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"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 63 JULY 1977 NUMBER 3

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ERRATUM

Behrstock, Robert A. 1976. First record of the decorated Warbonnet, *Chirolophis decoratus* (Jordan and Snyder 1902), in California waters. California Fish and Game 62 (4) :308-309.

Last line in first paragraph should read:

"The name currently accepted by the AFS/ASIH for this fish is decorated Warbonnet, *Chirolophis polyactocephalus* (Pallas 1811)."

Calif. Fish and Game 63 (3): 140–156 1977

FECUNDITY AND GROWTH OF THE TULE PERCH, *HYSTEROCARPUS TRASKI,* IN THE LOWER SACRAMENTO-SAN JOAQUIN DELTA[1]

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***Hysterocarpus traski* were collected at the Bureau of Reclamation's fish screen near Tracy, California, from September 1972 to November 1973. Additional specimens were borrowed from the California Academy of Sciences. The testes and ovaries of 130 fish were examined.**

Sexual maturation of gonads is cyclic. The males are sexually mature during the breeding season, May to late October. The ova of the females, through the mechanism of delayed fertilization, are not fertilized until mid-January. Gestation takes 3.5 months. The average number of young is 47.4. The young tule perch are not born sexually mature, but reach maturity within a few weeks. A female may be inseminated within weeks of her birth and will become pregnant in January.

INTRODUCTION

The tule perch, *Hysterocarpus traski,* (Figure 1) are the lone fresh water member of the viviparious surf perch family, Embiotocidae, in the lower Sacramento-San Joaquin Delta (Figure 2). Tule perch are relatively scarce in the Delta and especially scarce in the lower (southern) portion of the Delta. This is due to irrigation projects altering and destroying their habitat and to increased competition from introduced exotic fish species imported from the eastern United States and Eurasia. Although little information has been published, several MA

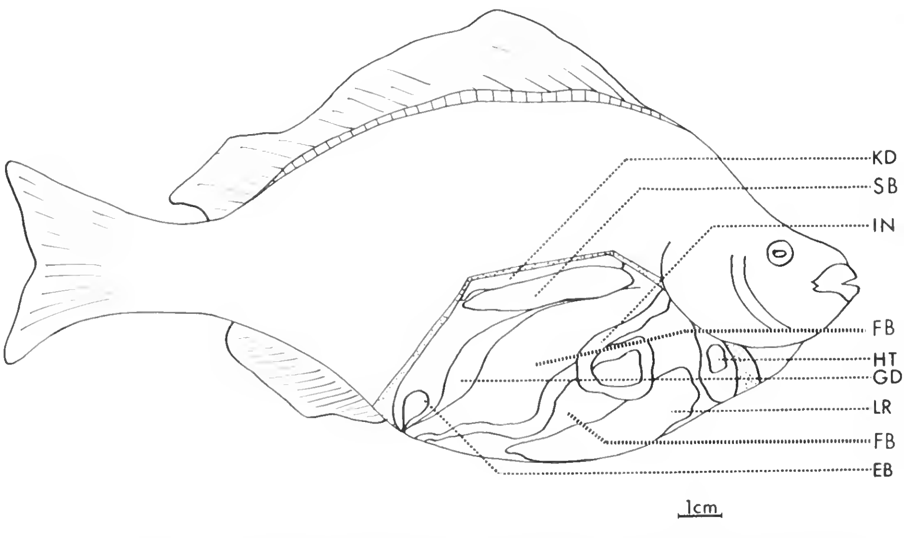

Figure 1. Relationship of internal organs within *Hysterocarpus traski.* (SB, swim bladder; EB, excretory bladder; FB, fat body; GD, gonad; HT, heart; IN, intestine; KD, kidney; LR, liver)

[1] This paper is based on a thesis written in partial fulfillment of requirements for the degree of Master of Arts at California State University, Long Beach.

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theses (Hopkirk 1962; Bundy 1970; Bryant 1974), student papers, and a Ph.D. thesis in part (Hopkirk 1974) have been written on the tule perch. This paper will contribute to the published knowledge of tule perch life history.

MATERIALS AND METHODS

One hundred and thirteen fish were collected throughout the year (September 1972 to November 1973). The majority of the fish were collected from the Tracy Fish Collecting Facility about 10 miles northwest of Tracy, California. Fifty-four fish were borrowed from the Museum of the California Academy of Sciences in San Francisco. All fish examined were from the lower Sacramento-San Joaquin Delta (Figure 2).

Each specimen used in the study was given a catalog number. Date, locality, and time of capture were recorded for each fish. Each fish was weighed to the

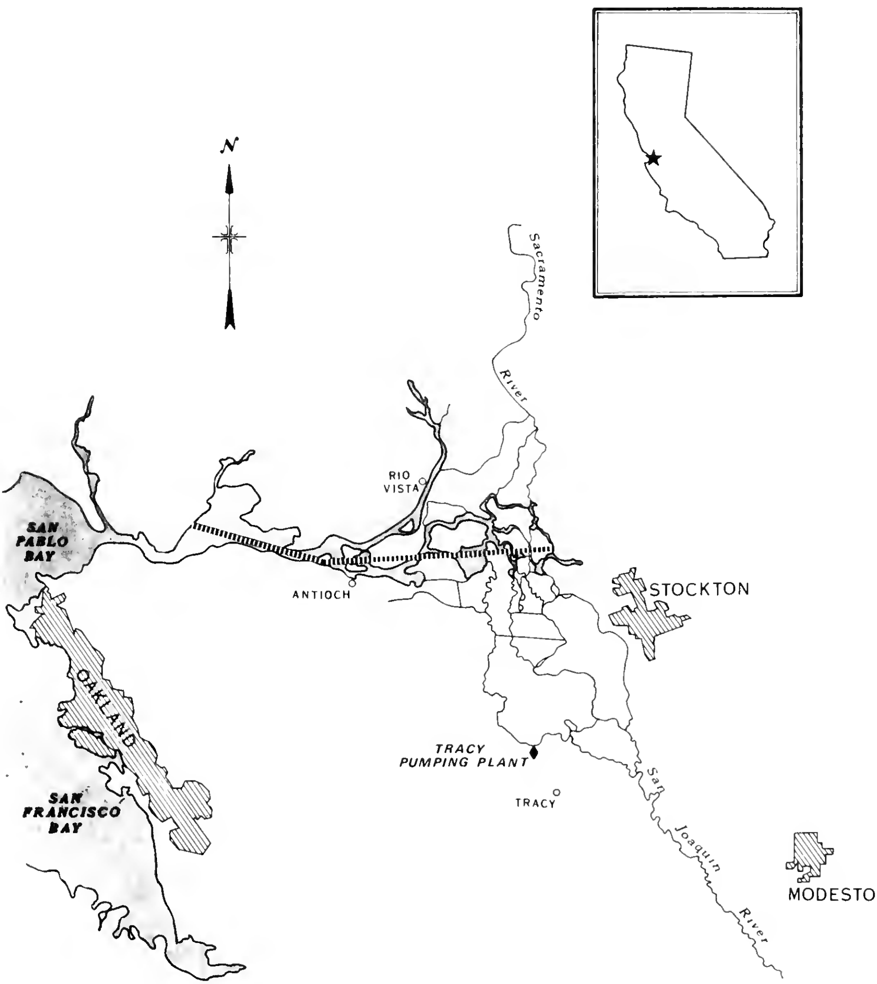

Figure 2. Sacramento-San Joaquin Delta, California and adjacent water. All fish examined were collected from the area south of the slashed line.

nearest tenth of a gram (g) on a triple beam balance. Standard length (SL) was measured with vernier calipers to the nearest millimeter (mm). Standard length was used for fish greater than 6 mm (0.24 inch). Total length (TL) was used until embryonic tail elements were discernable. Initial preservation was in 10% formalin; final preservation was with 80% ethyl alcohol.

The gonads of all fish were weighed and measured to the nearest millimeter and tenth of a gram. A gonadosomatic index (GSI) (Weibe 1968) was calculated by the following formula: gonad weight (g) × 100/fish weight (g). Ovaries of each female were opened to determine if the fish were pregnant. If pregnant, the length (mm), weight (g), and orientation and number of embryos were determined. The degree of maturity of sperm and ova was determined using an inverted compound microscope.

I used scales for age determinations. Use of scales has been proven a reliable method for determining the age of other embiotocids (Carlisle, Schott, and Abramson 1960; Wydoski and Bennett 1973). Scales were removed from different locations on the fish in an effort to determine the optimal area for scale sampling. The area located two scales below the hump in the lateral line and on a diagonal row from the base of the first dorsal spine was determined to be most suitable for taking easily readable scales. At least ten scales were taken from the left side of each fish. The scales were placed on a microscope slide with the anterior margin facing away from the reader. The anterior-lateral corners gave the most reliable, consistent readings. The scales were read with a stereozoom microscope at about 60×, using reflected light on a dark background.

Water quality at Tracy was continuously monitored by one of the Bureau of Reclamation's mobile multiparameter water quality monitoring stations. Several parameters were continuously monitored but only water temperature and length of day were graphed, examined, and related to the fecundity of the tule perch.

RESULTS AND DISCUSSION

General

Hysterocarpus traski are sexually dimorphic, the male having a fleshy glandular enlargement at the anterior portion of the anal fin. On either side of this enlargement is a bulbous gland with its tubular appendage (Figure 3). The function of the gland is still unknown (Shaw 1971). The anal fin thickening can be seen in embryonic tule perch a week or two prior to parturition as an opaque dot (Hopkirk 1962). Males also possess a crescent-shaped depression in the body surface (semilunar notch) dorsal to the anterior portion of the anal fin (Tarp 1952). Hubbs and Hubbs (1954) believe this area is used to receive the anal spines of the female during copulation. A genital papilla is present and is probably used for sperm transfer.

The mating of *Hysterocarpus traski* has been described only once, in a letter to the California Academy of Sciences by an aquarist named Stephens (1962). He states that the male fish turned a deep purple, quivered, curved slightly, forming a cup under the female fish, and brought his anal fin in close proximity to the female's anal fin. The male remained in this position only a few seconds. This description of the breeding habits, although sketchy, is similar to that of

Wales (1929) for *Damalichthys argyrosomous* and Wiebe (1968) for *Cymatogaster aggregata.*

The relative position of the internal organs are shown in Figure 1. The diagram represents neither female nor male, so it is important to note that a female with her ovary so arranged would be in a reproductively inactive state. A pregnant *Hysterocarpus traski* has her internal organs, especially the intestine, pushed anteroventrad by the greatly enlarged ovary.

The spermatozoa of the tule perch were observed by the use of a phase contrast microscope at 1,000 magnifications. The spermatozoan head is sausage-shaped and approximately 7 μ long. Some spermatozoa have one or two small spheres below the head, making up the mid-piece of the sperm. The flagellum

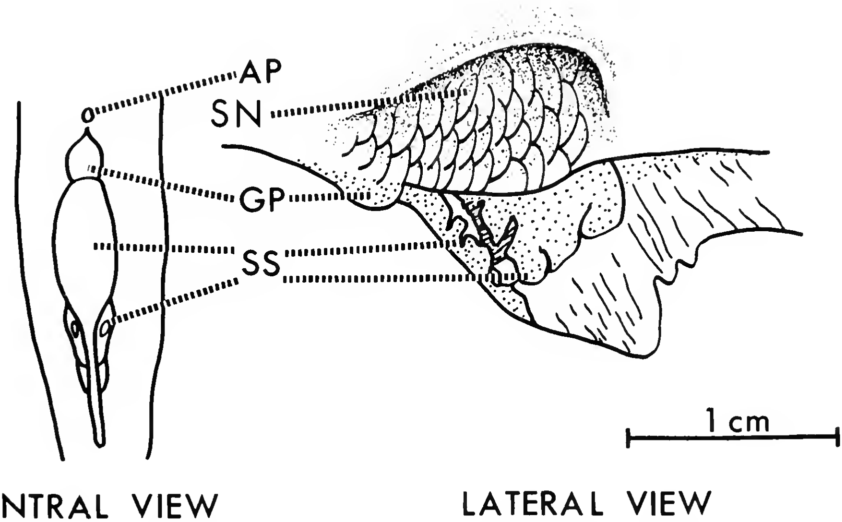

Figure 3. Diagrammatic representation of the male *Hysterocarpus traski* anal fin gland. (AP, anal pore; GP, genital papilla; SN, semilunar notch; SS, swelling and tubular structure of secondary sex character). (Adopted from Wiebe 1968 Figure 2).

of the sperm is about three times the length of the body, or about 21 μ long. The overall length, although a complete spermatozoan was never observed, is estimated to be about 28 μ long.

The tule perch ovary, like that of other embiotocids, is single, with two anteriorly divided arms. One arm is vestigial, thus giving the ovary a spindle-shaped appearance. Within the ovary are several convoluted, ovigerous folds which form two separate sacs, each with two to three compartments (Figure 4). The folds are attached dorsally and connected to one another at the anterior and ventral surfaces, but not posteriorly. It is interesting to note that Bundy (1970) states that the right sac is composed of three compartments while the left sac is composed of only two compartments. Hopkirk (1962) and other investigators, when describing ovarian structure, mention only two compartments in each sac. Personal observations showed that one female out of the 16 examined had three compartments in the left sac and two in the other. The other females examined had only two compartments in each sac. Although the sacs themselves have only two or three compartments, the entire ovarian cavity can be divided into seven or eight compartments (Figure 4). The two outside compartments are bound laterally by the ovarian wall and medially by the ovigerous folds.

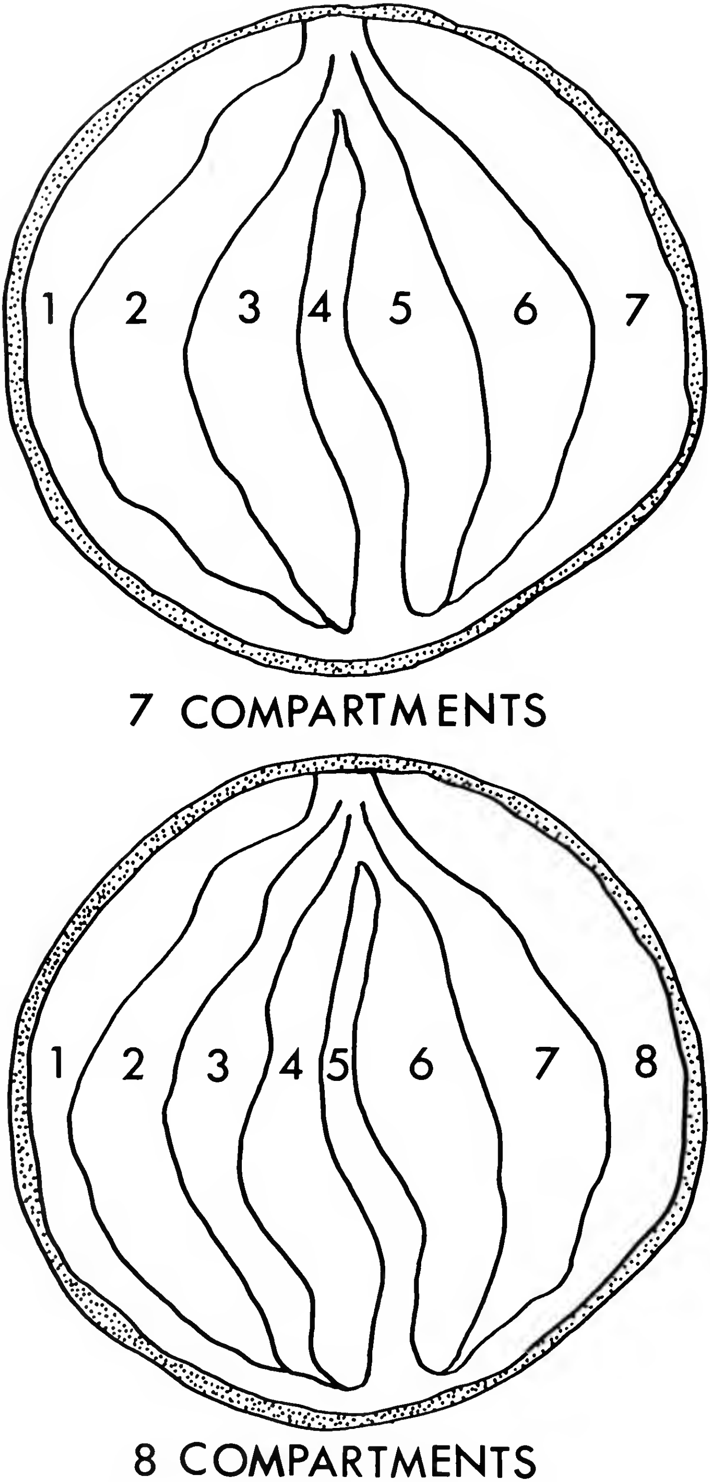

Figure 4. Diagrammatic cross section of an ovary containing seven or eight compartments.

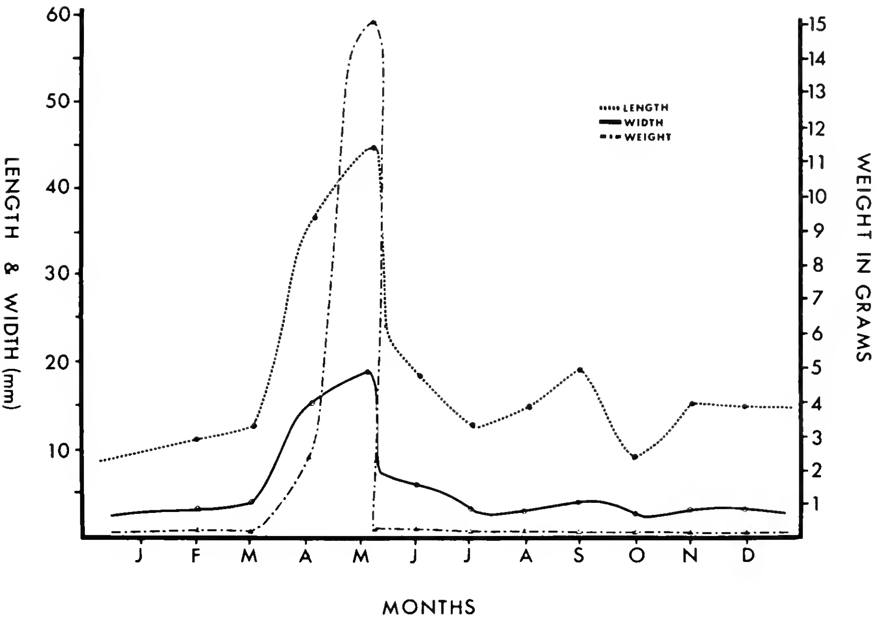

Figure 5. Comparison of ovary size throughout the year. Note the dramatic increase in standard length, width, and weight during the months of March, April, and May.

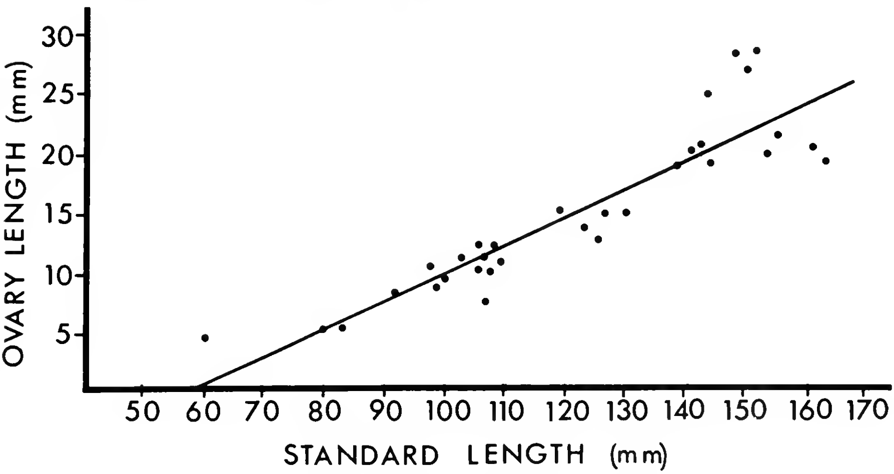

Figure 6. Standard lengths versus ovary lengths during the ovary's quiescent months, June through December.

Each ovarian compartment is filled with embryonic fish. The number of fish retained in each compartment was counted in five female fish caught on the same day. There did not seem to be a significant difference in the number of young per compartment but more counts are needed to verify an equal distribution of embryos among compartments. The ovarian wall becomes thin when distended by maturing embryos but within a few days after the release of the embryos the ovary returns to its quiescent state and the walls become relatively thick. Measurements show a five-fold increase in the diameter of the ovary between the quiescent period and the period where the embryos are almost fully mature. There is a three-fold increase in length and a forty-fold increase in weight (Figure 5). The ovaries of tule perch get larger as the fish increase in length and age. This gradual increase in length during the months when the ovary was quiescent (June to December) was plotted graphically (Figure 6).

Although copulation has never been observed *in situ* in *Hysterocarpus traski*, the approximate time of copulation, along with other related information, can be gained by plotting a gonadosomatic index (GSI) (Wiebe 1968) (Figure 7). The plot of the female's GSI looks very similar to Wiebe's (1968) plot for *Cymatogaster aggregata*. Fertilization occurs early in January; gestation proceeds to late April and parturition generally occurs in early May (Hopkirk 1962; Bundy 1970). Within days after parturition, the ovary reduces to a fraction of its former size. The plot of the males' GSI did not show a dramatic increase in testicular weight (Figure 7), however, because of the scarcity of male tule perch in the samples, only a fragmentary plot could be developed. The trend of the plot seems to indicate that spermiogenesis begins in early March, with sperm release over a period of several months, May to late October, with a restitution of testes and spermatogonia formation from early November to early May. A greater sample of mature tule perch testes should be examined to confirm the above suggestion.

Further microscopic observations on newly born young showed that young male and female tule perch are not sexually mature when born. The males become mature when their standard length is between 58 mm (2.28 inches) and 65 mm (2.56 inches). Females become mature by 55 mm (2.17 inches). Since fertilization in the tule perch does not occur until January, an attempt was made to find spermatozoa within the ovary prior to January and, therefore, prove delayed fertilization occurs. Hopkirk (1962) had observed, in histological sections, clusters of spermatozoa in the crevices of the ovarian sacs of females collected in October. Female tule perch young-of-the-year taken during the month of August were used. Any sperm found within their ovaries would remain there until January. Sperm in the ovary would show that copulation can take place prior to August as indicated by the male tule perch GSI. Spermatozoa found in a young-of-the-year fish would show not only that delayed fertilization does occur but also that young-of-the-year tule perch are inseminated. Phase contrast microscopy confirmed the above. Spermatozoa were found in the ovary of a young female. The sperm were gathered around a piece of material resembling a spermatophore 140 μ long and 35 μ wide.

Gestation

Modifications occurring within the embiotocid ovary and embryo during gestation have been described by Turner (1938), Ishii (1957), and Wiebe (1968). A summary of their findings will show how the embryos facilitate the exchange of nutrients and respiratory products. The epithelial cells lining the highly convoluted ovarian cavity and ovigerous folds develop internal fluid reservoirs. Extensive sloughing off of epithelial cells is caused by the breakdown of cell walls and the increase in fluid reservoirs. The epithelial cells secrete the fluid into the cavity. The fluid and epithelial cells are thought to have a nutritive

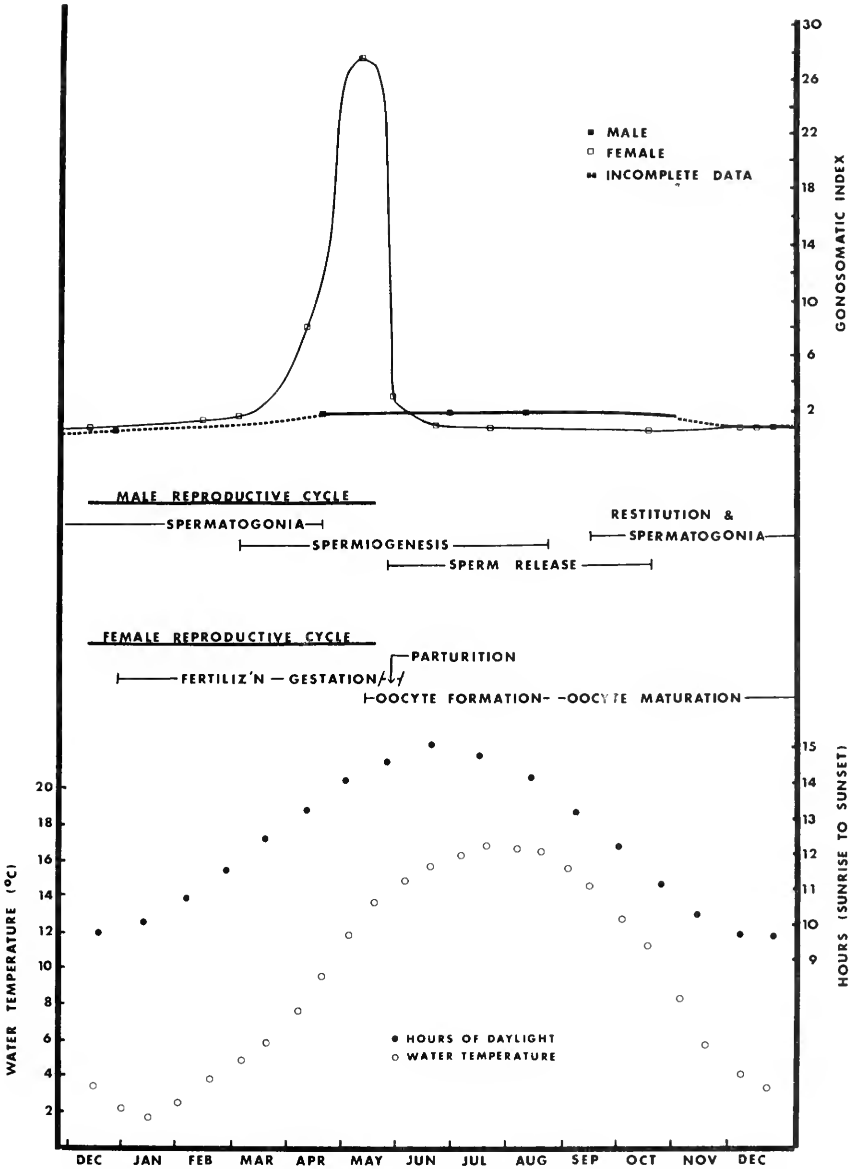

Figure 7. Cyclic nature of the male and female gonads compared to length of day and temperature. (Gonadosomatic index = gonad weight (g) × 100/fish weight (g))

function for the developing embryos. After the first gill cleft is formed, the alimentary canal begins to function and desquamated cells, sperm, and blood cells are used as food (Turner 1938; Amoroso 1960). Vascularity increases and ramifies just beneath the epithelium of the ovarian wall and ovigerous sheets. The embryos are thus provided with both nutrition and oxygen from the epithelial lining (Wiebe 1968; Webb and Brett 1972). Presumably, toxic nitrogenous wastes are also absorbed through the vascular ovarian tissue of the mother (Turner 1952) by whom they are later excreted along with parental waste. Rapid involution of the ovary occurs following the release of embryos. Most internal ovarian structures undergo a marked reduction in thickness, epithelium becomes cuboidal, fluid within the cells decreases, and the extensive capillary network within the tissue recedes (Ishii 1957; Wiebe 1968).

There is large fat body surrounding the ovary during early gestation (Hopkirk 1962). The amount of fat was observed to be cyclic, with the maximum amount occurring around October and a gradual decrease through winter and into May. The decrease in fat is probably due to: (1) absorption as an energy source during the winter months, (2) absorption as an energy source for maintenance and development of young.

The embryonic structures of the tule perch were studied by Bundy (1970) and are presented with my own personal observations (Figures 8a, b, c). I collected embryos from February to parturition in April and May. In mid-February the average embryo size was 0.25 mm (0.01 inch) TL. I believe this stage is the living larvae shortly after hatching into the ovarian cavity. This decision was made on the basis of information in Eigenmann (1894). By comparing the embryo size to those described by Eigenmann (1894), I determined that fertilization of the egg occurred sometime in January. Immediately following fertilization, which is intrafollicular, and before segmentation is complete, the egg hatches into the intraovarian cavity (Amoroso 1960). By the first of March embryos had reached a total length of 2.5 mm (0.10 inch) (Figure 8a). The larva is straight, with the notochord extending from beneath the hindbrain to the caudal fin. The eyes are not well differentiated and the dorsal and ventral fin folds are present. A yolk sac is present with a small amount of yolk. The hind gut extends beyond the yolk sac. By late March the embryo has reached a total length of 5.8 mm (0.23 inch). (Figure 8b). The lens of the eye is distinct, as are the head and gill regions. The liver is present and the yolk sac has disappeared. The heart is distinct and the intestine is coiled, with the hind gut protruding from the body.

As soon as the caudal region could be reliably discerned, approximately 6 mm (0.24 inch) TL, I started using standard length for measurements instead of total length. At the 9-mm (0.35-inch) SL stage, around the first of April, spatulate appendages are formed on the dorsal, caudal, and anal fins. The appendages lie free in the ovarian fluid but in juxtaposition to the hypertrophic ovarian epithelium. Because of their high degree of vascularization (Figure 9), the spatulate appendages are thought to act like the mammalian placenta (Wiebe 1968), absorbing oxygen and possibly nutrients. I observed that immediately following parturition, the heavy blood circulation in the spatulate portion of the fin is slowly reduced and within 45 minutes no more blood is pumped into the spatula. Shortly thereafter, all spatulas are worn off or disintegrate and the fins of the young tule perch attain their normal adult configuration.

Turner (1952) noted ovarian tissue inserted into the opercula of the embryos of *Cymatogaster aggregata*. I observed the same phenomenon in *Hysterocarpus traski*. The ovarian tissue is brought in direct contact with the gills. The operculum is distorted by the ovarian tissue but is not permanently affected. Only about half of the embryos had this invasion of ovarian tissue into their gill pouches. There is no apparent advantage or disadvantage to the invasion of ovarian tissue since all the fish looked and acted normally. The condition de-

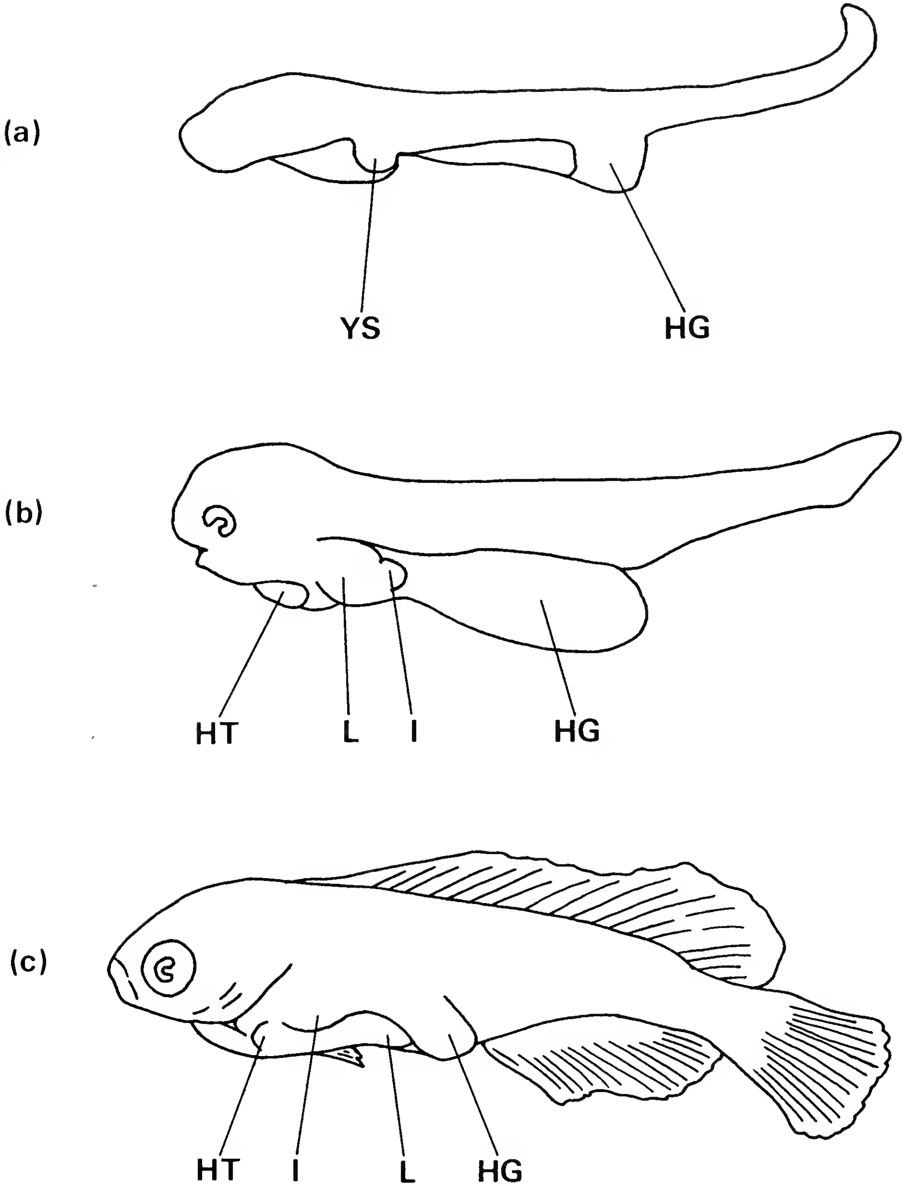

Figure 8. (a) Embryo at the 2.5 mm (0.10 inch) TL stage, (b) Embryo at the 5.8 mm (0.23 inch) TL stage, (c) Embryo at the 14 mm (0.55 inch) SL stage, (HG, hind gut; HT, heart; I, intestine; L, liver; YS, yolk sac).

Figure 9. Photograph of the spatulation on the fin of an embryonic *Hysterocarpus traski.* Notice the high degree of vascularization in the fin. Spatulas are lost shortly after birth.

scribed must, therefore, be considered, as Turner (1952) did, a facilitating mechanism and not essential to normal development.

By the middle of April the embryo is 14 mm (0.55 inch) long SL (Figure 8c). The caudal fin rays begin to develop during this time. There seems to be no change in the digestive system but the eyes, brain, opercle, and maxillary bones are well developed.

No larvae were obtained at the 20-mm (0.79-inch) SL stage, mid to late April, but Bundy (1970) described them as having well developed dorsal and anal fins. Pelvic and pectoral fin buds are present and the heart is beating. He also states that the dermal flaps (spatulate appendages) begin at this stage. As previously mentioned, they were noted at the 9-mm (0.35-inch) SL stage. Parturition occurs in late April or early May when the embryo's standard length is approximately 29 mm (1.14 inches). The embryos are fully developed, lateral lines and scales are present, and the intestine is completely within the body cavity. The pelvic and pectoral fins are well developed. Sexual dimorphism and color phenotypes are easily distinguished.

Table 1. Information on Ovaries Dissected Prior to Parturition

	Number of young per ovary	*Sex*		*Direction of Embryo*			*Coloration*	
		male	*female*	*ant.*	*post.*	*int.*	*barred*	*non-barred*
	5	0	5	1	1	3	0	5
	86	42	44	+	+	+	68	18
	70	*	*	14	40	16	*	*
	93	45	48	93	0	0	11	82
	85	37	48	75	3	7	4	81
	54	30	24	48	3	3	21	33
	11	4	7	11	0	0	5	6
	20	*	*	17	2	1	*	*
	39	*	*	14	19	7	*	*
	51	*	*	43	8	0	*	*
	23	*	*	2	7	5	*	*
	36	*	*	15	10	11	*	*
	43	*	*	30	13	0	*	*
Total	616	158	176	363	106	53	109	225
Average	47.4	26.3	29.3	30.3	8.8	4.4	18.2	37.5
Percentage ..		47	53	70	20	10	33	67

* Too young to determine sex
\+ Mother aborted prior to determination

The majority of tule perch are born tail first, but a few were observed coming out head first or in a convoluted state as if they were in the process of turning. Examination of fig. 12, near-term ovaries (Table 1) showed that 70% of all the embryos faced anteriorly, 20% faced posteriorly, and 10% were intermediate, lying oblique to the long axis and possibly in the process of turning. A greater percentage of embryos faced anteriorly the closer they came to parturition. The embryos were arranged in a space conserving manner, so the head of one embryo rested near or on the tail of another embryo.

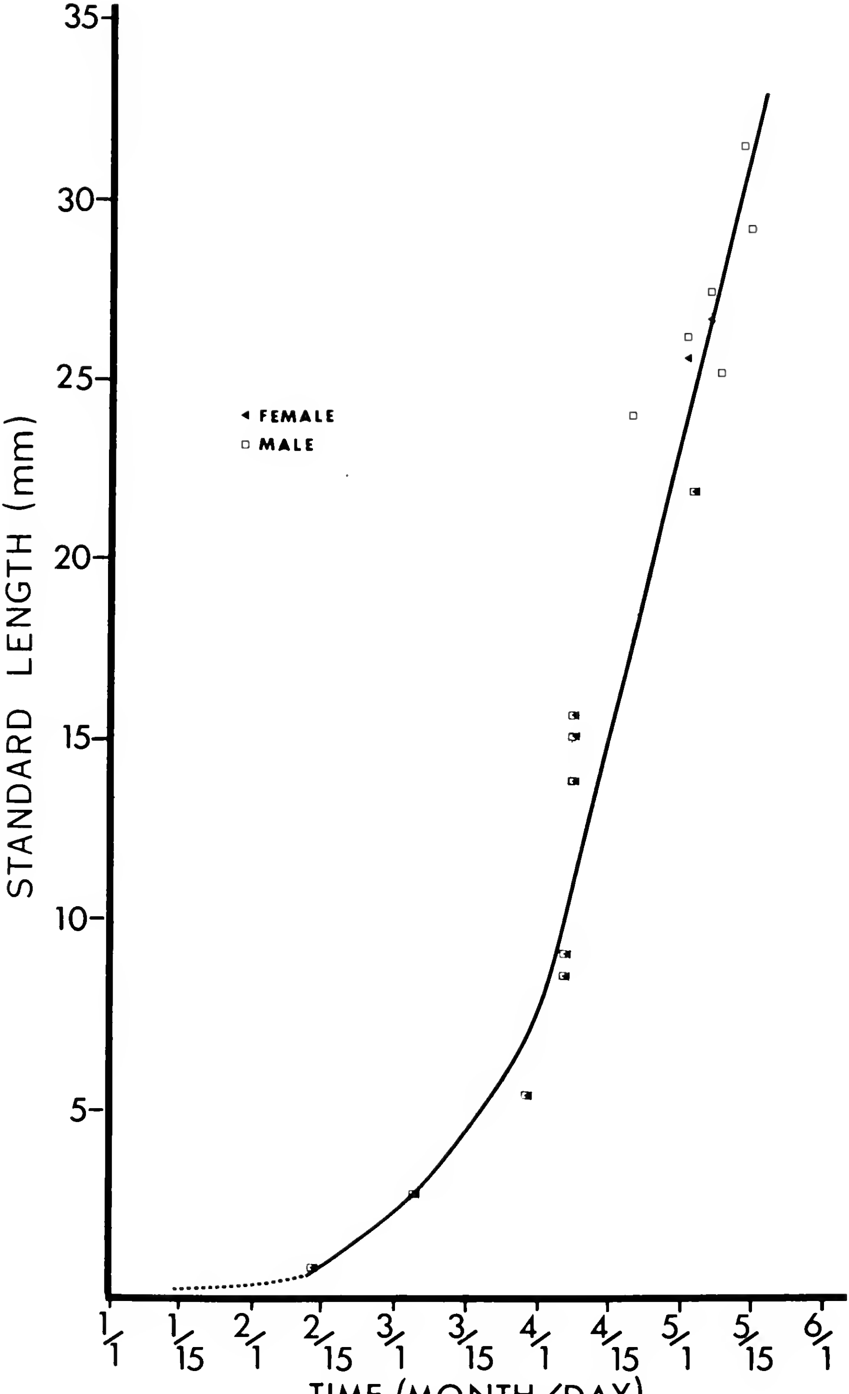

Figure 10. Growth rate of embryos from the smallest collected to parturition. The dotted line indicates no embryos obtained during that time.
*Total length was used for fish measuring less than 6 mm (0.24 inches). See materials and methods section.

Growth

A growth curve of prenatal embryos is slightly sigmoid (Figure 10). From the time of fertilization in January until the middle of February, there is little increase in length. The length of the embryo increases at a rate of 1 mm per week by March, with the most significant increase of 4.5 mm (0.18 inch) per week occurring between the first and fifteenth of April. No difference was found between the growth rates in males and females. The largest embryo observed was 31 mm (1.22 inches) SL and 0.7 g (0.02 oz). *Hysterocarpus traski* that are giving birth have, on occasion, part of the posterior part of the ovigerous fold protruding from the ovipore. This is immediately withdrawn after birth. Prenatal mortality was not studied, but in several ovaries there were dark granular spots which may have been remnants of an embryo being absorbed.

Generally speaking, smaller and younger tule perch produce fewer young. More than 25% of all of the fish examined had 70 embryos or more. All three year classes were represented in that 25%. The average number of embryos for all year classes was 47.4 (Table 1). This agrees with Bundy's (1970) data. His average number of embryos for all classes was 45.1. The slight imbalance in the sex ratio in the ovaries (males are 47% of the total) is interesting because, of 113 fish collected, only 42 were males, suggesting that the *Hysterocarpus traski*

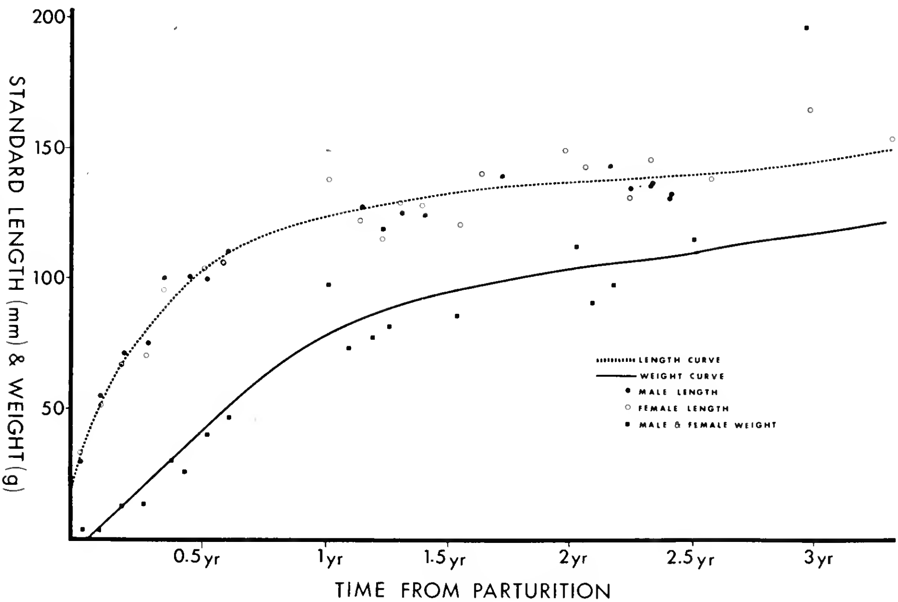

Figure 11. Increase in standard length and weight after parturition.

population is 37% males and 63% females. The above figures are probably misleading because Hopkirk (1962) has observed male and female tule perch schooling separately, which could mean the males are in another part of the Delta during certain periods of the year, with the schools coming together only during the mating season. It could also mean that females are more easily trapped.

The time from parturition (Figure 11) was computed in half-year increments by knowing the approximate time of parturition, period of scale annulus formation, and the date of capture. Fish caught between June 1 and November 30 were recorded as either 0.5, 1.5, or 2.5 years old. Fish caught from December 1 to May 31 were recorded as 1, 2, or 3 years old.

The most dramatic increase in the length of tule perch is within the first 7 months after parturition (Figure 11). By December of the first year and thereafter there is only a gradual increase in length. Most fish have obtained a length of 120 mm (4.72 inches) SL (Figure 11) by May 31 of the first year. The second year they are about 135 mm (5.31 inches) SL and by the third year they will be 145 mm (5.71 inches) SL or longer.

There is not a dramatic increase in weight the first 7 months (Figure 11), rather there is gradual climb to 60 g (2.12 oz) by the first year. The second year fish weigh around 90 g (3.17 oz) and the third year fish weight about 105 g (3.70 oz).

For the sake of comparison, the lengths of the fish for each age group were calculated in the traditional manner, with 0 equaling the time from parturition to January 1 and ages I, II, and III being the consecutive calendar years (Figure 12 and Table 2).

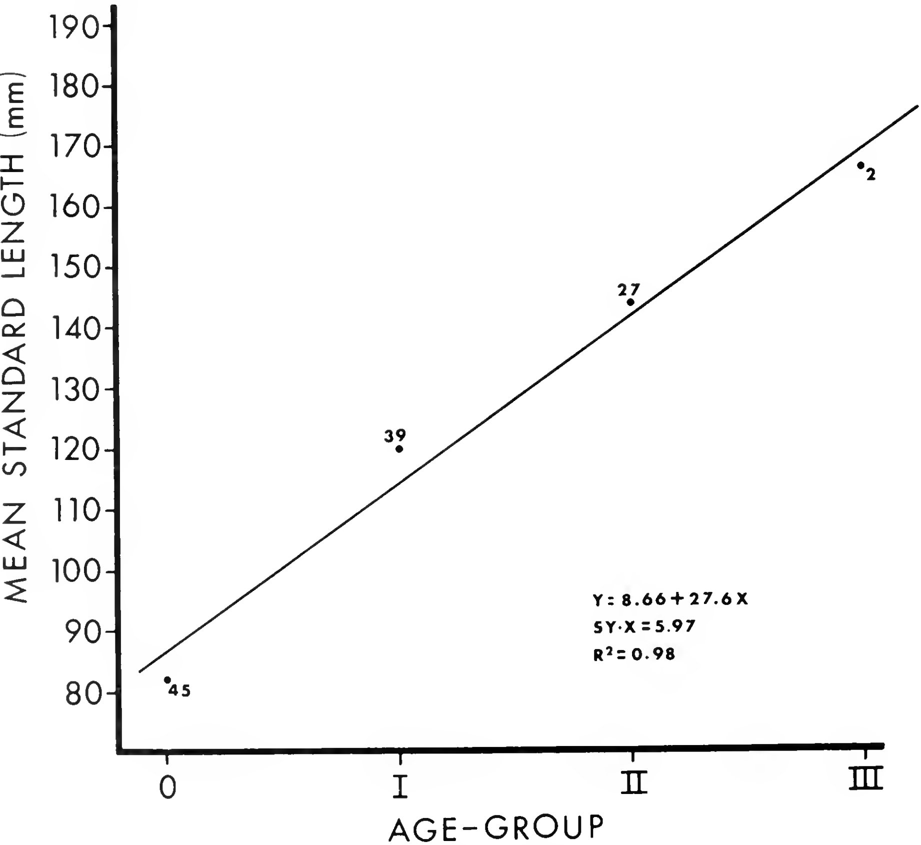

Figure 12. Mean length of fish in each age group. Numbers along regression line refer to the number of individuals sampled. (Y = regression line; Sy.x = standard error of estimate; R^2 = coefficient of correlation).

Table 2. Statistical Data Concerning the Standard Lengths of Fishes in Each Age Group

	Age class			
	0	*I*	*II*	*III*
N	45	39	27	2
$\overline{X} \pm S\bar{x}$	81.8 ± 3.6	119.7 ± 3.6	143.9 ± 1.8	165.5 ± 4.5
S^2	596.7	490.6	86.3	40.4
CV	30%	19%	6%	4%

N = Number of fish; $\overline{X}$ = mean of sample; $S\bar{x}$ = standard error; S^2 = variance; CV = coefficient of variation

Length and weight relationships (Lagler 1956) were calculated using the squares method and plotted (Figure 13).

$\text{Log } W = -6.0453 + (3.7819 \times \text{Log } L)$
Where W = weight in grams, L = standard length in millimeters, $-6.0453 = \log a$
$a = \times$ (correlation coefficient), 3,7819 = n (exponent, relationship of length to weight).

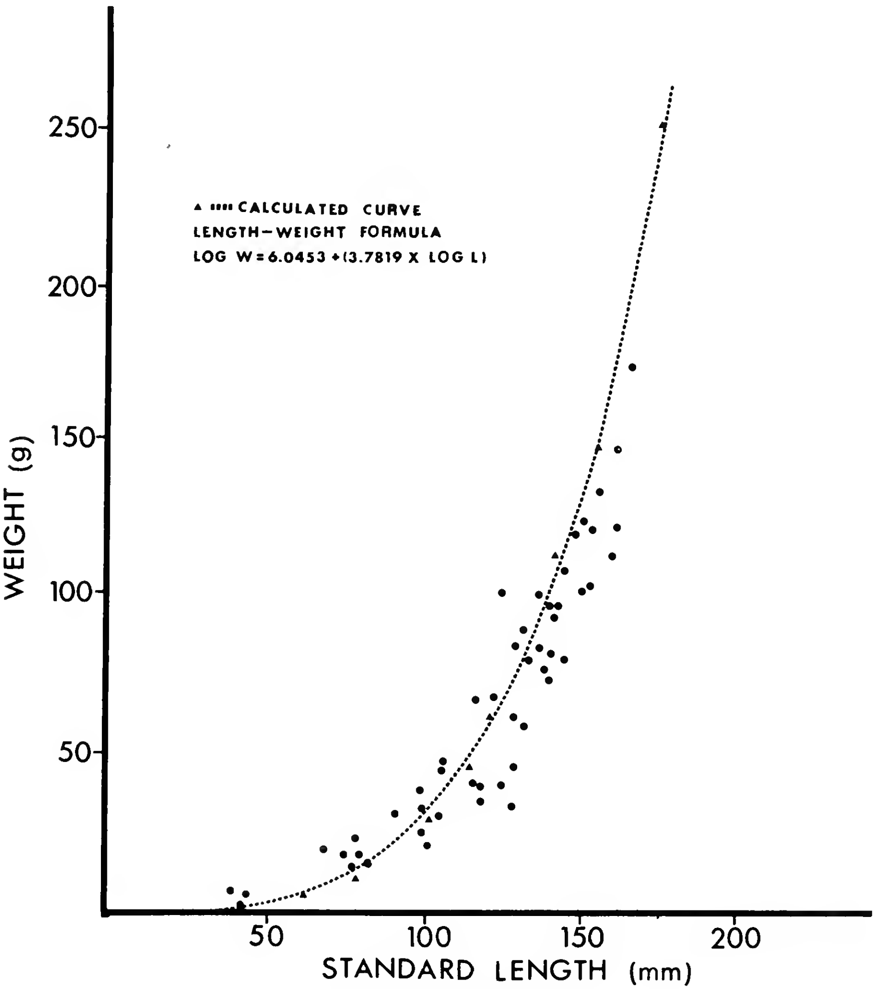

Figure 13. Relation of length versus weight in *Hysterocarpus traski.*

Length increases more rapidly than weight up to a length of 110 mm (4.33 inches); after that the rate of increase is equal.

Most of the studies on the tule perch have been focused on the live bearing characteristics of the fish, an area which is still open to much study, but there are many other aspects of tule perch biology which need exploring. Little is known about its distribution throughout the Delta, its schooling habits, food, survival of young after parturition and mating behavior, to name only a few. Even less is known about the effects of man's encroachment in the Delta on this species. This information, though not easily obtained, would make many interesting and challenging studies.

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I wish to express appreciation for the assistance given me by my advisor, George Callison, during all phases of this investigation. I am grateful also to Cliff W. Hill and Stuart L. Warter for their suggestions and critical review of the manuscript.

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MIGRATION OF THE NORTH KINGS DEER HERD [1]

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Forty-five deer were captured on summer and winter ranges from January, 1972, through July, 1975. Six newborn fawns and 24 adult does were radio collared and those with operating collars were closely monitored through four fall and four spring migrations to determine home ranges and migration patterns. North Kings deer make test trips above the winter range prior to spring migration. Spring migration lasted up to 7 weeks, largely dependent on weather and plant phenology. Deer migrating to higher summer ranges left their winter ranges at approximately the same time as those summering at lower elevations. Fall migration lasted up to 6 weeks, influenced mainly by weather. Deer at higher elevations began migration earlier than those at lower elevations. Migrational delays of up to 40 days were observed in holding areas located along migration corridors during both spring and fall migrations. Individual deer used the same migration routes, the same holding areas, and summer and winter home ranges each year.

Deer preferred herbaceous forage during spring migration and browse and acorns during fall migration. Cover is important along migration corridors, especially during fall migration. Roads, trails and other public use facilities eliminate habitat and public use disturbs migratory animals. Public access and developments in or near holding areas are detrimental, especially where cover is inadequate. Most holding areas evaluated lack adequate cover or forage indicating improvements are needed to improve the deer nutritional plane and possibly improve fawn survival. Habitat improvements can best be achieved by coordination with various forest land management activities.

INTRODUCTION

California's migratory deer herds have generally been on a gradual decline since the mid 1950's. Direct human usurpation of deer habitat and deterioration of range conditions are believed responsible. These factors have eliminated deer and reduced productivity.

The Department of Fish and Game, U. S. Forest Service, National Park Service and Fresno County Sportsmen's Club in 1970 jointly agreed upon a pilot deer management study, the North Kings Deer Management Project, in eastern Fresno County. The objectives were to determine the cause of poor fawn survival, devise means of coordinating deer habitat requirements with other land management practices and to develop, test, and institute habitat improvements to increase overall deer numbers.

The North Kings Deer Herd was named for the North Fork of the Kings River which bisects the summer and winter ranges. It is typical of many migratory deer herds of the Sierra Nevada. The population has declined from an estimated high of 17,000 (Longhurst, et al. 1952) to the present low of around 3,400. Fall fawn survival has generally declined since the mid-50's except for periodic fluctuations probably due to favorable weather. As in most of the Sierra, subdivisions, reservoirs, roads, recreation, and intensive forest management have had their impact.

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The herd range is in eastern Fresno County and encompasses roughly 2,077 km² (800 square miles) of the Kings River Watershed (Figure 1). The lower reaches have deep canyons and steep slopes. At higher elevations to about 2,743 m (9,000 ft), terrain is more moderate and interspersed with lakes, flats and meadows. Above 2,743 m there are many spectacular and rugged peaks with adjacent talus slopes. Elevations range from 304 m (1,000 ft) to over 3,963 m (13,000 ft), (Winter, et al. 1970).

The investigation began in 1971 with habitat improvement projects and studies on fawn production and survival, deer-cattle competition and deer migration.

FIGURE 1. Location map, North Kings Deer Herd.

METHODS AND MATERIALS

Trapping and Marking

Forty-five deer were trapped or otherwise captured on summer and winter ranges. Trapping on the winter range was most successful during December and January using Clover traps (Clover 1956) baited with mistletoe (*Phoradendron* sp.). Summer range trapping was difficult until the Stewart Modified Corral Trap (Rempel and Bertram 1975) was developed which was efficient for capturing deer around salt licks in early to mid summer. Tranquilizing was attempted on free ranging deer but was largely unsuccessful. Young fawns were hand captured at opportunity on the summer range. Trapping efforts were directed to areas where specific migration information was lacking.

Most adult does that were captured were fitted with a radio transmitter collar, a colored leather collar with a colored and numbered sheep bell and three 20–25 cm (8–10 inch) colored nylon streamers. A numbered metal ear tag with a 15 cm (6 inch) long colored streamer was attached to the ear (see Salwasser 1972). Bucks and 5 to 6-month old fawns were ear tagged with a streamer attached to the tag. Young fawns were fitted with radio transmitters on expandable collars. (Figure 2)

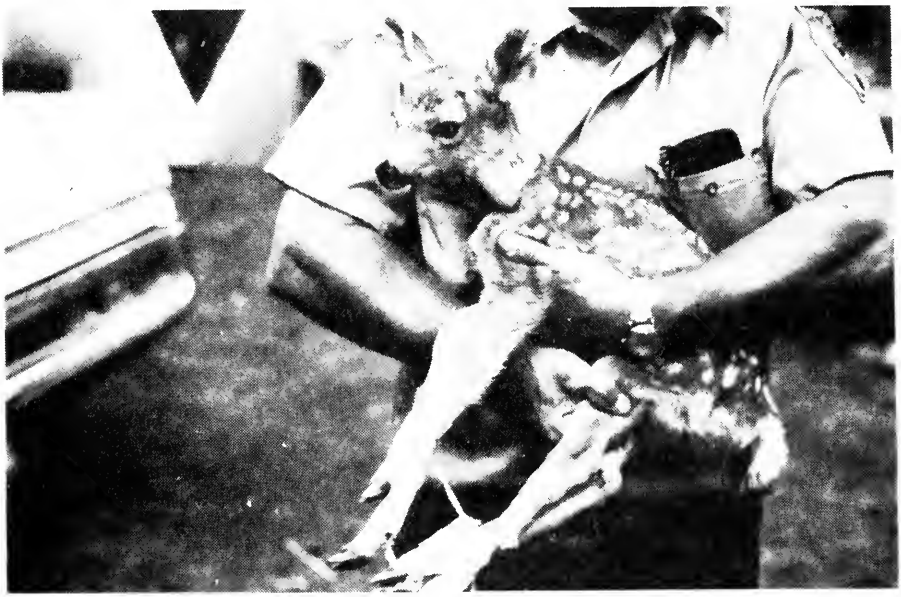

FIGURE 2. Young fawns were captured and fitted with expandable radio transmitters to help delineate home ranges and habitat requirements. Photo by Ron Bertram.

Telemetry Equipment

Twenty-five radio transmitter collars on frequencies between 31.18 MHz and and 31.54 MHz were placed on deer trapped between 1972 and 1974. Power sources were either mercury batteries, solar cells or a combination of solar cells and rechargeable Ni Cad batteries. Transmitter life varied with power source and manufacturer. Beginning in January, 1975, five lithium battery powered transmitters on frequencies between 159.315 and 159.405 MHz were placed on deer. Solar cells were no longer used due to transmission problems.

Radio deer were monitored from the air and on the ground with portable receivers. Follow-up checks on reports of marked deer contributed to the data. Also, much effort was directed to mapping migration trails on foot to verify telemetry information and fill in gaps.

Three different receivers in combination with various antennas were used to monitor the 31 MHz collars. The Department of Fish and Game plane is equipped with a Messenger (Johnson) 350 receiver and a pre-loaded whip antenna for aerial radio monitoring. This combination showed good signal sensitivity, but directionality would have been better with a loop antenna. For ground monitoring, an A. R. Johnson receiver with a pre-amplified loop antenna was used from 1972 through mid 1973. Since mid 1973, an OAR (Ocean Applied Research) FR206 receiver with a pre-amplified loop antenna has been used. This was the most sensitive and directional portable receiver combination of those used for monitoring the 31 MHz collars.

A Telonics TTR-1 receiver (Telonics, Inc.) was used for monitoring the 159 MHz collars. This receiver with a Telonics RA-5 vehicle mounted pre-loaded whip antenna was used for initial ground location. Ground search was done with this receiver and a Telonics two element beam antenna (RA-2A). Using this setup, signal directionality was excellent ($\pm 5°$) and was superior to the 31 MHz receivers used.

Approximately 120 airplane flights were made between January, 1972, and December, 1975, to monitor deer.

Delineation and Evaluation of Holding Areas

Holding areas were delineated by several means. Closely monitored radio collared deer delaying in an intermediate range location for several days were the principal indications of holding areas. Hunter concentrations following fall storms and areas where spot kill maps indicated increased numbers of deer were also used to locate holding areas.

Some 3,758 ha (9,280 acres) in eight holding areas were evaluated as to vegetative components. Arbitrary divisions of the areas by percent were generally made into the following categories for comparison: clearcuts, selective logged, meadow, brushfield and unlogged areas. Randomly located 10.1 m^2 ($\frac{1}{400}$ acre) plots were used to sample growth form and age classes of shrubs and trees and 1.9 cm diameter ($\frac{3}{4}$ inch) circular toe points located every 5 m (16 ft) along transect lines were used to determine ground cover composition.

Deer pellet group counts were made within the 10.1 m^2 plots. Deer days use were determined by assuming an average of 13 pellet groups per deer per day.

RESULTS

Winter

Deer on the winter range occupied home range sizes similar to those found in other Sierra Nevada deer herds (Leopold, et al. 1951, Jordan 1967). Most movements were confined to an area .8 km ($\frac{1}{2}$ mile) in diameter. Two exceptions were does 31.26b and 31.42 which wintered at the low end of the winter range, in fact below the recognized boundary of this herd. Doe 31.26b moved approximately 2 km ($1\frac{1}{4}$ miles) from a winter range location on January 20, 1975, to the edge of a 1974 wildfire, on March 24, 1975. Jordan (1967) indicated deer would shift to take advantage of detected winter range habitat improvements and deer 31.26b passed through or near the burn during fall arrival on the winter range and apparently later shifted home range to take advantage of the improved forage. Also, doe 31.42 shifted location approximately 2.4 km (1½ mile) between February 24, 1975, and March 24, 1975. Her earlier location was an oak-grass type whereas the new area had an abundance of wedgeleaf ceanothus (*Ceanothus cuneatus*). Shrub growth in this area begins in March and she probably also moved to take advantage of improved forage.

Deer in the heart of the winter range did not shift their range during the winter months.

Some deer, probably those in the upper portions of the winter range, showed uphill expansions of their home ranges during lulls in winter storm activity. Deer were seen in several areas in January and February normally considered summer range. In late January, 1975, we saw several sets of deer tracks near 1,800 m (6,000 ft) west of Dinkey Mountain and deer were reported on Patterson Mountain at 2,000 m (6,800 ft) by Forest Service employees. Normally deer are absent from those areas after early December.

Twelve of the 14 does marked on the winter range between 1972 and 1975 returned to their same winter home range the following winter. One doe died on the summer range leaving only one of the 14 unaccounted. Three does were seen on the same winter home range for three winters. Two of four adult bucks returned to the same winter home range the following year. The other two were shot during the hunting season. No winter observations of deer ear tagged as fawns on the winter range were made in the years following. Ear tags and streamers are difficult to see except at short distances and no effort was directed to specifically search for those deer.

Spring

Seventeen individual does were monitored during spring migrations and five were monitored through two successive spring migrations.

We documented two deer making "test" trips from the winter range to higher elevations in 1973 and one in 1975.

Conditions on the winter range began to deteriorate in late April. This caused deer to test higher elevations to determine whether forage conditions were more suitable. If not they returned to their previous location until the desired conditions developed. Based on our observations, phenology of similar plants differs about 2 weeks each 304 m change in elevation. Movements of the three deer which made test trips indicated elevational climbs to about 1,300–1,400 m (4,400 to 4,700 ft). They remained from 1 to 12 days and returned to their winter home range for several days before actual migration. This same type movement was detected from a radio collared doe in the Mineral King Deer Herd in 1970 (Franklin, G., California Department of Fish and Game, pers. commun.).

In 1972, deer began their movements approximately 2 weeks earlier than in 1973, 1974 or 1975. Rainfall was 40% of normal that year and winter range desiccation occurred early. Precipitation was above normal in 1973 and 1974 and near normal in 1975. In 1972, marked deer left the winter range between April 10 and April 24; in 1973, between May 8 and May 14 (with the exception of 31.40); in 1974, between April 27 and May 9 (again, with the exception of 31.40); in 1975, between May 7 and June 3. In 1975, late spring rainfall and snowfall caused deer to begin their spring migration approximately 2 weeks late. This reflected late development of forage at elevations above the migrating deer.

Plant phenology is important in determining timing of spring migration.

Deer delay in certain areas for varying lengths of time en route to the summer range. We call these holding areas. For North Kings deer the first holding areas range from 4.8 to 8.8 airline km (3 to 5.5 miles) from the winter home ranges and occur between 1,300 and 1,500 m (4,400 and 5,000 ft) along lower portions of ridges or slopes. Above there, slope change is abrupt and plant growth is in earlier phenological stages. Holding areas should be thought of as enlargements along the migration corridors since we found no evidence of deer deviating from their direction of travel in order to utilize better forage areas which may have been available. These areas apparently are as characteristic of individual deer as are the summer and winter home ranges. We monitored the same five deer through two successive spring migrations and they utilized the same spring holding areas. The stay in lower holding areas varies to approximately 40 days, most deer delaying 7 to 21 days.

In normal years deer are in the lower spring holding areas during late April through mid May. In mid May the next movement begins. For some deer this is a test trip to higher elevations. For example doe 31.40 made a test trip on May 24, 1973, from her holding area (elevation 1,400 m; 4,500 ft) to the 1,800 m elevation for several days. She returned to the holding area for several more days then moved up to her summer home range to stay.

Some deer settle on home ranges in the 1,800 to 2,000 m (6,000 to 6,500 ft) belt. This is a zone where meadows are abundant. At this general elevation, deer which eventually go to higher elevations have a second delay in migration. We have documented two upper holding areas where significant numbers of deer delay between 1,800 and 2,100 m (6,000 and 7,000 ft). Topography resembles that of lower elevation holding areas; that is, at the base of a mountain or ridge where further movement results in rapid changes in elevation and plant phenology.

In 1974 a mid May snow storm caused a reversal in migration. Three deer with operating transmitters left their respective holding areas and doe 31.52 left its summer home range because of the storm. The three dropped down their migration corridors 200 to 300 m (600 to 1,102 ft). Doe 31.52 was at a lower elevation and her movement was a shift to a south slope. An earlier freeze did not have that effect. Similar downhill movement was noted in the Dinkey Creek area during a mid May snow storm in 1971.

Necropsies of deer collected in 1973 and 1974 showed a significant drop in fat reserves of adult does within 3 weeks after leaving the winter range (Salwasser 1973; Holl 1974). The drop in condition in 1975 was not as drastic and reflected good distribution of late spring rains and resultant improvement in forage (Holl 1975b). This 3 week period corresponds with time spent in the initial holding areas and movement to about the 1,800 to 2,100 m elevation. For some deer this represents their summer home ranges. Salwasser speculated that rapid depletion of fat reserves between early and late May may have an adverse effect on fetal development and fawn survival. Indications of fetal size variations in the late stages of gestation were found in necropsies of does near parturition (Salwasser 1972). Condition of deer summering from 1,800 to 2,100 m began to improve after 3 weeks on the summer range.

Radio collared deer remained in upper holding areas up to 10 days, mainly during late May and early June. Deer summering above 2,100 m arrived on their summer home ranges generally in early June while those at lower elevations generally had arrived by mid May. Deer which summered at higher elevations did not leave the winter range earlier than those which summered at lower elevations.

Locations of radio collared deer by date and elevation during spring migrations are summarized in Tables 1 through 4.

Summer

A significant difference was noted between deer which summer at the lower elevations and those which summer above 2,100 m. Those at the lower elevations settled on relatively small home ranges as they arrived in mid to late May. Deer at higher elevations show somewhat erratic movements throughout a larger area than that which later becomes their summer home range. This was noted with all does monitored which summered above 2,100 m. The size of the early summer home range at the higher elevations averages some 10 km^2 (4 square miles), whereas deer summering at 1,800 to 2,100 m have summer home ranges of only 3 to 4 km^2 (1–1½ square miles). The large area used by high elevation deer in late May and early June appears to be enlargement of the more restricted home range utilized during July and August. We feel that these deer are searching for forage which has just begun to grow when they arrive. Meadow green-up begins in early June at those higher elevations and 2 to 3 weeks earlier at 1,800 m. Also, many wet meadows are shallow lakes at this time, restricting forage growth and deer use. One may speculate these deer are searching for a home range or fawning area; however, all radio collared does were adults and should have had pre-selected home ranges from prior years. This was supported by 10 radio collared deer located two consecutive summers and all utilized their same home ranges both years. Our findings of specific summer home ranges are verified by others (Jordan 1967; Gruell and Papez 1963). Deer at higher elevations settle on home ranges of approximately 3 to 4 km^2 by early July. This coincides with the period of fawn drop for this herd (mid June through mid July) and with optimum development of herbage growth.

Summer range deer trapping at cattle salt licks indicated that does would travel as far as 1.6 km (1 mile) away from their normal range for salt in June and July.

Six young fawns were hand captured on the summer range and fitted with transmitters with expandable collars. Monitoring indicates their activities are quite restricted up to 4 weeks of age but they gradually expand their range to the home range of their mothers by late summer (Salwasser 1974).

Fall

In early September three types of deer groups are seen commonly. These are does with fawns, does without fawns in groups, and groups of two to five bucks (Salwasser 1974). Toward late September there appears to be more aggregation of does, fawns and yearlings. Also at this time we have noted deer increases in some areas around the 2,000 to 2,100 m levels. In September the first frosts begin in the high country and it may be that deer showing up in new areas are those from home ranges desiccated by frost. Ashcraft (1961) observed similar early deer migration in the fall because of drought. Jordan (1967) and Hjersman, et al. (1957) noted early downward drift of deer with an absence of storms in the adjacent San Joaquin deer herd and we believe that is what we have seen. This was not verified by any radio collared deer, however.

In most years the first snow storm hits the high country in early to mid October. Deer at high elevations have been observed to anticipate approaching

TABLE 1—Spring, 1972. Migration Of Marked Deer From Winter To Summer Range

Deer number	Date left winter home range	Approx. winter range elevation (meters)	Dates and approximate elevations (meters)									Date arrived on summer home range
			4/3	4/10	4/17	4/24	5/1	5/9	5/15	5/27	6/5	
31.18a	4/10-4/17	975	975	975	1371	1371	1371	1371	2378	2195	**2804**	5/27-6/5
31.22a	4/3-4/10	853	853	975	975	975	975*	975*	2195	**2713**	2713	5/15-5/27
31.26a	4/3-4/10	609	609	975	975	609*	Radio quit					
31.30a	4/10-4/17	609	609	609	945	945	914*	1981	2195	2560	**2439**	5/27-6/5

confirmed within summer home range
* Elevation not reliable because of signal bounce in deep canyon.

TABLE 2—Spring, 1973. Migration Of Marked Deer From Winter To Summer Range

Deer number	Date left winter home range	Approx. winter range elevation (meters)	Dates and approximate elevations (meters) 3/28	4/9	4/26	4/27	5/4	5/7	5/8	5/9	5/14	5/16	5/21	5/24	5/26	5/27	5/29	6/11	6/18	6/26	Date arrived on summer home range
31.36	5/8	548	548	548	548	548	548	548	1280		1676	1676	1463				1859		2896	**2743**	6/18-6/26
31.40	3/28-4/9	1097	1097	1371	1371	1371	1371	1371	1371	1371	1371	1371	1371	1829	1371	1371	**1951**	1951	1951	1951	5/27-5/29
31.44	5/14-5/21	1097	1097	1097	1097	1432			1097	1097	1097		**1829**	1829	1829	1829	1829	1829	1829	1829	5/14-5/21
31.48	After 5/8	670	670	670	670	670	670	670	670	No Sig.						**2408**	2286	2286	2286	2286	5/24-5/27
31.52	5/9-5/16	609	609	609	609	609	609	1371		609		1371	1463				**1707**	1951	1951	1951	5/21-5/29

confirmed within summer home range

TABLE 3—Spring, 1974. Migration Of Marked Deer From Winter To Summer Range

			Dates and approximate elevations (meters)														
Deer number	*Date left winter home range*	*Approx. winter range elevation (meters)*	*4/1*	*4/15*	*4/22*	*5/6*	*5/9*	*5/11*	*5/13*	*5/14*	*5/16*	*5/20*	*5/23*	*5/28*	*6/10*	*6/24*	*Date arrived on summer home range*
31.36	5/6-5/13	548		548	548	548	1402	1524	1707	1707		1371		2134	**2682**	2652	5/28-6/10
31.40	4/1-4/15	1097	1097	1341	1341	1402	1402	1402	1463	**1768 to 1951***		—— Radio quit ——					5/14
31.46	5/6-5/11	1097		1097	1097	1097		1432	1676	1676	2012	1829	1859	2378	radio quit		Unknown
31.50	4/22-5/6	1097		1097	1097	1463		1463	1890	1890		1707	1829	2317	2317	**2621**	6/10-6/24
31.52	5/6-5/9	609		609	609	609	975 to 1280*	1585	**1768**	1829	1829	1829	1829	1829	1829	1829	5/11-5/13

confirmed within summer home range
* Followed while moving.

TABLE 4—Spring, 1975. Migration of Marked Deer From Winter to Summer Range

Deer number	*Date left winter home range*	*Approx. winter range elevation (meters)*	*Dates and approximate elevations (meters)*											*Date arrived on summer home range*
			4/21	*4/29*	*5/7*	*5/12*	*5/19*	*5/20*	*5/23*	*5/29*	*6/3*	*6/9*	*6/16*	*6/23*	
31.26b	5/19–5/28	609					365			1707		**2073**			6/3–6/9
31.30b		1097		1097		1097	———	———	———	radio quit	———	———	———	———	
31.34	5/29–6/9	365	365	304			365			365		**2073**			6/3–6/9
31.38b	5/12–5/19	609	609	609		609	1280		1707					**1824**	5/20–6/23
31.42	5/29–6/3	609	760	609	609	609	609			609	396	**1824**			6/3–6/9
31.46	5/23–5/29	1097	1097	1097		1341	1097		1097	1707	———	radio quit	———	———	
31.50	5/12–5/23	1097	1097	1097	1097	1097			1707	1829		2500	**2621**		6/9–6/16
159.390	4/29–5/7	487		487	731	853	1097	1219		1707	**1829**				5/29–6/3

confirmed within summer home range

storms. In mid October, 1972, a 5-day trip was taken into the Crown Valley area of the John Muir Wilderness Area. In the areas visited, elevations range from 2,400 to 2,900 m (8,000 to 9,500 ft) and only seven deer were seen. Heavy use of migration trails was evident on the 1st day of the trip even though the storm did not arrive until late the 2nd night. Similar trips taken in 1973, 1974 and 1975 preceded significant fall storms by more than 1 week and 70, 98 and 80 deer were classified on those trips.

Minor snow storms in October will trigger downhill movement of some high elevation deer. This occurred in 1973, 1974 and 1975.

Deer leave the higher elevations along historic routes. In some instances topography limits the choice of route such as through passes or to avoid vertical canyons. Deer crossing steep canyons such as the North fork of the Kings River and Dinkey Creek are forced to certain crossings due to near vertical canyon walls. We found that generally the same trails used in spring are used in the fall.

As deer drop from high elevations they first delay in fall holding areas between 1,800 and 2,300 m (6,000 and 7,500 ft) if not pushed by a significant storm. In 1972, heavy storm activity pushed deer through a fall delay area around Sugar Pine Hill. If deer had delayed that year they would have faced deep snow going up the other side of the canyon of the North Fork of the Kings.

In 1973, 1974 and 1975 some deer began moving into the upper holding areas in early October, and delayed some 3 to 4 weeks based on radio signals and animals seen. Another storm was required to push them further down their migration routes. In 1973, no major storm activity occurred until mid November and some deer were still seen in the Crown Valley area between 2,400 and 2,700 m until then.

In some years a reversal in fall migration occurs. This occurred in 1974 and 1975 when mild weather followed October storms. Three radio collared deer, two in 1974 and one in 1975, returned to their summer home range from holding areas. Distances covered were from 5 to 6 airline km (3–4 airline miles) and elevational changes varied from 240 to 640 m (800 to 2,093 ft).

Deer going to the winter range may use two or possibly more fall holding areas. The first ones occur between 1,800 and 2,300 m and the lower areas can range from 1,300 to 1,800 m (4,300 to 6,000 ft). Some of the holding areas used in the fall are also used in the spring.

Deer which summer at the lower elevations (1,800 to 2,000 m) may or may not delay in fall migration. Their fall migration varied from 1 to 10 days. Most made the move in less than 5 days. Of 11 such deer we were able to monitor, all were in the winter range within 10 days. Some of this time was spent within the winter range of the herd but the return to the specific individual winter home range areas sometimes took several days longer.

Arrival dates on the winter range vary with the weather. In 1972, several snow storms in October and early November forced most deer onto the winter range by early November. In 1973, light snow storms occurred in early October and on several days from November 6 through 18. Radio collared deer arrived on the winter range between November 13 and November 26. In 1974, fall weather conditions were intermediate in severity. Snow storms on October 4 and 7 (scattered) and a moderate storm on October 28–29 moved some deer onto their winter ranges by November 4; however, others remained on summer ranges through November 18. There was a lull in significant storm activities until

November 22 when most remaining deer finally left the high country. All deer located on November 25 were on their winter home ranges. In 1975, light snow occurred on October 9 and 10 and a moderate snowfall occurred on October 30. three of five monitored deer were within the winter range by November 3 and all were there by November 25.

Twenty-one deer were monitored during fall migrations and four were monitored during two consecutive fall migrations (Tables 5–8).

TABLE 5—Fall, 1972. Migration of Marked Deer From Summer to Winter Range

Deer number	*Date left home summer range*	*Approximate summer range elevation (meters)*	*Dates and approximate elevations (meters)* 10/28	11/27	*Date arrived on winter home range*
31.22a	Prior to 10/28	2700	1585	**853**	Prior to 11/27

confirmed within winter home range

DISCUSSION

Migration Corridors

The term "migration corridor" probably best describes deer migration routes. Most migratory routes consist of a number of trails or simply a general area through which deer pass. Some corridors are as wide as 1.2 km (¾ mile), yet where influenced by topography may be much narrower, Figure 3.

North Kings deer take the shortest and easiest route of travel to get to their respective summer and winter ranges. No general orientation to ridgetops in the fall or side slopes of canyons in the spring as was noted by Leopold et al. 1951 was evident here. We found that spring and fall routes were essentially the same and also that each deer uses the same corridor each year. Some ridge tops are utilized for the entire migration by some deer. Rodgers Ridge for example extends from winter range elevations of 365 m (1,200 ft) to summer range elevations up to 3,000 m (10,000 ft) near Spanish Mountain. Conversely deer migrate along the sides and bottom of Blue Canyon, then take vertical routes into or out of the canyon.

Deer do not necessarily follow a particular drainage from summer to winter ranges. Does 31.22 and 31.30a crossed two different drainages of the Kings River system and doe 31.36 and buck 3050/3052 left the recognized herd boundary to summer in the upper San Joaquin River drainage. These observations lend credence to the theory that migration and orientation to specific summer and winter home ranges are learned. Obviously deer encounter suitable summer and winter habitats long before some terminate their migrations.

Holding Areas

Holding areas appear as bulbous expansions of migration corridors. They are utilized by deer both on spring and fall migrations, except when prevented by severe weather.

Elevational and slope similarities exist between spring and between fall holding areas. Some areas are utilized for both spring and fall delay. Topography and vegetative composition vary substantially within these dual use areas. Spring holding areas are generally situated on south and west facing slopes at the base

TABLE 6—Fall, 1973. Migration of Marked Deer From Summer to Winter Range

Deer number	Date left summer home range	Approx. summer range elevation (meters)	Dates and approximate elevations (meters) 10/12	10/15	10/23	10/29	11/5	11/13	11/15	11/18	11/19	11/26	Date arrived on winter home range
31.22a	Unknown	2743	2073	Radio quit									Unknown
31.18b	11/16–11/18	1829	1829	1829	1829	1829	1829	1829	1829		731	**731**	11/19–11/26
31.18 (fawn)	10/30 11/14	1981	1981	1981	1981	1981	1554	1463	1463		731	**518**	11/19–11/26
31.36	10/2–10/14	2743		2225	2225	2012	2012	1829	**1463–547***	548	548	548	11/15
31.38a	11/13–11/19	1829	1829	1829	1829	1829	1829	1829			**1097**	1097	11/13–11/19
31.40	11/13–11/19	1951	1951	1951	1951	1951	1951	1951			1341	**1158**	11/19–11/26
31.44	11/18	1829	1829	1829	1829	1829	1829	1829	1829	1829	**1097**	1097	11/19
31.48	10/16–10/22	2134	2134	2134	1920	1920	1920	1707			**670**	670	11/13–11/19
31.52	11/6–11/12	1951	1951	1951	1951	1951	1951	**609**	609	609	609	609	11/5–11/13

confirmed within winter home range

* Followed while entering winter range.

TABLE 7—Fall, 1974. Migration of Marked Deer from Summer to Winter Range

Deer number	Date left summer home range	Approx. summer range elevation (meters)	Dates and approximate elevations (meters) 10/8	10/10	10/15	11/4	11/13	11/18	11/25	1/20	Date arrived on winter home range
31.26b	10/15–11/4	2073	2073	2073	2073	1524	548			**609**	11/13–1/20
31.30 (fawn)	Unknown	2134					**1097**	1097	1097	1097	Prior to 11/23
31.34	10/15–11/4	2073	2073	2963	2073	1829	1219		**365**	365	11/13–11/25
31.38b	After 11/18	1829				1189		1829			After 11/18
31.42	After 10/10	1829	1829	1829		**609**	609	609	609	609	Prior to 11/4
31.46	After 10/8	2560	2560					**1097**	1097	1097	Prior to 11/18
31.50	Unknown	2654				**1097**	1097	1097	1097	1097	
31.54	After 11/18	1829						1829	**640**		11/18 11/25

confirmed within winter home range

TABLE 8—Fall, 1975. Migration Of Marked Deer From Summer To Winter Range

Deer number	*Date left summer home range*	*Approx. summer range elevation (meters)*	*Dates and approximate elevations (meters)*									*Date arrived on winter home range*
			10/7	*10/14*	*10/20*	*10/27*	*10/28*	*11/3*	*11/10*	*11/24*	*12/1*	
31.26b	Unknown	2073								**365**	365	Prior to 11/24
31.34	11/3-11/24	2073	2073		2073	2073		2073		**365**	365	11/3-11/24
31.50	Unknown	2621						**1097**			1097	Prior to 11/3
159.390	10/28-11/3	1829	1829	1829	1829	1829	1829	792		**487**	487	11/3-11/24
159.315	10/20-10/27	2073	2073	2073	2073	1585		**792**	792	792	792	10/27-11/3
159.375	10/28-11/3	2073	2073	2073	2073	2073	2073	**976**	976	976	976	10/28-11/3
159.405	10/7-10/14	2195	2195	1951	2195				Illegal kill between 10/20-10/27 approx. 1829 m elevation			

confirmed within winter home range

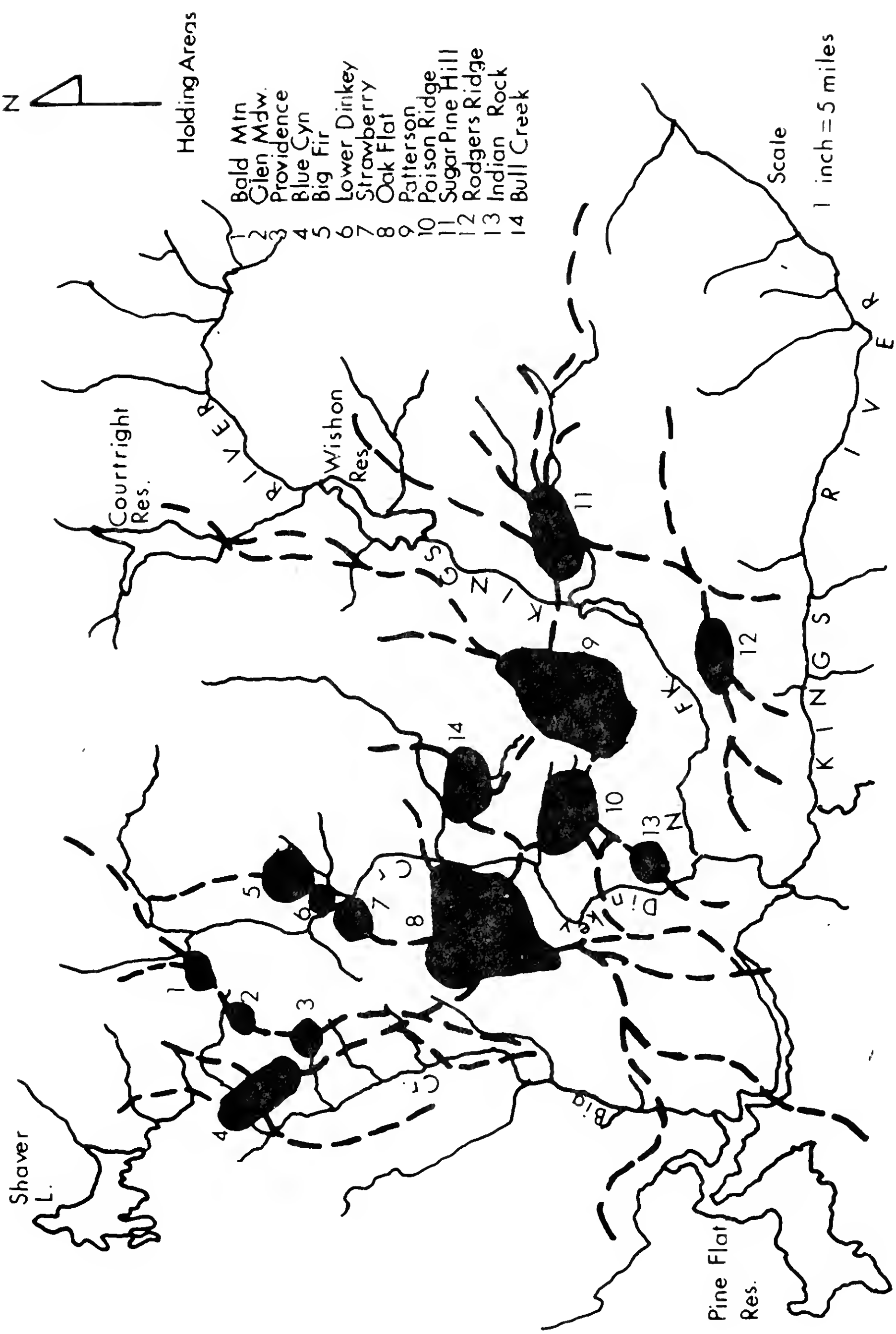

FIGURE 3. Main migration corridors and holding areas delineated for the North Kings Deer Herd.

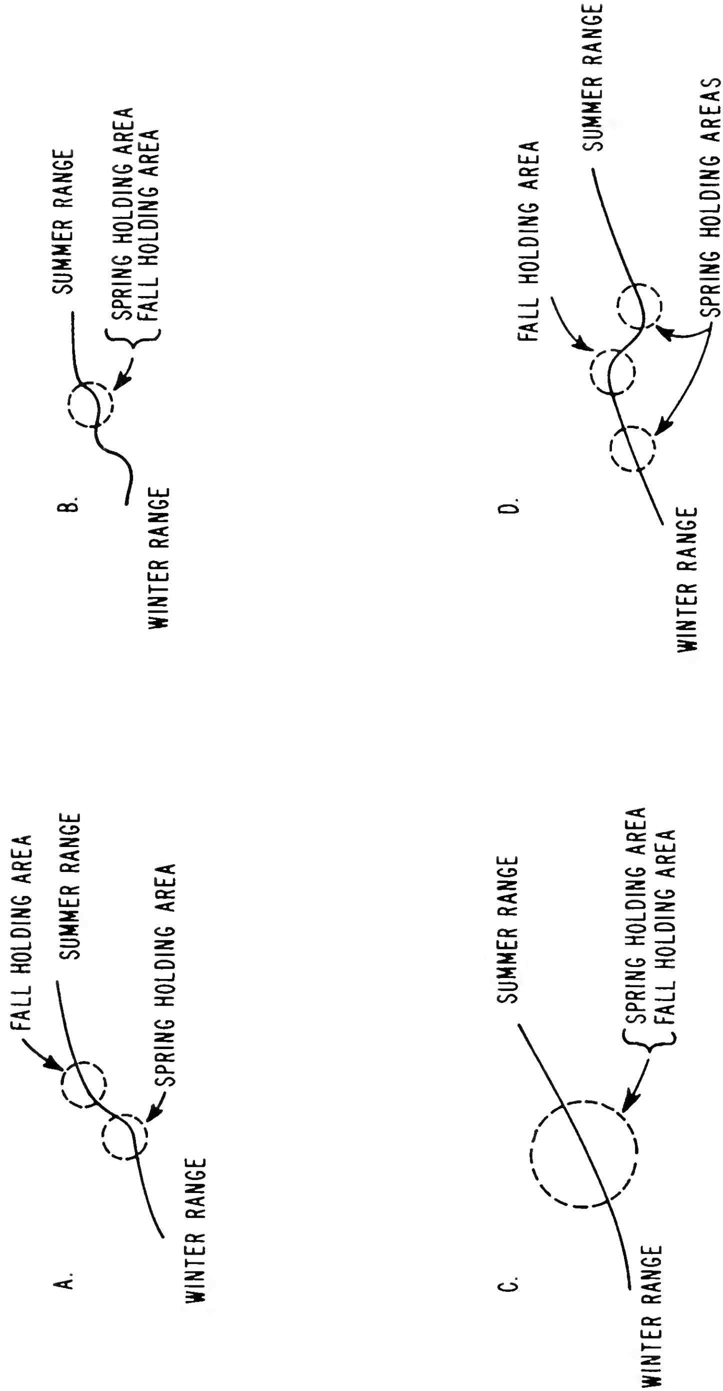

FIGURE 4. Diagrams of terrain situations where spring and fall holding areas occurred. A = Providence Creek; B = Oak Flat; C = Rodgers; and D = Patterson-Sugar Pine Hill.

of a ridge or mountain. Above there, slope changes are often abrupt and plant phenology is at an earlier stage. Fall holding areas are generally located where deer can descend rapidly if severe weather occurs. Figure 4 illustrates four terrain situations where spring and fall holding areas occurred. At Oak Flat and Rodgers Ridge the spring and fall holding areas are situated in the same location whereas at Province Creek and Patterson-Sugar Pine Hill there is a distinct spatial separation between them.

Spring Holding Areas

The first spring holding areas above the winter range occur roughly between 1,300 and 1,500 m. The major ones we have identified are Oak Flat, Blue Canyon and Indian Rock. The next series occurs from 1,700 to 1,800 m (5,500 to 6,000 ft) and includes the Strawberry, Poison Ridge, Rodgers Ridge, Lower Dinkey and Providence Creek areas. The uppermost ones we have identified occur between 2,000 and 2,100 m. These are the Big Fir, Patterson Mountain and Sugar Pine Hill areas. We suspect several other locations to be spring holding areas but time and manpower did not permit investigation.

Deer condition improved as their diet changed from predominantly browse in late May to more grasses and forbs in late June. Our impression is that when available, deer selected for herbaceous feed during spring migration. In the Oak Flat holding area spring deer use was highest in the open areas where grass and forbs comprised 25% of the ground cover. Deer use was progressively lower in the open brushfield types (9% grass and forb ground cover), clearcut areas (8% grass and forb ground cover) and selective logged areas (4.5% grass and forb ground cover). Spring deer use in a 2 ha (approximately 5 acre) legume seeding in the Sugar Pine Hill holding area illustrated deer preference for forbs in late May. All the legumes checked were eaten close to the ground each spring during the 2 or 3 weeks deer were in the area. Use on adjacent browse plants was light. Regrowth of the legumes was evident after deer left the area. Several other holding areas show the tendency toward higher spring deer use in the herbaceous forage areas.

In the lower spring holding areas and up to about 1,800 m there are few meadows. Most herbaceous feed is available only in natural openings or those created by logging or fires. Within the Big Fir, Sugar Pine Hill, Lower Dinkey, Providence Creek and Strawberry Meadow holding areas ground cover averaged 74% litter and rock and only 5 to 10% grasses and forbs. The potential for increased herbaceous forage production is quite low, even with favorable rainfall patterns. In contrast the Oak Flat holding area had recent logging activity and a portion was burned by a 1961 wildfire. Overall, rock and litter comprised only 58% of the ground cover. Benefits from a favorable rainfall year could be much better in this area. The benefits of site disturbance by logging or burning are obvious. Baring of the soil creates conditions favorable to growth of herbaceous vegetation, which invades naturally, or facilitates artificial seeding of an area.

Fall Holding Areas

Fall food habits information indicated preference and selection for browse and acorns. This was reflected within the fall holding areas by the use on preferred shrubs and occurrence of oaks. For example, in the Bald Mountain holding area 88% of the all-available form classes of mountain whitethorn (*Ceanothus cordulatus*) were moderately to heavily hedged. Oaks, predominantly huckleberry oak (*Quercus vaccinifolia*) and black oak (*Quercus kelloggii*), occurred at a rate of 119 per ha (48 per acre). The Glen Meadow holding area had 207 mountain whitethorn shrubs per ha (84 per acre) in available form classes and all were moderately to heavily hedged. No oaks were located in the sample plots but were numerous nearby in an area which we later found should have been included in our sampling and delineation of the holding area boundaries. The northern portion of the Strawberry Meadow holding area, which is used both fall and spring, had a density of 247 mountain whitethorn plants per ha (100 per acre) and 88% of available form classes were moderately to heavily hedged.

Dense cover is a necessary and major component of fall holding areas. This is probably due to harassment during the fall hunting season if good human access to holding areas exists, and also the need for shelter from fall storms. Cover may not be as critical during the spring migration, depending on disturbance levels.

Within the Sugar Pine Hill holding area 94 ha (232 acres) were prescribe-burned in 1971. This was a ground fire under a virgin stand of predominantly mixed fir (*Abies concolor* and *Abies magnifica*) utilized mainly for cover during the fall migration. To illustrate the difference in use period by deer, pellets were counted in June, 1973, after the spring migration and in October, 1973, after much of the fall migration had occurred. Twelve pellet groups per ha (five per acre) were found from spring migrating deer and 296 pellet groups per ha (120 per acre) from the fall migrants. The latter figure included use by summer residents, numbers of which were low. This burn is located at the upper end of the holding area whereas most spring use is on the middle and lower portions near the legume seeding mentioned earlier. Another unlogged and unroaded portion of the holding area below the burn was evaluated and had less than 1% ground cover of shrubs, grasses and forbs, with the exception of one small meadow near the periphery. A count made of deer beds visible within a 12 m (approximately 40 ft) wide strip along transect lines showed 8.4 beds per ha (3.4 per acre) over an area of about 41 ha (100 acres). There was an average of 1,272 white fir (*A. concolor*) trees per ha (515 per acre), largely in clumps and thickets. Of these, 81% were in young age classes which provide good cover and shelter.

An example of poor cover exists within the Patterson Mountain holding area. A portion of this was heavily logged following a large wildfire which occurred in 1961. Shrubs generated by the fire were mainly mountain whitethorn and bittercherry (*Prunus emarginata*). At this elevation (2,100 m) and on this east-facing exposure, mountain whitethorn does not get sufficiently tall to provide good escape cover. Bittercherry does provide escape cover when it occurs in large patches but these are the exception in this particular location. Bear clover (*Chamaebatia foliosa*) is widespread but its low growth form is poor cover. Deer have been observed to move into this portion of the holding area following the first fall storms. Storms in deer season attract hunters and Patterson Mountain is well known for its fall buildup in deer numbers. On Thursday, October 17, 1974, a walk through this area revealed that deer had moved in and were staying. On the following Tuesday the same trip showed that weekend hunter activity had been heavy throughout the area. Deer had left this open portion and gone to portions of the holding area that afforded better escape cover. Several secondary roads enter or bisect the area and vehicle traffic combined with foot hunters essentially cleared deer from some 203 ha (500 acres) of the holding area for several days. Deer select preferred sites but if forced to move, go to less desirable sites.

MANAGEMENT RECOMMENDATIONS

To properly manage migratory deer in the Sierra it is imperative that migration corridors and holding areas be delineated for each herd. Deer spend up to 7 weeks in spring migration and up to 6 weeks in fall migration. Indications are that both periods may significantly affect fawn survival.

While it is infeasible to concentrate efforts such as in this study for all deer herds, information can be pieced together from many sources to help delineate important areas. Forest Service employees are a good source of information. Most are interested in deer, spend a great deal of time in the field and generally can pinpoint locations. Other sources include livestock operators, packers, game wardens and hunters. Knowledge of local biologists and information such as spot kill maps marked by week of kill and compared to storm activity can give further information on holding areas and migration corridors. Ground follow-ups can help tie information together. Abrupt changes in elevation along migration corridors are typical holding area sites, with spring areas generally located at the base of south slopes where abrupt change in elevation occurs and fall areas at the top of slopes where a rapid drop in elevation occurs.

Holding areas are utilized generally from 1 to 3 weeks and adequate high quality forage must be available during that time. Approximate numbers of deer using a particular corridor and its holding areas can be determined by pellet group counts. In the lower holding areas and up to about 1,800 m, in this area, almost all pellet groups recorded are from migrants. At the higher elevations summer residents become more numerous and allowance must be made for their use.

Allocation of forage must consider livestock and other mast and forage consumers. Provision should be made to reserve additional forage for deer in years of abnormal whether when deer spend longer periods in holding areas. This is especially true of lower areas which are used each year. When snowfall forces deer through upper areas they spend longer periods in the lower ones and the same is true when late snow coverage causes longer spring delays.

Most of the holding areas evaluated were lacking various components of cover or forage. They should be managed with the idea of balancing winter and summer range populations with the number of animals that can be supported. That same number must also be supported in intermediate areas. Other less tangible effects on deer should be evaluated in holding areas. These include roads, campgrounds and other developments which may interfere with deer during the periods when they are in those locations. Necessary habitat improvements can be achieved by several means once goals are set. For example, forage production can be improved by prescribed burning, seeding, logging, type conversion or combinations of these to achieve desired results.

Some general recommendations for composition of holding areas can be made. In areas used both spring and fall, 25% of the ground cover should be palatable grasses and forbs in openings, including meadows. Forty percent should be dense escape cover well distributed and in blocks of 20 to 40 acres or larger. This may be dense tree cover or shrubs if the growth form is proper. Twenty to 40% should be in preferred shrubs in available form classes. Part of this may be included as escape cover if density and growth form are suitable.

Roads entering holding areas increase accessibility and disturbance to deer. New roads should be discouraged and existing roads not needed should be closed. If roads are considered necessary, roadside screening should be retained to reduce vehicular disturbance. Campgrounds and other facilities should be discouraged.

Oak retention and planting should be encouraged in holding areas to provide mast and browse. Fawns in this herd have doubled their body fat between late September and early December in a good acorn year (Holl 1975a). Since deer need considerable energy reserves to survive the fall and winter periods, availability of acorns may have an important influence on fall and winter fawn losses and on breeding success.

Spring holding areas could be improved by increasing early green feed. Seeding of desirable perennial grasses and forbs and fertilization to increase early yield and palatability are two management techniques being tested on the North Kings Project.

Improved holding areas should attract and delay deer for longer periods. This should reduce deer use on summer and winter ranges and result in improved physical condition. Fawn losses may be lessened during fall migration, yearling and adult ovulation should increase and more pregnant does should arrive on the summer ranges in good condition following spring migration. Also, maintenance of does on a high nutritional plane through the last trimester of pregnancy should lower early losses of fawns which occur shortly after birth.

Direct habitat improvements are quite costly and the acreage which may be treated is minimal. The greatest potential lies in coordination with other land management agencies. Logging, type conversion, road construction, fuel reduction, recreation, grazing and many other activities affect deer habitat. It is possible to manage these activities to maximize benefits to deer and minimize detriments.

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NOTES

A NEWLY INTRODUCED, BRACKISH-WATER SNAIL IN THE SALTON SEA BASIN, CALIFORNIA

On 6 March 1976, many snails were observed by an aquatic biology class from Pomona College in Whitefield Creek, a brackish-water creek located in the headquarters area of the Salton Sea State Recreation Area, Riverside County, at an elevation of 68.6 m (225 ft) below sea level. Further observations were made on 29 June and 20 July, 1976. Collected specimens were identified by Dwight W. Taylor, University of the Pacific, as *Thiara (Tarebia) granifera mauiensis* (Lea), a member of the Thiaridae (Prosobranchia: Mesogastropoda) and a native of Hawaii and other Polynesian islands. The first North American record for *T. granifera* was from Lithia Spring, Hillsborough County, Florida; the snail is believed to have been introduced from Hawaii about 1940 (Edmondson 1959). Records for *T. granifera* in western North America are summarized by Taylor (1975), but he lists none from California. D. W. Taylor (pers. commun.) has noted one previous, unpublished, record of *T. granifera mauiensis* in California. Taylor identified specimens collected by J. A. St. Amant, Calif. Dept. of Fish and Game, on 24 December 1969 from near the mouth of the Avenue 82 drainage ditch into the Salton Sea. This location is on the western side of the Salton Sea, 5 km (3 miles) north of Desert Shores, Riverside County, and about 35 km (22 miles) distant along the shoreline from the Whitefield Creek site. A drawing of this snail is provided by Edmondson (1959: Fig. 43.62b, p. 1138).

Whitefield Creek is a short, permanent, spring-fed stream of moderate salinity (3.5 to 4.0 $^0/_{00}$ in March 1976, 4.5 to 5.0 $^0/_{00}$ in June). Diverted towards the State Park boathouse in Varner Harbor in an attempt to prevent barnacle settlement on the patrol boats, Whitefield Creek now runs in a dredged channel throughout its entire length. This channel is about a meter wide, gradually deepening from 50 to 150 cm (20 to 60 inches) as it approaches Varner Harbor, to which it is connected by a culvert. Whitefield Creek flows through a region of typical alkali-sink scrub vegetation. Flowering plants within the stream itself are limited to cattails *(Typha domingensis)*, with occasional clumps of salt-grass *(Distichlis spicata stricta)* and rushes (*Juncus* sp) at the margins. Filamentous green and benthic blue-green algae are abundant. Besides the snails, the only obvious animals present are fish: native pupfish *(Cyprinodon macularius)*, introduced mosquitofish *(Gambusia affinis)*, introduced mollies (*Poecilia* sp), and the recently introduced tilapia, believed by State Park personnel to be *Tilapia zillii.* One muskrat *(Ondatra zibethica)* was seen on 29 June.

In the middle, flowing portion of Whitefield Creek, where the water is about 5 to 10 cm (2 to 4 inches) deep, *Thiara granifera* is common to abundant. The snails themselves are obvious and their tracks in the grey silt on the stream bottom are particularly conspicuous. Densities were not measured, but are estimated at up to 50 m^2. Very tiny specimens were present in March, June, and July, suggesting successful reproduction during at least this portion of the year; this species is ovoviviparous. About 100 m (330 ft) upstream from Varner Harbor, the stream passes under a State Park access road through a culvert with a 20 to 25 cm (8 to 10 inch) waterfall at the downstream end. While snails were abundant just below this waterfall, none was located at any point upstream from the culvert, despite apparently identical conditions of the water (salinity, temperature, clarity, velocity, depth), vegetation, and fish. This small waterfall seems to be a barrier to upstream migration of the snails.

Close to Varner Harbor, the channelized creek bottom is below the level of the rising Salton Sea, to which it is connected by the culvert at Varner Harbor. Measurements in this lower portion of the stream channel indicate marked salinity stratification. In March, with the stream contained entirely within its banks, bottom water of 11 $^0/_{00}$ was overlain by a layer of surface water of only 4 $^0/_{00}$. No snails were observed in this portion of Whitefield Creek in March. In June and July, with the level of the Salton Sea at its highest since 1915 (69.7 m, or 228.6 ft, below sea level) (Anon. 1976), this lower portion of Whitefield Creek had overflowed its banks, creating a series of shallow pools adjacent to the main channel. Salinities of surface waters in the stream and in these shallow pools were relatively low (5.0 to 6.5 $^0/_{00}$) all the way to the Varner Harbor culvert. In these pools, temperatures reached 37 C (99 F) when the main stream was 32 C (90 F) (air temperature in excess of 38 C, or 100 F). Deeper water in the main stream channel as close as 15 to 20 cm (6 to 8 inches) to the surface was much more saline (12 to 14 $^0/_{00}$), as well as cooler, than the surface water. Snails were abundant in the recently created shallow pools with lower salinities, though absent from the deeper, more saline portions of the main stream channel. The highest salinity in which snails were observed was about 10 $^0/_{00}$. These observations on the differential distribution of the snails in this stratified portion of the stream suggest that *T. granifera*, while euryhaline, either is tolerant of only modest increases in salinity, or is limited by the chemical composition of Salton Sea water present in the lower portion of the Whitefield Creek channel. This salinity barrier is about 12 $^0/_{00}$, about one-third the present salinity of the Salton Sea (37.5 $^0/_{00}$ on 29 June, just offshore from the State Park).

Apparently *T. granifera mauiensis* has only recently been introduced into Whitefield Creek. This snail and its tracks are conspicuous and, at present densities, would be difficult to overlook. No snails were collected or observed in Whitefield Creek in previous years during visits by aquatic biology classes from Pomona College, the most recent of which was 22–24 March 1974. State Park personnel first noted this snail in Whitefield Creek in December 1974.

T. granifera and other species of the Thiaridae are common in the aquarium trade. In view of the numerous recent introductions of tropical fish and invertebrates in streams, canals, and drainage ditches in the Salton Sea basin (St. Amant and Sharp 1971, St. Amant and Day 1972, Mearns 1975), it seems likely that *T. granifera* was also introduced into Whitefield Creek by aquarists or escapements from nearby tropical fish farms. However, its restricted distribution in Whitefield Creek, limited at the upstream end by the small waterfall and at the downstream end by higher salinity water from the Salton Sea, suggests that *T. granifera* must have been directly introduced into this stream. It is unlikely that the population in Whitefield Creek could have been derived from migration in from some nearby habitat, since there are no connections between this stream and any other watercourse other than through the Salton Sea itself.

Observations in the field and laboratory indicate that *T. granifera* feeds on microscopic algae, other micro-organisms, and small particles of organic matter. These snails are used by tropical fish aquarists to keep down algal growth and to prevent accumulation of organic debris in aquaria. While further study will be necessary to understand the ecological role of this newly introduced snail in Whitefield Creek, it is possible that there may be competitive interactions with the native pupfish, which also feeds on benthic algae and organic detritus (Naiman 1976). However, pupfish were more obvious in Whitefield Creek in 1976 than in previous years, before the introductions of either the tilapia or the snail.

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ABNORMAL VERTEBRAL DEVELOPMENT IN NORTHERN ANCHOVY, *ENGRAULIS MORDAX* GIRARD

On July 12, 1975, I collected eight abnormal northern anchovies, *Engraulis mordax* Girard, from the forebay of the Southern California Edison Steam-Electric Generating Station at Huntington Beach, Orange County, California. These fish exhibited various types of abnormal vertebral development, including lordosis (dorso-ventral curvature) and scoliosis (lateral spinal curvature). Such abnormalities have been described in many natural fish populations (Dawson 1964, 1966, 1971), and can be induced experimentally by a variety of stimuli including temperature, salinity, and dissolved oxygen variations; ionizing radiation; dietary deficiencies; and physical and mechanical irritations (Hickey 1972).

Comparison of radiographs of these eight obviously deformed anchovies (Figure 1) with normal individuals did not reveal vertebral fusion, which is often associated with abnormal spinal development, deformation of individual vertebrae, or evidence of injury. In the areas of spinal curvature, the intervertebral discs were deformed, a condition that probably resulted from the spinal curvature rather than having caused it. Vertebral number and dorsal and anal fin ray counts (Table 1) varied within ranges reported by Miller and Lea (1972). These eight anomalous anchovies were taken from a collection of approximately 17,-222 fish (aliquot estimation), yielding an approximate frequency occurrence of 0.46 per 1000.

Age estimations, based on length (Table 1), indicated that the largest fish could be 5 years old, but most were younger (John Sunada, Calif. Dept. Fish and Game, pers. commun.). Stimuli causing skeletal abnormalities generally act during early developmental stages (Hickey 1972), thus these anchovies might have been living for several years with their abnormalities.

None of these anomalies has been previously recorded in *Engraulis mordax,* but a specimen of a northern anchovy lacking ventral fins was reported by Marr (1945). The present occurrence is especially notable in that rarely are multiple anomalous fish taken in a single collection. These fish are deposited in the ichthyological collection of the Natural History Museum of Los Angeles County, Number 35251-1.

Various previously mentioned factors can stimulate spinal anomalies in fishes (Hickey 1972). Early developmental stages of *E. mordax,* an epipelagic schooling fish, are found in southern California coastal waters where most of these stimuli occur throughout the year. However, the habitat and the ages of these deformed anchovies preclude an identification of the particular factors involved in these abnormalities.

Relatively little information is known about the occurrence of various types of abnormalities in fishes from natural populations. Man's influence on the aquatic environment often includes many factors which have been shown to stimulate abnormal development in fishes. Power generating stations, sewage discharges, river flow alteration, and other activities include one or more of these factors, and for this reason it is important that occurrences, especially frequencies, of these and other abnormalities be reported.

TABLE 1. Data Taken from Eight Northern Anchovies, *Engraulis mordax,* Exhibiting Abnormal Vertebral Development. L = lordosis, S = scoliosis.

35251-1	*Standard length*[1]	*Vertebral number*	*Dorsal fin rays*	*Anal fin rays*	*Abnormality*	*Estimated age*
1	130.0	44	16	22	L	III–IV
2	108.5	44	15	22	L	0–I
3	129.0	45	15	21	L	III–IV
4	121.5	44	15	21	L	II–III
5	119.0	45(?)	15	20	L, S	II–III
6	115.5	44	15	20	L	I–II
7	138.0	45	15	23	L	IV–V
8	126.0	45	16	23	L	II–IV

[1] Standard length was measured from tip of snout to end of peduncle with fish held flat but without allowance for vertical spinal curvature.

FIGURE 1. Radiographs of *Engraulis mordax* showing lordosis (all specimens) and scoliosis (fifth from top). Specimens are arranged in numeric order (1–8) beginning at the top.

ACKNOWLEDGEMENTS

I would like to thank the Southern California Edison Company for access to the Huntington Beach Generating Station, Robert Lavenberg of the Natural History Museum of Los Angeles County for making the radiographs, and John Sunada for estimating the ages of the anchovies. I am indebted to John Fitch for reading the manuscript and for his helpful suggestions. I also thank Charel Cueva who typed the manuscript.

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—*Peter L. Haaker, Marine Resources Region, Department of Fish and Game, 350 Golden Shore, Long Beach, California 90802.* Accepted August 1976.

AN EXPANDABLE DROP-OFF TRANSMITTER COLLAR FOR YOUNG MOUNTAIN LIONS

INTRODUCTION

The need for a new type of radio-telemetry transmitting collar arose from having a young, captive-raised mountain lion which was ready for release. The lion had been sent to the Alexander Lindsay Junior Museum's Wildlife Rehabilitation Program, in Walnut Creek, California, for training and eventual release. Since there were no published accounts of a rehabilitation and release of this type, the reseachers wished to evaluate their training techniques by telemetry-tracking the young lion. The follow-up procedure would consist of tracking the lion for 2 to 4 months to observe whether he could survive and, if so, how he would set up his territory.

The 7-month-old male mountain lion cub had a neck circumference of 32 cm (12½ inches) and, when fully grown, would have a neck circumference of between 38 cm to 43 cm (15 inches to 17 inches). It was not known how much the neck size of the lion cub would grow over the next 2 to 4 months; therefore, an expandable collar was necessary. In addition, the collar was designed as a drop-off type so it would not be on the lion for an extended period of time. The use of gum rubber bands in a section of the collar was utilized because of their elasticity and rotting tendencies (Hamilton, 1962).

Another concern was to make the transmitter package and collar assembly as compact and inconspicuous as possible, because changes in the normal silhouette of familiar objects tend to upset a mountain lion (Bogue and Ferrari, Alexander Lindway Jr. Museum, pers commun.). Bogue and Ferrari also stated that a large transmitter package located under the chin of a mountain lion would be a possible source of injury during attacks on large prey. They pointed out the need of a lion to tuck its chin to avoid being kicked by hooves while trying for a neck bite on a deer. This defensive tucking action would be hindered by a large transmitter package under the chin.

The collar and transmitter package were painted with nontoxic paint, the same color as the lion, to aid in camouflaging the collar on the lion.

Several weeks prior to release, a prototype collar was built and fitted to the lion to test the design and to determine the reactions of the lion to the collar. The young lion ignored the collar, and at no time did he attempt to remove it. It was also observed that the young lion could kill and function normally in all other ways without hindrance from the collar.

CONSTRUCTION AND RESULTS

The base collar was constructed of nylon reinforced Neoprene belting. This material is flexible and durable. The belting was cut to a width of 4.5 cm (1¾ inches) and cut to length by measuring the lion's neck circumference and adding 12.7 cm (5 inches).

The transmitter components, minus the batteries, were first potted in a hard plastic cast with Plas-T-Pair (Rawn Co.) and allowed to harden thoroughly. The transmitter was then fastened to the collar material about one-third of the way from one end of the collar.

The side-mounted loop antenna was mounted on the remaining two-thirds of the collar, excluding 7.6 cm (3 inches) of the end. The length of the antenna loop varys with different frequencies, but there are no problems with space allowance for the transmitter antenna. The side-mounted loop is made from 9.5 mm (⅜ inch) wide flat copper stripping with a thickness of about .064 mm (.0025 inch). The antenna length is determined by the operation frequency. The antenna was attached to the collar by drilling a small hole through the collar material next to the inside edge of the copper strip and passing a small wire through the hole, around the copper strip, and attaching the ends (Figure 1). These small wire connecters were placed every 19 mm (¾ inch) on each side of the loop to ensure that the antenna was firmly attached to the collar material. It is also wise to have the collar material mounted on something circular and the same circumference as the lion's neck so no bends or stress points develop when the collar is put on the lion. An additional section of collar material, with the same dimensions as the collar, was used to reinforce the entire length of the side-mounted loop antenna and was placed on the inside of the collar. This section of collar material was mounted between the two ends of the antenna and then riveted to the main collar material. The additional segment of material lends extra strength and rigidity to the side-mounted loop and reduces the chance of breakage.

Two lithium batteries were taped, one on each side, to the transmitter and the collar, and their terminals connected to the transmitter. The battery and transmitter portion of the collar was placed into a mold. The mold was designed to allow at least 7.8 mm (3/16 inch) clearance on all sides of the package. This mold was filled with Isophthalic Polyester Resin (TAP), a permanently flexible resin which allows a certain amount of shock absorbance to the transmitter package. The resin must cover the collar material to a depth of about 7.8 mm (3/16 inch) above where the transmitter package is mounted (Figure 2). This resin covering over the collar will lend the extra strength needed to attach the transmitter package to the collar.

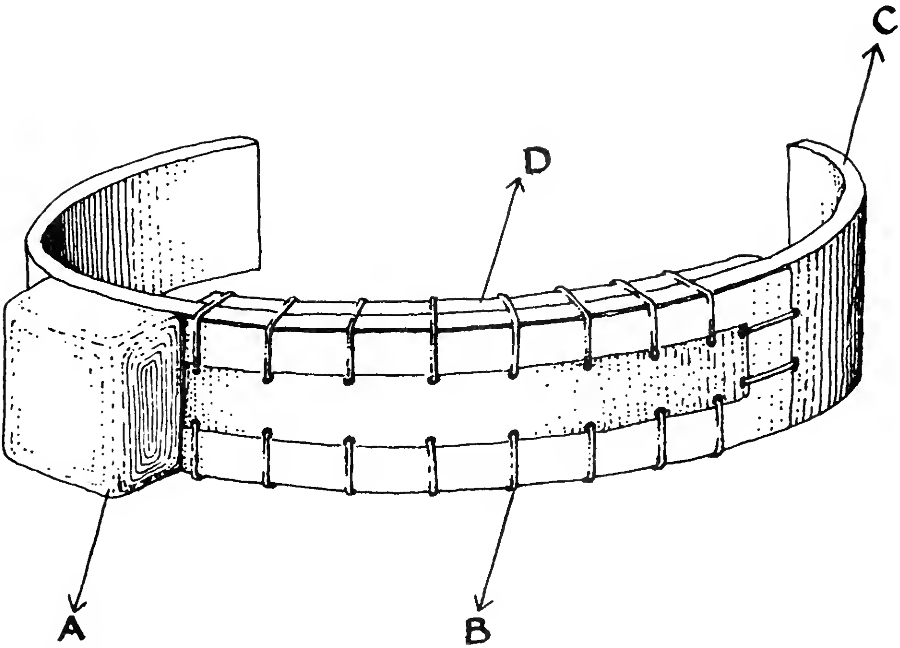

FIGURE 1. Radio transmitter collar.
A. Encased transmitter and two "C" lithium cells.
B. Small wire connecter used to secure antenna to belting.
C. Reinforced neoprene belting: Base collar material.
D. Extra section of belting used to reinforce transmitter antenna.

After the resin was allowed to set for 60 min, we removed the mold and examined the transmitter package to make sure that all parts had been covered. If additional resin was needed to cover a thin spot, we applied the resin with a small brush. After the resin on the transmitter package was allowed to harden for 2 hr, a thin coat of Surfacing Resin (TAP) was applied over the transmitter package. A coat of the Surfacing Resin was also painted over the side-mounted antenna to ensure that no moisture will act on the copper antenna.

After all the resin had hardened, the entire collar and transmitter package was painted with a nontoxic waterproof paint, the same color as the neck of the lion. The color will usually be a beige/brown and will help to camouflage the collar on the lion.

The expanding catch for the collar was constructed using large gum rubber bands and a metal clasp. The two gum rubber bands are about 127 mm (5 inches) long, 12.7 mm (½ inch) wide, and 1.5 mm ($\frac{1}{16}$ inch) thick. The clasp provides uniform tension on both gum rubber bands and connects the ends of the collar. About 7.2 cm (3 inches) of the two gum rubber bands were securely stitched with non-rotting thread to the shorter of the two ends of the collar (the side that does not have the side-mounted loop). The loose ends of the rubber bands were then folded back and stitched to the previously sewn portion of the loop (Figure 3).

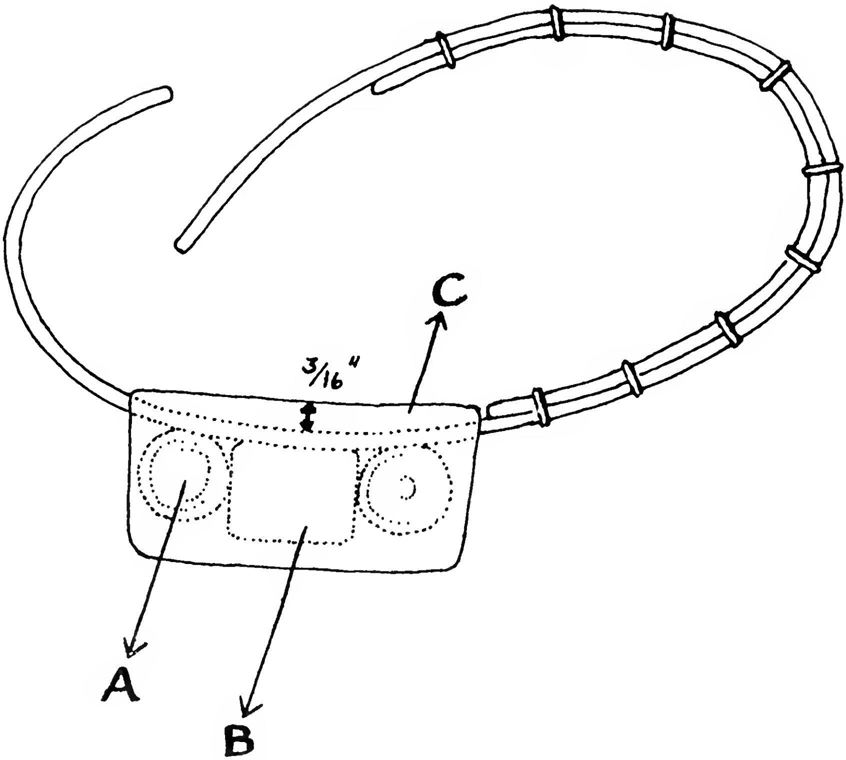

FIGURE 2. Radio transmitter collar.
A. One of the two "C" size lithium cells already encased in resin.
B. Transmitter component.
C. Extra resin used to attach transmitter package to base collar material. Should be approximately 3⁄16" deep above belting.

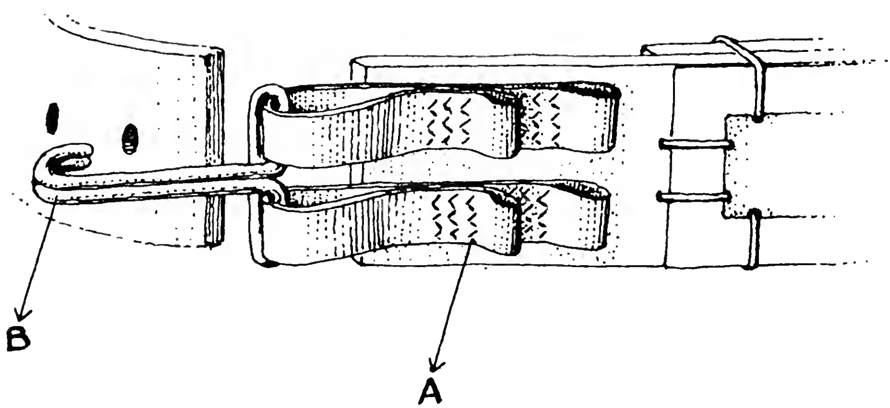

FIGURE 3. Collar clasp.
A. Overlapped gum rubber bands and stitching used to attach to belting.
B. Clasp used to attach the two ends of the collar. Provides even tension on expanding rubber bands.

The clasp was then attached to the gum rubber bands and holes drilled in the other end of the collar so the clasp could be crimped down to the opposite end of the collar. The gum rubber was expected to decay and drop the collar off the lion in 8 to 12 weeks.

A finished collar weighed approximately 9 ounces with two "C" type lithium batteries. With an average transmitter power input of 0.5 milliamps per hour, the transmitter should operate for a period of 8 to 9 months. A comparison of the lifetime of the transmitter to the expected drop-off time of the collar indicates that there is a possibility of retrieving the collar after it has fallen off the lion.

The young lion in this study wore the telemetry collar for 10 weeks before the transmitter signal was lost. A positive identification of the lion (minus the collar) was made a short time later.

ACKNOWLEDGEMENTS

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CALIFORNIA CONDOR SURVEY, 1975

A cooperative survey of the California condor (*Gymnogyps californianus*) population was conducted October 21, 1975. Forty-one observation stations were staffed by 80 observers. Stations were manned from noon until condor activity ceased, usually about 5:00 p.m. All condor observations were recorded by time of day, direction of travel, age of birds (adult, immature, or undetermined), and distinguishing characteristics of individual birds (e.g. missing flight feathers). Total sightings were later evaluated to arrive at a probable minimum number of condors seen. Evaluation procedures remained the same as reported by Mallette and Borneman (1966). Records were also kept of other raptorial birds seen during the survey.

The skies were clear at all stations on October 21, with daytime temperatures from 15.5 C to 18.3 C (60 to 65 F), except 21.1 C to 26.6 C (70 to 80 F) in the lower mountains around the Sespe Condor Sanctuary, Ventura County. Lowland stations reported light intermittent breezes, but Tehachapi Mountain ridges had 16 to 32 kmph (10 to 20 mph) winds, increasing to 32 to 48 kmph (20 to 30 mph) in late afternoon.

On October 22 it was clear to partly cloudy in the Sespe Condor Sanctuary, but most other stations were experiencing fog or rain, with moderate winds. It began clearing toward late afternoon, but hazardous road conditions prevented some observers from reaching their stations, so the October 22 survey was cancelled. The survey normally consists of two consecutive days of observations.

Survey evaluation of 134 sightings indicates a minimum of 29 condors seen on October 21: 20 adults, 5 immatures, and 4 unclassified. Other raptor sightings, 1,187, are summarized in Table 1.

TABLE 1. Raptors Observed During the Condor Survey, October 21, 1975.

Species	*Numbers 10/21/75*
Turkey vulture (*Cathartes aura*)	552
Golden eagle (*Aquila chrysaetos*)	79
Sharp-shinned hawk (*Accipiter striatus*)	23
Cooper's hawk (*A. cooperi*)	19
Red-tailed hawk (*Buteo jamaicensis*)	184
Swainson's hawk (*B. swainsoni*)	237
Ferruginous hawk (*B. regalis*)	2
American kestrel (*Falco sparverious*)	31
Prairie falcon (*F. mexicanus*)	4
Marsh hawk (*Circus cyaneus*)	7
Unidentified raptors	49
	1,187

No comparable counts were made in 1973 or 1974. Total estimated numbers and age ratios of condors in 1975 were similar to those from surveys in 1970, 1971, and 1972 (Mallette et al. 1972, Carrier et al. 1972, Mallette et al. 1973). However, this survey method is not sensitive enough to measure small changes in population number. When the annual survey data are combined with information derived from other counts and studies, it is apparent that a decrease in numbers has occurred since 1970, and not more than 50 condors now exist (Wilbur in press).

This report was prepared with the approval of the California Condor Recovery Team, and is a contribution from Federal Aid in Wildlife Restoration Project W-54-R "Special Wildlife Investigations."

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—*Sanford R. Wilbur, U.S. Fish and Wildlife Service; Robert D. Mallette, California Department of Fish and Game; and John C. Borneman, National Audubon Society.* Accepted July 1976.

REPORTED CASES OF AVIAN TUBERCULOSIS IN CALIFORNIA WATERFOWL

The first recorded case of avian tuberculosis in California waterfowl was in March 1947. At that time several pintails from a San Francisco bay delta island in Contra Costa County, presumed to have died from fowl cholera, were found to have lesions on their livers and spleens. Bacteriologic cultures and microscopic examination revealed that these lesions contained *Mycobacterium tuberculosis* var. *avian.*

Avian tuberculosis in fowl primarily affects the intestine, liver, and spleen. Hunters when cleaning their birds occasionally notice these tubercular lesions and report or bring the bird to a Fish and Game employee. The bird is then sent to the laboratory to have a necropsy performed. In most cases waterfowl diagnosed as having tuberculosis are hunter-killed birds. During the period July 1955 to September 1976 the wildlife disease laboratory necropsied 4,052 geese, swans, ducks, etc. During this period 17 birds (28 cases back to 1947) were diagnosed as having avian tuberculosis (Table 1). Comparing the number of waterfowl necropsied to diagnosed cases of tuberculosis in waterfowl indicates the occurrence of avian tuberculosis is very low.

In summary, the occurrence of avian tuberculosis in California waterfowl since its first record in 1947 has been very low. In most cases the birds were hunter-killed birds which upon being cleaned were noticed to contain tubercular lesions and then reported to the disease laboratory. Avian tuberculosis in California waterfowl at this time has only a minor effect on waterfowl populations.

TABLE 1. Waterfowl Diagnosed as Having Avian Tuberculosis March 1947–September 1976

Species	*Number*
Pintail (*Anas acuta*)	3
Mallard (*Anas platyrhynchos*)	2
Shoveler (*Spatula clypeata*)	2
Widgeon (*Mareca americana*)	4
Lesser scaup (*Aythya affinis*)	1
Ruddy (*Oxyura jamaicensis*)	2
Greenwinged teal (*Anas carolinensis*)	3
Cinnamon teal (*Anas cyanoptera*)	1
Duck spp.	5
Canada geese (*Branta canadensis*)	2
Goose spp.	1
Sandhill crane (*Grus canadensis*)	1
Coot (*Fulica americana*)	1
	28

Waterfowl Necropsied*
July 1955–September 1976

Species	*Number*
Ducks	2,100
Geese	1,500
Swans	250
Sandhill crane	2
Coots	200
Total	4,052

* Necropsies were not tallied prior to July 1955.

—*Robert Floerke, Department of Fish and Game, Wildlife Disease Laboratory, Sacramento, California 95819.* Accepted September 1976.

INSTANCES OF COPPER ROCKFISH CONSUMING A SPINY DOGFISH SHARK

A copper rockfish, *Sebastes caurinus,* that had ingested a spiny dogfish shark, *Squalas acanthias,* was noted during the course of investigations into the life history of bottomfish in Puget Sound, Washington, conducted by the National Marine Fisheries Service's Northwest Fisheries Center.

The rockfish, 422 mm (16.6 inches) total length (TL), was captured 12 August 1974 on hook and line in Saratoga Passage, Puget Sound, at a depth of approximately 25 m (82.5 ft). Its stomach contained a partially digested spiny dogfish, 322 mm (12.7 inches) TL, coiled into a ball with the anterior end of the shark at the center of the ball. The shark was identified by the presence of two dorsal spines and the absence of an anal fin. The rockfish stomach was greatly distended due to the size of the dogfish but did not exhibit any signs of mechanical damage from the shark's dorsal spines.

Another copper rockfish, 453 mm (17.8 inches) TL, captured on 28 June 1974 near Meadow Point in Puget Sound in 20 m (66 ft) of water, had two small spines, identified as those of a spiny dogfish, in its stomach.

These occurrences indicate that small spiny dogfish are eaten by large copper rockfish, a relatively abundant species in Puget Sound (Smith 1936; Delacy, Miller, and Borton 1972). Spiny dogfish have relatively few known predators. Man; lingcod, *Ophiodon elongatus* (Phillips 1959); and perhaps some sharks (Hart 1973) are known predators of dogfish. Copper rockfish have a diet largely composed of fish (Patten 1973), yet this is the first known incidence of dogfish predation by this species.

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FECUNDITY OF PACIFIC HERRING, *CLUPEA HARENGUS PALLASI,* IN HUMBOLDT BAY

INTRODUCTION

The Pacific herring, *Clupea harengus pallasi,* is a commercially important fish of the northeast Pacific coast. During winter and early spring, adult herring move into the shallow waters of bays and estuaries to spawn, primarily on aquatic vegetation. Fishery biologists who survey spawning areas are able to estimate the biomass of the adult spawning stock on the basis of knowing the approximate numbers of eggs spawned per weight of fish.

Although there are four commercial fisheries for roe along the California coast, only two herring fecundity studies have been made, both in Tomales Bay (Hardwick 1973; M. Kaill, unpublished manuscript reported by Spratt 1975). Because Humboldt Bay and Tomales Bay herring populations could be distinct stocks, a fecundity estimate was made in conjunction with a biomass estimate of herring spawning in Humboldt Bay.

METHODS AND MATERIALS

Herring were caught in January 1975 with a graded-mesh sinking nylon gill net, 38.1 by 1.8 m (125 by 6 ft) with equal lengths of bar mesh 1.3, 1.9, 2.5, 3.2, and 3.8 cm (½, ¾, 1.0, 1¼, and 1½ inches). The net was set for no more than 10 min per set in areas where birds and seals were actively feeding. Each fish was placed in a separate plastic bag, weighed to the nearest 0.1 g and frozen.

The herring were not processed while fresh because many females were in a running ripe condition and excessive handling would have caused a loss of eggs. Also, the eggs in a ripe female are unmanageable because of their adhesiveness, a condition that is greatly reduced after the fish are frozen.

The fish were thawed later in 5% formalin, reweighed, measured to the nearest 1 mm standard length (SL), and the ovaries removed. Scales were taken for age determination. The ovaries were cleaned of ovarian tissue and adhering parasites and weighed to the nearest 0.01 g. A 1 g sample was removed from the center of each ovary, and the eggs in the sample were teased apart and counted. Because shell fragments produced by the teasing process made accurate counts difficult to obtain, only samples which lacked shell fragments were counted.

The total number of eggs per female was estimated by multiplying the mean number of eggs per gram in the sample by the total weight of the ovaries.

RESULTS

Fecundity was estimated for 37 female herring 2 through 9 years old, standard lengths of 147 to 232 mm (5.8 to 9.1 inches), and weights of 53.7 to 238.9 g (0.1 to 0.5 lb). Number of eggs per fish ranged from 9,511 to 50,489 (Table 1). The mean number of eggs per gram of adult female herring was 220 ± 35 at the 95% confidence interval. Average ovarian weight equaled 25% of the total weight and ranged from 17 to 32%. The mean number of eggs per gram of ovary was 916 (range, 671 to 1,362) (Table 1).

TABLE 1. Fecundity Data for 37 Pacific Herring, *Clupea harengus pallasi*, Caught January 1975, Humboldt Bay.

Length (mm SL)	*Weight (g)*	*Age (year)*	*Ovary wt (g)*	*Mean # eggs/g ovary*	*Fecundity*
178	121.2	4	20.90	1,076.5	22,499
155	72.8	2	17.78	901.0	16,020
165	76.3	2	17.39	996.5	17,329
195	151.5	4	47.27	761.0	35,972
158	65.4	2	12.06	1,224.0	14,761
181	121.0	4	31.09	849.0	26,395
189	135.4	4	29.62	1,019.0	30,183
181	106.7	3	26.08	904.0	23,576
176	94.2	3	23.33	772.0	18,011
192	126.4	3	31.23	969.5	30,277
229	238.9	9	58.10	843.0	48,978
205	173.2	5	33.73	1,102.0	37,170
197	141.3	5	32.98	930.0	30,671
150	53.7	2	10.55	901.5	9,511
231	207.6	7	52.19	929.5	48,511
177	92.0	3	23.43	761.0	17,830
182	111.0	4	20.65	1,362.5	28,136
173	81.3	?	20.63	969.0	19,990
177	100.0	3	27.50	837.5	23,031
232	216.7	9	66.66	671.0	44,729
212	192.2	6	61.06	737.0	45,001
207	180.4	7	54.55	762.0	41,567
214	218.3	8	64.44	783.5	50,489
206	189.7	6	55.72	798.0	44,465
214	203.5	8	56.75	797.0	45,230
164	75.6	?	19.20	880.0	16,896
208	205.0	6	57.35	813.5	46,654
150	56.7	2	13.26	952.0	12,624
158	68.6	2	13.82	882.0	12,189
168	79.3	2	20.80	872.5	18,148
162	78.1	2	19.32	820.5	15,852
158	67.8	2	16.20	887.5	14,378
217	184.0	5	49.39	830.5	41,018
163	77.5	?	16.14	1,121.0	18,093
211	165.5	7	49.02	739.0	36,226
147	54.5	2	9.21	1,296.0	11,936
147	57.8	2	10.38	1,130.5	11,735

There is a linear relationship between body length and egg production (Figure 1). The regression coefficient, (slope) was tested and found to be significant, $t_s = 22.2685$ ($t_{.001}(35) = 3.599$). The correlation coefficient, r, between body length and number of eggs produced was 0.9665.

DISCUSSION

We found that, for each fish, two 1g samples of ovary produced nearly equal numbers of eggs and that the mean of the counts provided a representative number of eggs per gram of ovary. Nagasaki (1958) found that the mean weight of two samples of 250 eggs represented a reliable sample weight.

Our fecundity estimate of 220 ± 35 eggs per gram of Humboldt Bay herring did not differ significantly from the two previous fecundity estimates of Tomales

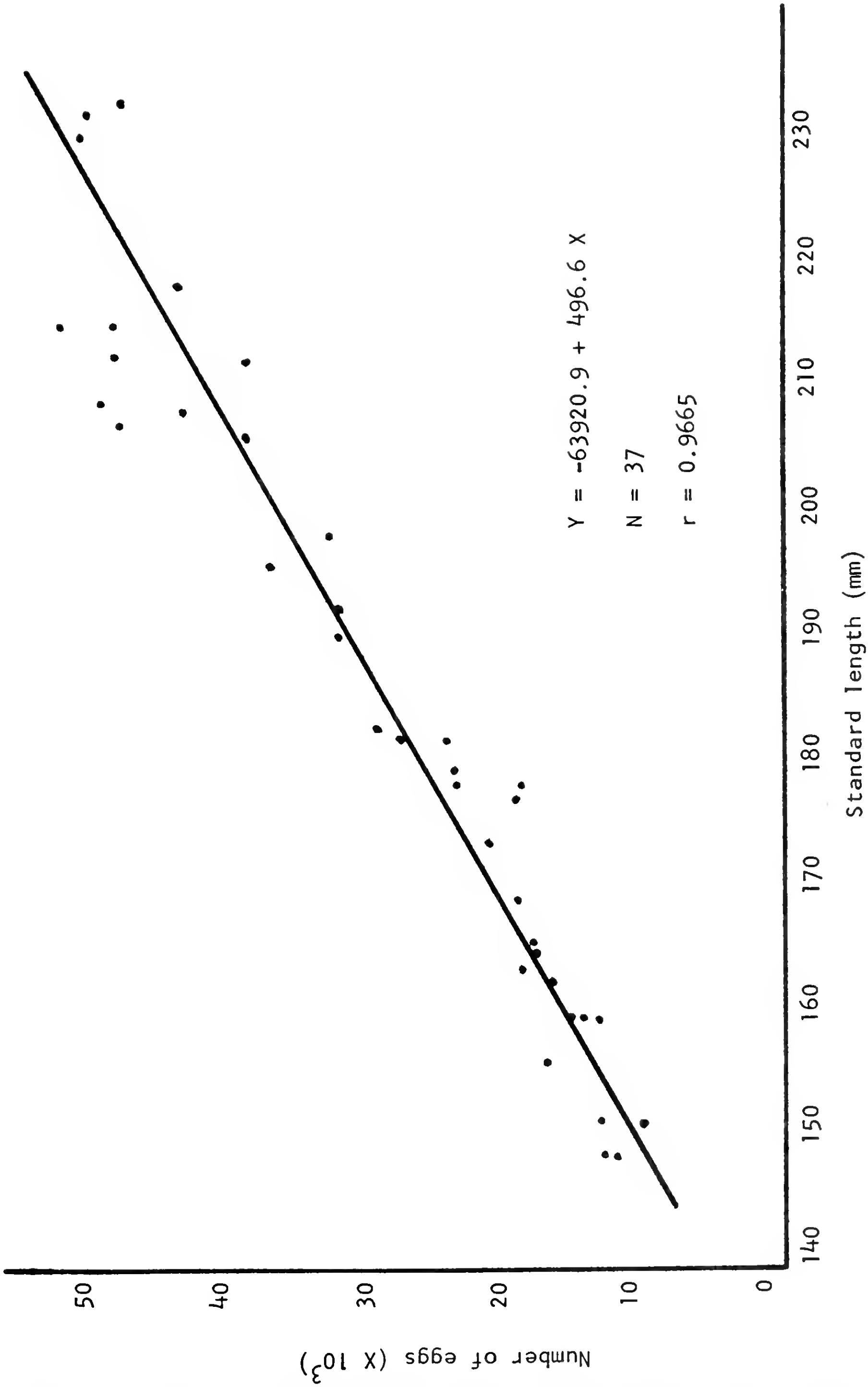

FIGURE 1. Relation between standard length and number of eggs produced in *Clupea harengus pallasi*, in Humboldt Bay, California, 1975.

Bay herring. Hardwick (1973) reported a mean fecundity of 227 eggs per gram of herring, and M. Kaill (in Spratt 1975) reported a mean fecundity of 216 eggs per gram of herring for Tomales Bay.

We obtained a correlation coefficient, r, of 0.966, before any data transformation, suggesting a linear relationship between body length and numbers of eggs produced. Bagenal (1967) stated that a curvilinear relationship exists between body length and fecundity, and suggested that a logrithmic transformation should be used for statistical analysis. Nagasaki (1958) found a linear relationship between egg production and length for Canadian herring stocks ($r = 0.8027$).

We believe that the fecundity estimates obtained are representative of the herring population of Humboldt Bay. Few herring were caught during the spawning season whose length fell outside the length range of the fish for which fecundity was estimated.

ACKNOWLEDGMENTS

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SOUTHERN RANGE EXTENSIONS FOR CHUM AND SOCKEYE SALMON, *ONCORHYNCHUS KETA* AND *O. NERKA*

On September 27, 1974, a San Diego sportfisherman, James Darland, observed several large fish chasing a school of bait near the Chula Vista launching ramp in south San Diego Bay. He cast a jig near the fish and on the third cast, he had a hook-up and landed a 4.7-kg (10.3-lb) chum salmon, *Oncorhynchus keta.* The fish was a 787-mm (31-inch) TL male which had developed the hooked jaw typical of spawning salmon. I examined body color and gill rakers and counted pyloric caeca to make the specific identification. Carl L. Hubbs, Scripps Institution of Oceanography, examined scales (figure 1) and John E. Fitch, California Department of Fish and Game, examined otoliths (figure 2) to confirm identification. They both determined that the fish was in its 4th year.

FIGURE 1. Scale from male chum salmon, *Oncorhynchus keta,* taken in San Diego Bay, September 1974.
Photograph by Jack W. Schott.

Messersmith (1965) reported a chum salmon taken off Del Mar, California, in 1955 by the purse seiner *Saint Louis.* The San Diego Bay chum salmon was 40.2 km (25 miles) south of Del Mar, straight line distance, or 56.3 km (35 miles) swimming distance.

Since then, Dominic J. Balestreri, a commercial fisherman from San Pedro, has caught two chum salmon off Portuguese Bend, Palos Verdes Penninsula, Los Angeles County. Both were taken in a gill net from his boat, *Dawn Patrol.* The first, a 760-mm (29.9-inch) TL ripe male weighing 5.5 kg (12 lb), was caught July 13, 1975. The second fish, taken 1 week later, was a 4.6-kg (10-lb) male.

Identifications of these fish were verified by John E. Fitch, using the otolith key of Casteel (1974).

Several other salmon reportedly were taken in southern California waters during July 1975, but only one of these was made available to Department of Fish and Game biologists for identification. The fish turned out to be a sockeye salmon, *O. nerka*, dip-netted from the waters of Los Angeles-Long Beach Harbor by Robert Knowles on July 21, 1975. The 518-mm (20.4-inch) FL male was in spawning condition. John E. Fitch used gill raker counts, body color, and otoliths to identify this fish. Based upon growth zones on its otolith, it had spent 2 years in freshwater and 2 years in the ocean before being caught.

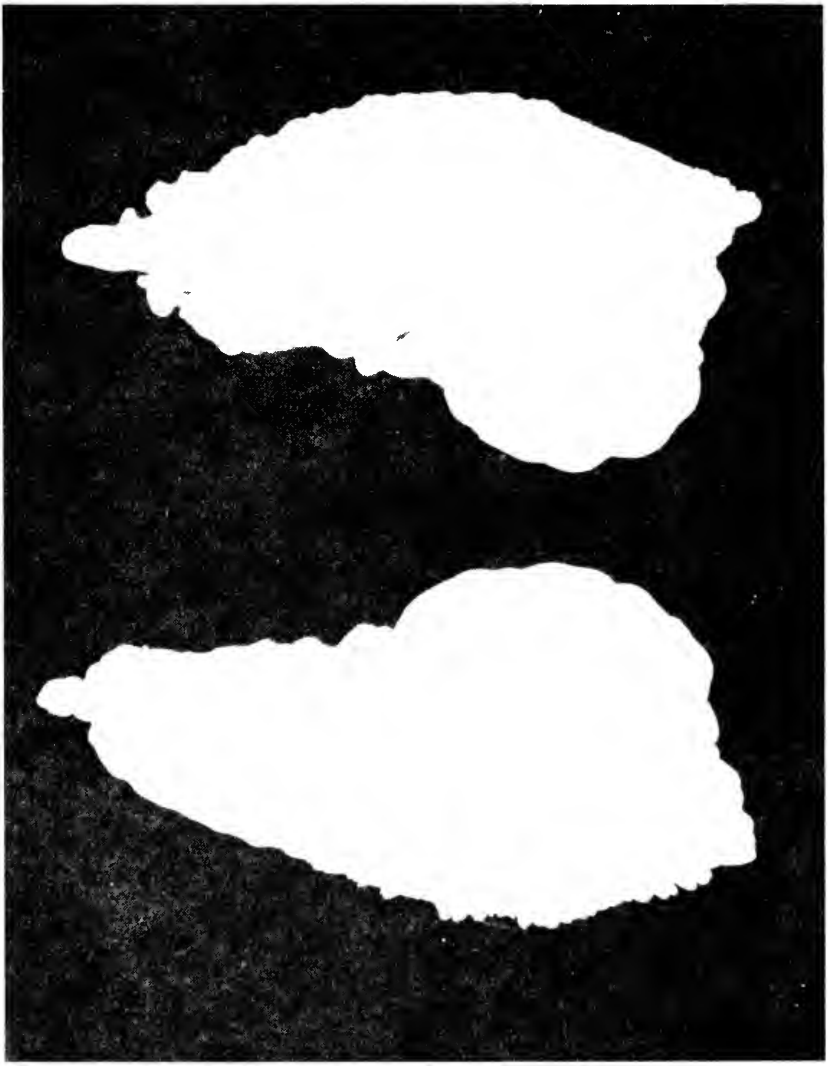

FIGURE 2. Otoliths from male chum salmon, *Oncorhynchus keta*, taken in San Diego Bay, September 1974.
Photograph by Jack W. Schott.

Fry (1973) gives the southern range limit of sockeye salmon at sea as "Central California". Miller and Lea (1972) give its range as "Sacramento River system to Bering Sea and Japan". This recovery is approximately 640 km (400 miles) south of the previously reported range.

None of the above salmon was a hatchery-reared fish, although future salmon catches in southern California will need to be examined carefully to determine this. In 1975, approximately 100,000 juvenile silver salmon, *O. kisutch*, were released in two southern California drainage systems. The Santa Margarita River, Camp Pendleton, San Diego County, received 60,000 fish and Calleguas Creek in Ventura County received 40,000. Similar plantings are to be continued in 1976 and 1977 to determine if this is a feasible method of improving angling for southern California sportsmen. If this program is successful, it could mean the casual acceptance by fishermen, of any southern California caught salmon as a "planted silver", and captures of far ranging chum and sockeye salmon such as reported herein will go unnoticed.

ACKNOWLEDGMENTS

Without the interest and cooperation of fishermen Darland, Balestreri, and Knowles, these salmon would not have come to the attention of the Department of Fish and Game. I am indebted to the following Department of Fish and Game personnel: Jack Schott took the photograph of the chum salmon otoliths and scale; Charles Hooker was instrumental in obtaining specimens and data on the 1975 captures; Kay T. DeSpain typed both the draft and final copy of the manuscript; and P. Patricia Powell checked the references for accuracy.

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BOOK REVIEWS

The Ageing of Fish: Proceedings of an International Symposium Edited by T. B. Bagenal, Unwin Bros. Ltd., The Gresham Press, Old Woking, Surrey, England, 1974; vi + 234 p., illustrated. £5. paper.

Since this symposium was sponsored by the European Inland Fisheries Advisory Commission of F.A.O., The Fisheries Society of the British Isles, and The Freshwater Biological Association, it follows that the underlying theme concerns freshwater fishes and fisheries. Twenty-one papers by 22 authors are grouped under five major categories: Some considerations of the scientific basis of age determination (6 papers); Mechanical aids to age determination (2 papers); Elimination of errors in age determination (6 papers); Some sources of age reading errors (2 papers); and the effects of errors in age determination on subsequent studies (5 papers).

Although some authors had more new information to report than others, and some obviously had not done their homework as well as they could have, all of the contributions are pertinent and meaningful. I was especially interested in the information offered in a 12-page report by K. Simkiss entitled "Calcium metabolism of fish in relation to ageing," and believe that salmonid biologists (particularly) would do themselves a favor by taking note of his statement that "there is no evidence for any resorption of otoliths . . ."

Giorgio Pannella offers a great deal of sound advice in his contribution entitled "Otolith growth patterns: an aid in age determination in temperate and tropical fishes." He explores briefly such phenomena as daily, bimonthly, monthly, and annual growth, and illustrates these patterns with some excellent scanning electron micrographs. In light of his comment that "because the daily journal can be followed in otoliths and not in scales, the precision and amount of data are far superior in the former," fishery biologists who, historically, have depended upon scale readings might find it enlightening to investigate otoliths.

One of the weakest (poorest) of the 21 contributions, in my opinion, is a nine-page report by C. P. Mathews entitled "An account of some methods of overcoming errors in ageing tropical and subtropical fish populations when the hard tissue growth markings are unreliable and the data sparse." Confusion as to species involved, questionable ageing techniques, sloppy proofreading, and other inconsistencies cast serious doubt on the reliability of the information presented.

Generally, however, these are "quality" reports and so much useful information is presented that this volume should be required as either background or refresher reading for those likely to be involved in age studies or already involved.—*John E. Fitch.*

Marine Game Fishes of the Pacific Coast from Alaska to the Equator.

by Lionel A. Walford; Reprint of 1937 edition published by Univ. Calif. Press; with new 19-page introduction; Smithsonian Institution Press, Washington, D. C. 1974. $15.

Although first published in a limited edition in 1937, out-of-print shortly thereafter, and a collector's item during the past three decades, Walford's *Marine Game Fishes of the Pacific Coast* is still the most helpful publication there is for identifying many of the fishes inhabiting tropical and subtropical waters between Panama and California. Now, with re-publication, not only is it available at a price most of us can afford, it is more useful than ever because of a 9-page "addendum" that updates scientific names, notes changes in common names, lists new species and synonymizes others.

As pointed out by the publisher "This edition is reprinted from the original without change except for the addition of a new introduction . . . and color plates printed on both sides of each page."

Upon comparing this reprint with an original, one can see immediately that the color plates lost nothing in reproduction, but the black-and-white plates now have a dirty grey background.

Although the new information presented in the "addendum" is for the most part priceless, there are omissions, and some groups have been given better coverage than others. Although printing errors are scarce, several very minor items could stand correcting. On p. 13, the range for *Nematistius* should read San Clemente (city), California to Peru, and on p. 18 *Epinephelus niphobles* is misspelled. On p. 14, *Seriola mazatlana* is noted as being of doubtful validity with the suggestion that it may be synonymous with *S. peruana*. My studies of *Seriola* lead me to believe that *S. mazatlana* is a junior synonym of *S. dorsalis*. A dwarf species inhabiting nearshore waters off Central America remains unnamed, but represents a fourth *Seriola* for the eastern Pacific.

What is needed now is a publication covering all the fishes and fish families inhabiting the highly productive stretch of ocean between California and Panama.—*John E. Fitch.*

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