of greater vulnerability to the net, as females are on the average larger, but could also be due to females migrating more readily, or even to a natural difference in sex ratio. However, the pattern of an increasing proportion of females in larger fish is a very widespread one and on close investigation is usually found to be accompanied by increasing mortality selective against males. There is no good reason to believe this process does not operate on the Gulf of California population of ratfish.

The cause of the migratory movements of ratfish is unknown, but most of the fish species in the northern Gulf of California are more abundant in early spring, so a casual agent with a rather generalized action should be looked for; quite possibly temperature, oxygen concentration and currents are of great importance.

A different mesh size was used in spring 1972 (4.5 cm) and June 1971 (5.5 cm), so the ratfish caught were subject to different net vulnerabilities at different sampling periods. However, there is no reason to believe that the marked seasonal differences in distribution are caused by biased sampling arising from the different equipment used, as the material collected in August–September 1971 was also collected with the finer mesh cod-end (4.5 cm) as opposed to the courser mesh used to gather the material collected in June 1971. There were no significant differences in distribution or abundance recorded between June and August 1971; therefore, the change in mesh size did not significantly affect the vulnerability to the net of the fish present.

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I wish to acknowledge the help of the Captain, F. Hernández Ascensio, and crew of the Alejandro de Humboldt who made the work of collection so much easier and more agreeable by their friendly participation. I also wish to acknowledge the help of Biol. H. Chávez, Sr. Humberto Pedraza and T. P. Armando Arias, who were instrumental in helping to collect the data on which this paper is based.

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NOTES

AN UNUSUALLY FAST GROWTH RATE FOR *TILAPIA ZILLII*

Tilapia zillii is an herbivorous cichlid from East Africa, and it is one of many species of *Tilapia* introduced into the United States for the biological control of aquatic weeds (Scheffer 1960; Avault, Smitherman, and Shell 1968). It was authorized for introduction into California waters in 1971 (Pelzman 1973). Any successful method of biological control of aquatic weeds in the irrigation systems in southern California would be welcomed. Large sums of money are spent annually for the mechanical removal of aquatic weeds since chemical controls cannot be applied because irrigation water also provides the potable water supply.

On 5 May 1972, the California Department of Fish and Game released 250 *T. zillii* in an irrigation drainage ditch near the southeastern edge of Imperial Valley, approximately 15 miles east of Calexico, California. No other *T. zillii* have been stocked in this drainage ditch since the initial introduction. At the time of stocking, the fish averaged 5.7 g (5 per oz) (F. G. Hoover, California Department of Fish and Game, personal communication) and approximately 70 mm (2.75 inches) (unpublished data).

Recently, nine large *T. zillii* were captured in this drain, probably individuals from the original introduction. They were collected on 16 January and 13 March 1974 by seining and throw-netting. Scale samples were taken from a dorso-lateral location near the base of the caudal peduncle. The scales were mounted between two glass slides and examined with a binocular microscope at 10 power magnification. Distances between annuli were measured at least twice with an ocular micrometer.

The specimens ranged from 257 to 315 mm (10.1 to 12.4 inches) TL and weighed 380 to 709 g (0.84 to 1.56 lb) (Table 1). All were 2 years old. Back-calculated lengths ranged from 133 to 185 mm (5.2 to 7.3 inches) and averaged 164 mm (6.5 inches) at the end of the first year. At the end of the second year of growth, the range was 225–300 mm (8.9 to 11.8 inches) and the average, 249 mm (9.8 inches).

Chimits (1957) reported a faster growth rate for *T zillii*, but most reports indicate that this species requires 4 to 6 years to reach approximately 300 mm (11.8 inches) in length (El Zarka 1961; Fryer and Iles 1972). Lowe (McConnell) (1955) reported a 2-year old *T. zillii* weighing 765 g (1.69 lb), but she does not indicate whether the fish grew under wild or cultured conditions. The maximum reported length and weight for *T. zillii* is 350 mm (13.8 inches) and 800 g (1.76 lb), respectively, (Chimits 1957) although there is a single report of one which weighed 2948 g (6.50 lb) (Anon. 1955). In addition, the fish I collected grew faster than nearly all *Tilapia* sp. reported by Iles (1971) and Fryer and Iles (1972).

The largest fish I collected were males. Ben-Tuvia (1959), El Bolock and Koura (1960), El Zarka (1961) and Fryer and Iles (1972) also reported that males were usually longer than females, particularly after they matured.

Unfortunately, this growth rate does not represent the growth rate of all *T. zillii* in California waters, but rather, is an example of the growth potential of this species when released into an environment with a long growing season, little competition, and abundant food. This growth rate most likely will not be sustained as the population increases.

TABLE 1.—Size at the time of capture, sex, and growth of *Tilapia zillii* in a southern California irrigation drainage ditch.

Date	Sex	Length (mm)	Weight (g)	Length at age	
				I	II
13 March 1974	M	315	709	185	300
13 March 1974	M	301	608	161	244
13 March 1974	M	297	595	178	242
13 March 1974	F	290	572	133	240
13 March 1974	M	285	522	174	253
16 January 1974	--	280	508	171	245
16 January 1974	--	278	587	173	244
13 March 1974	F	271	438	157	244
13 March 1974	F	257	380	140	225
Average	--	286 (11.3 inches)	547 (1.20 lb.)	164 (6.5 inches)	249 (9.8 inches)

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NOTES ON SOME FISHES COLLECTED OFF THE OUTER COAST OF BAJA CALIFORNIA

The 12 fishes listed in this report represent geographic range extensions, definite collection localities, or they are taken so infrequently as to warrant a published record. The fishes were collected by the authors aboard the Department of Fish and Game research vessel *Alaska*. Previously unpublished data, from fish collected during other Departmental research cruises, are also included. Latitudes and longitudes have been included for all collecting localities (Table 1). Miles are in nautical miles.

TABLE 1.—Latitudes and Longitudes of Localities of Capture (Arranged from North to South)

Locality	Latitude	Longitude
Baja California		
Todos Santos Bay	31° 46.6′ N.	116° 45.3′ W.
San Martín Island	30° 28.8′ N.	116° 2.7′ W.
Pt. Canoas	29° 44.0′ N.	115° 50.0′ W.
Pt. Canoas (33.3 km W)	29° 27.8′ N.	115° 31.5′ W.
Playa María Bay	28° 56.2′ N.	114° 31.7′ W.
Sebastián Vizcaíno Bay (27.8 km SW of Playa María Bay)	28° 49.7′ N.	114° 48.2′ W.
Cedros Island (12.9 km W. of northern end)	28° 23.7′ N.	115° 21.0′ W.
Cedros Island (17.6 km NNW of northern end)	28° 21.2′ N.	115° 17.9′ W.
San Benito Islands	28° 20.3′ N.	115° 31.6′ W.
Lagoon Head	28° 14.9′ N.	114° 5.5′ W.
Sebastián Vizcaíno Bay (22 fathom spot)	28° 6.0′ N.	114° 23.0′ W.
Sebastián Vizcaíno Bay (27.8 km E. of Pt. Eugenia)	27° 50.0′ N.	114° 50.0′ W.
Turtle Bay (14.8 km SW of Turtle Bay)	27° 36.2′ N.	115° 1.0′ W.
San Cristobal Bay	27° 22.4′ N.	114° 37.8′ W.
San Pablo Point	27° 12.9′ N.	114° 30.5′ W.
San Hipolito Point (11.1 km SE)	26° 52.0′ N.	113° 52.0′ W.

Eptatretus stoutii (Lockington)—Pacific hagfish

On three separate occasions, a total of four Pacific hagfish was captured off the coast of central Baja California: (i) 27.8 km (15 miles) SW of Playa Maria Bay on October 2, 1970, (ii) 33.3 km (18 miles) W of Pt. Canoas on October 3, 1970, and (iii) on June 21, 1971 off San Pablo Point. These fish ranged from 178 to 420 mm (7.0 to 16.5 inches) total length (TL). Our identification was confirmed by Carl L. Hubbs, Scripps Institution of Oceanography, La Jolla, California. Two of these hagfish taken on October 2 and 3, 1970, are now in the ichthyological collection at Scripps Institution of Oceanography (SIO 73-373 and SIO 73-374). The hagfish, taken on June 21, 1971, is catalogued as SIO 71-164.

E. stoutii also was captured 12.9 km (7 miles) W of the northern end of Cedros Island in 278 to 281.6 m (152 to 154 fm) of water on January 17, 1959 by John Seapin. This previous southern limit to the range was never published. The hagfish captured off San Pablo Point extends the range south a distance of approximately 148.3 km (80 miles) from off Cedros Island to San Pablo Point.

Hexanchus griseus (Bonnaterre)—Sixgill shark

On October 6, 1970, a sixgill shark measuring 850 mm (33.6 inches) TL was captured in a midwater trawl in Todos Santos Bay. The trawl was fished from surface to a depth of 14.6 m (48 ft) in water 38.1 m (125 ft) deep. This is the first record of *H. griseus* from Mexican waters. The specimen is deposited in the Natural History Museum of Los Angeles County (LACM 31679-1).

Hydrolagus colliei (Lay and Bennett)—Ratfish

Six ratfish were collected in a bottom trawl off Point Canoas on June 26, 1971, in 58.5 m (32 fm) of water. These fish ranged from 370 to 450 mm (14.6 to 17.7 inches) TL. The vertebral column of a small *Hydrolagus* had been found in the stomach of a giant sea bass, *Stereolepis gigas,* taken at the "22 fathom spot" in Sebastian Vizcaino Bay, two days earlier. Unfortunately, our evidence was inadvertently washed overboard. Two *H. colliei* were captured on January 17, 1959, approximately 17.6 km (9.5 miles) NNW of northern end Cedros Island in 182.9 to 183.2 m (100 to 101 fm) of water. These two specimens were 360 and 462 mm (14.2 and 18.2 inches) TL.

The occurrence of the ratfish off Cedros Island extends the range south along the outer coast of Baja California 389.2 km (210 miles) from Santo Tomás to Cedros Island and evidently Sebastian Vizcaino Bay. Although the specimens captured off Point Canoas are now deposited at the Natural History Museum of Los Angeles County, they have not been catalogued at this time.

Anchoa exigua (Jordan and Gilbert)—"Anchovy"

A number of these engraulids was collected at three separate localities in Sebastian Vizcaino Bay. Our first collection was made 27.8 km (15 miles) E of Point Eugenia in Sebastian Vizcaino Bay on October 1, 1970, where the fish were dip-netted from tide pools. The subsequent capture localities were at Lagoon Head (Oct. 2, 1970) and Playa Maria Bay (Oct. 3, 1970). These fish were captured by beach seine and ranged in size from 52 to 60 mm (2.0 to 2.4 inches) standard length (SL).

Clearing and staining facilitated identification of these fishes and meristics corroborated with those given by Hildebrand (1943). Specimens from the above collections are deposited at California Academy of Sciences (CAS 28745 and 28746).

These fish extend the known range northward approximately 370.6 km (200 miles) from San Juanico Bay (McHugh and Fitch 1951) to Playa Maria Bay.

Physiculus rastrelliger Gilbert—Hundred-fathom codling

Eight *Physiculus rastrelliger,* ranging from 127 to 178 mm (5.0 to 7.0 inches) SL, were captured in prawn traps on June 21, 1971, from a depth of 182.9 m (100 fm) off San Pablo Point. This collection is near the type locality for this species as reported by Fitch and Barker (1972). Their occurrence seems noteworthy, however, because this species is by no means common. All eight specimens (2 whole and 6 skeletonized) are now deposited at the Natural History Museum of Los Angeles County (LACM 32755-1).

Anoplopoma fimbria (Pallas)—Sablefish

Two sablefish were captured on June 23, 1971, in prawn traps off San Benito Islands. The traps were set in 219.4 m (120 fm) of water and these fish measured 380 and 403 mm (14.9 and 15.9 inches) SL. Fitch and Lavenberg (1971) note Cedros Island as the southern limit for this species. San Benito Islands are at a latitude equivalent to Cedros Island. These specimens are deposited at the Natural History Museum of Los Angeles County (LACM 32700-1).

Zaniolepis latipinnis Girard—Longspine combfish

Eleven longspine combfish were collected in a bottom trawl off San Cristobal Bay on June 22, 1971. The specimens ranged from 65 to 150 mm (2.6 to 5.9 inches) SL. Fitch (1953) recorded the southern limits as 2.8 km (1.5 miles) southwest of San Martin Island; thus, the present specimens extend the southern limits 222 km (120 miles).

Zaniolepis frenata Eigenmann—Shortspine combfish

A single shortspine combfish, 57 mm (2.2 inches) SL, was taken 14.8 km (8 miles) SW of Turtle Bay in a midwater trawl on June 22, 1971. The specimen captured off Turtle Bay extends the range southward a distance of 105.5 km (57 miles).

Agonopsis sterletus (Gilbert)—Southern spearnose

Two southern spearnose poachers were taken in a bottom trawl SE of San Martin Island. These fish were captured at a depth of 4.2 m (23 fm) on June 28, 1971, and measured 56 and 123 mm (2.2 and 4.8 inches) SL.

While searching for other individuals of this species, we found an *A. sterletus* deposited at the Natural History Museum of Los Angeles County (LACM 20819) which had been captured 11.1 km (6 miles) SE of San Hipolito Point. This fish measured 106.5 mm (4.2 inches) SL and was netted in 65.8 to 71.3 m (36 to 39 fm) of water on April 29, 1950.

Jordan and Everman (1896) report the southern limit for this species to be Los Coronados Islands. The capture at San Hipolito Point extends the range southward 685.6 km (370 miles).

Epinephelus niveatus (Valenciennes)—Snowy grouper

A snowy grouper was captured with a bottom trawl in San Cristobal Bay. This fish, netted at a depth of 67.7 m (37 fm) on June 22, 1971, measured 104 mm (4.1 inches) SL. Although this capture is within *E. niveatus* range, it is captured so infrequently, that this netting satisfies much needed catch localities of this species. This fish is deposited at California Academy of Sciences (CAS 28420).

Parophrys vetulus Girard—English sole

Four English sole were caught in a bottom trawl fished at a depth of 67.7 m (37 fm) in San Cristobal Bay on June 22, 1971. These fish ranged from 119 to 147 mm (4.7 to 5.8 inches) SL. The southern limit is extended from Cedros Island approximately 92.5 km (50 miles) southward by this collection.

Microstomus pacificus (Lockington)—Dover sole

Two dover sole, 158 and 203 mm (6.2 and 8.0 inches) SL, were captured in a bottom trawl on June 22, 1971, in San Cristobal Bay. The southern limit of this species has been recorded as San Quintin Bay, Baja California (Fitch and Lavenberg 1971), and Guadalupe Island (Roedel 1953). The specimens caught in San Cristobal Bay extend the known range over 185.3 km (100 miles) southward.

ACKNOWLEDGEMENTS

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OCCURRENCE OF THE PROWFISH *ZAPRORA SILENUS* JORDAN, 1896 IN MONTEREY BAY, CALIFORNIA

On the morning of October 15, 1973, a 50.1 cm (19.8 inch) Standard Length (SL) specimen of the rare prowfish, *Zaprora silenus* Jordan, 1896 was collected by John Fumotara on the trawler *New Janet Ann*. It was taken at 118 m (390 ft) on the north shelf of the Monterey Submarine Canyon at lat 36° 50′ N, long 121° 59′ W. This represents a southward range extension of approximately 161 km (100 miles) since it has recently been reported from Bodega Bay (Fitch and Lavenberg 1971; Miller and Lea 1972).

The specimen was brought to the vertebrate museum at the Moss Landing Marine Laboratories where all measurements, counts and photographs were taken. It has subsequently been deposited in the ichthyology collection at the California Academy of Sciences (CAS 30693).

Information on the monotypic prowfish is scarce because most references consist chiefly of notes on range extensions, some with meristic and morphometric data presented (Kendall 1914; Dymond 1928; Schultz 1934; Scheffer 1940; Schultz and Harvey 1945). However, Chapman and Townsend (1938) reviewed the osteology and early life history of the prowfish based on 36 specimens collected in the northeast Pacific off Washington, British Columbia and Alaska. Fitch and Lavenberg (1971) presented natural history notes summarizing the

TABLE 1.—**Meristic and morphometric data from *Zaprora silenus* (CAS 30693).**

Measurements	cm	% SL	% HL
Total length	50.1	119.9	575.9
Standard length (SL)	41.8	--	480.5
Head length (HL)	8.7	20.8	--
Body depth	11.6	27.8	133.3
Bony interorbital space	3.7	8.9	42.5
Snout length	2.0	4.8	23.0
Orbit diameter	1.7	4.1	19.5
Maxillary length	3.3	7.9	37.9
Depth caudal peduncle	4.7	11.2	54.0
Predorsal length	7.1	17.0	81.6
Preanal length	23.6	56.5	271.3
Length longest pectoral ray	8.0	19.1	91.6

Counts	
Dorsal fin rays	LVI
Anal fin rays	IV 26
Pelvic fin rays	absent
Pectoral fin rays	23
Branchiostegals	6
Gill rakers	8-18

known information on this species. McAllister and Krejsa (1961) reviewed its enigmatic taxonomic position, finally placing the family Zaproridae in the superfamily Stichaeoidae. Greenwood et al. (1966) have further placed the family in the suborder Blennioidei. Because little is known of this fish, even where it is more abundant to the north, the specimen was examined in detail to contribute as much information to its life history as possible.

The meristic and morphometric data (Table 1) compare favorably with published information on northern specimens (Kendall 1914; Dymond 1928; Chapman and Townsend 1938; Scheffer 1940) with the exception that our specimen, when carefully dissected and examined by X-ray, had four anal spines and 26 soft rays.

The right sagitta (otolith) was removed and measured 4.1 mm across its longest axis and exhibited three winter rings, with the last on the distal margin not quite complete, indicating that this fish was in its third year. As determined by serial sections of the gonad, our specimen was found to be an immature female with developing ova, indicating the possibility of spawning during the next season. Thus our specimen would probably have spawned in its fourth year, which agrees with growth zone readings on the otolith from a 33-inch male by Fitch and Lavenberg (1971). All of the juvenile specimens of *Zaprora* caught by Chapman and Townsend (1938) off Alaska were taken during the months of May, June and July, which may indicate a seasonality to their spawning habits, and thus a seasonality in the abundance of young prowfish in the plankton.

The stomach of our specimen was empty but the intestine contained the remains of nine hyperiid amphipods. No trace was found of jellyfish remains as reported by Fitch and Lavenberg (1971). No external or gill parasites were present. The specimen showed no unusual coloration, appearing uniform grayish blue with a slightly lighter ventral surface, and very noticeable light blue head pores.

ACKNOWLEDGEMENTS

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BOOK REVIEWS

Endemism in Fishes of the Clear Lake Region of Central California

By John D. Hopkirk; University of California Press, Berkeley, 1973; 135 p., illustrated in black-and-white photos.

The largest freshwater fish province within California is the Sacramento province. The Clear Lake region studied by Hopkirk encompasses all or part of 7 of the 10 districts within this province. It extends from 50–60 miles north and east of Clear Lake, to the Golden Gate on the south and the Pacific Coast on the west.

Citing fluviolacustine speciation, the Clear Lake minnow (*Endemichthys grandipinnis*), the Clear Lake splittail (*Pogonichthys ciscoides*), the Clear Lake hitch (*Lavinia exilicauda chi*), and the Clear Lake tuleperch (*Hysterocarpus traskii lagunae*) are described from the Clear Lake basin, as is an unnamed subspecies of *Cottus asper*. In addition, the tuleperch of the Russian River subprovince is now recognized as a new subspecies, *H. t. pomo.*

According to the author, the evidence from the fish fauna can now be added to that of the molluscan fauna, and that of the flora, in support of the thesis that the Clear Lake area is a center of endemism. There will be arguments, however, as to the strength of this evidence. The differences between these "endemics" and that of their extrabasin congeners is small and the argument can be raised that, for example, *P. ciscoides* deserves no more than subspecific recognition.

Endemichthys grandipinnis, a new genus *and* species, is based upon 12 specimens collected in 1939 and 1940. The characteristics that distinguish this taxon from related taxa are minor indeed, and one might conclude we are dealing with hybrids grandipinnis, between *Lavinia exilicauda* and *Orthodon microlepidotus*, as earlier workers who examined this material have done. No less an authority than Dr. Carl L. Hubbs, however, reportedly agrees with the author's diagnosis.

In any event, the author has compiled a considerable amount of data on native fishes of the Clear Lake region and their distribution. Particularly valuable is a listing of these fish (exclusive of Petromyzontidae, Acipenseridae, and Salmonidae) in the collections of 7 ichthyological museums through about 1966. The systematic discussion of each genus and species is especially detailed, but I would like to have seen more graphical and statistical treatment of the data presented, particularly where the new species and subspecies are concerned. The sections on geology, biogeography and zonation of fishes are brief but informative.

Not since Snyder's work on the fishes of the Lahontan system has there been a comprehensive treatment of the native fishes of a major California region. Regardless of whether or not one agrees with its taxonomic conclusions, it is a welcome addition to the sparce taxonomic literature on California's native freshwater fishes. —*Stephen J. Nicola*

Western Trout Fly Tying Manual

By Jack Dennis; Snake River Books, Jackson Hole, WY 1974; 258 p., illustrated. $6.95

Finally, a book about western fly patterns! The "west" in this case means Montana, Wyoming, Idaho, and Colorado but the patterns described include many patterns commonly used in California.

Jack Dennis has written an extremely useful "How-to" book for both the beginner and the more advanced tyer. Over sixty patterns are detailed in the Manual: Drys, wets, streamers, nymphs, and a special section on hair flies for our more turbulent western waters.

The origin of each fly is briefly described, the most commonly used sizes listed, and information on how it would be fished is often illustrated with a personal experience. A detailed list of materials is provided and finally, step-by-step photographs (black and white) of the actual tying process. As always, a picture is worth a thousand words; the photos are clear, the proportions obvious, and the photo of the finished fly gives the novice tyer something to shoot at.

The Manual also has a brief chapter on materials and tools, a chapter on special fly tying techniques, and a special section on the use of the whip finishing tool. The author explains what equipment and hooks he prefers, and tells where they can be obtained. Far too infrequently do authors provide enough information on brand names and sources of supply; this feature will be appreciated by the beginning tyer.

The *Western Trout Fly Tying Manual* is available in paperback at a price of $6.95; there is also a special limited edition, signed and numbered by the author for $35.00.—*K. A. Hashagen, Jr.*

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INSTRUCTIONS TO AUTHORS

EDITORIAL POLICY

The editorial staff will consider for publication original articles and notes dealing with the conservation of the fauna and flora of California and its adjacent ocean waters. Authors may submit two copies, each, of manuscript, tables, and figures for consideration at any time.

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