CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

Volume 37 San Francisco, January, 1951 Number 1

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FISH AND GAME
San Francisco, California

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California Fish and Game is a journal devoted to the conservation of wildlife which is published quarterly by the California Division of Fish and Game. Contributions should be sent to Mr. Phil M. Roedel, Editor, State Fisheries Laboratory, Terminal Island Station, San Pedro, California. Manuscripts must be typed, double spaced, and conform to the style of previous issues.

This periodical is sent free of charge to interested persons, who may have their names placed on the mailing list by writing to the editor. Subscriptions must be renewed annually by returning the postcard included with each October issue. Subscribers are requested to notify the editor immediately of changes in address, giving the old address as well as the new.

CALIFORNIA FISH and GAME

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VOLUME 37 | ISSUED JANUARY 31, 1951 | NUMBER 1

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AN INVESTIGATION OF THE CALIFORNIA SAND DAB, *CITHARICHTHYS SORDIDUS* (GIRARD)[1]

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Natural History Museum, Stanford University[2]

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INTRODUCTION

The sand dabs of the California coast are small flatfishes belonging to the family Bothidae. They rarely exceed two pounds in weight. There are two commercial species, *Citharichthys sordidus* and *C. stigmaeus*. The former was once commonly known as the "soft flounder" but this name has now been almost entirely supplanted by the name "sand dab." *C. stigmaeus* is taken commonly in the region around Santa Catalina Island by hook and line and is known in the southern part of the State as the "Catalina sand dab." Both of these fishes are quite different from the Atlantic sand dab, *Hippoglossoides platessoides*, which belongs to the family Hippoglossidae. *C. sordidus* constitutes by far the larger element in the commercial catch of California, but both species are included in the fishery statistics under the name "sand dab." This study deals exclusively with the biology of *C. sordidus*.

[1] This paper is in part the condensation of "An investigation of the California sand dab, *Citharichthys sordidus* (Girard)," by Harbans Lall Arora, a dissertation submitted to the School of Biological Sciences and the Committee on Graduate Study of Stanford University in partial fulfillment of the requirements for the Degree of Doctor of Philosophy, December, 1948. Submitted for publication April 1950.

[2] The author is now Assistant Research Officer, Central Marine Fisheries Research Station of the Government of India, Mandapam Camp, South India.

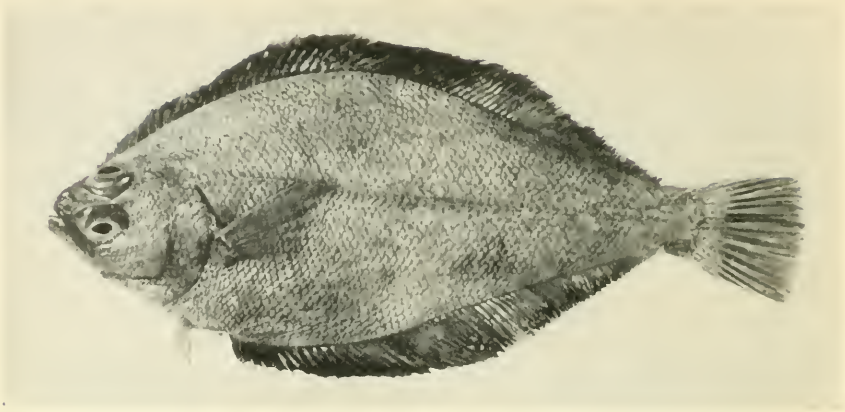


FIGURE 1. The California sand dab (*Citharichthys sordidus*)

The catch of sand dabs off the coast of California is small compared with the catches of the major fisheries of the State, but it is of considerable local importance especially in the San Francisco region. The fish is popular and commands a high price on the fresh fish market. The catch was formerly much above the present level. In 1917 the total catch was over 2,500,000 pounds but this was much reduced during the depression of 1921. Subsequently it rose gradually and was again nearly 2,000,000 pounds in 1925. It then dropped to 473,000 in 1931 and has fluctuated around 500,000 pounds in recent years.

Because of the relatively minor importance of the sand dabs in the California fisheries the species has not previously been made the subject of special study although data had been collected from time to time as opportunity offered. As a result, when the present study was undertaken there were available a large number of data in the files of the Division of Fish and Game. Most of these data related to representative samples collected by the patrol and research vessel "Albacore." The collections made on the "Albacore" were made with a special net with 1½-inch stretched mesh. The hauls were made between Point Reyes and the entrance to San Francisco Bay and offshore 30 or more miles, somewhat beyond the Farallon Islands. They were made in depths ranging from 20 to 50 fathoms. Scales and otoliths were collected from some of the sand dabs taken by the "Albacore" but there were not enough to serve as a satisfactory basis for age determination. In order to supplement the scale and otolith collections a special trip was made by the author on the "Alex Paladini" of the A. Paladini Company of San Francisco. The trip was a regular commercial fishing trip made on February 5, 1947, to the trawling grounds off Point Reyes and near the Farallon Islands. A large number of specimens were secured on this trip and brought into the laboratory for study. Because of the larger mesh size of the commercial net (four-inch) fewer small fish were captured than were taken in the special net operated on the "Albacore." Most of the small specimens taken were recovered from the trash and mud caught in the sack

at the end of the net. These collections were supplemented by specimens secured on frequent visits to the fish markets of San Francisco and Monterey.

I am under special obligation to the California Division of Fish and Game for allowing me to make use of their extensive data on the sand dab, for providing facilities at their laboratory on Terminal Island, and for providing some financial assistance. Mr. Wm. Ellis Ripley, Marine Biologist, was particularly helpful.

It is a pleasure to express my great appreciation to A. Paladini & Co., San Francisco, for many courtesies extended during the course of this study.

I wish to express my gratitude to Dr. Willis H. Rich, Chairman, Fisheries Advisory Committee, School of Biological Sciences, Stanford University, for his keen interest and ungrudging help throughout the investigation. To Dr. F. W. Weymouth and Dr. George S. Myers, both of Stanford University, I am grateful for their valuable criticism and suggestions on various aspects of the problem.

To the Directors of the Natural History Museum, Stanford University, and the Hopkins Marine Station, Pacific Grove, my thanks are due for the many facilities provided while working at these places.

METHODS

Length Measurements

Throughout this study the total length of the fish has been used for all measurements of length. The total length was measured from tip of the mandible of the closed mouth to the extreme end of the caudal fin. The standard length, measured from tip of the mandible of the closed mouth to the origin of the caudal fin, however, can be derived from the total length as shown in Figure 28. The total length was measured by placing the fish on a board, the axis of its body at right angles to, and the tip of its mandible just touching a raised end piece. The length was read by means of a millimeter scale set into the measuring board along the midline.

Egg Measurements

Sexual maturity and the spawning period of the sand dab was determined by a study of measurements of the egg diameters. In making the measurements a small piece of one of the ovaries was teased out on a slide and the diameters measured by means of an eyepiece micrometer in a compound microscope. The arbitrary units of the eyepiece micrometer were found to have a value of 0.008 mm. Since the eggs were taken from preserved specimens they were commonly more or less distorted. In order to avoid selection of the diameter to be measured, and possible bias, the following procedure was followed: The micrometer scale was always kept so that it ran from left to right in the field of the microscope. The eggs to be measured were selected carefully at random and without relation to their position in the field. Then, always, the diameter from left to right was read. By this procedure the greatest diameter was read

on some eggs, the least on others but usually some intermediate diameter was read. This gave unbiased mean values but the variance was undoubtedly increased.

Scale Studies

All the scales used in the determination of age and growth were taken from the axillary region just behind the pectoral fin. The integument of the sand dab is generally quite delicate and the scales are apparently lost frequently. When the scales are regenerated the surface markings from which age is determined are lacking over most of the new scale so that such regenerated scales are useless for age determination. Behind the pectoral fin, however, the scales are usually perfect. Each scale, after it was removed from the fish, was rubbed with the bare fingers to remove skin and dirt and then was cleaned in water. The more adhesive skin with pigment cells or dirt was removed with fine forceps. For mounting, waterglass (sodium silicate) diluted with water was found best. This medium brought out the surface structure of the scale in fine relief. Glycerine-gelatin medium also gave satisfactory results.

The scales thus mounted were examined with the aid of a projection apparatus so arranged that the projected image appeared on the table beside the microscope at a magnification of 42.

In measuring the projected image, a paper ruler divided into centimeters and millimeters was placed along the diameter which bisects the posterior (caudal) area of the scale. The zero of the scale was placed at the center of the image and the ruler was marked at each annulus and at the anterior margin of the scale. A separate paper ruler was used for each scale. Subsequently there were recorded on the paper ruler such pertinent data as length of fish, sex, locality and date of collection. These measurements of the scale were used in computing the lengths of the fish by the formula given on page 23. All computations were made with a slide rule or with a calculating machine.

Otolith Studies

The otoliths used in the determination of age were ground sufficiently on a hard sharpening stone to remove the surface irregularities. This permitted more light to pass through the otolith and made the annuli much more obvious. The photomicrographs of the otoliths were taken by the same method as that used for the scales, i.e., using transmitted light.

DESCRIPTION OF THE SPECIES

The body of the sand dab is slender, more or less elliptical in outline and covered with large, thin, cycloid, deciduous scales. Both the eyes are rather large and invariably present on the left side of the body (sinistral). The interorbital space is narrow, slightly concave anteriorly and crossed by an oblique ridge posteriorly. A sharply elevated ridge is located above the lower eye. The upper margin of the upper eye touches the dorsal profile of the head. The mouth is terminal with the lower jaw more or less prominent. The teeth are small and are subequal anteriorly but do not form distinct canines. The gill rakers are rather long and slender, 15 or 16 on the lower part of the anterior arch. The lateral line is simple, straight, and gradually rises in front. The maxillary reaches to below

the middle of the lower eye. The dorsal fin begins slightly on the blind side and a little in front of the upper eye. The ventral fin of the colored side is on the ridge of the belly, and the pectoral fin is about two-thirds of the length of the head.

The males can be easily distinguished from the females by holding the fish against light. The female shows a long tapering ovary extending backwards into the hinder part of the body, whereas in the male no such organ is visible.

Citharichthys sordidus occurs along the Pacific Coast of the United States from British Columbia to Southern California. It is taken on a commercial scale from Bodega Head to Monterey Bay. It is also fairly abundant in Puget Sound.

Bathymetrically it has been reported to occur from 10 fathoms to 100 fathoms. My own experience during the fishing trips shows that it is very plentiful between the depths of 20 to 50 fathoms.

Large specimens measure up to 40 centimeters and rarely exceed two pounds in weight. Adults are generally 16 to 30 centimeters long. Females are as a rule larger than the males.

MATURATION AND SPAWNING PERIOD

Maturation of Eggs

The maturation of the California sand dab was determined from a series of measurements of the diameters of the eggs. Frequency distributions were obtained for the egg diameters of 172 eggs from three mature females taken during the spawning season and of 189 eggs from the same number of maturing females taken just before the spawning season. The curves are shown in Figure 2.

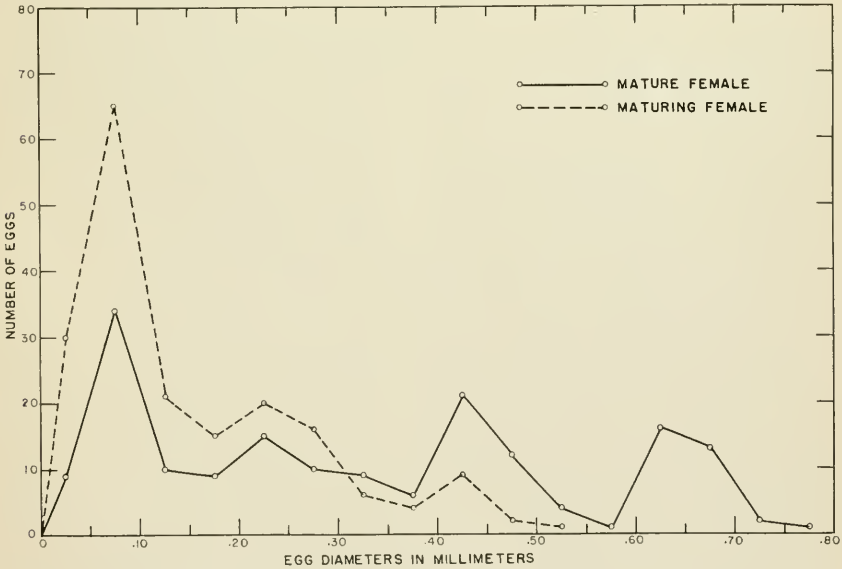


FIGURE 2. Size distribution of eggs from mature females and from maturing females

TABLE 1

Percentage Frequency Distribution by Months of Egg Diameter of California Sand Dab Collected From San Francisco Market During the Year 1947*

Class range, mm.	Mid-point	January	February	March	April	June	July	August	September	October	November	December
0.00-.04	0.02	6	5							2	10	6
.05-.09	.07	46	35	7						52	54	40
.10-.14	.12	35	37	14	9					28	36	52
.15-.19	.17	10	6	31	25					14		2
.20-.24	.22	3	12	27	48	2				4		
.25-.29	.27		4	19	16	7						
.30-.34	.32		1	2	2	4						
.35-.39	.37					11			4			
.40-.44	.42					31	5		16			
.45-.49	.47					27	3	4	14			
.50-.54	.52					6	16	4	4			
.55-.59	.57					10	10	9	2			
.60-.64	.62					2	27	11	30			
.65-.69	.67						22	28	24			
.70-.74	.72						5	24	2			
.75-.79	.77						10	16	4			
.80-.84	.82						2	4				
.85-.89	.87											
.90-.94	.92											
Means		0.099	0.12	0.18	0.20	0.45	0.62	0.67	0.57	0.10	0.08	0.09

* Only the larger eggs in each fish were measured because only these can be considered to be most nearly representative of the eggs that are destined to mature during the next spawning season.

Based on the positions of the modes of these curves three stages in the development of the eggs are recognized. Stage I consists of immature eggs only, with the mode at about 0.07 millimeter. These eggs are microscopic and transparent and characterize a resting stage between spawning seasons. Stage II, an intermediate group, consists of maturing eggs, that is, eggs that are developing toward maturity. This group is further divided into two subgroups. Subgroup (i), the smaller eggs of the intermediate group, are semiopaque and with the mode falling at about 0.22 millimeter; subgroup (ii), the larger of the intermediate group, are opaque-white eggs with mode at about 0.42 millimeter. These are readily seen in females nearing maturity. Stage III consists of mature eggs only, with the mode at about 0.65 millimeter. These form the largest group of eggs, are transparent and contain a single oil globule ranging in diameter from 0.09 to 0.1 millimeter.

These classifications correspond to the maturity scale adopted by Walford (1932) in the California barracuda and Clark (1934) in the California sardine. Walford divides the developmental stages of the ovary of the California barracuda into three stages as outlined above. He adds another stage (Stage IV) which consists of spent fish. The ovaries in such fish are full of immature eggs only, with few maturing and mature eggs. Clark, on the other hand, describes 12 stages in the maturation of the eggs of the California sardine. She, however, groups these 12 stages into five categories, viz., (1) immature, (2) maturing, opaque eggs, (3) maturing, transparent eggs, (4) mature, transparent eggs free in the oviduct, and (5) spent. Categories (2) and (3) of Clark are designated in the California sand dab as Stage II and categories 1 and 4 correspond to our Stage I and Stage III respectively.

Spawning Period

The spawning period was determined from a series of egg measurements made during each month of the year except May. The data are given in Table 1. It should be noted here that while measuring eggs for this purpose only those of the largest group of eggs in each fish were measured. The immature eggs were so numerous that to measure them in their true ratio would have increased the work manyfold and nothing was lost by not including them in the measurements because only the larger eggs are destined to mature during the next spawning period.

From the curve showing the average size of these largest ovarian eggs for each month except May (Table 1) it is evident that the maximum size is attained during late July, August, and early September. The average size of the eggs maturing during these months was 0.619, 0.674 and 0.571 millimeter respectively. These eggs were mature and on pressing the ovary would flow out freely. All the females examined during August were mature and full of ripe eggs. In late September, however, a greater percentage of the females were found spent, and in October practically all the females were spent. It is concluded, therefore, that the sand dab starts spawning in July, reaches the peak of spawning in August and that the spawning period ends sometime in September. The males during these months are also fully mature. When the belly of a mature male is pressed, the milt oozes through the opening of the gonaduct.

It should be noted here that the material upon which this conclusion is based was collected from the markets and taken from different fishing grounds. The effects, therefore, of depth, temperature, and other important factors which may alter the ripening period of the eggs have not been taken into consideration.

Frequency of Spawning

There is some evidence to indicate that the California sand dab may spawn more than once during each season. If there were only one spawning a season one would expect to find spent fish in increasing proportions in the catch throughout the season and only two groups of of eggs in the spawning females, i.e., the immature (Stage I) and the mature (Stage III). However, no spent female was observed during the peak of the spawning season. The ovaries of ripe females showed, not only immature (Stage I) and mature translucent eggs, but also semi-opaque and opaque-white eggs (Stage II) as is obvious from Figure 2. The ovaries of females taken before the spawning season show only two chief groups of eggs, the microscopic immature eggs (Stage I) and the opaque intermediate eggs (Stage II). It seems quite possible that by the time one group of eggs has attained maturity, a second maturing group is distinguishable. Such a group of maturing eggs appears between 0.37 and 0.52 millimeter in the graph for mature females in Figure 2. This second maturing group may then gradually develop from the intermediate class as the first maturing eggs increase in size so that, by the time the first eggs are ready to be spawned, the second lot can be clearly distinguished.

Throughout the season, the ovaries of the mature females contain opaque-white eggs (Stage II) as well as mature and immature eggs. Since no spent female was observed during the peak of the spawning season, it seems probable that the sand dab spawn more than once during a season, but much more extensive observations will be needed to prove this hypothesis.

AGE AND GROWTH

Results of Scale Studies

The scales of the sand dab are cycloid. They are generally oval or subcircular in outline but may take various shapes depending upon the region of the body from which they come. A typical scale from a fish, 238 millimeters in length and captured on February 5, 1947, is illustrated in Figure 3. The outer surface is sculptured with many striations, concentric or nearly so. These are termed circuli (C) and mark successive stages in the growth of the scale. The circuli are interrupted and divided into short sections by numerous radial ridges called radii (R). The side which is directed towards the tail when the scale is in its position on the fish, is designated as "posterior" and the side opposite is the "anterior." The area within the central ring is designated as the focus (F). If the circuli be followed from the focus outwards, it may be seen that the first six are very widely spaced and complete. Following these, in the anterior region of the scale, there are zones in which the circuli are successively widely and narrowly spaced. In the posterior region the complete circuli are comparatively few. The areas in which the circuli are narrowly spaced and less distinct represent the periods of slow growth; and those

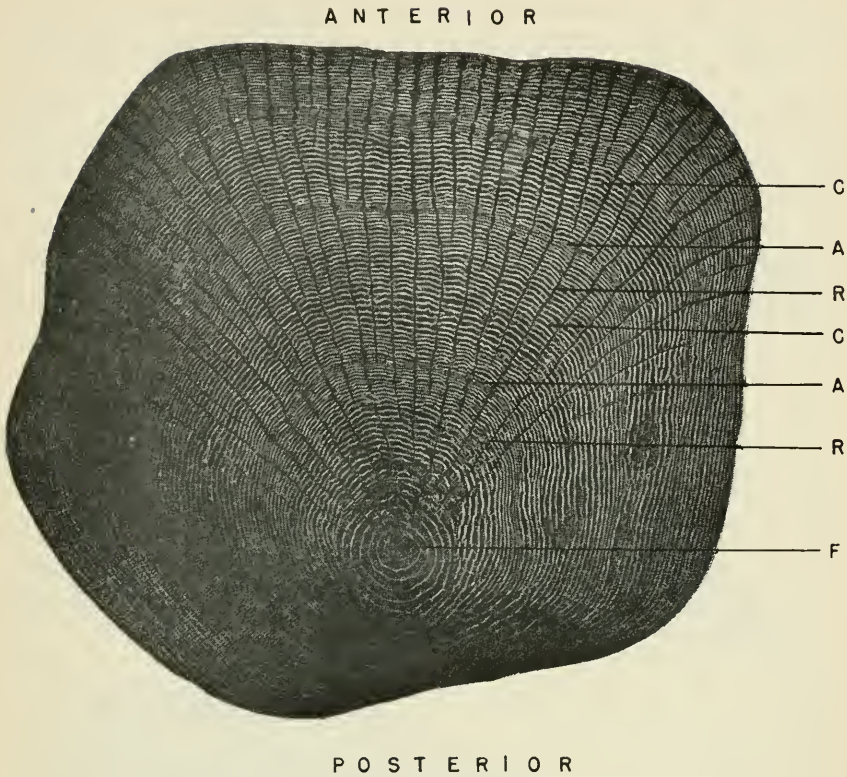


FIGURE 3. Typical scale of a California sand dab. The fish measured 238 mm. in length and was taken in February, 1947, near the Farallon Islands.

in which the circuli are widely spaced represent periods of rapid growth. The break between a winter band of slow growth and the succeeding band of rapid growth stands out as a rather sharply defined line and is here called the annulus (A). This marks the end of the year's growth.

With respect to these annuli, various irregularities may appear. Approximated circuli sometimes appear between two true annuli so as to form what has been termed an "accessory annulus" (a, Figure 11). This temporary retardation of growth during periods of rapid growth may be interpreted as a result of some unusual circumstance in the life of the individual, such as an injury, disease, starvation, etc. Sometimes these accessory annuli simulate the true annulus so closely as to make accurate age determination difficult.

In some scales a check (approximation of circuli) is seen immediately outside of the few widely separated circuli around the focus and commonly separated from the latter by six or eight circuli (Figure 6, B). This first check is certainly not an annulus because, in the first place, its appearance is not constant in all fish examined and, secondly, this check if present is shortly followed by another which was observed in young fishes captured in February, 1947, and is certainly the first annulus (Figure 6). The check which is formed immediately outside of the first wide rings around the focus is, therefore, termed a "false annulus."

It is undoubtedly due to some unfavorable condition and may be formed during the migration of the larvae from a pelagic to a demersal environment and the subsequent drift inshore.

In some scales there is a wide central area, quite devoid of circuli, often rough or granular in appearance and irregular in outline. Such scales have been regenerated after the original scales have been lost and the size of the central area approximates the size of the scale that was lost. If the scale was lost early in life the area is small; if later, it is large. Examples of such regenerated scales are illustrated in Figure 13. Small scars of patches commonly found on scales presumably are repaired injuries. These scars are irregular in form and devoid of circuli or annuli.

These irregularities in the structure of scales do not invalidate necessarily the scale method of age determination but emphasize the necessity of examining several scales from each individual.

Period of Annulus Formation

Most of the scales collected by the author from fish captured in February, 1947, showed checks (annuli) at the periphery of the scales. Examples of this are shown in scale photographs presented in Figures 6 to 12. Scales were also examined from fish taken during other parts of the year. Magnified photographs of the peripheral region of the selected scales are shown in Figures 4 and 5. Fish captured during August showed pronounced growth in the periphery of their scales (B, Figure 4). The commencement of growth was observed in March or April as is evident from a few widely spaced circuli at the periphery of the scale shown in Figure 4 (A). Retardation in growth is observed in fish captured from November to January, (C, Figure 4; A and B, Figure 5). The margin of the scale from a fish captured on February 7, 1948, shows the completion of an annulus (C, Figure 5). Thus, it is apparent that the growth is arrested and a check formed sometime during the winter. Since most of the scales taken from fish captured on February 5th showed the formation of annuli, it may be inferred that the check is normally completed in December or January. This may, therefore, be regarded as marking the end of the year's growth.

Age Groups

Ages were recorded as the number of winters completed, the area between annuli being considered indicative of spring, summer and autumn growth and of winter quiescence. For the purpose of this study, December 31st was arbitrarily designated the last day of winter and of the biological as well as the calendar year. Thus a scale which registered no annulus but showed the growth of the previous summer and autumn was recorded as belonging to the 0 year class prior to January 1st but to the I year class on that date. Since all the fish for scale method of age determination were collected on February 5, 1947, and in a single locality, no fish was grouped into the 0 year class. Those fish in which the first year check was just forming at the periphery of the scales were considered to have completed their first year and thus belonging to age group I. Those which had completed two checks were put in age group II; those with three checks in age group III and on the same basis, subsequent age groups were designated.

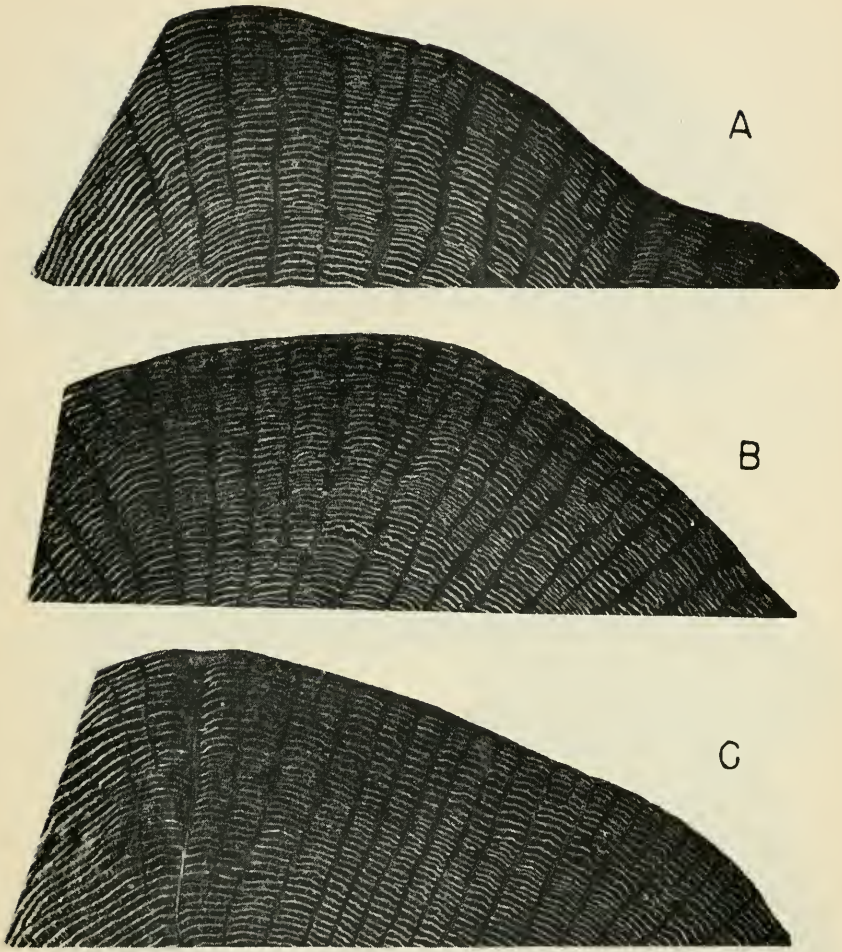


FIGURE 4. Scales of California sand dabs taken from near the Farallon Islands. (Only marginal region shown.) A—From 210 mm. female, March 24, 1947. B—From 245 mm. male, August 12, 1947. C—From 179 mm. male, December 10, 1947.

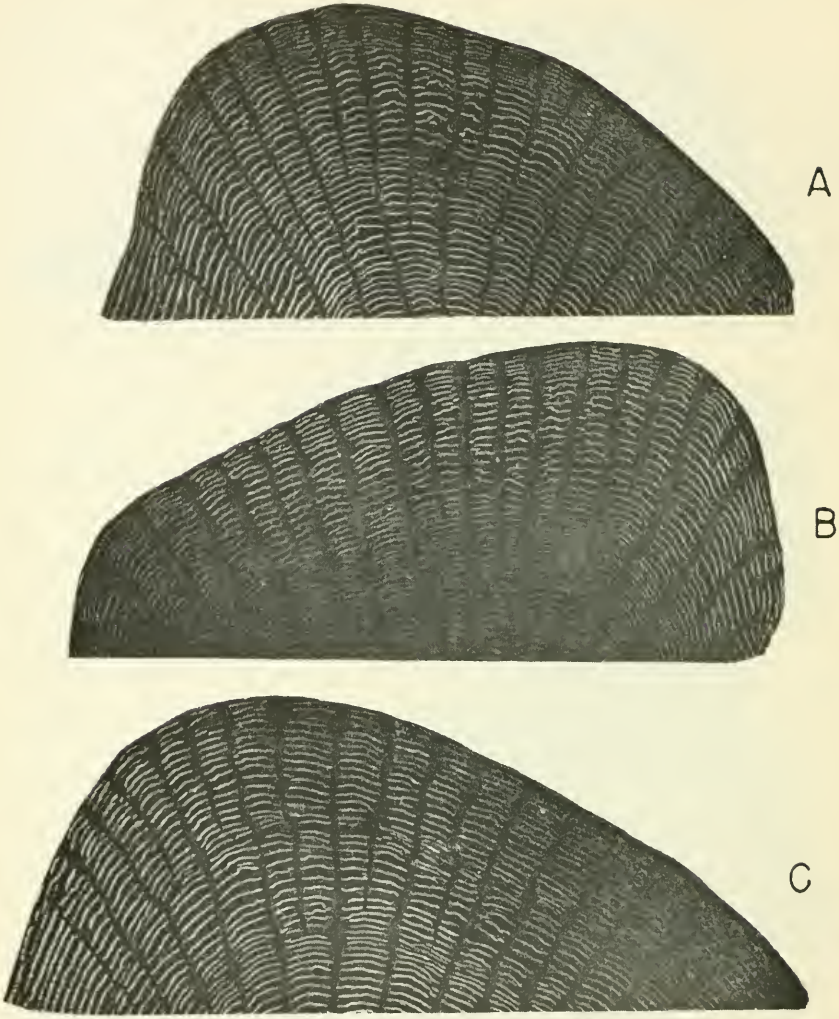


FIGURE 5. Scales of California sand dabs taken from near the Farallon Islands. (Only marginal region shown.) A—From 158 mm. female, December 29, 1947. B—From 163 mm. female, January 21, 1948. C—From 200 mm. male, February 7, 1948.

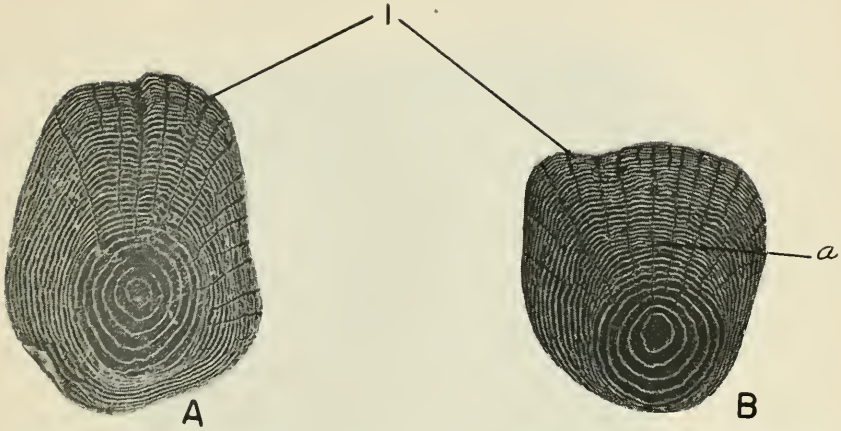


FIGURE 6. Scales of California sand dabs taken from southwest of Point Reyes, February 5, 1947. A—From 100 mm. female. B—From 101 mm. female. Both scales show one annulus.

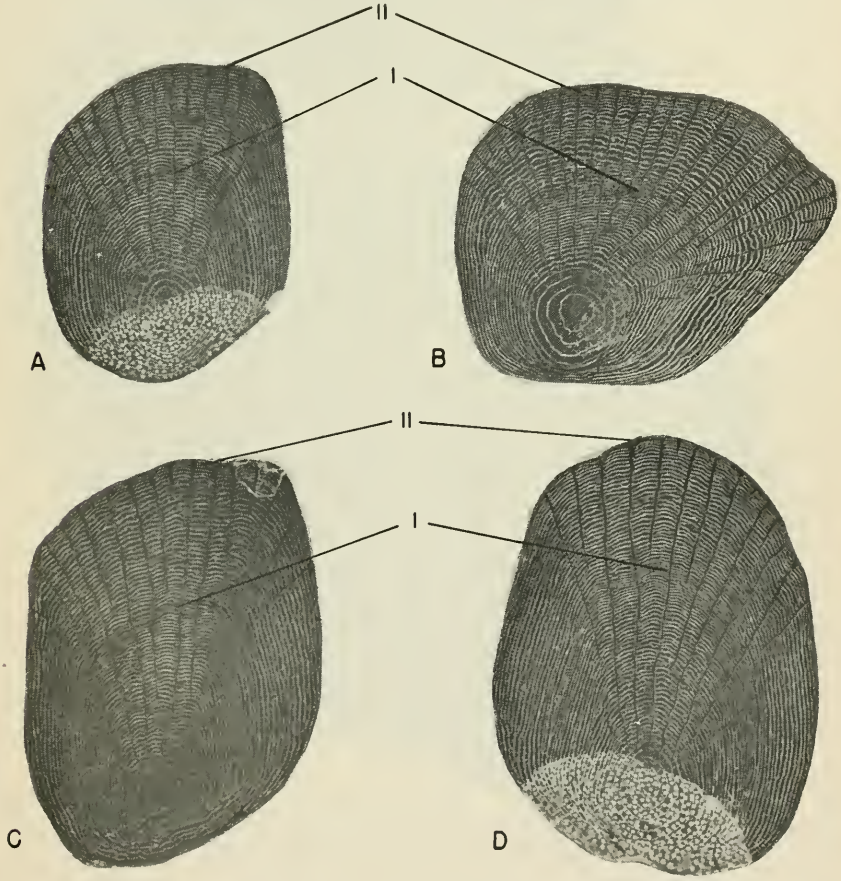


FIGURE 7. Scales of California sand dabs taken from southwest of Point Reyes, February 5, 1947. A—From 124 mm. male. B—From 128 mm. male. C—From 148 mm. female. D—From 153 mm. male. All scales show two annuli.

FIGURE 8. Scale of California sand dab taken from southwest of Point Reyes, February 5, 1947. Female, 187 mm. showing three annuli. Note the accessory annulus (a).

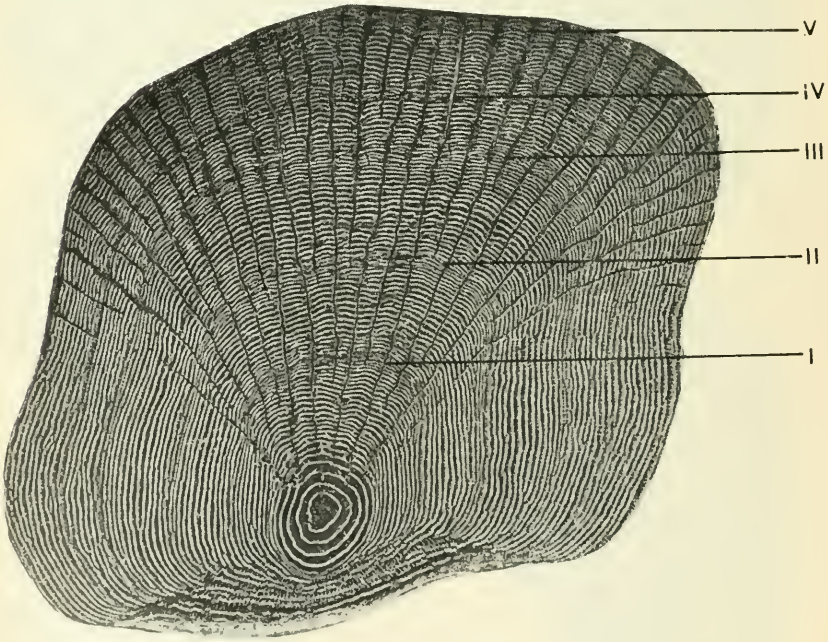


FIGURE 9. Scale of California sand dab taken from southwest of Point Reyes, February 5, 1947. Female, 234 mm. showing five annuli.

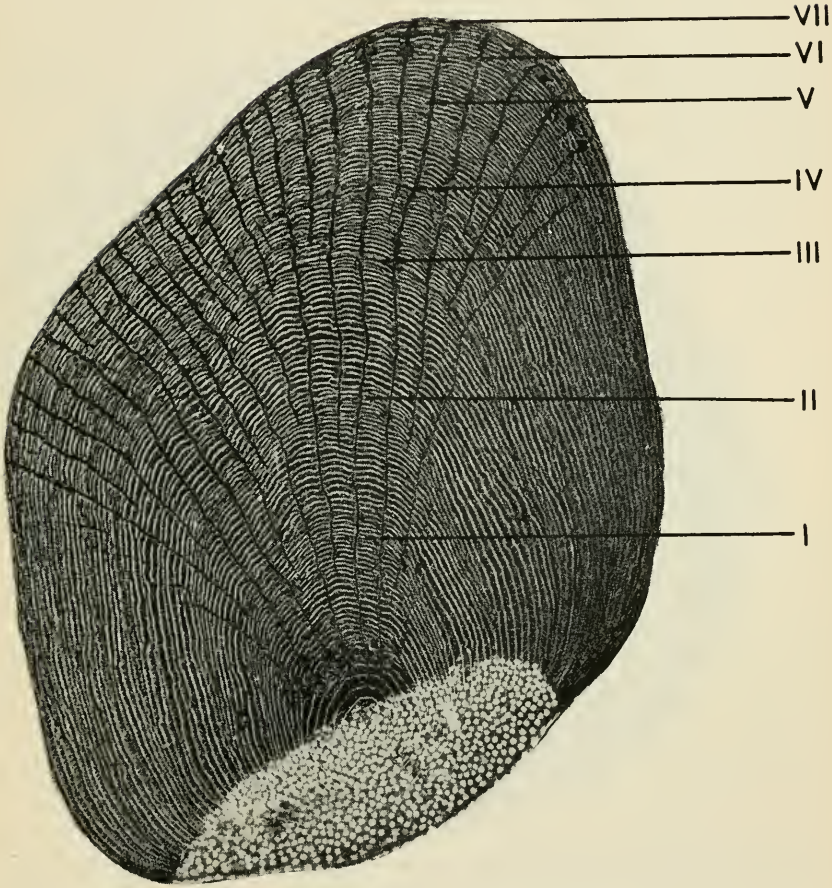


FIGURE 10. Scale of California sand dab taken from southwest of Point Reyes, February 5, 1947. Male, 260 mm. showing seven annuli.

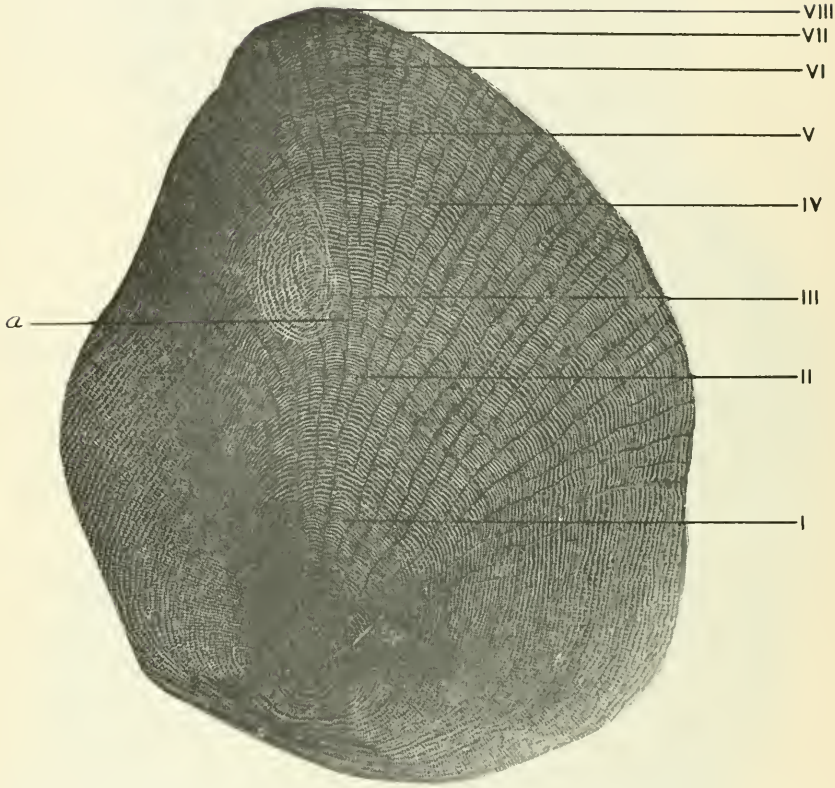


FIGURE 11. Scale of California sand dab taken from southwest of Point Reyes, February 5, 1947. Female, 260 mm. showing eight annuli. Note the accessory annulus (a).

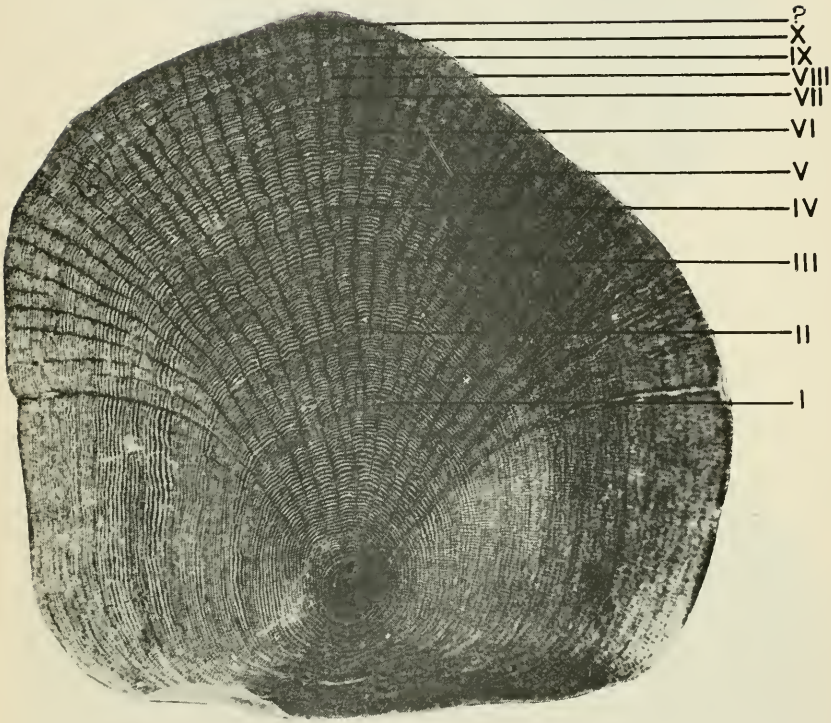


FIGURE 12. Scale of California sand dab taken from southwest of Point Reyes, February 5, 1947. Female, 297 mm. and showing 10 (11?) annuli.

FIGURE 13. Regenerated scales of California sand dabs taken from southwest of Point Reyes, February 5, 1947. A—From 297 mm. female. Recently regenerated scale. B—From 269 mm. female. Early regenerated scale.

TABLE 2

Length Frequency Distributions of Age-Groups of Fish Captured on February 5, 1947. Age Determined by Examination of Scales

Class range (mm.)	I	II	III	IV	V	VI	VII	VIII
73- 82								
83- 92	5							
93-102	9							
103-112	4							
113-122								
123-132		3						
133-142								
143-152		8						
153-162		4	1					
163-172		3	1					
173-182			4					
183-192				1				
193-202			1	1				
203-212			1					
213-222			1	2	4			
223-232			1		1		1	
233-242			1	1	4	3		
243-252					4			
253-262					2	2	3	2
263-272					1	1	1	
273-282					1		1	1
283-292							2	
293-302								2
Total number	18	18	11	5	17	6	8	5
Mean*	95	148	192	226	240	248	266	277
Standard deviation*	10.4	13.0	25.5	29.3	18.1	13.3	21.0	17.0

* Calculated from an extended table in which the class interval was 2 mm.

Photographs of scales from fish of different ages are presented in Figures 6 to 12. While the spaces between the first seven or eight annuli were sufficiently wide for reasonably consistent and accurate counting, those beyond seven or eight became too narrow, and the year marks too crowded, to justify any attempt at trustworthy age determination beyond eight years.

After all the scales had been interpreted, length-frequency distributions were made for each separate age group (Table 2). The average length and standard deviation for each age group are shown at the bottom of the table. The data on the total number of individuals of each age group is rearranged in Table 3 to facilitate comparative study of the difference

TABLE 3

Average Length of Males and Females at Each Age-Group

Age-group	Males		Females	
	Number	Mean total length (mm.)	Number	Mean total length (mm.)
I	9	98	9	100
II	12	137	6	155
III	5	164	6	199
IV	2	212	3	213
V	4	236	13	243
VI	3	244	3	253
VII	2	246	6	274
VIII			5	277

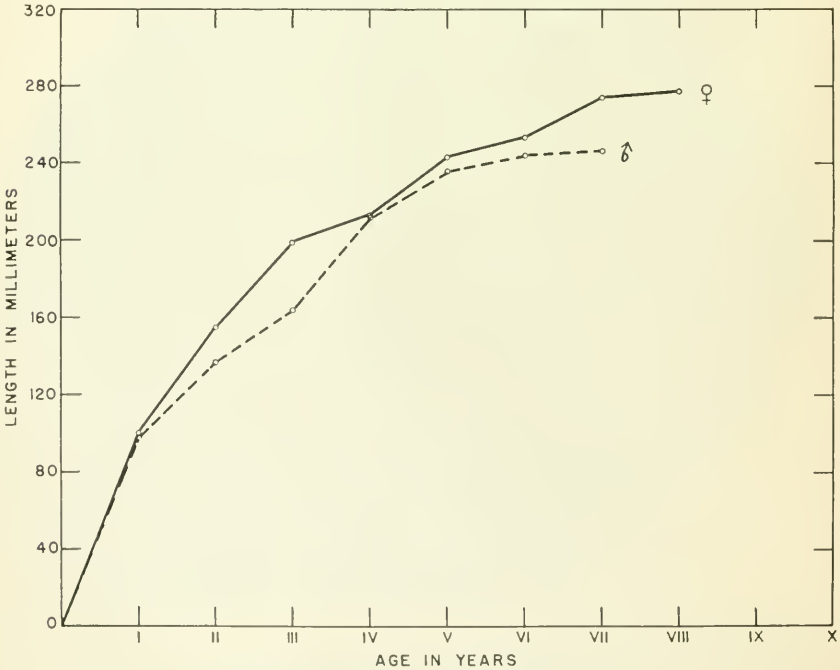


FIGURE 14. Growth curves of male and female sand dab. Lengths observed at different ages.

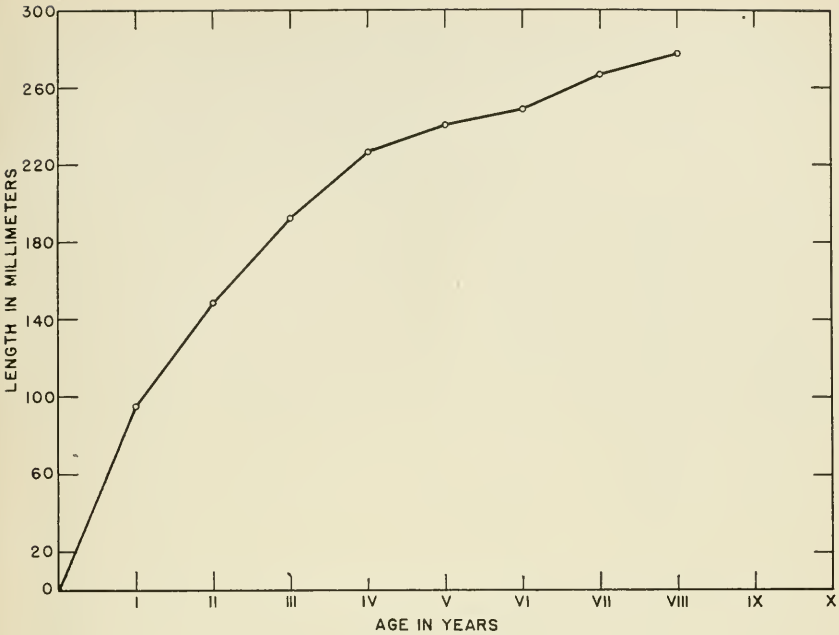


FIGURE 15. Average growth curves of males and females combined. Lengths observed at different ages.

in the lengths of male and female fish at each age group. The growth curves of males and females, based on these mean lengths of different age groups, are shown in Figure 14, and of the two together in Figure 15. It will be seen that the females are on the average slightly larger than the males. As is typical of the growth curves of fishes, the increase in length is most rapid during the first year and shows a fairly constant decline with each successive year. This is true of both males and females. This feature of the growth is also seen in the photographs of the scales and in the calculations of lengths at different ages based on scale measurements and given in Table 2.

Estimates of Annual Growth

Lee (1920) and other investigators have shown that the scales grow almost or quite in proportion to the increase in length of the body of the fish. Such being the case, the length at the end of each year of life may be computed from a series of measurements of a scale of a fish of a known length. Given the total radius of a scale, the radius to the annulus of any given year (x), and the total length of the fish from which the scale is taken, the length of the fish at the end of the year x is determined by the use of the following formula:

$$\frac{S_x}{S_T} = \frac{F_x}{F_T} \quad \text{or } F_x = \frac{S_x F_T}{S_T}$$

where S_x is the distance from the center of the scale to a particular annulus, x; S_T the distance from the center of the scale to the edge of the

TABLE 4

Calculated Total Lengths of Sand Dab at End of Each Year of Life, as Determined From Measurements of Scales

Age	Length (mm.)	Sex	Yearly calculated length in millimeters							
			1	2	3	4	5	6	7	8
I	85	M	80							
I	95	F	86							
I	98	F	92							
I	100	M	95							
I	100	F	98							
I	100	F	93							
I	101	F	96							
I	105	M	99							
II	124	M	70	117						
II	128	M	56	116						
II	135	M	85	130						
II	143	M	86	140						
II	145	M	66	135						
II	146	F	93	140						
II	148	F	81	142						
II	148	M	82	142						
II	149	M	107	147						
II	150	F	99	145						
II	152	M	103	144						
II	153	M	95	150						
II	156	M	79	131						
II	156	F	72	151						
II	158	M	100	158						
II	166	F	96	162						
II	168	F	90	162						
II	178	M	92	175						
III	128	M	78	106	124					
III	154	M	62	116	149					
III	168	F	71	116	156					
III	175	M	110	145	173					
III	180	F	72	132	168					
III	180	M	76	128	152					
III	182	M	86	138	163					
III	194	F	85	132	177					
III	207	F	81	150	191					
III	220	F	97	157	194					
III	225	F	85	153	206					
III	233	M	86	156	222					
III	268	F	119	196	262					
IV	187	F	75	120	163	179				
IV	202	M	88	135	172	192				
IV	215	F	71	135	179	206				
IV	216	F	98	158	182	212				
IV	221	M	80	138	188	210				
IV	236	F	84	149	210	227				
V	201	M	66	130	162	185	200			
V	216	F	61	114	163	189	212			
V	221	F	70	114	169	198	219			
V	225	F	71	116	156	197	223			
V	231	F	72	116	161	189	225			
V	236	F	74	131	173	208	232			
V	239	F	101	159	186	203	233			
V	240	F	79	121	166	208	236			
V	243	F	109	168	191	210	228			
V	245	F	76	142	194	216	234			
V	247	M	72	122	174	211	232			
V	259	F	72	132	191	236	257			
V	262	M	81	144	206	238	259			
V	269	F	66	130	196	230	260			
V	275	F	105	168	226	248	268			
VI	234	F	100	142	184	222	245	264		
VI	235	F	82	132	172	198	212	228		
VI	238	M	84	156	199	215	229	233		
VI	245	M	73	123	160	202	224	236		
VI	257	M	112	158	210	226	249	254		
VI	262	F	65	124	172	210	240	251		
VI	263	M	107	168	216	232	249	261		
VII	228	M	58	123	163	180	206	216	222	
VII	253	F	78	113	143	191	218	236	246	
VII	260	F	92	120	146	210	236	252	258	
VII	260	M	66	118	161	191	224	248	256	
VII	272	F	84	128	165	204	233	252	267	
VII	280	F	99	178	216	241	258	267	274	
VII	290	F	85	130	185	208	225	239	248	
VII	292	F	84	125	157	204	255	280	288	
VIII	260	F	64	115	146	181	206	233	248	256
VIII	260	F	80	120	148	195	220	240	252	258
VIII	275	F	64	112	161	192	227	245	260	267
VIII	293	F	70	121	162	195	216	232	270	282
VIII	295	F	114	167	220	243	265	277	285	291

scale; F_x the length of the fish at the time the annulus x was formed; F_T the length of the fish at the time of the observation. Substituting in this formula the radius to the annulus of each year, the length of the fish at the end of each successive year of life is computed. From these lengths the mean for each year is calculated and the mean growth increment for each year is obtained by a simple subtraction.

Scale measurements of 80 fish of different ages were taken and the lengths for each year were calculated by the above formula. The results are shown in Table 4. The mean lengths of male and female at the end of each year of life were calculated. The mean growth curves are shown in Figure 16. As would be expected, the calculated growth curves are relatively smoother. Both males and females grow approximately at the same rate for the first four years at the end of which period they attain a length of 208 millimeters. After this, the males grow at a relatively lesser rate than the females. At the end of the seventh year the males grow to a length of 239 millimeters whereas the females attain a length

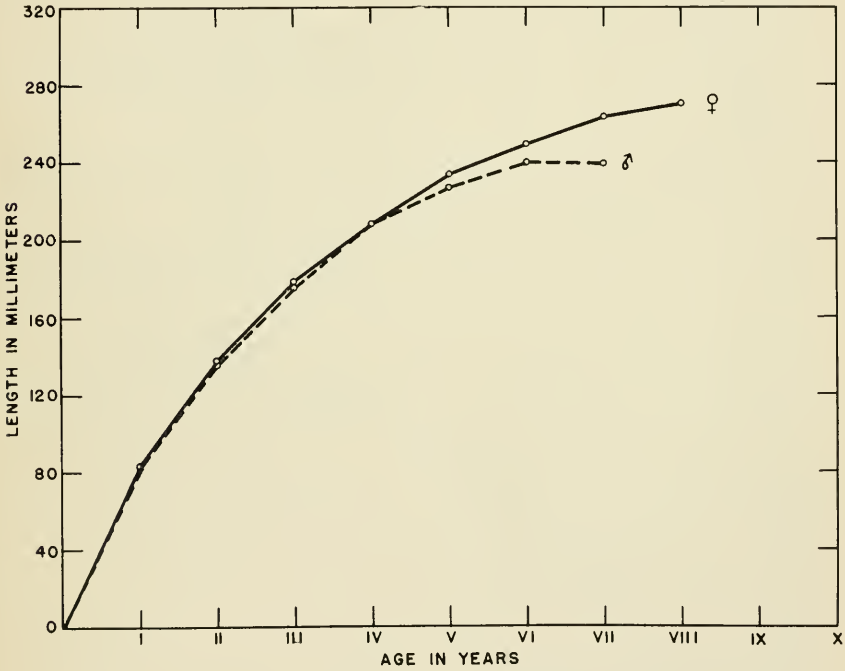


FIGURE 16. Growth curves of male and female sand dab. Lengths calculated from scale measurements.

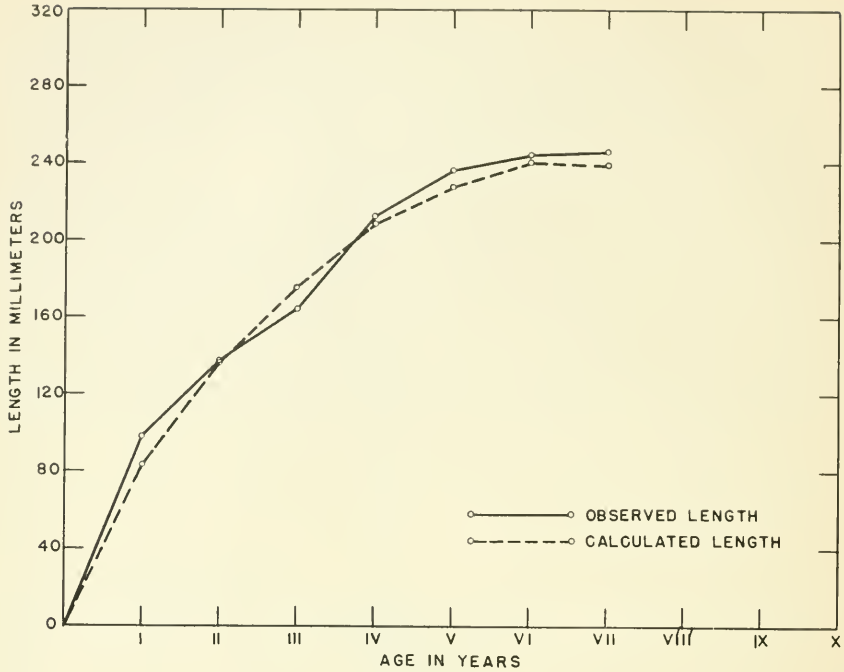


FIGURE 17. Growth curve of male sand dab

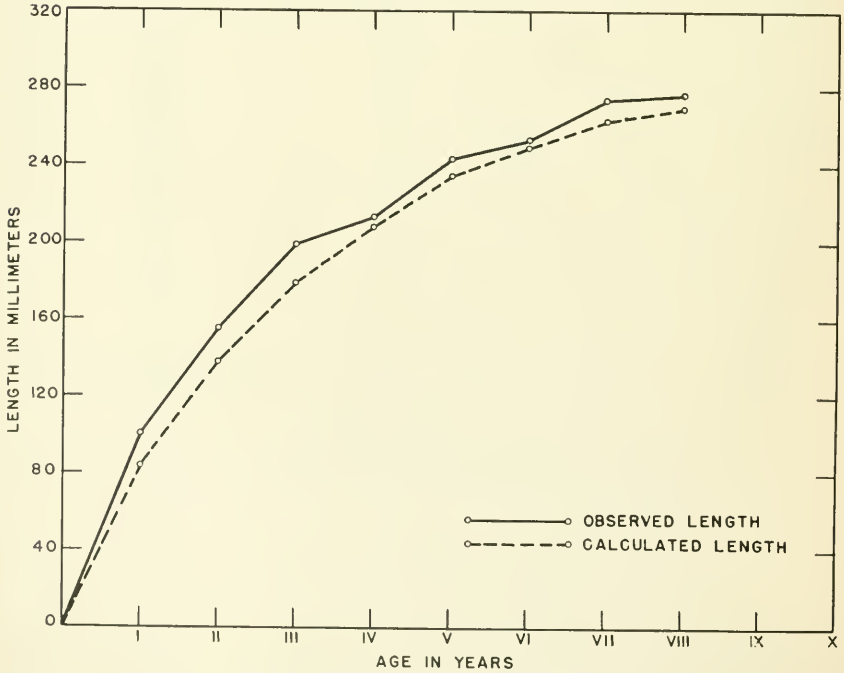


FIGURE 18. Growth curve of female sand dab

of 263 millimeters. When the calculated lengths of male and female fish are compared with the corresponding observed lengths (Figures 17 and 18), it is found that the two are closely approximated. This evidently indicates that the lengths of the fish, as calculated from scale measurements, are fairly accurate.

Otolith Studies

The otoliths of fishes are concretions of calcium carbonate with some intermixture of organic material (Immermann, 1908; Maier, 1906). Those of the sand dab are more or less flattened, disc-shaped bodies that lie in the sacculi of the auditory organs. The concave surface is to the outside and the inner, convex side is marked by a longitudinal groove along which a main branch of the auditory nerve is attached. When examined under the microscope either by reflected light against a dark background or by transmitted light, the otolith shows the characteristic alternating light and dark concentric bands (see Figure 19, A). The photomicrograph of the otolith shown in this figure was made in transmitted light. The bands that appear white in transmitted light appear dark in reflected light. The central part of the otolith consists of a nucleus or "kernel." This contains a small central translucent part (not visible in the photograph) around which lies an opaque band which in turn is followed by a broader translucent ring. In this study all these together are designated as the "core" of the otolith. According to Thompson (1930), the nucleus represents the otolith before metamorphosis. Radial lines which run from the core through the alternating white and dark bands out to the periphery are apparent in the photograph. These lines are produced by surface grooves and have no significance so far as the age determination is concerned.

Cunningham (1905) has shown that, in the otoliths of Gadidae and Pleuronectidae, the opaque bands are due to increased calcification which occurs during the period when growth is most rapid and that the translucent bands are formed when growth is very slow or at a standstill. The same is true of the otoliths of the California sand dab. In Figure 19 are presented photographs (made in transmitted light) of a scale (B) and an otolith (C) from a one year old fish captured on February 5, 1947. Both the scale and the otolith obviously represent all, or nearly all, of the growth of the first year. When the new (2d) growth period begins, a new opaque band will be formed outside the present margin of the otolith. In the otolith this outer band and the other bands that appear dark in the photographs are relatively opaque and the bands that appear light in the photograph are relatively translucent.

Similar correspondence between the translucent rings of the otolith and the annuli of the scale is shown in older specimens in Figure 20. In this figure again both the otolith and the scale are from the same fish, 180 millimeters in length. Three annual checks are recognized on both. Otoliths from fish older than three years were also studied and photographed as shown in Figure 21. In the otoliths of very old fish (B in Figure 21), the first seven or eight year marks are generally well defined; but the subsequent ones are so closely crowded and so easily confused that they cannot be counted with a very high degree of confidence. On comparing this otolith with the scale of the fish from which

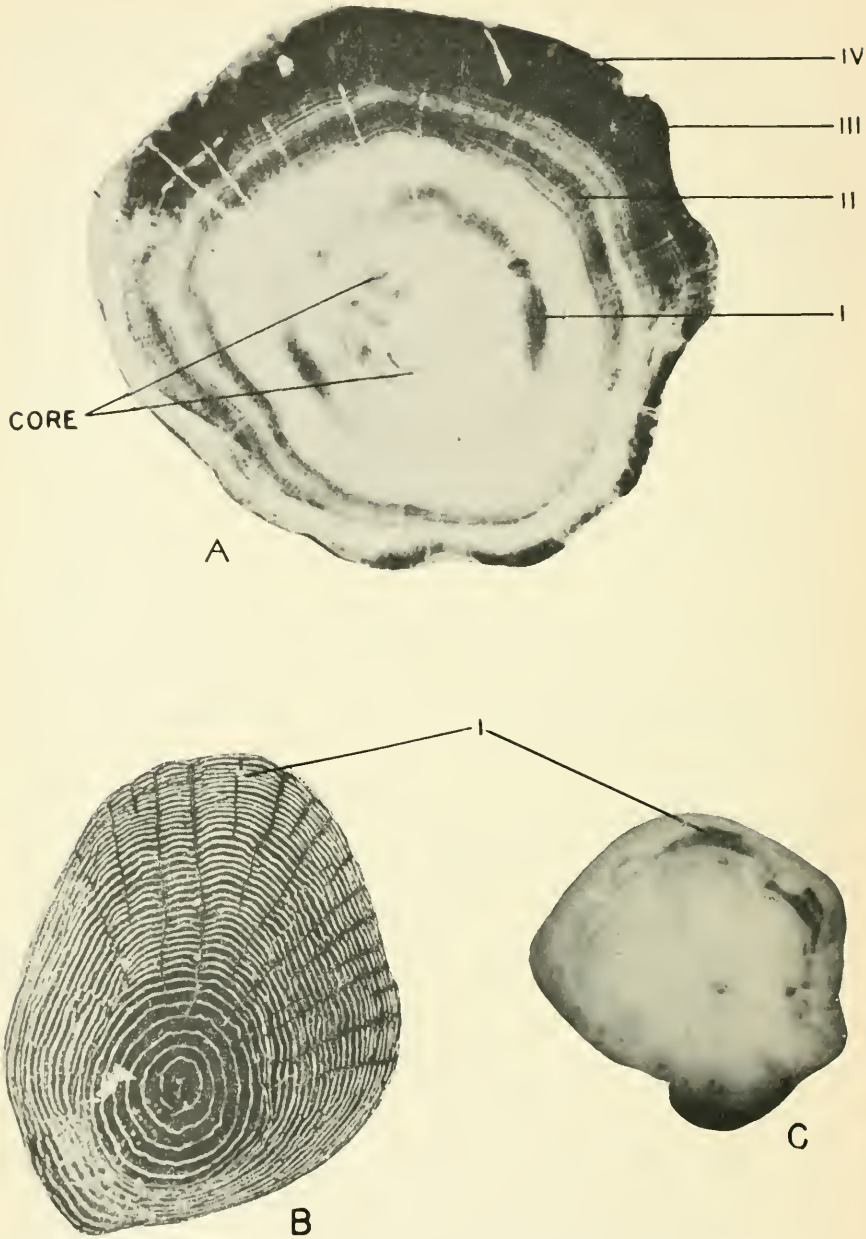


FIGURE 19. Otoliths (A and C) and scale (B) of California sand dabs taken near the Farallon Islands, February 5, 1947. A—Otolith from 216 mm. female showing four annuli. B—Scale from 98 mm. female showing one annulus. C—Otolith from 98 mm. female showing one annulus.

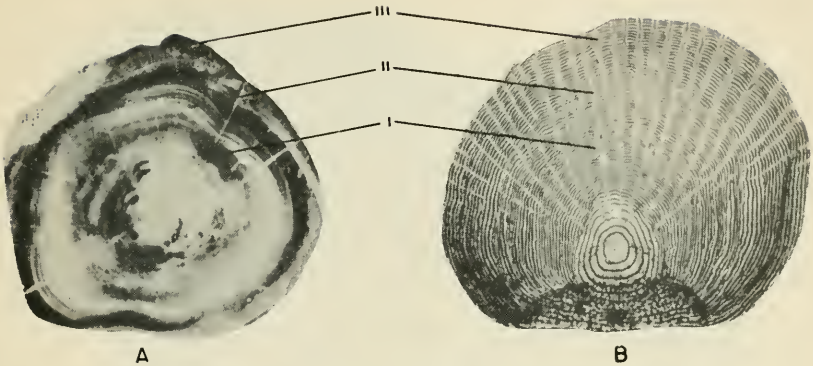


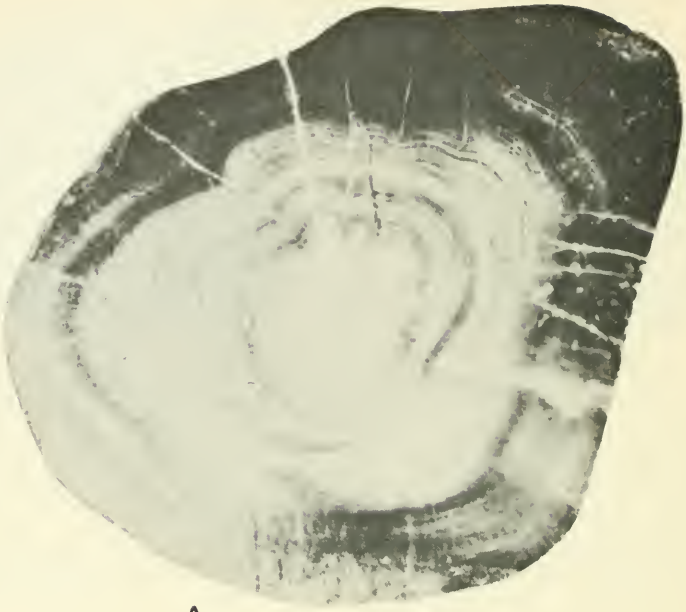
FIGURE 20. Otolith (A) and scale (B) of California sand dab taken southwest of Point Reyes, February 5, 1947. Female, 180 mm. showing three annuli.

this otolith was taken, a close similarity in the number of annual checks will be observed (see Figure 12 for scale photograph). Both of these structures were taken from a female fish which measured 297 millimeters in length and was captured on February 5, 1947.

There is, therefore, at least a general agreement between the otolith rings and scale annuli and it is evident that either may be used for determining the age of the sand dab.

Length-Frequency Distributions

The length measurements of the sand dab taken by the "Albacore" during 1935 and 1936 were classified into size groups with a class interval of 10 millimeters and the length-frequency distribution of each sample prepared. The samples have been combined by months and the monthly distributions are presented in Table 5. The length-frequency distributions for each month for which data are available are graphically presented in Figure 22. All fish which were derived from eggs spawned during the summer and captured before December 31st are placed in the age group 0; all those captured during the calendar year next following that in which the eggs were spawned are placed in age group I and on the same basis, subsequent age groups were determined.



A

B

FIGURE 21. Otoliths of California sand dabs taken from southwest of Point Reyes, February 5, 1947. A—From 235 mm. female showing four (five?) annuli. B—From 297 mm. female showing 10 (11?) annuli. Only eight annuli are decipherable in the photograph.

TABLE 5

Length-Frequency Distribution of California Sand Dab Taken in by "Albacore" in 1935-36

Class-range (mm.)	Mid-point (mm.)	1935 Oct.	1936							
			Jan.	Feb.	April	July	Aug.	Sept.	Nov.	Dec.
43- 52	47.5	--------	--------	1	--------	--------	--------	--------	--------	--------
53- 62	57.5	--------	1	1	--------	4	1	--------	--------	--------
63- 72	67.5	--------	--------	1	5	1	1	1	2	3
73- 82	77.5	12	5	6	7	5	3	8	23	28
83- 92	87.5	46	25	41	37	13	6	14	45	62
93-102	97.5	27	37	48	83	37	6	20	42	45
103-112	107.5	35	25	34	79	52	23	19	57	53
113-122	117.5	28	20	37	43	39	14	31	31	51
123-132	127.5	19	10	25	22	27	8	20	39	52
133-142	137.5	25	7	24	11	22	5	26	15	54
143-152	147.5	33	21	20	24	19	11	15	14	13
153-162	157.5	23	29	25	22	21	14	18	18	28
163-172	167.5	32	19	28	39	34	9	17	17	22
173-182	177.5	16	15	32	32	28	18	38	18	21
183-192	187.5	15	26	20	25	21	17	37	18	26
193-202	197.5	13	24	24	26	25	10	21	15	26
203-212	207.5	14	14	20	20	14	12	30	20	16
213-222	217.5	9	3	10	15	8	7	17	11	1
223-232	227.5	3	7	7	8	5	2	18	13	10
233-242	237.5	1	10	5	2	4	2	15	7	2
243-252	247.5	2	--------	2	2	1	5	7	1	1
253-262	257.5	--------	2	2	--------	--------	1	3	4	1
263-272	267.5	2	2	1	1	1	2	1	--------	1
273-282	277.5	--------	--------	1	--------	1	--------	--------	--------	--------
Totals	----------	355	302	415	503	382	177	376	410	516

The length-frequency histogram of the sample of 302 fish captured on January 18, 1936, is given on a larger scale in Figure 23. It shows three distinct modes, the first at 97.5 millimeters, the second at 157.5 millimeters and the third at 187.5 millimeters. These represent fish belonging to age groups I, II, and III respectively. In other words, the fish representing the mode at 97.5 millimeters must have been spawned in 1935; those distributed around the mode at 157.5 millimeters, in 1934; and those with the mode at 187.5 millimeters, in 1933. This interpretation of the age groups represented by the several modes is also in excellent agreement with the age-length data obtained from the collection made on February 5, 1947, and presented in Table 2. For ready comparison of the two series of data there has been superimposed on the histogram of Figure 23 three lines that show the position of the mean lengths of age groups I, II, and III of the 1947 collection and the limits for each group as defined by the mean plus and minus twice the standard deviation. (In normal distributions these limits would include approximately 95 percent of the variates.) There is obviously a close correspondence between the modes of the histogram and the means of the age groups determined from the scales. The spread around the means of the three age groups also agrees reasonably well with the apparent spread of the three year classes represented in the histogram.

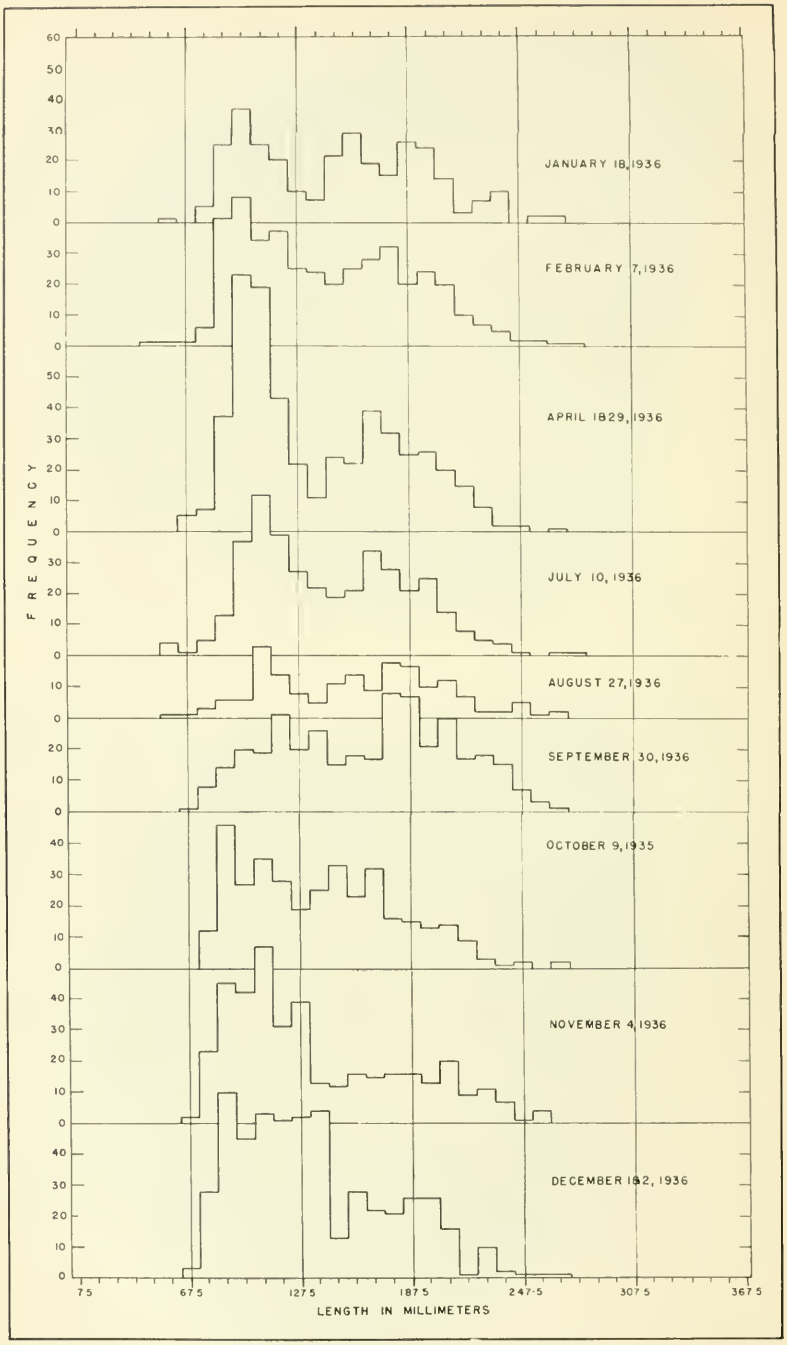


FIGURE 22. Length-frequency histograms of the different collections of sand dab made during 1935-36, by the *Albacore*

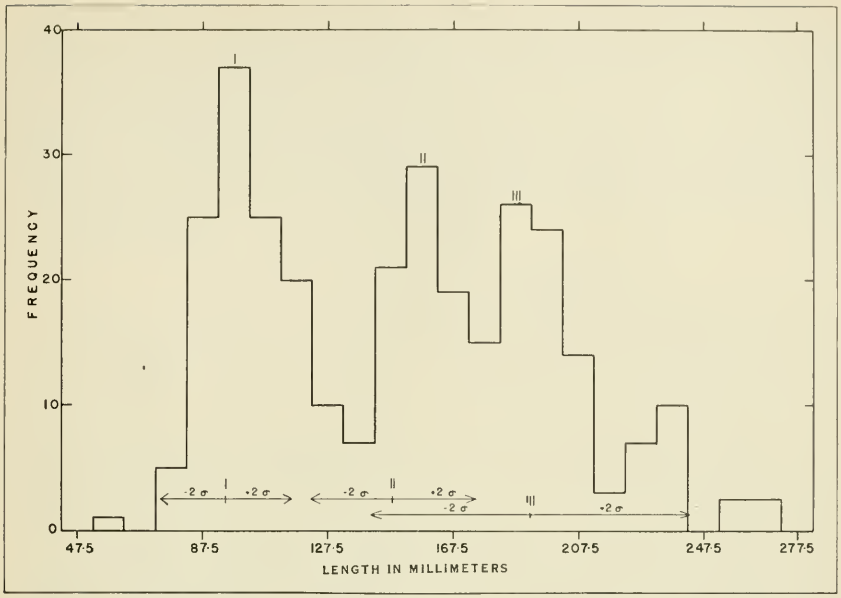


FIGURE 23. Histogram of length-frequency distribution of a sample of 302 fish obtained in January, 1936, upon which are superimposed the means and two standard deviations for the age-groups I, II, and III, as established by the examinations of the scales from sand dabs taken in 1947

We have, therefore, in satisfactory agreement, three methods whereby the age of the younger sand dabs have been determined—methods using the scales, the otoliths and the length-frequency distributions. Of these three methods only the scales and otoliths can be used for age determination of the older fish because of the excessive overlapping of the frequency distributions. In comparing the scales and otoliths the scales are much easier to collect, prepare and to read. Especially with the oldest fish, those six or seven years and older, the otoliths are much more difficult to read than are the scales.

The growth of the fish was studied by following the progression of the modes through the year. Because of the great difficulty of determining theoretical modes in multimodal distributions, the empirical modes have been used for this purpose. They are, of course, less stable but it is believed that the general picture presented is valid. Assuming that each mode represents the average length of the year class, the change in their position gives a direct indication of the average change in length of the different age groups from time to time. These modal lengths, when plotted, give the growth curve for the three years covered by the data (Figure 24). It is obvious that the period of most rapid growth is during late summer and early fall. After this, growth probably continues, but at a much lower rate, for two or three months. There is apparently very little growth between January and July.

In Figure 22 the 0 group (i.e., fish in their first year of life) is not well enough represented in the samples collected during July, August, and September to produce distinct modes. This is undoubtedly due to the fact that spawning takes place chiefly during these months and

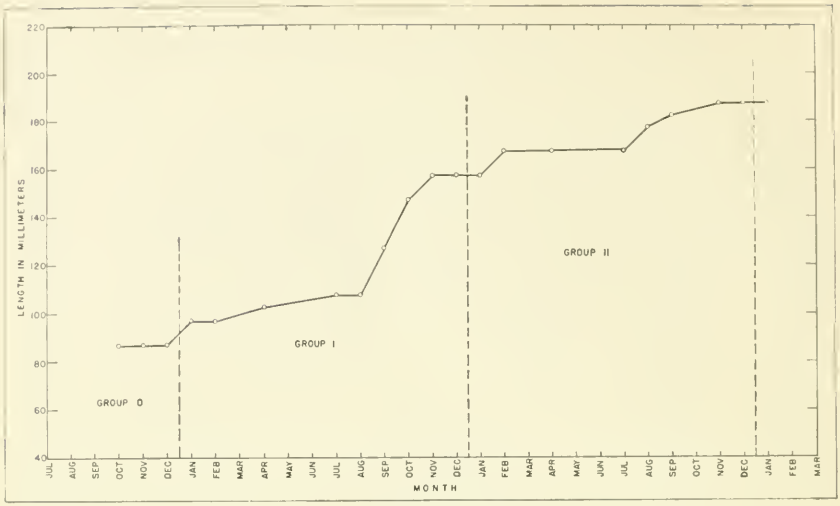


FIGURE 24. Growth curve of sand dab for each age and each month for which data are available. (Curve derived from length-frequency histograms of Figure 22.)

the collections did not include the smallest fish in proportion to their abundance in the population. It may well be that the size of the mesh of the net ($1\frac{1}{2}$-inch, stretched) permitted them to escape. Or it may be that, for some reason not understood, the smallest fish are not as available for capture as the larger ones. The samples collected in October, November, and December, however, show clearly the appearance of group 0, though the modes are not very sharply defined. The fish during these months have attained a modal length of about 87.5 millimeters and, evidently, are retained by the net of $1\frac{1}{2}$-inch mesh.

The I group, a continuation of the 0 group of December, is very distinct in January and throughout the later collections except those of November and December. It makes its appearance in January with a modal length of 97.5 millimeters and by July attains a length of 107.5 millimeters, the average growth being comparatively slow during this interval. This is undoubtedly related to the fact that the season of most rapid growth does not begin until March or April or even later. This has been shown in the section dealing with scale studies. In September, 1936, group I shows two empirical modes, one at 117.5 millimeters and the other at 137.5 millimeters. The center of this group probably lies somewhere between these two values. The mode of group I in the collection of October, 1935, is about 147.5 millimeters. Group I cannot be clearly distinguished in the length-frequency distributions for November and December; but in January the same year class, now age group III, presents a mode at 157.5 millimeters.

The modes representing group II can be followed through to the September collection. In September the mode appears to be at 177.5 or 187.5 millimeters. Its identity is lost in the collections for October, November, and December.

Group III cannot be identified satisfactorily in any of the length-frequency graphs. It may be that the poorly marked mode at 187.5

(197.5) millimeters in the January collection and at 197.5 millimeters in the February collection represents this age group; but this can only be offered as a suggestion.

In view of the difficulty of identifying the modes of the year groups, especially of the older ones, and the doubtful location of some of the modes, it is fully recognized that the conclusions drawn from these length-frequency histograms do not possess great accuracy. Nevertheless, they probably do give us a reasonably good picture of the trend of growth of the sand dab for the first three years.

AGE AND SIZE AT FIRST MATURITY

The data employed in the determination of size of the sand dab at first maturity are based on 227 fish obtained from the commercial catch from the San Francisco market. Because of the uncertainty of the maturity of the testis, no male fish was included in the sample. The conclusions drawn, therefore, apply to the female fish only. The presence of eggs of Stage II (maturing eggs) and Stage III (mature eggs) in the ovary was considered sufficient evidence that spawning would take place during the same season. Furthermore, fish taken only during the peak of the spawning season, that is during August, were considered. The fish collected at the outset and at the close of the season were omitted. This omission was necessary because all fish do not start to mature nor cease spawning at the same time.

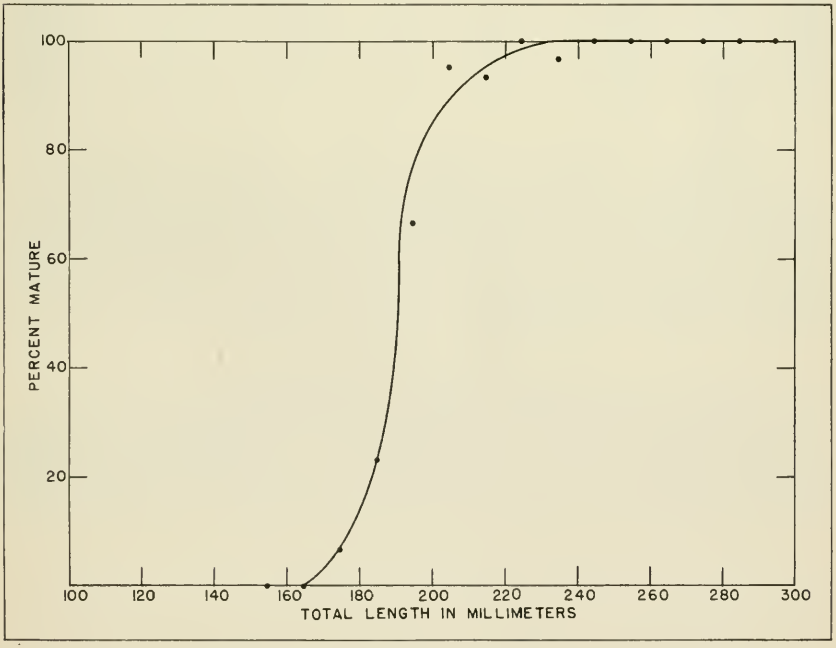


FIGURE 25. Size of sand dab at first maturity, as indicated by the percentage of females mature in each 10 millimeters of length. (Curve drawn by eye.)

The number of immature and mature sand dab grouped by 10 millimeter length classes are shown in Table 6. Figure 25 shows graphically the percentage of mature fish among those of each length, plotted by millimeters. The curve is smoothed by eye to show the trend. The curve indicates that no mature fish were found with a length less than 165 millimeters; 6.6 percent of the females was mature at 175 millimeters; 23 percent at 185 millimeters; 66 percent at 195 millimeters and practically all fish over 225 millimeters in length were mature.

TABLE 6

Number and Percentage of Mature Sand Dabs in Each 10 Millimeters of Length

Total length in millimeters	Total fish observed	Number mature	Percent mature
100-109			
110-119			
120-129			
130-139			
140-149			
150-159	4	0	0.0
160-169	9	0	0.0
170-179	15	1	6.7
180-189	13	3	23.1
190-199	18	12	66.7
200-209	21	20	95.2
210-219	15	14	93.3
220-229	19	19	100.0
230-239	31	30	96.8
240-249	25	25	100.0
250-259	17	17	100.0
260-269	15	15	100.0
270-279	10	10	100.0
280-289	12	12	100.0
290-299	3	3	100.0

Comparison of this size-maturity curve with data presented graphically in Figure 16 shows that most of the maturing fish belong in age group III. Some of the larger fish of age group II may also mature and, of course, some may not mature until in group IV or older. It may be stated with assurance, however, that the sand dab female normally matures in three years from the time the egg is laid and at an average length of about 190 millimeters.

LENGTH-WEIGHT RELATIONSHIP

It is a common practice among fishery biologists to record size in terms of length. However, it is frequently of interest to know also something about the weights of fish of different lengths. This is conveniently given by formulae or graphs showing the relationship between length

and weight so that one may be converted into the other if such a conversion is desired. This length-weight relationship was obtained from 150 fish taken near the Farallon Islands on February 5, 1947. The data are given in Table 7. The weight-length data of the sand dab were fitted to the formulae:

$$W = c(L)^n$$

$$\text{or} \quad \log W = \log c + n \log L$$

TABLE 7

Average Observed and Calculated Weights of Sand Dabs Captured on February 5, 1947

Size-groups (mm.)	Number of individuals				Average length (mm.)	Average weight (gm.)	Calculated weight (gm.)
	Unsexed	Male	Female	Total			
70- 79.9	1			1	70.0	3.0	2.7
80- 89.9	2			2	85.5	5.0	5.1
90- 99.9	18			18	93.7	6.6	6.8
100-109.9	11			11	101.6	8.5	8.9
110-119.9							
120-129.9		3		3	125.3	17.0	17.7
130-139.9		3	2	5	134.5	22.2	22.3
140-149.9		7	10	17	143.5	27.8	27.6
150-159.9		7	14	21	153.8	34.3	34.5
160-169.9		3	6	9	163.3	40.8	42.0
170-179.9		4	2	6	176.5	55.2	54.2
180-189.9		2	1	3	186.3	63.3	60.0
190-199.9		1	1	2	193.3	69.3	72.9
200-209.9		2	3	5	203.8	84.6	86.5
210-219.9		1	1	2	215.0	96.8	103.0
220-229.9		3	3	6	224.6	116.5	118.9
230-239.9		0	11	11	232.4	134.0	133.7
240-249.9		1	3	4	246.2	160.7	160.3
250-259.9		0	5	5	253.8	173.2	177.0
260-269.9		1	3	4	260.2	181.0	191.9
270-279.9			8	8	275.7	225.1	215.3
280-289.9			2	2	284.0	258.5	255.3
290-299.9			5	5	292.7	296.5	281.2

The material was grouped into size classes and the logarithms of the means of the various groups were plotted; the resulting graph was very definitely a straight line (see Figure 26). The value of n is 3.26 and that of log c, $\bar{5}.59$. The equation relating log W to log L, therefore, is as follows:

$$\log W = \bar{5}.59 + 3.26 \ (\log L)$$

or expressed in the antilog form:

$$W = 0.0000257L^{3.26}$$

The calculated weights for the sand dab are shown in Table 7 and these give, as shown in Figure 27, an excellent fit to the class means of the observed weights.

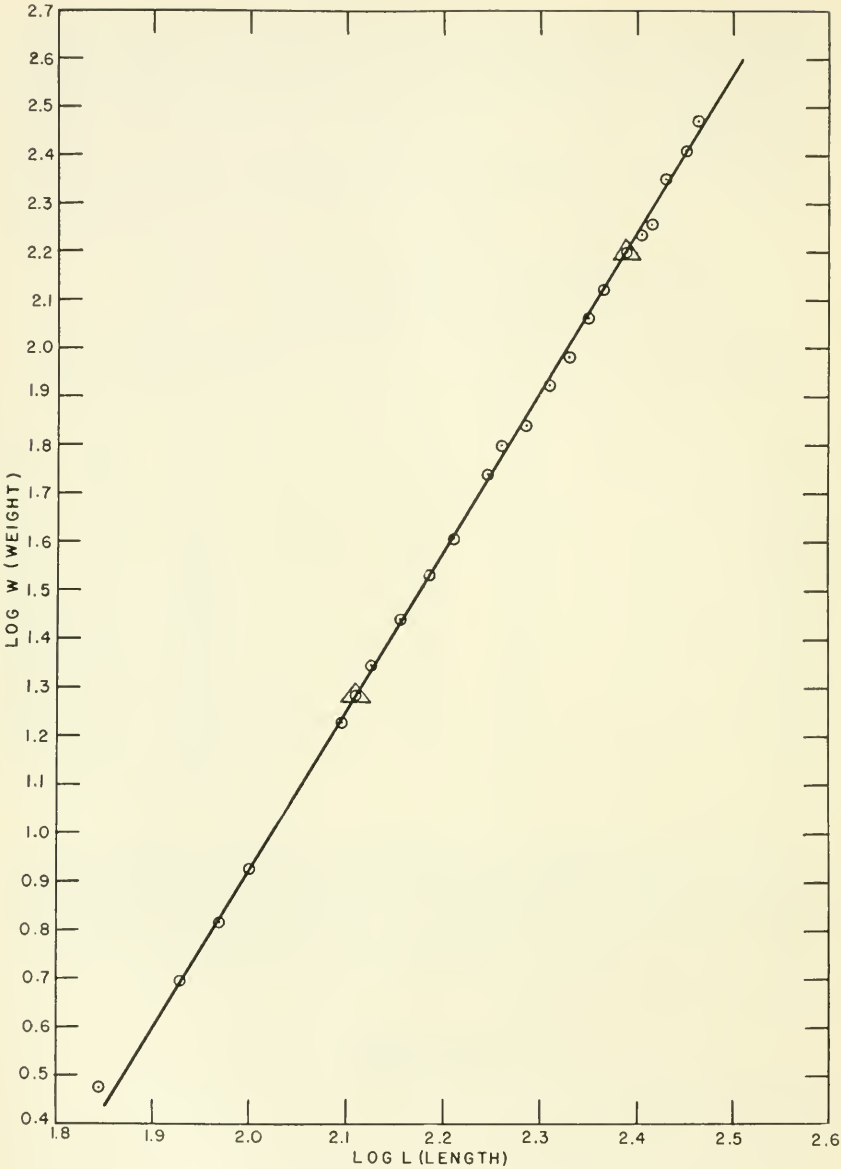


FIGURE 26. Line of best fit showing relation of the logarithm of weight to the logarithm of length of sand dab

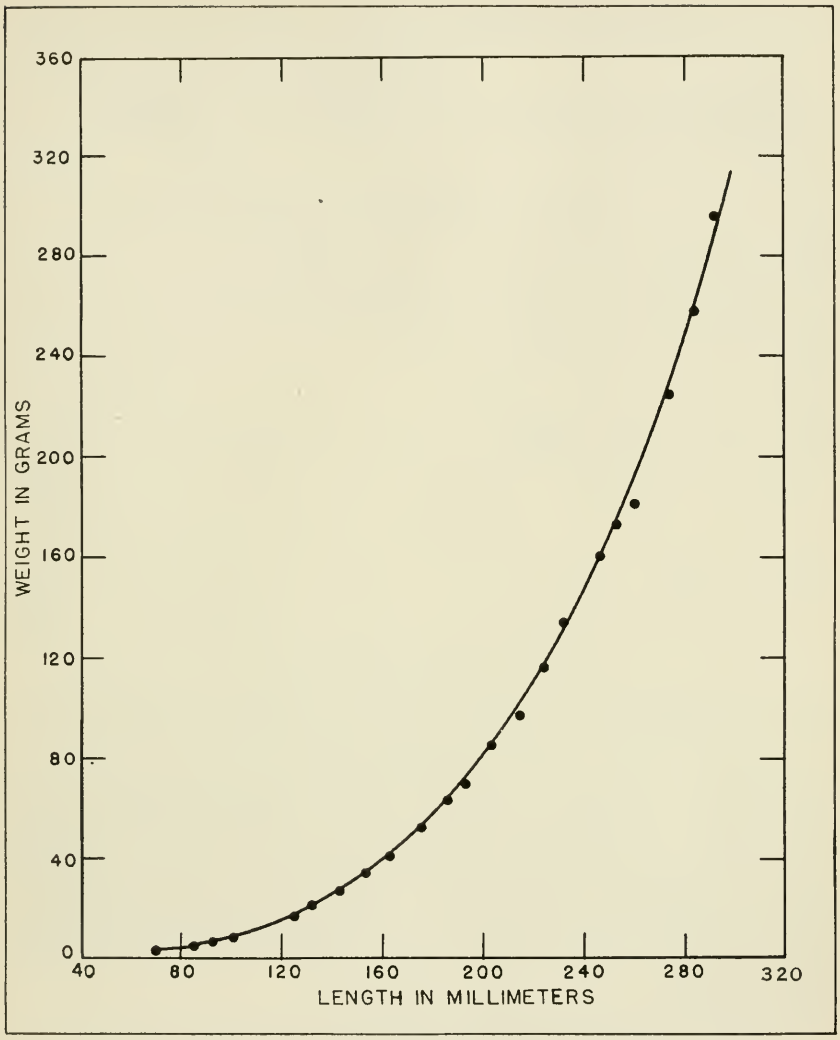


FIGURE 27. Calculated length-weight curve (solid line) fitted to the average length-weight values (solid circles) for California sand dab

RELATIONSHIP BETWEEN TOTAL AND STANDARD LENGTH

An analysis of the relationship between the total length and the standard length of the sand dab was made to determine the degree of association of these two characters and to establish an equation for the determination of one measurement from the others.

For this purpose 124 fish of various sizes were selected. The smallest fish measured 42 millimeters and the largest, 211 millimeters in total length. When the standard length (Y) is plotted against the total length (X), the points, as would be expected, are found closely clustered around a linear regression line (see Figure 28). The coefficient of correlation, 'r', was found to be 0.99.

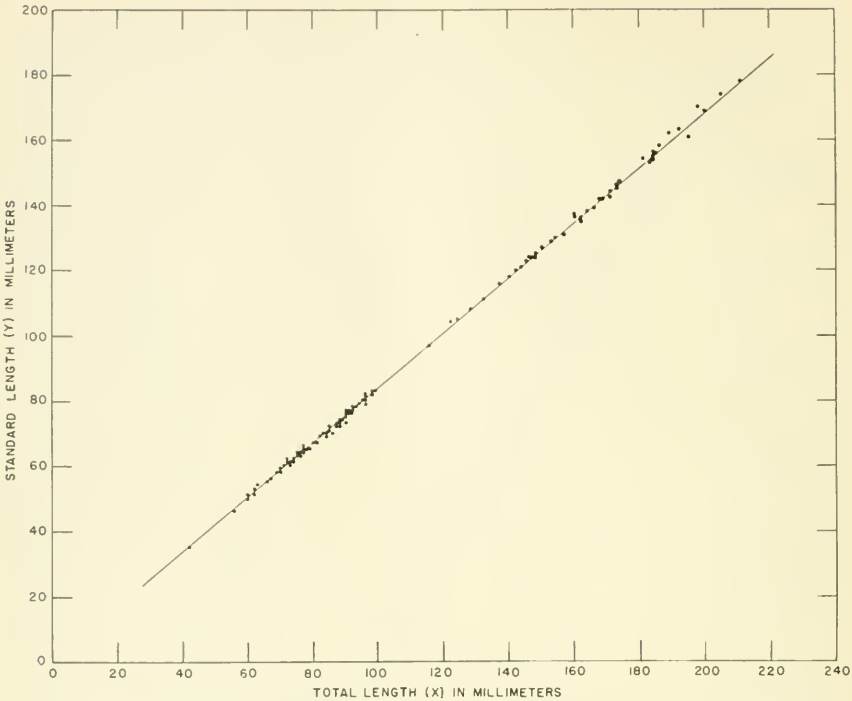


FIGURE 28. Relationship between total and standard length of the California sand dab. (Scatter diagram and regression line fitted by the method of least squares.)

To express the relationship between the two variates X and Y, the equation for the regression line, $Y = a + b X$, was used. The slope of this line (b) gives, on the average, the increase in the standard length associated with a unit increase in total length. The equation for the regression line was found to be $Y = .30 + .84 X$. The constant (a) is so small that it may be disregarded; so that, for all practical purposes, the equation is $Y = .84 X$. In other words, for every 100 millimeters increase in the total length of the sand dab, the standard length increases approximately 84 millimeters.

SUMMARY

The report presents the results of an investigation of the California sand dab *(Citharichthys sordidus)* of the coast of California.

The general morphology and systematic characters of the species are described on the basis of the literature and from material obtained from Monterey Bay and the fishing grounds off San Francisco.

The sand dab ranges in distribution from British Columbia to Lower California. Bathymetrically it occurs in depths from 10 to 100 fathoms.

The largest specimens reach 400 millimeters in length and rarely exceed two pounds in weight. Adults are commonly 160 to 300 millimeters long.

The spawning season of the sand dab is from July to early September, the peak of the season being in August.

The mature eggs are spherical, translucent, contain a single oil globule and measure from 0.57 to 0.77 millimeter in diameter.

The available evidence shows that individual sand dabs spawn more than once during each spawning season.

Age and growth of the sand dab was determined primarily by the scale method but was verified by the otolith and length-frequency methods.

It is established for the sand dab scale that one annulus is formed each year and that it is formed during the winter.

Sand dabs average about 95 millimeters in length when they become one year old, 148 millimeters when two years old, 192 millimeters when three years old, and 226 millimeters when four years old. Thereafter the females grow faster than the males. The length of the females at the end of the seventh year averages 274 millimeters and that of the males, 246 millimeters.

The calculation of growth from scale measurements was based on the usual assumption that body length and scale diameter show a constant ratio at all lengths. The calculated lengths of the males and the females at the end of each year approximate very closely the observed lengths at the end of the corresponding years.

In the otoliths the annulus is identified as a more or less translucent band concentric with the margin and representing winter growth. The opaque or calcified bands in between the two annuli indicate summer growth. It was observed that there is a general agreement between the otolith rings and scale year marks from the same fish.

The length-frequency distributions of the sand dabs show the first two age groups; the mode of group I falling at 97.5 millimeters and of group II, at 157.5 millimeters. Age group III cannot be identified satisfactorily in any of the length-frequency graphs. It may be that the poorly marked modes at 187.5 millimeters in the January collection and at 197.5 millimeters in the February collection represent this age group. There was a close correspondence between these three age groups and the means of the first three age groups as determined from the scales. The high degree of overlap of the length-frequency distributions beyond age group II, makes lengths alone a poor index of age. From the growth curve derived by plotting the modal lengths of each age group at the end of each month for which data were available, it is concluded that the sand dab grows very rapidly from July to October or November.

No mature female was found with a length less than 165 millimeters; 23 percent were mature at 185 millimeters, 50 percent at 191 millimeters and 90 percent at 205 millimeters. Practically all fish over 225 millimeters were mature.

The weight of the sand dab increases at a rate slightly greater than the cube of the length. For the data studied the formula for the length-weight relationship was found to be $W = 0.0000257(L)^{3.26}$, where $W =$ weight in grams; $L =$ length in millimeters.

An analysis of the relationship between the total length and the standard length of the sand dab showed that for every 100 millimeters increase in the total length of the sand dab, the standard length increased approximately 84 millimeters.

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SOME DEER RANGE SURVEY METHODS[1]

By William P. Dasmann, Game Range Technician
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INTRODUCTION

Deer management programs that aim at production of maximum numbers on a sustained yield basis must be founded on sound range management. The trend in carrying capacity in many places in the West points out the need for managing deer on a plane considerably more productive and much less wasteful than is now the case on many ranges. As events make necessary more intensive management of deer herds than has been common in the past, an increasing amount of attention must be given toward balancing deer numbers against deer forage supply.

On some areas, artificial improvement of ranges for deer can be justified. Artificial improvements may include (1) the thinning of undesirable plants by use of chemical sprays; (2) the reduction of forest climax vegetation to, or the holding of subclimax cover at, a desirable subclimax stage through use of fire; (3) the reduction of unavailable stands of sprouting brush species to a succulent sprout stage by controlled burning; (4) the planting of seed or transplants; (5) fertilizing; and (6) erosion control structures.

On other areas, management must consist primarily in maintaining the forage now present, or in improving it through the regulation of stocking by range animals, whether domestic or wild.

RANGE INVENTORIES

As a first step toward regulation it is necessary to take inventories. There is need to determine the present condition of deer ranges and to learn whether they are being depleted, maintaining themselves, or improving. To do this, the deer manager must turn to range condition and forage utilization surveys.

During the initial period, these surveys of necessity may have to be of a cursory nature. But as a deer management program develops, and the need for adjustments becomes apparent, more intensive survey methods will become necessary. The over-all impressions of rapid reconnaissance methods of survey will hardly prove adequate for year by year comparisons of forage utilization and trend.

Range condition surveys consider primarily the condition of vegetation and soil. Ratings made on the basis of such surveys usually are indices of present conditions as compared with optimun conditions. Vegetation may be rated on the basis of quantity or quality or both.

[1] Submitted for publication June, 1950.

Forage utilization surveys may sample all vegetation or be limited to primary forage species. Such checks are important in that they keep the range manager informed about the current intensity of cropping of various plant species. Since the only method of improving vegetation cover that is economically practical on much range land is usually through control of the degree of cropping of palatable plant species by range animals, emphasis must be placed on leaving enough of the current vegetative growth in place to insure reproduction and a continuing supply of forage.

Two survey methods in use in California are the line-point and the line-intersection methods of sampling range vegetation. Both methods, as used in our deer management program, yield an analysis of the ground cover, an analysis of shrub and tree form and age classes,

CALIFORNIA DIVISION OF FISH AND GAME
FORAGE SURVEY FORM

AREA *Bear Creek Range* FORAGE TYPE *5 - Ptr - Atr - Cra*

PLOT Nº *12* LOCATION *2 mi. south on Power Line*

DATE *9-28-49* EXAMINERS *AH & J.S*

POSITION ON TAPE	FORM CLASS 1	2	3	4	5	6	7	8	AGE CLASS	bare	rock	litter	Ptr	Ptr (dead)	Atr	Atr (dead)	Cra	Asp	POA
										Number of Line Points									
										⊠⊠ □	⊡	⊠⊠ ⊏	⊠	∵	⁞∵	∵	□	∵	∴
	Percentages									28	9	26	10	3	5	4	8	2	5 = 100
										Percentage Cropping									
4, 5			✓						D				40						
14, 15	✓								M						10				
20-22	✓								M								5	30	5
28		✓							Y						25				
40-44			✓						M				55						
48	✓								M								10		
60-62	✓								Y								15		
70-71		✓							Y						25				
74-78						✓			D				70						
81, 83			✓						D				30						
92			✓						Y				45						

FORM CLASSES

1. ALL AVAILABLE, LITTLE OR NO HEDGING
2 MODERATELY HEDGED
3 HEAVILY HEDGED
4 LARGELY AVAILABLE LITTLE OR NO HEDGING
5 MODERATELY HEDGED
6. HEAVILY HEDGED
7 MOSTLY UNAVAILABLE
8 UNAVAILABLE

AGE CLASSES

S - SEEDLING
Y - YOUNG PLANT
M - MATURE PLANT
D - DECADENT PLANT

FIGURE 29. Field form used for line-point surveys

and an analysis of current intensity of cropping. These data not only serve to determine present conditions, but may be used as a basis for evaluating future trends.

THE LINE-POINT METHOD

The line-point method described by Parker (1942) is simple in principle and fairly rapid in application. Men can learn rather quickly to gather data by this survey method that are satisfactorily uniform.

As used in California, permanent plots 100 feet long are marked by iron stakes. A tape is stretched between the stakes and the dominant class of cover that occurs either directly under or over each of the foot marks on the tape is recorded on a field record form (Figure 29). Because there are 100 marks on the tape, the number of hits made on each class of cover on a plot may be read directly as percentage.

Where vegetation is scattered or patchy, it is advisable to establish plots 200 or 300 feet long and record data at every second or third foot or, in some instances, to record the full 200 or 300 points and divide the sums by two or three to get percentages.

In the line-point method the frequency of cover classes is recorded, rather than area of ground surface supporting each class of cover. This method assumes that frequency of cover is directly proportional to percentage coverage of the ground surface.

It is as important in this method as in any other to set up standards. It is necessary to define each cover class. Bare ground and rock are easily defined. Litter may be considered as any vegetable matter covering the ground surface. Some forbs may be considered as hit when their leaves dominate the area directly under the line-point, but hits on grasses may be limited to those points that are directly over the basal area of the grass plants. With shrubs, bushy trees, and some forbs, a hit may be recorded when the point falls within the circumference of the perennial crown, even though the point is directly over or under an interspace. Were such interspaces recorded as misses, the growth or loss of a few leaves or small twigs might result in data indicating changes in coverage not warranted by actual stand conditions. The same standard may be applied to dead shrubs which are still in place. Individual plants may be identified for future reference by recording the tape numbers hit by the plants.

FORM AND AGE CLASSES OF SHRUBS

Concurrent with the recording of ground cover data, form and age classes of shrubs and trees are checked off on the field form.

When shrubs and trees are not browsed, or only lightly browsed, they tend to assume the natural forms, or shapes, which are normal for each species. As intensity of browsing increases, the departure from these normal shapes becomes more striking. Continued heavy browsing, year after year, results in tightly hedged or high-lined, and partly dead browse plants which stand out as evidence of poor deer range condition and declining forage yield.

Forms of browse plants are classified as follows:

Form class 1: All available, little or no hedging.
Form class 2: All available, moderately hedged.
Form class 3: All available, tightly hedged.
Form class 4: Largely available, little or no hedging.
Form class 5: Largely available, moderately hedged.
Form class 6: Largely available, tightly hedged.
Form class 7: Mostly unavailable.
Form class 8: Unavailable.

FIGURE 30. Form Class 3: All available, heavily hedged. Age class: mature.

FIGURE 31. Form Class 6: Largely available, heavily hedged. Age class: decadent.

FIGURE 32. Form Class 8: Unavailable. Age class: mature. *U. S. Forest Service photo*

Browses are classed by age into seedling, young, mature and decadent plants.

Percentage utilization figures for the various plants that are hit by line points are entered on the form. It is advisable, as well, to make a record of general condition of soil, soil erosion, slope, plant cover and other factors affecting the site in the immediate vicinity of each plot.

THE LINE-INTERCEPTION METHOD

In the line-interception method, described by Canfield (1939) and Hormay (1949), the linear spread of ground cover along a stretched tape is measured. A record is made to the nearest inch, or less, of the spread of bare soil, rocks, litter, dead shrubs, and living plants by species, intercepted by the transect line. The data then are converted to percentages.

It is assumed that linear spread of cover along a line is directly proportional to area covered by each class of ground cover. Tests have shown that this method yields results very close to true as determined by more exact, time-consuming procedures.

The line-interception method is slower and more tedious than the line-point method, and compilation of plot data takes more time, but the interception method no doubt is more accurate. The considerations mentioned in regard to standards for the line-point method apply also to the interception method. Form and age classes of browse plants and percentage cropping estimates are made as with the method previously described.

ANALYSIS OF DATA

With either method, the data on ground cover can be used as an index of present range condition as shown by percentages of bare ground surface, litter-covered ground surface, and by composition of the vegetation cover. These percentages also will serve as a base with which to compare future measurements, made at five-year intervals, in order to determine range trend. They may be used also to facilitate comparisons of different deer ranges.

The data on form classes of browses may be used as an index of degree of past use, availability of forage, and present condition of the deer range resource.

An analysis of the age classes of forage species not only gives information on the condition of the stand, but may also be used as an indicator of future trend in forage condition.

The forage utilization check, which will ordinarily be made at annual or biannual intervals, will indicate the current intensity of cropping, and may be used in recommending harvest of the game species concerned.

SAMPLING

Usually a minimum of 20 plots per sampling unit is needed to yield an average that is reliable. When possible, 100 plots in each sampling unit are desirable. Once the plot data are at hand, statistical checks may be made to determine whether the sample is sufficient.

Plots should be established at random and without bias. It has been the practice here to set out plots at predetermined intervals along roads, trails and compass lines. While this is not true randomization, it is accepted as a close approximation.

Where key areas have been determined, plots may be limited to them. Since it is logical that overcropping will not occur generally, if it is held at a proper level on the key areas where deer normally concentrate, this procedure may be used to cut down the size of the areas sampled.

The job of checking forage utilization also may be lightened by limiting the check to key forage plant species, since it can be assumed that where the plant species most preferred by deer are not overcropped, other less desirable species will generally not be overcropped. Sometimes on year-long ranges, plant species offering sufficient nutrients at a time of the year when the other vegetation is low in nutritional value may be considered key species.

It is believed that data derived from one of the two methods described, or from other comparable methods which inventory range condition and check forage utilization and range trend, are basic to intensive deer management.

NOTES ON UTILIZATION CHECKS

Two methods for checking utilization of browse plants are the visual estimate and the twig measurement method.

Visual Estimate Method

The technique used for visual estimates of utilization varies with browse species. With shrubs like sagebrush (*Artemesia* spp.), manzanita

(*Arctostaphylos* spp.) and snowbrush (*Ceanothus velutinus*), on which seasonal growth is not easily measured, the following procedure is used: (1) the bush is examined to reveal the extent of cropping, (2) the bush is mentally reconstructed as it would have appeared had it not been cropped, (3) an estimate in percentage is made of the amount of seasonal growth that has been utilized. A comparison of browsed with unbrowsed shrubs facilitates estimation. Where heavy use prevails, it is sometimes necessary to protect some shrubs from browsing in order to have them available for comparison at the time the check is made.

With shrubs like bitterbrush (*Purshia* spp.) the twig growth of the year is easily defined. The visual estimate method described by Hormay (1943) works well with this class of browse plants. This involves the estimation of average uncropped leader length, average cropped leader length, and percentage of the leaders which have been cropped.

FIGURE 33. Bitterbrush showing uncropped leaders

It is good practice to measure with a ruler or tape the uncropped leaders on perhaps a half dozen twig clusters on each bush to help the eye to estimate twig lengths. The bush is then scanned to determine if the measurements are representative of the seasonal growth on the entire bush. The final average, so determined, is recorded for future reference.

Average length of cropped leaders may be determined in a similar fashion. Estimation of percentage of the twigs that have been cropped may be aided by an actual count of cropped and uncropped leaders on several twig clusters picked at random.

The final estimate for a shrub on which uncropped leaders average five inches in length and cropped leaders average two inches, and on which 30 percent of the leaders have been cropped would be 60 percent $\times$ 30 percent, or 18 percent average utilization.

On deer winter ranges, where checks are made in the fall to determine the percentage of the forage crop consumed by livestock before deer arrive, the average uncropped leader length for each shrub is recorded for reference when the second survey to determine full utilization is

made. This record helps immensely on ranges where most shrubs are heavily cropped by the end of the browsing season.

Twig Measurement Method

The twig measurement method is sometimes used where seasonal growth tends to be linear. With this method one to several twig clusters on each bush or tree to be sampled are marked with short pieces of brightly colored insulated wire. A measurement is then made of the length of twiggage between the marker and the branch tips.

A first measurement is taken after the plant has made its full growth in order to determine the amount of twiggage available for browsing. A second measurement is taken just before the start of the next growing season, to determine the amount of twiggage left at the end of the growth year.

The method gives best results where browsing occurs after the seasonal growth of the plants is made. If browsing does occur during the growing period, or if only the one measurement at the end of the browsing season is taken, it becomes necessary to compare average length of uncropped with cropped twigs in order to determine the percentage of growth used by browsing animals. These variations can hardly be applied where use is so heavy as to leave relatively few uncropped twigs on the plants at the time the survey is made.

It has been found best to mark fresh twig clusters each season, rather than to remeasure the same clusters year after year. Under the latter practice, the pattern of growth is apt to become complex and harder to measure accurately with each succeeding season. For the same reason, simple rather than complex twig clusters should be chosen for measurement where possible. Often, towards the end of the growth year it is difficult to distinguish old from current growth. Where twig patterns are simple and well defined, the probabilities of error are much reduced.

FIGURE 34. Measurement of cropping on juniper twig

Good sampling will distribute twig measurements on shrubs at different height levels in order to reduce the effect of differential browsing. Where browsers commonly crop more than the seasonal growth, it may be best to measure all twiggage above the branch marker, rather than to confine measurements to the growth of the year.

It is our practice to take just one over-all length measurement from the marker to the tip of the branch on such browses as juniper. With other browse plants, such as bitterbrush, each separate twig or leader on the twig cluster is measured to determine the total linear growth.

Discussion

Because the twiggage on tall shrubs or trees with foliage mostly unavailable (Form Class 7) is often only lightly cropped even where range use is generally heavy, and because such plants usually offer relatively small volumes of forage, it appears advisable to eliminate this form class from the utilization sample. The younger and more available plants make up the class which should be protected from overcropping, since it is this class which will continue to produce available forage in the future. The inclusion of cropping data from Form Class 7 browses will often tend to lower the average for the unit and perhaps obscure the vital picture of what is happening to the range.

The Growth Factor

One factor that affects percentage utilization from year to year is volume of growth as influenced by variations in precipitation and other climatic conditions. In order to evaluate the influence of volume of growth on degree of cropping, a simple growth index is suggested for use where length of twiggage is either measured or estimated. The average for all such twig lengths per unit may be computed and used as an index of quantity of forage. For example, if the average length of bitterbrush leaders on a range unit is five inches one year and three inches another, there is indication that there was approximately 40 percent less bitterbrush forage the second year than the first. In such a case, utilization the second year can be expected to be considerably heavier even though the number of browsing animals has remained constant. It is believed a simple growth index of this nature has an important place in the analysis of utilization data, and can serve as an indicator of fluctuations in forage production from year to year.

SUMMARY

As events make necessary more intensive management of deer herds than has been common in the past, an increasing amount of attention must be given toward balancing deer numbers against deer forage supply.

On some areas, artificial improvement of ranges for deer can be justified. In other areas, management must consist primarily in maintaining what is now present, or in improving it naturally through regulated rates of stocking by range animals.

In either case, inventories are necessary to determine vegetation and soil condition trends on deer ranges. To get such information, the deer manager must turn to range condition and forage utilization surveys.

The line-point method and the line-interception method of sampling vegetation cover are used in California where intensive survey methods

appear necessary. When coupled with checks on shrub and tree form and age classes, and on forage utilization, either method will inform about present condition of deer range and indicate current trend as influenced by forage utilization. Also, either method will provide a base with which future measurements may be compared to determine periodic trend and to show ecological changes in vegetation cover.

It is believed that data derived from one of the two methods described, or from other comparable methods which inventory range condition and check forage utilization and range trend, are basic to intensive deer management.

Two browse utilization check methods, the twig measurement and the visual estimate method, are used in our deer range surveys. Several suggestions regarding technique are given and a simple growth index is described.

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AN EASY METHOD OF SEPARATING KING AND SILVER SALMON[1]

By Fred B. Hagerman
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California Division of Fish and Game

The separation of the king salmon, *Oncorhynchus tshawytscha*, from the silver salmon, *Oncorhynchus kisutch*, is often a difficult task under field conditions. This is especially true when working with ocean-caught immature fish.

Fishermen and marketmen experienced in handling large quantities of both species can tell them apart at a glance, but are usually unable to explain on what basis they do it. The average sportsman and some commercial fishermen are unable to separate the two or can identify them only with considerable effort. There are several anatomical features that ichthyologists use in the positive indentification of these fishes but they are of limited value to other persons, and do not lend themselves to rapid field identification. The king salmon tends to be more heavily spotted along its back and tail but this is not always true of immature fish. The caudal fin of the king is sometimes devoid of spots, while the tail of the silver, usually with no spots, may have a few. There are differences in various counts and measurements, but many of these either

Figure 35. Left, silver salmon ; right, king salmon. *Photograph by the author.*

[1] Submitted for publication September, 1950.

overlap or are not easy for an inexperienced person to assess, particularly if he has only one species at hand. For example, the caudal peduncle is much stouter in the silver than in the king. The number of pyloric caeca offers a positive separation, there being 45-83 in the silver and normally from 140-185 in the king (kings have been found with as few as 93 caeca). However, the fish are often landed cleaned so this character is of limited value in segregating the two species in the markets. Further, counting the caeca is tedious and time-consuming work.

A simple efficient method of distinguishing the two species is shown in Figure 35. It was discovered that the silver salmon differs from the king salmon by having a white epithelial lining over the crown of the gums, through which the teeth protrude. This white gum is bordered on each side by a darker pigmented lining that also lines the remainder of the mouth cavity and tongue. The king salmon invariably has a darker pigmented mouth cavity and the gum is dark.

In the 1948 salmon season this characteristic was checked in over 5,000 salmon, and on smaller numbers in 1949 and 1950. There have been no exceptions to this rule. One easy way to remember this diagnostic characteristic is to associate the "silver salmon with the silver lining." A word of warning to those fishermen who may catch steelhead and confuse them with silver salmon is that the steelhead has its mouth cavity completely white, unlike the silver salmon.

NOTES ON THE SQUARETAIL, *TETRAGONURUS CUVIERI*[1]

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Tetragonurus cuvieri Risso is found in temperate seas throughout most of the world. It is a dark colored fish with oblique rows of ridged and overlapping scales running across the whole body. Two sharp keels or ridges on either side of the tail give the fish its common name. The young are said to be pelagic and in the Mediterranean are found in conjunction with a certain kind of medusa on which they feed. Later in

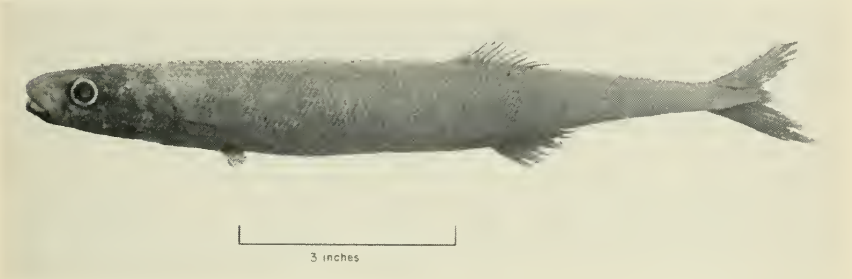

Figure 36. Squaretail, *Tetragonurus cuvieri*

Figure 37. Anterior portion of *T. cuvieri* illustrating lower jaw teeth and grooves at hind margin of eye. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

[1] Submitted for publication July, 1950.

life the squaretail supposedly descends to great depths and approaches the surface only at night. Squaretails are known to attain a total length of some 24½ inches though most specimens taken are less than 15 inches long. In the Mediterranean the flesh of this fish is considered to be extremely poisonous if eaten. Its toxicity in other localities is not known.

Thompson (1919) published the first record of the occurrence of *Tetragonurus cuvieri* off the California coast. He listed a 14-inch specimen taken off San Pedro by a fisherman and numerous larvae up to an inch and a half in length collected by the "Albacore" in "the small meshed nets" used in the research work then being conducted by the Division of Fish and Game. Fitch (1949) recorded two more specimens, one from La Jolla in 1947 and one from Davidson Sea Mount some 70 miles southwest of Monterey, in 1948. Since 1948, five more squaretails taken off our coast have come to the attention of the author. During July, 1949, a large individual 340 millimeters in standard length was removed from the mouth of a Pacific halibut (*Hippoglossus stenolepis*) by Mr. Fred Hagerman. The halibut was caught off Eureka by the drag boat "Molly Lou." On the night of May 23, 1950, four *T. cuvieri* were caught in gill nets by the crew of the Division's research vessel "Yellowfin." These nets were set some 60 miles west of Point Conception (Lat. 34° 25′ N.; Long. 121° 37.5′ W.) in waters of more than 2,000 fathoms and hung between five and thirteen fathoms beneath the surface. The catch included, as well, 35 very large jack mackerel (*Trachurus symmetricus*) and one large paralepid of an unknown genus.

The comparative rarity of this species in any one locality has limited taxonomic study and has left much question as to the number of valid species. Two have been described. *T. cuvieri* Risso 1810 has been reported more or less throughout the world but most commonly in the Mediterranean, the type locality. The other, *T. atlanticus,* was described from a single specimen from Madeira by Lowe (1839) who differentiated it from *T. cuvieri* particularly by size of eye and length of head. A number of young specimens (18-83 millimeters in length) taken from the stomachs of albacore caught in the Gulf of Gascogne (eastern Atlantic) were ascribed by Legendre (1934) to *T. atlanticus.* Parrott (1948), on the other hand, contends that all specimens of *Tetragonurus* so far discovered belong to one variable species, *T. cuvieri.*

A detailed study was made of seven of the eight large California specimens and the measurements and counts obtained are presented in Table 1. The California specimens are compared with one from the Mediterranean and four from the New Zealand-Australia region in Table 2. The figures in these two tables show the extreme variability of characters of *Tetragonurus* from any one locality. This is particularly true with reference to fin counts and jaw tooth counts, two characteristics which are frequently used as specific criteria.

The number of teeth in California specimens, which ranged from 107 to 340 millimeters in standard length, shows an increase in both jaws which can be correlated with increase in size (Table 1). For example, the 107 millimeter specimen had only 16 teeth in one side of the upper jaw and 23 on the same side of the lower jaw. The 251 millimeter specimen had 27 and 39 respectively; and the 340 millimeter

TABLE 1

Counts and Body Proportions of Seven California Squaretails

Standard length is expressed in millimeters, other measurements as a percentage of standard length

	La Jolla	Davidson Sea Mount	West of Point Conception				Eureka
Dorsal fin	XV; 12	XVI; 13	XVI; 13	XVII; 11	XVII; 13	XVII; 11	XVIII; 13
Anal rays	12	13	12	12	12	12	12
Pectoral rays			16	16	17	17	
Ventral rays	I; 5	I; 5	I; 5	I; 5	I; 5	I; 5	I; 5
Caudal rays		10, 9, 8, 9[1]					
Pores on lateral line (to keels)	99	100	98	100	101	103	101
Transverse scales[2]							
above lateral line	8	8	8	9	9	7	8
below lateral line	18	20	21	22	21	21	21
Teeth, upper left	16	27	29	32	35	32	34
Teeth, lower left	23	39	45	48	52	49	54
Grooves on rear border of eye	14	14	14	14	15	11	14
Gill rakers							
upper limb	5	5	6	5	5	6	6
lower limb	12	9	11	12	12	14	11
Vertebrae							
precaudal		28			27		
caudal		24			26		
Total		52[1]			53[3]		
Standard length	107mm	251mm	285mm	287mm	301mm	308mm	340mm
Total length	113.3%	111.6%	114.0%	113.2%	113.6%	114.0%	110.6%
Depth	17.3	14.3	15.8	15.7	16.9	17.2	17.4
Head	24.0	21.5	20.7	20.9	19.9	21.1	19.6
Pectoral	13.9	10.4	9.8	9.4	9.3	11.4	9.4
Ventrals	6.5	4.4	4.9	4.5	4.0	4.5	4.4
Keel	6.5	7.6	6.3	5.9	6.3	5.2	6.8
Eye	5.0	4.0	3.9	3.5	3.7	3.9	3.4
Maxillary	9.9	7.6	8.2	8.0	8.3	8.1	7.4
Snout to front eye	7.5	4.8	6.7	6.6	6.6	6.5	5.9
Snout to 1st dorsal	38.2	30.9	30.5	32.1	33.6	31.8	32.2
Snout to 2d dorsal	59.6	57.4	60.0	60.6	61.8	62.7	61.2
Snout to anal	61.4	63.3	63.9	64.5	66.4	64.9	62.4
Snout to ventral	32.1	27.9	26.7	27.5	27.6	25.3	26.3
Snout to anus	59.1	62.5	61.4	62.3	64.5	62.3	59.7
Snout to 1st nare	3.9	2.8	2.8	2.8	2.7	2.9	2.6
Snout to 2d nare	6.0	4.8	4.6	4.5	4.3	4.4	4.3
1st dorsal to 2d dorsal	20.9	27.9	30.2	29.2	28.9	32.5	30.1
Base 2d dorsal	11.6	12.1	10.9	10.9	11.0	10.7	12.4
Base anal	8.9	9.6	9.1	8.7	9.3	9.7	9.1
Sex			male	female	female	male	
Age					4 yrs.[4]		

[1] Determined by X-ray.
[2] First transverse scale row behind ventrals counted.
[3] Actual count after flesh removed.
[4] Determined from otoliths.

fish had 34 and 54. No tooth counts are available for the New Zealand-Australian specimens. However, the Mediterranean squaretail had more teeth in the upper jaw than in the lower, the reverse of the California fish. The range in number of spines and rays for California *Tetragonurus* is not nearly so marked as those from the New Zealand-Australia region, but the largest California specimen falls far short of the maximum size from New Zealand. Here again, however, the trend is definitely toward an increase in number of both spines and rays with increased length. Presumably the same holds true for Mediterranean fish as dorsal spine counts there are said to range from 15 to 21 (lengths not available) and dorsal ray counts from 14 to 21.

The data in Table 2 suggest that California and New Zealand-Australian *Tetragonurus* belong to the same species. However, the detailed values in Table 3 giving relative head lengths and eye diameters throw

TABLE 2

Comparison of Various Counts and Body Proportions of Squaretails From Different Localities

Standard length is expressed in millimeters, other measurements as a percentage of standard length

	7 California specimens (Table 1)	1 Mediterranean (Seurat-1933)	4 New Zealand-Australian specimens (Parrott, 1948)	1 *T. atlanticus* Lowe[1]
Dorsal spines	XV–XVIII	XVI	XV–XXI	XV
Dorsal rays	11–13	14	13–17	11
Anal rays	12–13	12	12–16	11
Pectoral rays	16–17	16	16–21	16
Ventral rays	I; 5–I; 6	I; 5	I; 5–I; 6	I; 5
Scales in lateral line (total)	114–126	125	108–126	----------
Scales in lateral line to keels	98–103	112[2]	107[3]	83
Vertebrae	52–53	58 (36+22)	----------	----------
Transverse scales	7–9/18–22	10/25	9–13/23–26	----------
Teeth, upper jaw	32–70	70	----------	(40 or 50 on each side)
Teeth, lower jaw	46–108	64	----------	----------
Standard length	107–340 mm	290 mm	377–590 mm	231 mm[4]
Total length	110.6–114.0%	115.5%	105.3–108.8%	----------
Head length	19.6–24.0	19.0	21.0–21.7	----------
Depth	14.3–17.4	----------	18.1–18.6	----------
Pectoral	9.3–13.9	----------	6.9[3]	----------
Ventral	4.0–6.5	----------	4.2[3]	----------
Eye	3.4–5.0	3.1	3.4–3.6	----------
Snout to 1st dorsal	30.5–38.2	----------	33.4–37.4	----------
Snout to anus	59.1–64.5	69.0	----------	----------

[1] Type specimen.
[2] Counted on photograph.
[3] One fish only.
[4] From Parrott, 1948.

doubt on this interpretation. Gill raker and tooth counts as well as a few other measurements would be extremely helpful.

The Mediterranean species (Table 2) differs markedly from the California fish in the number of vertebrae, in the number of teeth on the upper compared to the lower jaw, and in the distance from snout to anus. It differs from both the California and New Zealand-Australian fish in head length and eye diameter (Table 3).

TABLE 3

Head Length and Eye Diameter for Individual Fish Expressed as a Percentage of Total Length

	Total length, mm	Head, percent	Eye, percent
La Jolla	122	21.2	4.1
Davidson Sea Mount	280	19.3	3.6
West of Point Conception 1	325	18.2	3.4
2	325	18.5	3.1
3	342	17.5	3.2
4	351	18.5	3.4
Eureka	376	17.8	3.1
Mediterranean	335	16.4	2.7
New Zealand 1918	410	19.3	3.2
New Zealand 1944	621	20.7	3.1
Madeira	234	22.2	6.3

T. atlanticus is separable from all other species in head length, eye diameter and number of scales from the origin of the lateral line to the origin of the keels. A critical study of additional material from all localities will be necessary before the validity of the assumption that there are at least four species (Mediterranean, Atlantic, California, and New Zealand-Australian) can be tested. Undoubtedly this fish is much more common than past records of its capture would indicate.

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THE BROWN SHARK, *APRISTURUS BRUNNEUS*, IN CALIFORNIA[1]

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The brown shark, *Apristurus brunneus* (Gilbert), is a not uncommon species in the Pacific Northwest (De Lacy and Chapman, 1935; Schultz, 1936; Clemens and Wilby, 1946) but off most of the California coast it is rarely caught and still more rarely recorded. What is apparently the fourth known specimen from south of Point Conception was taken in mid-April, 1950, by Mr. J. Leidington, a commercial fisherman. He caught the fish on a set line operated in some 200 fathoms of water near Point Vicente, about eight miles in a westerly direction from the entrance to Los Angeles Harbor. The specimen, a female, 45½ cm. (18 inches) total

Figure 38. Female brown shark, *Apristurus brunneus*, 18 inches long, caught near Pt. Vicente, California. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

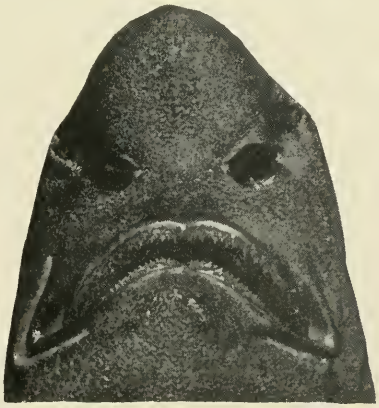

Figure 39. Brown shark, *Apristurus brunneus*. Lower surface of head of specimen shown in Figure 38. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

[1] Submitted for publication July, 1950.

length is shown in Figures 38 and 39. It has been deposited in the collection of the California Academy of Sciences, San Francisco (No. 20454).

The earlier Southern California specimens were collected off San Diego County. The first, the type of the species, was caught in February, 1889, about ten miles west of Point La Jolla in 359 fathoms. Through an error, pointed out by Beebe and Tee-Van (1941), it was long thought that this individual was taken in the Gulf of California, but no valid records from Mexican waters are to be found. The second and third are in the Stanford University collection (No. 22335). They were caught at "Albatross" station 4317, near San Diego in 161-510 fathoms, in 1904.

There seems to be but one published record of this shark from Northern California, Townsend and Nichols (1925) reporting a small specimen from "Albatross" station 5696 north of Point Conception in 440 fathoms. There are at least two previously unpublished records. The California Academy of Sciences has a specimen concerning which Dr. W. I. Follett of that institution wrote: "(It) is a female, TL 522 mm., CAS Cat. No. 20403, and bears a label indicating that it was taken August 6±, 1925, 24 miles off Santa Cruz, California, in 400-500 fathoms, by E. F. Ricketts of the Pacific Biological Laboratory, Pacific Grove. I have confirmed the identification of this specimen. It may possibly be the basis for the Monterey Bay reference by Jordan, Evermann, and Clark, Rept. U. S. Comm. Fish., 1928(2), 1930: 12, and by Walford, Fish Bull. 45, 1935: 26." Another specimen was found in the Monterey fresh fish markets by R. D. Byers in February, 1939, according to J. B. Phillips, Division of Fish and Game. This shark was 26 inches long and appears from a photograph to have been a male. The place of capture is unknown but was undoubtedly in the Monterey region.

In the northernmost part of California, where the trawl fishery has expanded its operations to considerable depths in recent years, the brown shark has been found to be relatively abundant in deep water. John W. Schott, Division of Fish and Game, reports that it is a familiar fish to most drag boat operators at Eureka, and that as many as three specimens have been found in a single sample taken from the commercial catch.

The brown shark is one of the three members of the catshark family, Scyliorhinidae, found in California. The others are the filetail shark (*Parmaturus xaniurus*) which is a deep water form, and the swell shark (*Cephaloscylium uter*) which is common in shallow water along the Southern California coast. The catsharks are distinguished from other California sharks by having the first of the two dorsal fins far back on the body over the pelvic fins, and by having an anal fin. The brown shark has prominent labial folds (furrows at the corners of the mouth; see Figure 39) with that on the upper jaw slightly longer than that on the lower. The filetail shark also has labial folds, but that on the lower jaw is about twice as long as that on the upper. In the swell shark, the folds are absent or rudimentary.

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THE SEA LION POPULATION OF SANTA BARBARA ISLAND, CALIFORNIA, IN THE 1950 BREEDING SEASON[1]

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For many years the number of California sea lions, *Zalophus californianus,* in the waters of Southern California has been a matter of interest to both conservationists and fishermen. The authors had reason to believe that in the three years since the last sea lion census was made by the California Division of Fish and Game there had been a considerable increase in the numbers of these animals on some of the Channel Islands. Evidence for this belief was supplied by repeated counts of the pinniped population of San Nicolas, the outermost of the Channel Islands, between May, 1949, and April, 1950 (Bartholomew, ms.). These surveys revealed that the number of sea lions present on San Nicolas greatly exceeded that which could be anticipated on the basis of the earlier state-wide censuses made by the California Division of Fish and Game. In fact, during the second week of July, 1949, the 2,658 one-year-old or older animals on San Nicolas made the *Zalophus* population of this single island equal to 85 percent of the known summer population of this species in the entire State at the time of the last census, 1947 (Bonnot and Ripley, 1948).

To determine whether or not this increase in numbers was limited to San Nicholas Island, or was an expression of a more widespread population growth, the authors made a count of the sea lions on Santa Barbara Island on June 21, 22, and 23, 1950. This national monument which lies approximately 24 nautical miles northeast of San Nicolas was chosen because Bonnot and Ripley (op. cit.) reported that in the 1947 breeding season it was occupied by 1,000 *Zalophus* (not including newborn young), the largest rookery which had been reported in the State to that time.

Since the precipitous cliffs which characterize the greater part of this island make it possible to look down on the beaches and observe the animals without in any way disturbing them, in the present census, after a preliminary reconnaissance of the island on the Division of Fish and Game patrol boat "Bluefin," all of the animals except those in area 10 (Figure 40) were counted from shore. Except in the examination of a few of the smaller groups of sea lions which could be approached closely, all counts were made through a 20X telescope mounted on a tripod. This technique allowed us to determine the animals' sex and age as accurately as can be done under field conditions and made it possible to search carefully for newborn young.

[1] Submitted for publication July, 1950.

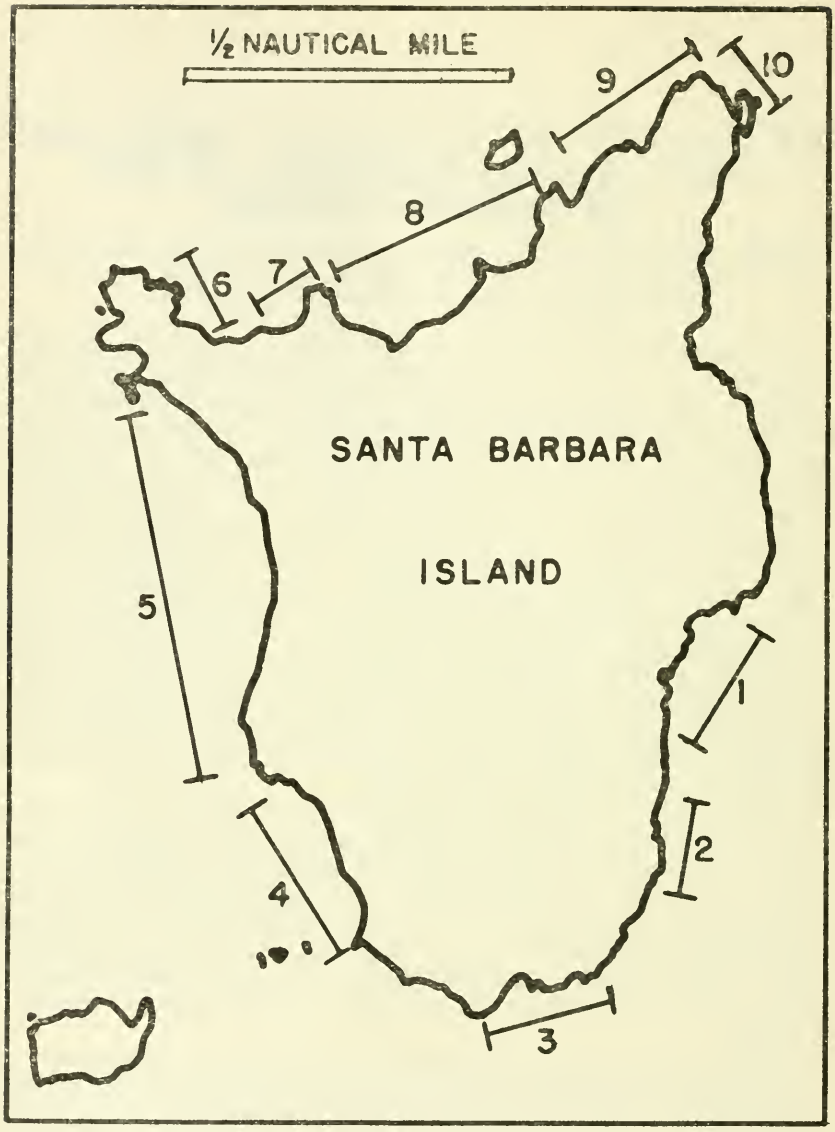

FIGURE 40. The distribution of sea lions on Santa Barbara Island, June 21-23, 1950. The number of animals in each of the numbered areas is shown in Table 1.

The results of our census are summarized in Figure 40 and Table 1. The numbers entered in the table represent individual animals seen and recorded on hand tally counters. Although at the time of the earlier censuses by the Division of Fish and Game (Bonnot, 1928) the sea lions on Santa Barbara were confined to a small area on the northwest part of the island, during our visit the suitable beaches on all sides of the island were occupied by at least a few animals. This more general

TABLE 1

An Analysis of the *Zalophus* Population of Santa Barbara Island, California, on June 21, 22, and 23, 1950. The Location of the Areas Mentioned Is Shown in Figure 40

Area	Adult male	Subadult male	Adult female	First and second year animals	Newborn
1	57	0	2	3	0
2	233	20	0	45	0
3	38	0	0	0	0
4	16	0	294	0	93
5	23	0	599	0	253
6	33	12	8	103	2
7	2	0	91	0	125
8	4	0	156	6	97
9	3	0	131	0	75
10	2	0	6	0	2
Totals	411	32	1,287	157	647
Total one year old or older, 1,887					
Total newborn, 647					

distribution of the sea lions on the island is undoubtedly associated with the greatly increased size of the population.

Figure 41 summarizes the known history of the *Zalophus* population of Santa Barbara Island during the breeding season (the winter

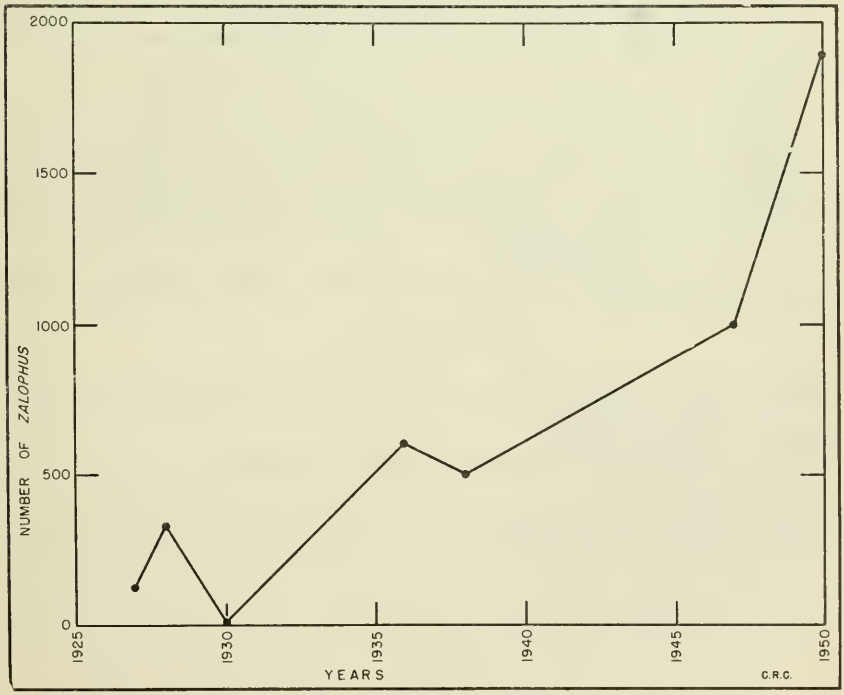

FIGURE 41. A summary of the breeding censuses of the sea lion population of Santa Barbara Island. All figures except for 1950 are taken from Bonnot and Ripley (1947).

census published by Fry, 1939, is not included in the following discussion). In the two decades during which the Division of Fish and Game followed this population, there was a general but irregular increase in its size and by 1947 it numbered 1,000. Our figures show that between 1947 and 1950 the absolute increase of the population has been as great as that recorded during the preceding 20 years.

Our count of 1,887 one-year-old or older individuals on Santa Barbara make the population of this island during the 1950 breeding season equal to approximately 60 percent of the known population of the entire State during the 1947 breeding season. The large absolute size of the sea lion population of this island as well as the striking growth which it has shown since 1947 suggests that the spectacular increase in numbers of sea lions previously noted on San Nicolas Island is not an isolated phenomenon and that it was not caused by a wholesale emigration of individuals from this adjacent rookery.

There can be little doubt that the summer population of sea lions in the southern Channel Islands is at the highest point that it has attained during the past quarter of a century.

Table 1 classifies the sea lion population of Santa Barbara Island by age and sex. The class designated as "mature female" necessarily includes an indeterminant number of young males for these animals cannot readily be distinguished from females in the field. Even so our figures indicate the adult male population during this breeding season could not have been more than half as great as that of the adult females. Moreover, 80 percent of the adult males were segregated in areas in which females and pups were not present in significant numbers and as a result presumably would not participate in the population's reproductive efforts.

Since the period during which the young are born was not yet over at the time of our visit, the 657 newborn animals counted does not represent the entire 1950 crop. Even so, the total number of newborn is approximately equal to one-third of the total number of individuals one year old or older which suggests that sea lions on Santa Barbara Island are still increasing markedly.

No pinnipeds other than the California sea lion were seen on the island during our visit.

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CALIFORNIA STATE-WIDE ANGLING CATCH ESTIMATES FOR 1949[1]

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Annual postal card surveys of angling success provide the California Division of Fish and Game with state-wide catch records. These records constitute the only reliable source of information about trends in angling pressure and angling success for important sport fisheries on a state-wide basis. Covering the period from 1936 to the present, they have made it possible to follow and evaluate the explosive increases in angling pressure experienced by California's sport fisheries as a result of the great population influx into the State during and immediately following World War II. They have also provided a wealth of other information which is important in many connections having to do with the sound, long-range management of California's game fish resources. The various applications of these postal card records have been discussed at some length in a preceding report (Calhoun, 1950), which summarized the whole series of surveys up to and including 1948. It also considered the statistical reliability and the validity of the numerical estimates obtained.

The present report is limited to a summary of the results of the routine 1949 survey. This project represents something of a departure from earlier procedure, in that its sole purpose was to maintain continuity in major trends. The elaborate breakdowns by counties and other special analyses which have been made routinely in the past are not believed to be necessary each year. Future plans call for biennial surveys of the type made in 1949, to maintain trends, coupled with intensive, complete surveys on a larger scale at five-year intervals.

The random sample of 1949 angling licensees who were sent postal card questionnaires totaled 7,815 individuals. This represented 0.79 percent of all licensees, since 991,981[2] angling licenses were sold in California in 1949. This approached the desired 0.80 percent closely, indicating that practically all license stubs were sampled. It is, of course, necessary to determine the sampling rate for these surveys well in advance of the time when total license sales are known, and this was done for the 1949 survey on the following basis. It was decided that a final sample of about 2,500 individual postal card returns from the State as a whole would be sufficient to obtain the desired 1949 state-wide estimates with sufficient accuracy. This was arrived at on the basis of the variability of the individual species catch reports in earlier surveys, and the proportions of all anglers fishing for the various species. Since there is invariably about a 30 percent response to the questionnaires, it was necessary to

[1] Submitted for publication August, 1950.
[2] Not the final figure, but sufficiently accurate for present purposes.

mail about 8,000 cards to obtain the desired number of returns. A total angling license sale approximating 1,000,000 was anticipated in 1949. Sampling was therefore done on an 0.8 percent basis, to obtain a final random sample of about 8,000 licensees. In practice, the eleventh stub from each fifth book of 25 stubs was extracted and included in the sample. Selection of names and addressing of cards was carried on throughout 1949, as the stubs were received from district offices. This made it possible to mail most of the questionnaires during the second week in January.

In all, 2,353 licensees responded to the questionnaires, representing 30.1 percent of the total sample mailed. Of these respondents, 1,870 (79.5%) caught one or more fish, 325 (13.8%) fished unsuccessfully, 97 (4.1%) did not fish, and 61 (2.6%) caught nothing, but failed to state whether or not they fished. The percentages in these four groups were essentially unchanged from 1948.

In converting postal card reports to state-wide estimates, it is assumed that the former represent a true cross-section of all angling licensees. Surprisingly enough, this assumption appears to be entirely justified under present conditions in California, on the basis of studies described in the preceding report, already mentioned. In practice, the various totals from the postal card reports are multiplied by a projection factor which is the ratio: $\frac{\text{licensed anglers}}{\text{postal card respondents}}$. The 1949 projection factor is $\frac{991{,}981}{2{,}353}$, or 421.6.

The 1949 estimates pertaining to numbers of anglers catching each of the various kinds of fish covered by the survey are outlined in the upper portion of Table 1. The nature of the postal card questionnaires is such that anglers do not report unsuccessful angling for individual kinds of fish, and all of the estimates obtained are therefore in terms of anglers *catching* rather than *fishing for* a given category. However, it is possible to estimate the actual number of individuals angling for a given fish on the basis of certain data obtained from the 1948 personal interview survey, and contained in the preceding report. This has been done in deriving the fifth horizontal row of figures in Table 1, by assuming that the proportions of successful and unsuccessful anglers for each fish were the same in 1948 and 1949, and applying a correction to the 1949 successful-angler figures accordingly.

The lower portion of Table 1 summarizes 1949 annual catch estimates. Zero catches cannot be included in deriving mean catches, and the true means for all anglers, including those who were unsuccessful for a given kind of fish, will of course be somewhat below those shown. A good idea of the relationships between the mean catches of all anglers and those of successful anglers alone can be obtained from the results of the 1948 personal interview survey already mentioned.

The general picture of 1949 angling obtained from the postal card survey almost duplicates that of 1948. The explosive increase in angling pressure which occurred in California immediately after World War II has leveled off sharply. The increase in angling license sales within the

TABLE 1

California State-wide Angler and Catch Estimates From the 1949 Postal Card Survey

	Trout	Striped bass	Black bass	Crappie	Sunfish	Catfish	Salmon	Barracuda
Number of postal card catch reports	1,023	391	274	250	270	381	160	262
Estimated number of California anglers catching the indicated species	431,000	165,000	116,000	105,000	114,000	161,000	67,000	110,000
Standard error	10,100	7,610	6,560	6,300	6,520	7,530	5,150	6,430
Percent of all angling licensees	43	17	12	11	11	16	7	11
Estimated number of California anglers fishing for indicated species, including unsuccessful ones	541,000	243,000	169,000	124,000	131,000	190,000	135,000	147,000
Mean (average) catch	38.7	10.6	10.0	23.1	35.3	24.4	4.4	12.7
Standard deviation	57.2	16.6	16.2	39.2	49.0	41.26	6.25	18.6
Standard error of mean	1.79	0.84	0.98	2.48	2.98	2.11	0.49	1.15
Median catch	----------	5	5	10	20	12	2	7
Totals, state-wide catch	16,700,000	1,750,000	1,160,000	2,430,000	4,020,000	3,930,000	298,000	1,400,000
Standard error of total catch	840,000	161,000	132,000	298,000	410,000	387,000	39,800	151,000

TABLE 2

Statistical Comparison of Numbers of Successful Anglers in 1948 and 1949

	Successful anglers in 1948	Standard error	Successful anglers in 1949	Standard error	Difference	Standard error	P	Statistically significant difference
Trout	415,000	6,250	431,000	10,100	16,000	11,900	>.05	No
Striped bass	161,000	4,800	165,000	7,610	4,000	9,000	>.05	No
Black bass	128,000	4,300	116,000	6,560	12,000	7,810	>.05	No
Crappie	116,000	4,100	105,000	6,300	11,000	7,520	>.05	No
Sunfish	118,000	4,100	114,000	6,520	4,000	7,710	>.05	No
Catfish	182,000	5,000	161,000	7,530	21,000	9,040	.02	Yes
Salmon	65,000	3,200	67,000	5,150	2,000	6,060	>.05	No
Barracuda	94,000	3,700	110,000	6,430	16,000	7,420	.03	Yes

TABLE 3

Statistical Comparison of State-wide Mean Catch Estimates for 1948 and 1949

	1948 mean catch	Standard error	1949 mean catch	Standard error	Difference	Standard error	P	Statistically significant difference
Trout	44.5	1.43	38.7	1.79	5.8	2.27	.01	Yes
Striped bass	10.3	0.52	10.6	0.84	0.3	0.99	>.05	No
Black bass	14.7	0.96	10.0	0.98	4.7	1.37	.001	Yes
Crappie	23.8	1.29	23.1	2.48	0.7	2.80	>.05	No
Sunfish	41.0	2.54	35.3	2.98	5.7	3.91	>.05	No
Catfish	30.7	1.71	24.4	2.11	6.3	2.71	.02	Yes
Salmon	4.9	0.31	4.4	0.49	0.5	0.58	>.05	No
Barracuda	15.4	1.32	12.7	1.15	2.7	1.75	>.05	No

TABLE 4

Statistical Comparison of State-wide Total Catch Estimates for 1948 and 1949

	1948 total catch	Standard error	1949 total catch	Standard error	Difference	Standard error	P	Statistically significant difference
Trout	18,400,000	635,000	16,700,000	840,000	1,700,000	1,050,000	>.05	No
Striped bass	1,650,000	97,000	1,750,000	161,000	100,000	188,000	>.05	No
Black bass	1,890,000	138,000	1,160,000	132,000	730,000	191,000	.0001	Yes
Crappie	2,760,000	178,000	2,430,000	298,000	330,000	347,000	>.05	No
Sunfish	4,820,000	344,000	4,020,000	410,000	800,000	535,000	>.05	No
Catfish	5,560,000	347,000	3,930,000	387,000	1,630,000	520,000	.002	Yes
Salmon	321,000	25,400	298,000	39,800	23,000	47,200	>.05	No
Barracuda	1,440,000	137,000	1,400,000	151,000	40,000	210,000	>.05	No

TABLE 5

County of Residence Distribution of California Angling Licensees in 1949

County	Resident licensees in sample		Projected total resident licensees	County population 1950 census[1]	Licensees as percent of population
	Number	Percent			
Alameda	618	7.9	78,437	734,740	10.7
Alpine	1	----------	----------	235	----------
Amador	5	----------	635	9,091	7.0
Butte	90	1.2	11,423	64,374	17.7
Calaveras	10	0.1	1,269	9,850	12.9
Colusa	7	0.1	888	11,573	----------
Contra Costa	285	3.6	36,173	297,400	12.2
Del Norte	16	0.2	2,031	8,027	25.4
El Dorado	21	0.3	2,665	16,021	16.6
Fresno	239	3.1	30,334	274,344	11.0
Glenn	13	0.2	1,650	15,341	10.7
Humboldt	115	1.5	14,596	67,848	21.5
Imperial	56	0.7	7,108	62,512	11.4
Inyo	22	0.3	2,792	11,486	24.3
Kern	181	2.3	22,973	225,928	10.2
Kings	38	0.5	4,823	46,295	10.4
Lake	18	0.2	2,285	11,380	20.0
Lassen	35	0.4	4,442	18,403	24.1
Los Angeles	2,308	29.5	292,935	4,116,901	7.1
Madera	26	0.3	3,300	36,763	9.0
Marin	84	1.1	10,661	81,739	12.6
Mariposa	7	0.1	888	5,086	----------
Mendocino	52	0.7	6,600	39,996	16.5
Merced	63	0.8	7,996	67,636	11.8
Modoc	21	0.3	2,665	9,643	27.6
Mono	5	0.1	635	2,081	----------
Monterey	99	1.3	12,565	129,898	9.7
Napa	51	0.7	6,473	46,373	14.0
Nevada	27	0.3	3,427	19,300	17.8
Orange	143	1.8	18,150	214,061	8.5
Placer	47	0.6	5,965	41,266	14.5
Plumas	26	0.3	3,300	13,398	24.6
Riverside	129	1.7	16,373	168,959	9.7
Sacramento	260	3.3	33,000	275,760	12.0
San Benito	13	0.2	1,650	14,330	11.5
San Bernardino	197	2.5	25,004	278,577	9.0
San Diego	333	4.3	42,265	535,967	7.9
San Francisco	404	5.2	51,276	760,381	6.7
San Joaquin	218	2.8	27,669	199,414	13.9
San Luis Obispo	71	0.9	9,011	51,114	17.6
San Mateo	148	1.9	18,784	234,030	8.0
Santa Barbara	72	0.9	9,138	97,087	9.4
Santa Clara	233	3.0	29,573	288,852	10.2
Santa Cruz	78	1.0	9,900	65,920	15.0
Shasta	52	0.7	6,600	35,985	18.3
Sierra	6	0.1	762	2,361	----------
Siskiyou	64	0.8	8,123	30,517	26.6
Solano	120	1.5	15,231	102,194	14.9
Sonoma	102	1.3	12,946	102,685	12.6
Stanislaus	159	2.0	20,181	126,613	16.0
Sutter	33	0.4	4,188	26,140	16.0
Tehama	21	0.3	2,665	19,169	13.9
Trinity	13	0.2	1,650	5,045	32.7
Tulare	111	1.4	14,088	148,711	9.5
Tuolumne	17	0.2	2,158	12,504	17.3
Ventura	89	1.1	11,296	113,351	10.0
Yolo	49	0.6	6,219	40,453	15.4
Yuba	36	0.5	4,569	24,240	18.8
Out of State	58	0.7	7,361	----------	----------
Totals	7,815	100.00	----------	10,472,348	----------

[1] Preliminary in that they do not include persons counted away from home.

State, from 960,000 in 1948 to 992,000 in 1949 was negligible. A comparison of 1948 and 1949 estimates of the numbers of anglers fishing successfully during the year for the various fish covered in the survey is outlined in Table 2. The only statistically significant differences were a small decrease in anglers catching catfish and a small increase in those catching barracuda. Mean annual catch per angler, similarly compared in Table 3, remained unchanged except in the case of trout, black bass, and catfish, all three of which continued their previous downward trend (Calhoun, 1950). Total annual catch estimates, compared in Table 4, were down significantly from 1948 in the case of black bass and catfish. They remained static for the other six kinds of fish covered in the survey.

The regional distribution of licensed anglers within the State is a matter of some interest. This could not be readily evaluated for 1948 because of certain minor peculiarities of the sample which arose in connection with the double survey that year. It has therefore been worked out for 1949 with the result shown in Table 5. Estimates of the numbers of licensees residing in each of the counties were derived by multiplying the number of county residents in the 1949 random sample by the factor $\frac{991,981}{7,815} = 126.9$.

SUMMARY

This report covers the results of the state-wide postal card survey of California angling during 1949. Estimates of total state-wide catches, average catches, and numbers of anglers for eight important game fish are given. The general picture paralleled 1948 closely, indicating that recent increases in angling pressure have leveled off. County of residence distribution of 1949 angling licensees is also outlined.

REFERENCE

Calhoun, A. J.
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THE 1948 SURVEYS OF CALIFORNIA'S HUNTING TAKE AND THEIR SIGNIFICANCE[1]

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INTRODUCTION

Administration of the wildlife resource is predicated upon legislatively providing the hunting pressure required to reap annually the maximum harvest of the several game species. These efforts are contingent upon the maintenance of the maximum breeding populations which habitats can support on a sustained yield basis. It is physically impractical and financially impossible to conduct state-wide game censuses before and after open seasons to determine the take and the residual breeding populations. Another method of estimation of the take must be employed which is inexpensive, obtainable shortly after the close of the hunting seasons, and which is sufficiently accurate to be considered reliable. Hunter and Fry (1941) are careful to point out that the game kill estimate ". . . by itself, is not a reliable index of abundance." However, it should be borne in mind that the relative abundance of the game species may be inferred by comparing the game take from year to year, tempered with field observations. By determining the mean kill for each species successfully bagged by the average hunter we derive a figure which may be safely utilized in making annual comparisons.

Prior to 1935 and subsequent to 1939 estimates were based upon reports of fish and game wardens, interested hunters, governmental agencies such as the U. S. Forest Service, and, more recently, from intensive studies made in compartively small areas. Successful deer hunters have been required by law to submit information regarding their deer kills since 1927. The weak point of this system is that successful hunters have not been penalized for failure to return this information, unless apprehended by a warden for some other game law infraction. Thus, records have been received from the prompt, conscientious hunter, while the universe of the procrastinator and the uncaught violator has been sampled to an unknown degree.

During the years 1935-39, kill data were derived from questionnaires attached to hunting license applications and from questionnaires mailed to a random sample of license buyers. It was found that close agreement existed between results obtained by these two methods. The mailed questionnaire sample method is preferable to the license application questionnaires in that results are compiled a full year earlier and fewer ballots are handled, thus reducing the time and cost of processing. Both of these methods are weak in that nonresponse is high. About 70

[1] Submitted for publication June, 1950.

percent of those receiving mailed questionnaires do not return them, while, as Hunter and Fry (1940) report, ". . . the percentage of usable questionnaires (license application) from the individual counties varies from 10 to 50 percent." The study did find that the mailed questionnaires were filled out with more care, and presumably with more accuracy, than the license application questionnaires.

The basic assumption, in handling these two methods, was that the number of deer reported killed on the returned deer reports was fundamentally correct. Data secured for all other game species were corrected by a factor derived by adjusting the reported deer kill to the number reported on deer tags. It was also assumed that the reported kill of small game was not exaggerated appreciably more or less than the deer kill.

In conducting the present study it has been deemed advisable to determine the take of an entirely random sample of the hunting license buying population. For this purpose it was felt that data secured by an outside organization should represent careful response and contain a minimum of answers influenced by the legal daily and seasonal bag limits. The Opinion Research Center of the University of Denver was commissioned to conduct such a game take survey based upon personal interviews. A concurrent post card mailed questionnaire was designed as a check on previous studies and on the personal interview survey, to determine the feasibility of future use of post cards for game take surveys.

METHOD

A 2 percent random sample was selected from the 501,377 state resident hunting license purchasers for the 1948-49 hunting season, the source being the hunting license stub books. A mathematically random subsample which provided 1,250 actual interviews was derived from this sample by the Opinion Research Center. The Opinion Research Center, hereafter designated as the ORC, employed a field staff of experienced interviewers who completed the actual interviews. Respondents residing in the Counties of Inyo, Kings, Lake, Mono, Plumas, San Benito, and a portion of San Bernardino, were interviewed by division personnel. Certain small counties which were similar in important geographic and economic respects were grouped together in order to provide interviewing assignments of a practical size.

Of the 1,250 respondents approximately two-thirds, or 827, received post card questionnaires prior to being interviewed. These were coded so that the information could be compared with the data from the corresponding interviews. It was hoped that this comparison would indicate a correction factor which could be applied to future post card questionnaire results. The remainder of the respondents did not receive post cards in order to determine the possible effect of the questionnaires on the answers given in the personal interviews.

An entirely separate 2 percent random sample was drawn from the remaining 1948-49 hunting license stub books, including both resident and nonresident license buyers. A special effort was made to obtain these names from a constant position in the interior of the books to eliminate any possible bias owing to sale of the first licenses to preferential customers such as mayors, police chiefs, etc. Post card questionnaires

were sent to the 9,412 persons in this sample and a total of 2,990 usable questionnaires were returned, or 31.8 percent of those mailed.

The method of projection was to multiply the total figures secured by the total hunting license sale divided by the numbers involved in the samples. No assumptions were made that any of the resulting kill data necessitated adjustment to reported kills secured in any other manner. Both methods involved the securing of the total bag of the several game species and the counties in which they were hunted. The interviews also went into considerable detail as to types of areas hunted, crippling losses, return of bands from pheasants and waterfowl, and opinions on controversial questions.

RELIABILITY OF THE INTERVIEW RESULTS

The following is quoted from the report tendered by the ORC:

"Statistically speaking, for a sample of 1,250 from a large universe (in this case 501,377 licensees) the chances are less than 5 in 100 that any error arising from the size of the sample will be greater than about 3 percentage points more or less than the sample percentage. In other words, the maximum error that would be expected in 95 surveys out of 100 with similar samples would be 2.82 percent above or below the obtained results.

"This concept of statistical range of error also applies when projections are made from sample results to estimate total bag or days hunted by all hunters in the state. Since this estimate is not derived from a percentage, however, the range of error is computed differently, using the standard error of the mean. For example, in the case of pheasants, the 1,250 respondents bagged 1,394 birds, an average of 1.12 birds apiece. The estimated bag for the state (by state residents) is therefore 501,377 licensees times 1.12 birds or a total of 561,500 (in practice these projections are made directly from the sample bag without figuring the mean, but, except for differences due to rounding, the results are the same). The standard error of the mean bag per licensee is 0.07, which means that the chances are 95 out of 100 that the true mean is between 0.98 and 1.26 [1] birds per licensee. For the whole state, then, the chances are 95 out of 100 that the actual bag is within the range of 491,300 and 631,700. All estimates given in this report should be interpreted with this in mind."

VALIDITY OF THE INTERVIEW SURVEY METHOD

A novel method was employed in obtaining an evaluation of the validity of results obtained on the personal interviews. Honesty and memory were essentially the two unknown factors—whether or not respondents would give true answers in regard to their hunting, and how well they remembered where they hunted and the numbers killed for each game species. A pilot study was employed wherein the interviewers submitted names of 21 friends known to be hunters. These names were then submitted to other interviewers who completed the interviews. The friends were subsequently unobtrusively reinterviewed by their interviewer friends and the results compared. It was determined that

[1] Two standard errors, or 0.14, greater than or less than the mean.

TABLE 1

Game Take Statistics for 1948 Determined From ORC Personal Interviews

	Number	Percentage
1948-49 licensees who hunted	482,300	96.2
1948-49 licensees who did not hunt	19,100	3.8
Totals	501,400	100.0

	Estimated number	Percentage of all license buyers
Reported deer take		
Number of hunters	301,600	60.2
Successful	77,800	15.5
Unsuccessful	223,800	44.7
Total estimated bag	91,000	
Number of unrecovered cripples (not included in the total bag)	18,400	
Reported bear take		
Number of hunters	18,800	3.8
Successful	2,800	0.6
Unsuccessful	16,000	3.2
Total estimated bag	2,800	
Number of unrecovered cripples	400	
Reported duck take		
Number of hunters	209,700	41.8
Successful	176,500	35.2
Unsuccessful	33,300	6.6
Total estimated bag	2,875,700	
Number of unrecovered cripples	637,000	
Reported goose take		
Number of hunters	104,700	20.9
Successful	63,800	12.7
Unsuccessful	40,900	8.2
Total estimated bag	347,000	
Number of unrecovered cripples	51,300	
Reported coot take		
Number of hunters	11,300	2.2
Successful	9,300	1.8
Unsuccessful	2,000	0.4
Total estimated bag	117,100	
Number of unrecovered cripples	27,700	
Reported dove take		
Number of hunters	161,300	32.2
Successful	142,800	28.5
Unsuccessful	18,400	3.7
Total estimated bag	2,378,000	
Number of unrecovered cripples	262,700	
Reported band-tailed pigeon take		
Number of hunters	28,900	5.7
Successful	19,200	3.8
Unsuccessful	9,700	1.9
Total estimated bag	349,800	
Number of unrecovered cripples	107,100	

TABLE 1—Continued

Game Take Statistics for 1948 Determined From ORC Personal Interviews

	Estimated number	Percentage of all license buyers
Reported mountain quail take		
Number of hunters	73,800	14.7
Successful	49,700	9.9
Unsuccessful	24,100	4.8
Total estimated bag	451,600	
Number of unrecovered cripples	89,900	
Reported valley or desert quail take		
Number of hunters	163,300	32.6
Successful	125,600	25.1
Unsuccessful	37,700	7.5
Total estimated bag	1,465,700	
Number of unrecovered cripples	257,100	
Reported pheasant take		
Number of hunters	215,400	43.0
Successful	142,400	28.4
Unsuccessful	73,000	14.6
Total estimated bag	559,100	
Number of unrecovered cripples	117,100	
Reported cottontail and brush rabbit take		
Number of hunters	93,800	18.7
Successful	75,800	15.1
Unsuccessful	18,000	3.6
Total estimated bag	767,000	
Number of unrecovered cripples	71,800	
Reported jackrabbit take		
Number of hunters	101,900	20.3
Successful	84,300	16.8
Unsuccessful	17,600	3.5
Total estimated bag	1,159,600	
Number of unrecovered cripples	120,300	
Reported tree squirrel take		
Number of hunters	24,100	4.8
Successful	19,700	3.9
Unsuccessful	4,400	0.9
Total estimated bag	105,100	
Number of unrecovered cripples	7,700	

there was no tendency toward dishonesty in answering the questions except occasionally where there was some question as to legal bag limit. Validity was also increased by sending letters from the director of the ORC to the respondents which explained the purpose of the survey and primed the respondent for the interview.

RESULTS OF THE ORC PERSONAL INTERVIEW SURVEY

Results of the personal interview game take survey are shown for the individual species in Table 1.

VALIDITY CHECKS

Several checks were incorporated within the surveys to measure their correlation with known data, such as license sales and band returns.

The actual 1948-49 sale of deer tags was 304,052 or just 0.8 percent over the 301,600 ORC estimated number of deer hunters. The independent post card survey indicated a deer tag sale of 293,300, or 3.5 percent less than the actual sale. Both methods show a good correlation with the known sale.

There were 223,900 active duck hunters, according to ORC. Because each hunter over 16 years old is required by law to purchase a federal migratory waterfowl stamp before hunting waterfowl, the sale of these stamps should approximate that figure. The actual sale was 188,387 in California, making the reported figure 18.9 percent higher than the actual sale. The contrast is heightened by an unknown amount in that nonhunter philatelists purchase these stamps for their collections. The contrast is lessened, however, in that persons under 16 years of age are not required to buy "duck stamps." In addition, the percentage of adult waterfowl hunters who do not purchase stamps is unknown. It is possible that these latter factors account for a large part of the discrepancy.

The total number of waterfowl hunters derived from the post card survey, 202,368, was much closer to the actual "duck stamp" sale than ORC, being just 7.4 percent greater.

Returns of duck bands showed a very poor correlation. Of the 5,200 reported turned in by hunters only about 1,500, or 28.8 percent, were actually turned in for the 1948-49 hunting season in California.

During the year 1948 all liberated male pheasants were banded. A total of 2,155 bands were returned by hunters, although 5,200, which is 141 percent greater, were reported sent in by ORC respondents. This percentage should be borne in mind in view of the results secured from a similar survey in regard to pheasants alone in 1949.

During the 1949 season Cooperative Hunting Areas were operated for the first time in California. These areas were authorized by Senate Bill No. 677 to give added trespass protection to landowners in exchange for greater public access to private lands in order to hunt upland game birds. To evaluate properly hunter use, checking stations were established on each of these areas to determine hunting effort and success. It was found that 37,500 persons hunted on these areas, which compared favorably with the 41,166 permits issued. Probably even greater agreement exists because permits were surrendered at the checking stations whenever hunters left the area. Upon re-entering, hunters were issued new permits because of difficulties involved in the reissuance of original permits. This very probably accounts for the 10 percent difference.

However, the total reported take of 35,510 pheasants on these areas, as determined from a special post card survey, was 164 percent greater than the calculated take of 13,452 derived by projecting the known take of permittees to the slightly greater total number of permits issued. In view of the fact that the correlation between actual and reported hunter use of the areas is considered good, it is felt that this exaggeration is significant with regard to pheasants. The close correlation with the band return data previously mentioned indicates that we have a correction factor of about 0.4 which may be applied in estimating the actual kill of pheasants from the reported kill in a similar special sample. It is noteworthy that the standard post card game survey for the 1949 season indicated a state-wide pheasant take of 388,700. This is less than 2 percent greater than the 381,400 reported taken on a post card survey conducted among a 2 percent random sample of pheasant tag buyers.

The ORC and the post card survey both agree that the deer kill was probably considerably greater than the total derived from "Hunter's Reports of Deer Kill." Each method indicated a 1948 season deer kill of about twice the 47,789 reported by the hunters. It is felt that the difference is largely the result of procrastination and violation of game laws reducing the number of hunter reports mailed to this organization. Enhancing this possible explanation of the discrepancy in the deer kill data is another which leads toward a reduction of the survey totals. If persons jointly killing a deer are members of the survey sample, each participant may report bagging the identical deer. Hence, the actual take of deer lies somewhere between 50,000 and 100,000 but we cannot say where.

In view of the material presented, it is apparent that we cannot rely implicitly upon data concerning game take as derived from either post card or personal interview surveys. An unexplainable factor is present which causes the average hunter to overestimate his bag, whether writing or talking about it. Calhoun (1950) showed that the problem of nonresponse to post card surveys can be disregarded as being insignificant. However, there is the real problem of veracity of reporting on the part of the average hunter. It is felt that this condition exists as a malfunction of memory, rather than being any intent of misinformation or self-glorification on the part of the hunter. The possibility does exist that the latter two categories played an important role in the special survey of pheasant tag buyers.

Information gathered in this manner is definitely of value in that trends may be indicated. For instance, the 1949 reported state-wide kill of 388,700 pheasants was 66 percent of the 1948 reported kill of 586,100, both figures being derived from post card surveys. This drop in hunter success was verified by field observers. The reported take during the 1949 season is shown in Table 2 and graphically depicted by number in the bag in Figure 42.

TABLE 2

Pheasant Take—1949 Post Card Reports

Total bag	388,700
Number of successful pheasant hunters (32.5% of total hunting license buyers)	126,500
Mean bag per hunter and error at 5% level	3.07 ± 0.16

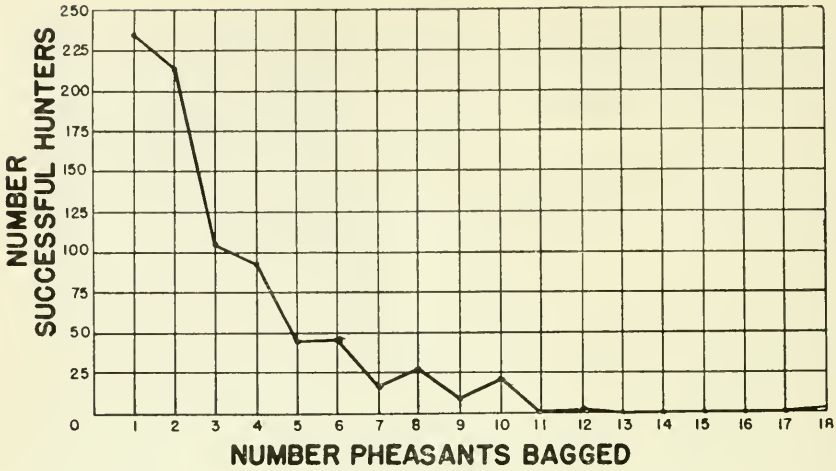

FIGURE 42. Success of hunters bagging pheasants during the 1949 season. Data compiled from post card reports.

THE 1948 REPORTED GAME TAKE

In these discussions concerning methodology and checks designed to explore the feasibility of conducting game take surveys by the medium of post cards, the main space should be devoted to the results attained. Hunter and Fry (1940) reported that about 10 percent of the hunters were either unsuccessful in their hunting efforts or did not hunt during the 1938 hunting season. This group increased to over 23 percent in 1948. The majority of the successful hunters took relatively few of the several game species. The effect of daily bag limits is clearly shown in the data in Figure 44. Hunters tend to remember their kills the easy way, i.e., in multiples of 5 or 10. This is not shown in any of the accompanying curves but is markedly noticeable in the raw kill data for ducks, quail and doves.

Figure 43 depicts the 1948 post card reported kill for all game species in hundreds of thousands. Succeeding pages provide further information on the estimated state-wide and county take of each of the game species. The correlation between post card and interview surveys by county of kill is poor. Generally, the leading counties are the same for a given species regardless of the method employed, but they usually do not appear in the same order. As county breakdowns imply greatly reduced samples, the percentage of error increases to such an extent that game kill figures for small counties are almost meaningless. The state-wide trend is of definite value and the post card interviews will be continued with this in view.

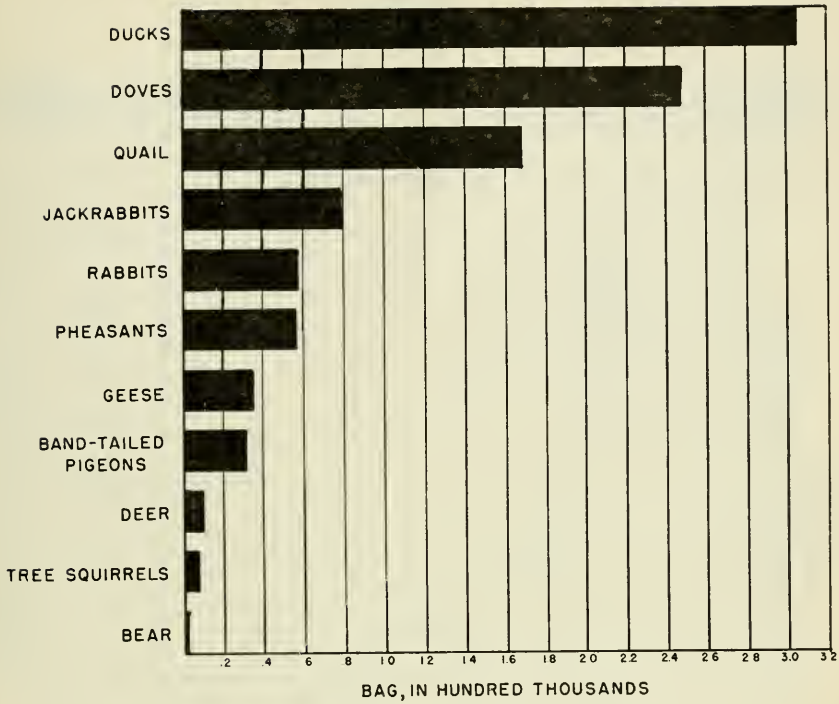

FIGURE 43. State-wide game take by species for 1948 as reported by post card respondents

TABLE 3

Deer Take—1948 Post Card Reports

Total bag	100,000
Number of successful deer hunters	89,500
(17.7 percent of all hunting license buyers)	
(29.4 percent of all deer tag buyers)	
Mean bag per hunter (all licensees)*	0.20
Mean bag per deer tag buyer*	0.33
Mean bag per successful deer hunter*	1.12

* These means are arithmetic

TABLE 4

Ten Leading Counties of Deer Kill—1948

Rank	ORC survey			Post card survey		Deer reports	
	County of kill	Total hunters	Total bag	County of kill	Total bag	County of kill	Total bag
1	Mendocino	25,300	8,000	Mendocino	6,500	Mendocino	3,627
2	Siskiyou	15,200	7,600	Siskiyou	5,800	Siskiyou	2,865
3	Lake	22,500	5,600	Modoc	5,500	Plumas	2,322
4	Modoc	25,300	3,900	Plumas	4,700	Lake	2,120
5	Plumas	18,400	3,900	Fresno	4,700	Humboldt	2,083
6	Tuolumne	16,800	3,900	Humboldt	4,000	Fresno	2,050
7	Fresno	15,600	3,200	Monterey	3,900	Modoc	2,022
8	Sierra	9,200	3,200	Tulare	3,700	Lassen	2,019
9	San Benito	4,400	2,800	Lake	3,300	Tehama	1,806
10	Tehama	8,000	2,800	El Dorado	3,200	Shasta	1,686

TABLE 5

Pheasant Take—1948 Post Card Reports

Total bag	575,100
Number of successful pheasant hunters (32.3 percent of total hunting license buyers)	162,906
Mean bag per hunter and error at 5 percent level*	3.53 ± 0.16

* In 95 out of 100 cases the true mean would lie between 3.37 and 3.69 birds per successful pheasant hunter. All subsequent references are to be considered in the same manner.

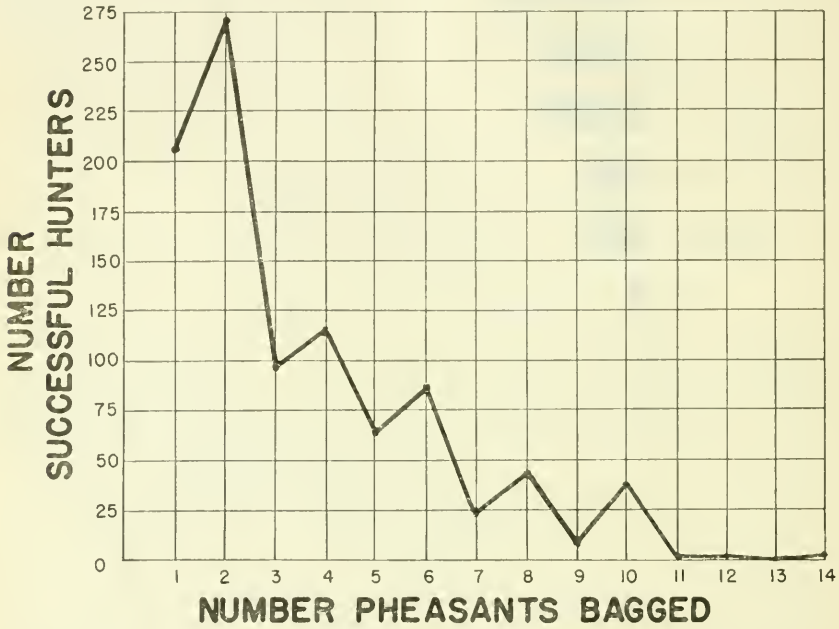

FIGURE 44. Success of hunters bagging pheasants during the 1948 season. Data compiled from post card reports.

TABLE 6

Ten Leading Counties of Pheasant Kill—1948

Rank	ORC survey				Post card survey	
	County of kill	Total hunters	Mean bag per hunter	Total bag	County of kill	Total bag
1	Colusa	22,900	3	71,400	Colusa	75,600
2	Sutter	14,800	5	70,500	Butte	70,200
3	Yolo	24,400	3	62,600	Yolo	55,200
4	Stanislaus	18,400	3	60,600	Glenn	47,500
5	Butte	16,100	4	58,600	Sacramento	45,200
6	Glenn	10,800	3	37,700	Sutter	43,100
7	Sacramento	15,200	2	34,500	Stanislaus	37,100
8	San Joaquin	13,200	2	26,500	San Joaquin	20,800
9	Yuba	5,200	3	16,400	Yuba	18,800
10	Contra Costa	5,600	2	12,000	Fresno	16,000

TABLE 7

Duck Take—1948 Post Card Reports

Total bag	3,075,500
Number of successful duck hunters (40.2 percent of total hunting license buyers)	202,400
Mean bag per hunter and error at 5 percent level	14.16 ± 0.86

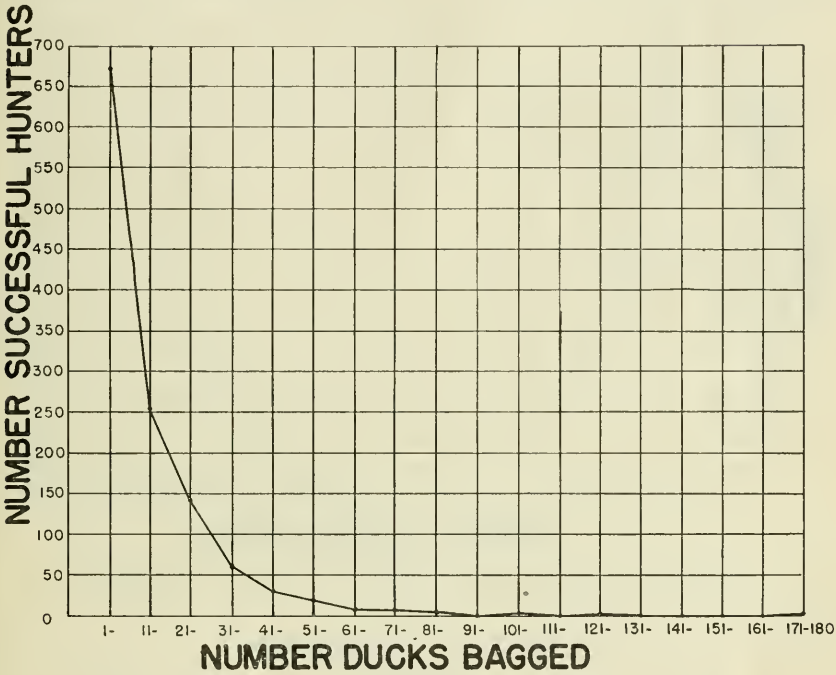

FIGURE 45. Success of hunters bagging ducks during the 1948 season. Data compiled from post card reports.

TABLE 8

Ten Leading Counties of Duck Kill—1948

Rank	ORC survey				Post card survey	
	County of kill	Total hunters	Mean bag per hunter	Total bag	County of kill	Total bag
1	Merced	12,400	22	273,500	Merced	321,300
2	Colusa	18,000	13	233,400	Colusa	206,000
3	Humboldt	7,300	23	166,100	Solano	203,700
4	Butte	12,800	12	154,800	San Joaquin	161,600
5	Glenn	8,400	18	148,400	Butte	151,600
6	Sutter	8,000	17	136,000	Imperial	148,300
7	Solano	10,800	11	122,300	Alameda	127,000
8	Stanislaus	12,000	10	114,300	San Diego	126,500
9	Modoc	7,300	14	102,700	Fresno	103,100
10	San Joaquin	9,600	10	100,300	Sacramento	87,600

TABLE 9

Goose Take—1948 Post Card Reports

Total bag	354,800
Number of successful goose hunters	82,500
(16.4 percent of total hunting license buyers)	
Mean bag per hunter and error at 5 percent level	4.34 ± 0.41

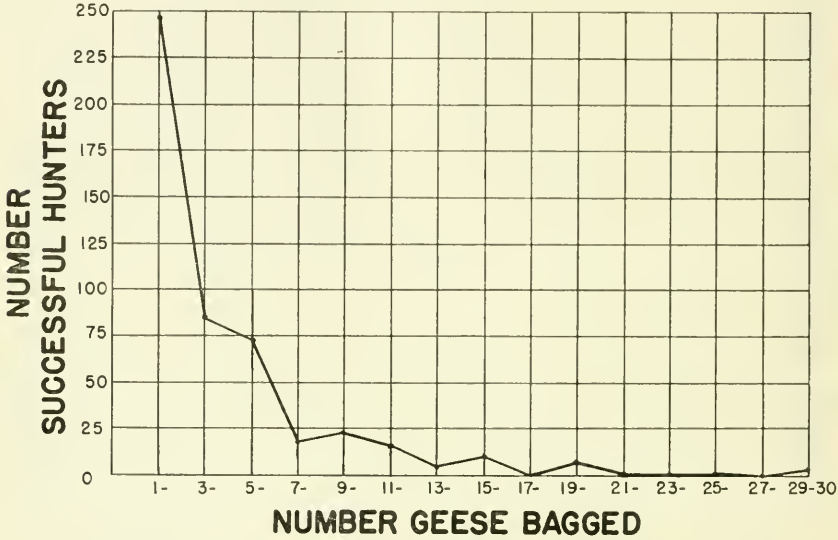

FIGURE 46. Success of hunters bagging geese during the 1948 season. Data compiled from post card reports.

TABLE 10

Ten Leading Counties of Goose Kill—1948

Rank	ORC survey				Post card survey	
	County of kill	Total hunters	Mean bag per hunter	Total bag	County of kill	Total bag
1	Colusa	15,600	8	131,900	Colusa	77,000
2	Modoc	6,300	6	38,900	Glenn	34,300
3	Merced	8,000	3	25,700	Butte	32,900
4	Yolo	7,600	3	24,500	Siskiyou	25,200
5	Sutter	4,400	5	20,900	Sutter	21,100
6	Glenn	6,400	3	19,200	Solano	20,200
7	Butte	8,800	2	14,000	Merced	17,200
8	Solano	4,400	3	11,200	Yolo	15,700
9	San Joaquin	5,600	1	8,000	Modoc	13,900
10	Stanislaus	7,600	1	7,300	Fresno	9,100

TABLE 11

Quail Take—1948 Post Card Reports

Total bag	1,683,400
Number of successful quail hunters	149,800
(29.7 percent of total hunting license buyers)	
Mean bag per hunter and error at 5 percent level	11.04 ± 0.70

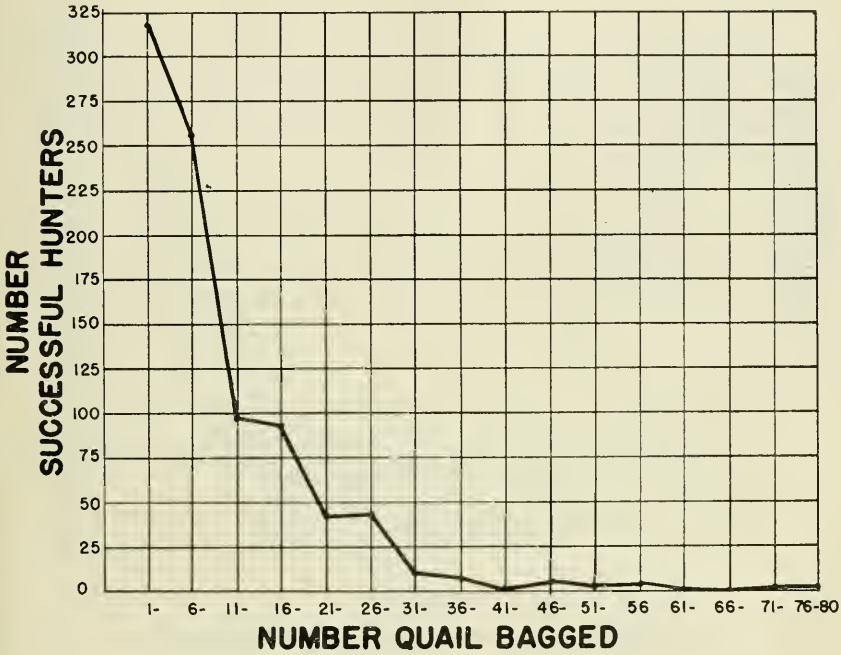

FIGURE 47. Success of hunters bagging quail during the 1948 season. Data compiled from post card reports.

TABLE 12

Ten Leading Counties of Quail (All Species) Kill—1948

Rank	ORC survey				Post card survey	
	County of kill	Total hunters	Mean bag per hunter	Total bag	County of kill	Total bag
1	Kern	14,000	8	118,700	Riverside	94,600
2	Riverside	12,800	9	113,600	Fresno	94,300
3	Modoc	3,600	31	113,200	Kern	93,200
4	San Diego	7,200	15	104,600	San Diego	83,200
5	El Dorado	4,300	21	91,000	Imperial	75,600
6	Los Angeles	12,400	7	83,200	Tulare	65,400
7	Tehama	2,800	25	70,300	Los Angeles	60,000
8	Mendocino	4,000	17	69,300	San Luis Obispo	58,600
9	Stanislaus	5,900	11	63,000	Santa Barbara	49,200
10	Sonoma	4,800	12	57,700	Santa Cruz	48,000

TABLE 13

Dove Take—1948 Post Card Reports

Total bag	2,486,000
Number of successful dove hunters (30.8 percent of total hunting license buyers)	155,300
Mean bag per hunter and error at 5 percent level	16.2 ± 0.92

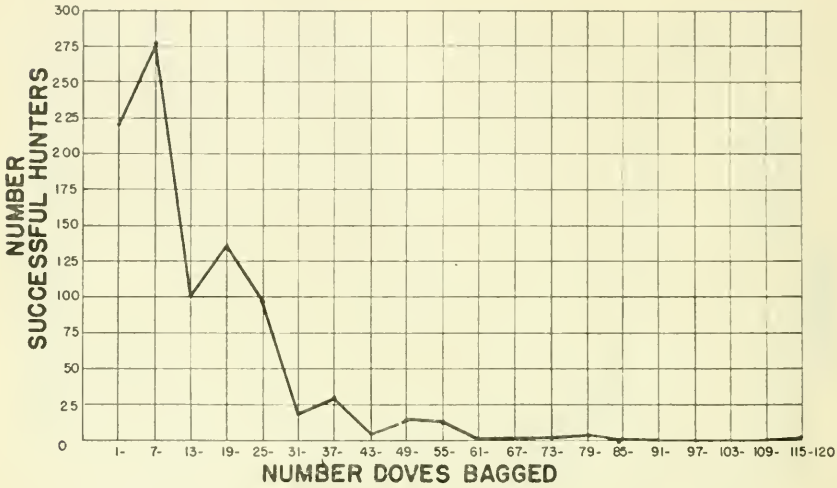

FIGURE 48. Success of hunters bagging doves during the 1948 season. Data compiled from post card reports.

TABLE 14

Ten Leading Counties of Dove Kill—1948

Rank	ORC survey				Post card survey	
	County of kill	Total hunters	Mean bag per hunter	Total bag	County of kill	Total bag
1	Imperial	16,400	20	334,900	Imperial	366,900
2	Fresno	9,200	19	172,500	Tulare	200,300
3	Tulare	7,600	22	170,500	Fresno	181,000
4	Kern	12,400	13	157,600	Kern	138,400
5	Riverside	11,600	13	147,200	Riverside	137,400
6	Stanislaus	8,800	14	121,900	Stanislaus	120,500
7	San Luis Obispo	4,000	30	120,700	San Luis Obispo	103,800
8	Modoc	3,600	28	99,900	San Joaquin	78,800
9	Kings	4,400	19	85,900	San Diego	70,500
10	San Diego	6,300	10	66,200	Los Angeles	63,700

TABLE 15

Band-tailed Pigeon Take—1948 Post Card Reports

Total bag	318,700
Number of successful pigeon hunters (5.7 percent of total hunting license buyers)	28,700
Mean bag per hunter and error at 5 percent level	11.11 ± 1.56

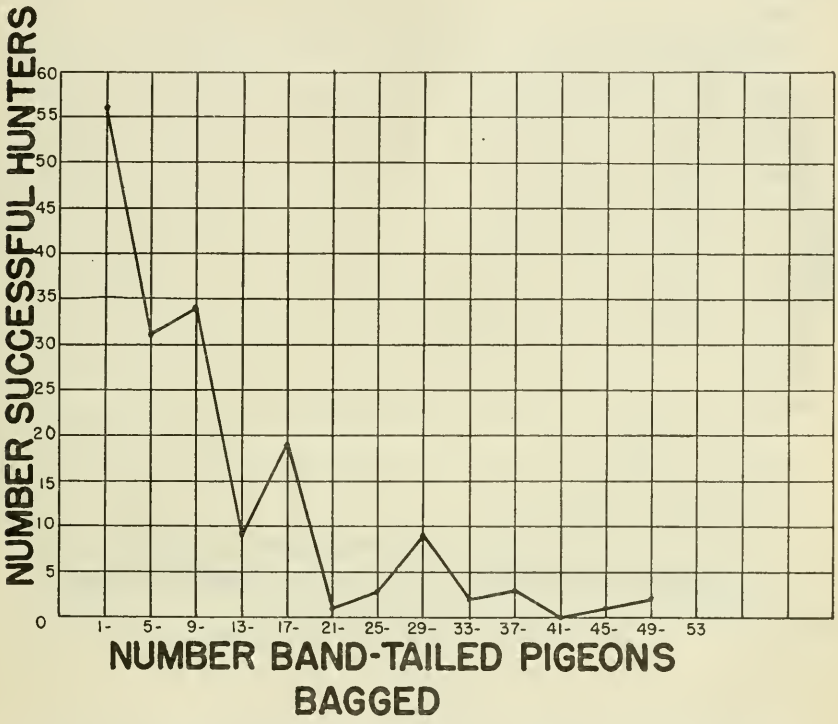

FIGURE 49. Success of hunters bagging band-tailed pigeons during the 1948 season. Data compiled from post card reports.

TABLE 16

Ten Leading Counties of Band-tailed Pigeon Kill—1948

Rank	ORC survey				Post card survey	
	County of kill	Total hunters	Mean bag per hunter	Total bag	County of kill	Total bag
1	San Luis Obispo	5,600	34	192,500	San Luis Obispo	117,800
2	San Diego	2,400	14	33,300	San Diego	26,700
3	Santa Clara	800	14	11,200	Fresno	26,000
4	Mendocino	1,600	7	10,400	Madera	24,100
5	Humboldt	400	25	10,000	Monterey	16,500
6	Madera	1,200	8	9,600	Santa Barbara	11,600
7	Kern	2,400	4	8,500	Humboldt	9,100
8	Modoc	400	20	8,100	Butte	6,200
9	Riverside	2,400	3	8,100	Shasta	5,300
10	El Dorado	400	18	7,300	Napa	5,300

TABLE 17

Cottontail and Brush Rabbit Take—1948 Post Card Reports

Total bag	575,700
Number of successful rabbit hunters (17.1 percent of total hunting license buyers)	86,300
Mean bag per hunter and error at 5 percent level	6.76 ± 0.63

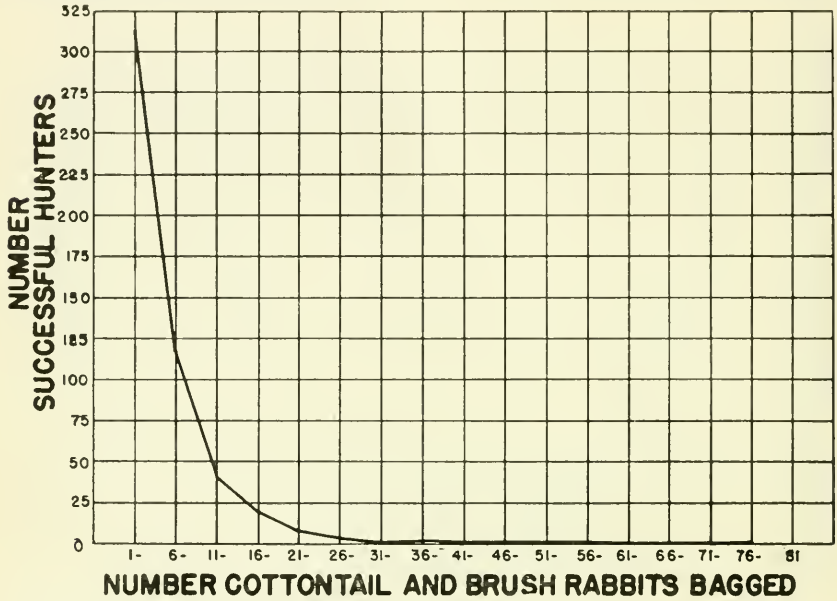

FIGURE 50. Success of hunters bagging cottontail and brush rabbits during the 1948 season. Data compiled from post card reports.

TABLE 18

Ten Leading Counties of Cottontail and Brush Rabbit Kill—1948

Rank	ORC survey				Post card survey	
	County of kill	Total hunters	Mean bag per hunter	Total bag	County of kill	Total bag
1	Riverside	14,400	15	215,800	Riverside	85,800
2	Los Angeles	16,000	7	117,900	San Diego	83,700
3	San Diego	6,800	12	81,400	Los Angeles	47,100
4	San Bernardino	8,000	9	71,800	Kern	40,500
5	Kern	9,200	4	39,700	San Bernardino	38,500
6	Santa Cruz	3,200	12	36,900	Imperial	36,900
7	Siskiyou	1,600	16	25,700	San Mateo	20,600
8	Imperial	3,200	8	24,100	Santa Cruz	19,500
9	Modoc	1,200	15	17,600	Monterey	17,400
10	Monterey	2,400	7	17,600	Fresno	15,100

TABLE 19

Jackrabbit Take—1948 Post Card Reports

Total bag	790,600
Number of successful jackrabbit hunters (20.5 percent of total hunting license buyers)	103,500
Mean bag per hunter and error at 5 percent level	7.57 ± 0.84

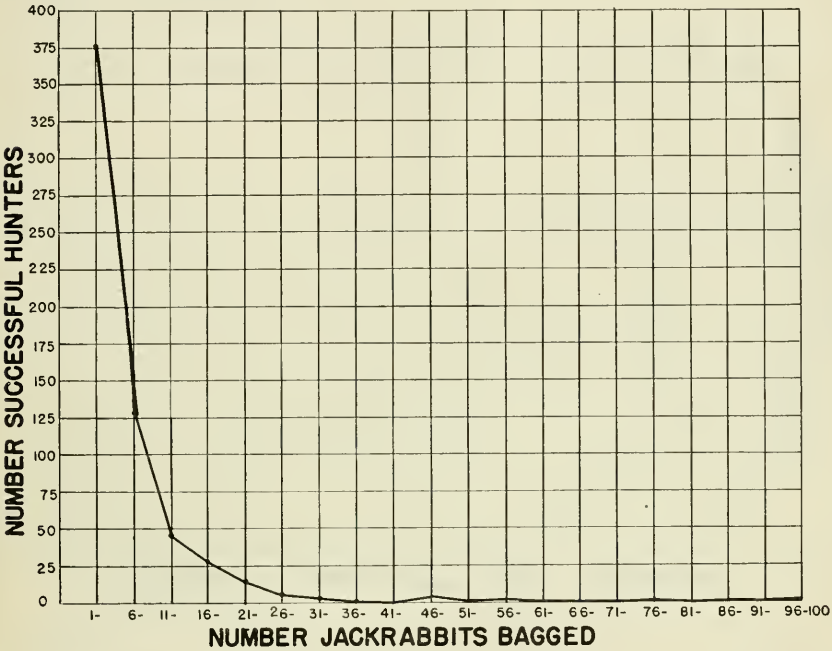

FIGURE 51. Success of hunters bagging jackrabbits during the 1948 season. Data compiled from post card reports.

TABLE 20

Ten Leading Counties of Jackrabbit Kill—1948

Rank	ORC survey				Post card survey	
	County of kill	Total hunters	Mean bag per hunter	Total bag	County of kill	Total bag
1	Modoc	3,600	62	222,600	Stanislaus	101,800
2	Los Angeles	14,800	6	93,800	Kern	64,200
3	Tulare	2,000	27	54,900	Yolo	60,700
4	San Joaquin	5,500	9	52,100	Los Angeles	57,900
5	Alameda	2,800	18	50,900	Sonoma	35,200
6	San Bernardino	6,800	7	48,900	Sacramento	33,800
7	Fresno	4,400	11	47,700	Riverside	33,600
8	Stanislaus	3,200	15	47,000	Fresno	32,700
9	Contra Costa	3,200	14	45,800	Butte	31,700
10	Yolo	5,500	8	44,500	San Joaquin	29,000

TABLE 21

Tree Squirrel Take—1948 Post Card Reports

Total bag	75,900
Number of successful tree squirrel hunters (4.5 percent of total hunting license buyers)	22,600
Mean bag per hunter and error at 5 percent level	3.57 ± 0.72

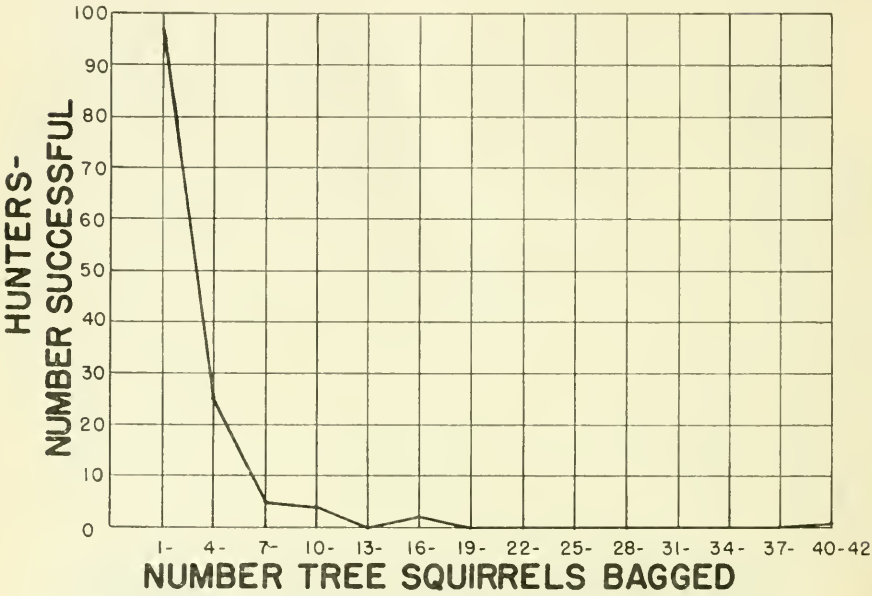

FIGURE 52. Success of hunters bagging tree squirrels during the 1948 season. Data compiled from post card reports.

TABLE 22

Ten Leading Counties of Tree Squirrel Kill—1948

Rank	ORC survey				Post card survey	
	County of kill	Total hunters	Mean bag per hunter	Total bag	County of kill	Total bag
1	Stanislaus	1,600	13	21,100	Kern	7,400
2	Plumas	400	50	19,900	Marin	7,100
3	Tulare	3,200	3	9,500	Tulare	6,900
4	El Dorado	1,200	6	7,100	Shasta	6,600
5	Shasta	2,400	3	7,100	Butte	4,200
6	Tehama	1,600	3	5,200	Fresno	4,200
7	Tuolumne	1,200	4	4,400	Tuolumne	3,400
8	Madera	2,000	2	3,600	El Dorado	3,000
9	Calaveras	1,200	2	2,800	Yolo	2,500
10	Kern	2,400	1	2,800	Modoc	2,000

TABLE 23

Bear Take—1948 Post Card Reports

Total bag	2,200
Number of successful bear hunters (0.4 percent of total hunting license buyers)	2,200
Mean bag per hunter (all licensees)	.004
Mean bag per successful bear hunter	1.0

There were so few bear hunters sampled in this survey it is felt that any further breakdown would be meaningless because of the inherent inaccuracies.

SUMMARY

1. A personal interview and concurrent post card game take survey was conducted for the 1948 hunting season in California which showed good correlation of hunting success for the main species and poor correlation for the lesser game species.
2. Hunting success reported by the two methods indicated good correlation in the case of pheasants, but two distinct studies, offering positive checks, revealed a two and one-half times exaggeration of take.
3. A correction factor of 0.40 must be applied to the reported take of pheasants in a special post card sample to derive the known 1949 take on the Cooperative Hunting Areas.
4. Post card surveys are useful in determining trends of game take on an annual basis but, in themselves, do not disclose the actual take per species.
5. Correlation of the post card and interview methods of securing kill of game species by county is poor. Decreased sample size results in increased error.

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IN MEMORIAM

FRANK SCHULMEYER

Frank Schulmeyer, Game Conservation Aid, Division of Fish and Game, passed away on January 30, 1950.

Frank started work for the Division June 24, 1941, as laborer with the Bureau of Hydraulics working on fish screens and ladders. On June 6, 1942, Frank transferred to Bureau of Game Conservation, and was stationed at Gray Lodge Refuge. From the period July 1, 1943 to January 1, 1946, Frank was in charge at Gray Lodge. Due to ill health he resigned on December 18, 1949.

The many friends of Frank mourned his passing, and the Division lost a loyal and conscientious employee.—*L. H. Cloyd, California Division of Fish and Game.*

RETIREMENTS

ALICE M. RANKIN

After almost 31 years of state service, Mrs. Alice M. Rankin, Senior Account Clerk, Bureau of Fish Conservation, retired on September 30, 1950. Before coming to work for the Division of Fish and Game, Mrs. Rankin worked for the Bureau of Mines, having started with that Bureau at San Francisco in 1919. She was transferred to the Department of Natural Resources, Sacramento, in 1927 and then transferred to the Bureau of Fish Conservation at San Francisco in 1928. As Senior Account Clerk, Mrs. Rankin cared for all fiscal matters pertaining to the Bureau of Fish Conservation. Her pleasant manner and thorough knowledge of fiscal procedures brought her high respect from all who knew and worked with her. Mrs. Rankin intends to spend the greater part of her well-earned retirement at her home in Berkeley to be near her son, daughter and grandchildren. Our best wishes go to Mrs. Rankin for a long and happy retirement.—*A. C. Taft, Chief, Bureau of Fish Conservation.*

ROSS A. McCLOUD

Ross A. McCloud, Fish Hatchery Foreman, Basin Creek Hatchery, retired from the service on September 30, 1950. Prior to entering state service with the Division of Fish and Game on July 6, 1920, Mr. McCloud was employed by the U. S. Forest Service where his last assignment was that of District Ranger, Squaw Creek District, Shasta National Forest. For many years when fish distribution was mostly done by railroad car, Ross was superintendent of Fish Car 02 with headquarters at Mt. Shasta. He was promoted to Fish Hatchery Foreman, Mt. Shasta Hatchery in 1931 and transferred in this capacity to the Kaweah Hatchery, Tulare County, September 15, 1941. On November 1, 1941, he was transferred to the Basin Creek Hatchery, Tuolumne County, and remained at this location until his retirement. We wish to extend to Mr. and Mrs. McCloud our best wishes for a long and enjoyable retirement.—*A. C. Taft, Chief, Bureau of Fish Conservation.*

REVIEWS

The Angler's Handbook

By Ted Trueblood; Thomas Y. Crowell Company, New York, 1949; viii + 434 p. $4.95.

In the recent spate of angling books this one is outstanding. It definitely fulfills the criteria for a handbook. It is inclusive (for the fresh-water field); the organization is good; each topic is set off by subheadings; it is well indexed. Its usefulness as a reference is further increased by the inclusion of the standard N. A. A. C. C. tables of hook sizes and fly line and leader calibrations and their glossary of tackle terminology. The diagrams by G. Don Ray are good and their placement ties in well with the text.

More than a third of the book is devoted to tackle and tackle work. There is a short section on casting (fly, bait, and spinning). The remainder of the text covers the actual catching of the principal North American fresh-water gamefishes.

The section on tackle is excellent. There is a thorough treatment of the differences between various types of rods, lines, leaders, and hooks which should be of interest to the modern expert and bring the old timer up to date. Yet it is so clearly written that it will not confuse the novice. Many angling writers—unlike writers on firearms—are reluctant to mention trade names or to decry certain types of gear or materials. Trueblood likes the products of certain manufacturers, and says so. He definitely prefers silk to nylon in fly casting lines, and single action to automatic fly reels. Again he says so. The reviewer considers this a salutary practice. Trueblood is also an advocate of the school which says ". . . the fly line is more important than the rod . . . buy the line first and then select a rod to match it." (However, there are those anglers who feel that in some of his other articles—if not here—that he has gone overboard a bit on this idea.)

There are many books which give a fuller treatment of "fish catching" but few which emphasize the fundamentals as well. Trueblood wastes no time in striving to tell the reader how to meet every possible stream situation, and there is a minimum of the personal (and often irrelevant) reminiscences so dear to the heart of most angling writers.

This is a book to buy, keep, and turn to for easy and frequent reference.—*William A. Dill, California Division of Fish and Game.*

Trout Waters and How to Fish Them

By Joseph D. Bates, Jr.; Little, Brown and Company, Boston, 1949; xxiii + 316 p., illustrated $6.

Fishermen and biologists alike will welcome this book which takes the findings of the latter group and makes them easily available to the angler. After all, one can't hope to catch trout unless one knows where to find them. Bates not only discusses the "wheres" and "whens" of locating trout; he utilizes the studies of aquatic biologists to explain the "whys." For example, why is midsummer lake fishing with surface lures usually so poor? His lucid explanation of thermal stratification and the temperature and oxygen requirements of trout explains this phenomenon. (Incidentally, there is a much fuller discussion of lake fishing than is found in most angling books.) Several of the most treasured theories of angling—Bates calls them "superstitions"—are taken to task. Among these are the beliefs concerning barometic pressure, sun and moon tables, and early and late day fishing. The author is gentle enough with their proponents, but he is one of the first popular writers to ultilize the careful researches which have gone far toward disproving such beliefs.

Intermingled with clear explanations of the physical and biological factors affecting trout are a wealth of fishing experiences. Both eastern and western readers should be satisfied with the waters described: Maine "square-tail" lakes; the Beaverkill; Lake Pend d'Oreille and its Kamloops trout; the Deschutes; California's Klamath River; and the Gunnison.

The author acknowledges the help of many angling experts and several well-known fisheries biologists, and includes a bibliography primarily of scientific papers. There is a constant reiteration of conservation practices and a warning to the angler that the future of trout fishing depends primarily upon safeguarding our land and water from the inroads of "civilization's" destructive practices.

It is unfortunate that the book has not been subjected to more "cutting," for there is a considerable amount of repetition (for emphasis?) which could have been avoided. Nevertheless, "Trout Waters" is recommended as interesting reading, and its 30 drawings, a brightly colored frontispiece, and 16 excellent photographs make the book a very attractive one.—*William A. Dill, California Division of Fish and Game.*

Trout Fishing

By Dan Holland; Thomas Y. Crowell Company, New York, 1949; xvii + 420 p. $5.

Holland's book follows the usual line of discussion: trout and their habits, tackle, flies, casting, and special types of fishing (dry-fly, wet-fly, nymph, streamer and bucktail, spinner, spinning, baitcasting, and bait fishing). It also includes chapters on fly-tying, fishing for lake trout, steelhead and sea trout, the effect of the elements, big trout, playing the fish, and conservation. It is indexed; contains some good photographs by the author; has an amusing introduction by Corey Ford and Alastair McBain; and is attractively decorated by William J. Schaldach's always welcome drawings.

What does this add up to? Just another good book on trout fishing? In some ways, yes. Still this is not the fault of the author; American angling literature is simply becoming a bit surfeited with general books on the subject. Taken alone, "Trout Fishing" is very good. And—even in comparison with its competitors—this book has several features worth special mention. To begin with, Dan Holland has an easy sense of humor. He is a man who obviously has fun fishing, and through his anecdotal style the technical aspects are introduced smoothly and without that grim seriousness that some authors evince. Secondly, he stresses fundamentals instead of overwhelming the reader with confusing detail. Furthermore, his wide experience ". . . from the Arctic to Arizona, from the Sierras to the pasture streams of Connecticut . . ." (as the blurb reads) should make this of interest to all American anglers.

Finally, the chapter, "Conservation and the Future" is one of the best popular summaries the reviewer has seen. Holland's conclusions are about as follows: that the planting of fingerlings produces very small returns except in new or barren waters; that the returns of fall-planted trout are generally low; that stocked trout usually tend to stay where put; that the spring stocking of legal-sized fish to be caught out soon is the best approach where there is a very heavy load of fishermen; but that large plantings of hatchery fish should never be made where fishermen are not on hand to catch them, and that where natural reproduction can bear the fishing burden that wild stock is preferable to hatchery stock. Aside then from such planting of "legals" as is necessary in areas of very heavy fishing, he says, "The answer, then, to the perpetuation of the race is quite obvious: if the environment is right, it's practically impossible to catch out all the trout. Anyone who claims that a stream is 'all fished out' has a high and mighty idea of his ability as a fisherman."—*William A. Dill, California Division of Fish and Game.*

The Complete Fly Tier

By Reuben R. Cross; Dodd, Mead and Company, New York, 1950; xiv + 169 p. $3.

Here, in one volume, Rube Cross has gathered together the material which comprised his two previous books: "Tying American Trout Lures" (1936), and "Fur, Feathers and Steel" (1940). The pertinent material has been reprinted without change, and the only addition of importance is a chapter on salmon flies. Actually, there is very little material on the mechanics of tying flies in this new section. It includes a diagram of a conventional Atlantic salmon fly and describes a few patterns. The remainder of this chapter is composed of letters on flies and fishing from several well-known anglers.

The title is too inclusive. There are many other books which are much more complete manuals on fly-tying, and the earnest pursuer of this art will hardly be satisfied to master only the methods which are outlined here. However, Cross' instructions are easy to follow, and his illustrations of certain tricks (such as tying clipped

deer hair bodies) are excellent. A major difficulty for a beginner is gaining knowledge of the materials used, and—as the author said in an earlier book, ". . . especially the materials that make a fly of good character." The sections on this subject and the many photographs will do much to lessen the neophyte's confusion.

Finally, since Rube Cross is acknowledged to be one of America's finest fly-tiers, anyone can profit by patterning after his methods.—*William A. Dill, California Division of Fish and Game.*

Birds of the West

By Ernest Sheldon Booth; Stanford University Press, Stanford, California, 1950; xi + 402 p., profusely illustrated in black and white, 8 color plates. $6.

This is a book designed for the amateur and written so that a beginner can identify western birds without help and with a minimum of effort. It is a key to the birds, not a group of disconnected accounts of the birds. While biologists are familiar with keys, their application in popular literature has been quite limited. This key, like all others, consists essentially of a series of pairs of opposed statements, and to use it one selects the applicable statement in each succeeding pair until he reaches the name of the bird. It is easy to follow and has stood the test of 10 years' use.

All of the birds found from Canada to Northern Mexico, and from the Pacific to the western edge of the Great Plains, are included. The descriptions, embodied as they are in the key, are of necessity brief, containing just enough information on appearance to insure identification of species. There are notes on the nests, and ranges are given for subspecies as well as species. Each description is accompanied by a black and white illustration of the bird, and many species are shown in the colored plates as well. There is an appendix which includes short discussions of nests and eggs, bird photography, the construction of feeding tables and nesting boxes, and bird banding. It lists bird societies, leading journals and pertinent references. The book is attractively printed on quality paper which assures good reproduction of the many figures.

The book is not intended for the expert who knows all the birds, and it has its limitations for the amateur. The key is largely confined to males in adult summer plumage, and, as noted, there is little descriptive material. Dr. Booth, who is head of the Department of Biological Sciences at Walla Walla College, Washington, is quite aware of these limitations and recommends that the book be supplemented with one containing more complete accounts. However, the fact that it is a key is the thing which makes it unique, and the other general references to western birds are themselves limited in that they do not make use of the key technique. Anyone who wants to learn the birds will find this a most valuable book.—*Phil M. Roedel, California Division of Fish and Game.*

Black Bass

By John Alden Knight; color plates by Dr. Edgar Burke; line drawings and sketches by Harold Bush. G. P. Putnam's Sons, New York, 1949. 200 + xix p., 34 figs., 3 colored plates. $4.

This rather comprehensive work treats of both the largemouth and smallmouth black bass. Both fish and fishing methods are covered in logical sequence, starting with an account of the life cycle of the bass, and, in turn, covering the fish's behavior, food and feeding habits, proceeding to treatises on bass fishing equipment, including rods, reels, lines and leaders and lures, fishing clothes and boats, and ending naturally with discussions of fishing methods with both the fly rod and casting rod. Knight skips lightly over any explanation of angling with spinning outfits, as he admittedly has little use for this recent innovation, claiming that a light bait casting outfit is more effective. Of special interest to the angler is a chapter on general fishing tactics, which evidently is based on insight gained in long hours spent on bass waters.

As is a common shortcoming of angling books for western anglers, the locale covered in "Black Bass" is eastern. The types of waters described, however, have some counterparts here in the West, and techniques described in the book should produce similar success on western waters.

The book covers the subject quite thoroughly from the angler's viewpoint, and contains some interesting observations on bass behavior and habits that will appeal to the naturalist as well.—*Charles K. Fisher, California Division of Fish and Game.*

Tracks and Trailcraft

By Ellsworth Jaeger; The Macmillan Company, New York, 1948; 381 p. $3.95.

Mr. Jaeger, who is curator of education at the Buffalo Museum of Science, has in his book "Tracks and Trailcraft" covered a vast majority of our crustaceans, mollusks, insects, birds, mammals and reptiles found both here in the United States and abroad.

His illustrations, which occupy almost half the entire book, are both educational and humorous. Measurements are given as to the average width and length of each subject's track as well as the normal distance the prints are found apart.

A brief description is given along with interesting notes concerning certain peculiarities and habits of each individual. The pen sketches are quite life-like.

In the closing chapters of his book, Mr. Jaeger has for the benefit of the young naturalist illustrated and explained the method of making plaster of Paris reproductions of tracks, track silhouettes, games in tracking, trail blazing, etc.

This book would be of most value to young sportsmen groups, naturalists and especially to recreation directors.—*Alvin A. Hightower, California Division of Fish and Game.*

The Quails

By Edward S. Spaulding; illustrated by Francis Lee Jaques; The Macmillan Company, New York, 1949, 123 p. $6.50.

This attractive little volume covers briefly each of the six species of quail native to the United States—valley (California), desert (Gambel), mountain, massena (Mearn's), scaled and bobwhite. In addition the masked bobwhite and Benson (yaqui or elegant) quails of Mexico, and the migratory quail, Hungarian partridge and chukar partridge of the Old World are very briefly discussed.

The chapters devoted to the United States species cover chiefly hunting and the author's personal experiences in the field. Such information on the biologics of quail as is presented appears to be accurate and the result of acute observations. The exotic species are discussed mainly under a chapter on transplanting and restocking. The fact that neither common nor scientific nomenclature is consistent throughout lends a certain amount of confusion.

The chief appeal of this work lies in the seven excellent illustrations by Jaques of individual quail of different species. The quality of these should compensate most buyers for the relatively high price.—*Fred L. Jones, California Division of Fish and Game.*

A Sand County Almanac

By Aldo Leopold; illustrated by Charles W. Schwartz; Oxford University Press, New York, 1949, second printing 1950, xiii + 226 p. $3.50.

Here is collection of essays which "attempt to weld the three concepts . . . that land is a community . . . , that land is to be loved and respected . . . that land yields a cultural harvest . . ."

The book is divided into three sections. The first of these is entitled "A Sand County Almanac" and consists of episodes, arranged in seasonal sequence, occurring on Dr. Leopold's sand-farm in Wisconsin. The second, "Sketches Here and There," is composed of essays inspired by experiences throughout the United States, Mexico and Canada. The third, "The Upshot," both sums up and focuses attention on a revision of ethics in conservation thinking.

The author states that new ethics regarding land use must be evolved before progress can be made in reducing exploitation and annihilation of wilderness, and in returning lands to healthy, sustained-yield status. The land user must develop a feeling of responsibility toward the land other than that induced by pure economics. It will not suffice to place dollar value on all land use considerations. This prevailing point of view must be altered to include scientific, recreational, and esthetic interests.

Each of the many essays comprises a brilliant juxtaposition of ecological workings and of finely constructed philosophies. Each affords informative and highly stimulating reading. Anyone who has ever paused to notice or wonder at a manifestation of natural phenomena will find immense enjoyment in these sketches. The land is laid open to fuller understanding by this man who met his responsibility as a thinking unit of his environment.—*Fred L. Jones, California Division of Fish and Game.*

Doves and Dove Shooting

By Byron W. Dalrymple; G. P. Putnam's Sons, New York, 1949; 243 p., illustrated. $4.50.

Byron Dalrymple has brought together a wealth of material concerned with both dove facts and dove shooting. Extensive experience on the end of a gun and extensive research through scientific and historical works is evident.

The history and general habits of doves and pigeons throughout the world are discussed in considerable detail. Included are many fascinating facts about this bird family that are not generally known. The greatest part of the book is devoted to those species indigenous to the United States that are or have been hunted. These are the passenger pigeon, mourning dove, band-tailed pigeon and white-winged dove.

The story of the passenger pigeon is told in detail and points out how strongly the immense concentrations of birds conflicted with agriculture. The author believes that the two were incompatible and that the pigeons were bound to go. He further states that the shocking manner in which they did go has served a worthy purpose as an object lesson to prevent a recurrence. Everyone who reads this section should obtain a more complete understanding of the passenger pigeon saga.

The band-tails and white-wings are discussed chiefly from a hunting viewpoint, though methods of conservation are repeatedly stressed. The mourning dove is treated more thoroughly than the others. Its life history, habits and management are especially well presented. This material is based on research done by workers in several states, but chiefly on McClure's study in Iowa. Several sound points of possible future management are proposed. Two of these are: reservation of the low dove-density northern states as breeding areas, with no shooting, to supply a reservoir of birds to counterbalance local catastrophes in the southern states; and giving up of early opening dates to save nestlings.

Conservation is the keynote throughout. It is continually stressed and the many ideas set down should serve as starting points for the same trend of thinking in less astute sportsmen.—*Fred L. Jones, California Division of Fish and Game.*

The Sea Fishes of Southern Africa

By J. L. B. Smith; Central News Agency, Ltd., Capetown, South Africa; American representative, Hafner Publishing Co., New York; 1949 (second impression, 1950); xvi + 550 p., 519 figs., 105 plates (104 colored), 32-p. distribution chart. $15.

This volume was intended primarily for the fishermen of South Africa. However, it should be placed on the "must have" list of every student of ichthyology regardless of geographical locality.

The book starts with short sections dealing with such subjects as: zones of the sea and their fishes, the South African region, the tides, the effects of fishing, scientific nomenclature, a classification of fishes, and dangers of the shore. In addition, there are numerous general notes covering the various senses, organs, and habits of fishes.

Aided by the relatively simple but revolutionary principal key, it is possible to identify many of the marine species found in the South African region. Other less readily distinguishable fishes often can be identified by the more complex keys embodied within the volume; however, many of these keys are only as complete and up-to-date as knowledge permits.

The profusion of illustrations is of greatest value to the American student of fishes, who might normally have little or no interest in the South African fauna. Of 1,245 illustrations nearly 700 are in color. To thumb through the pages and view these serves to acquaint one with family characteristics—a tremendous aid in familiarizing the individual with marine fishes in general. Most of the families included have representative species in the waters of both coasts of North America.

There are many brief but interesting natural history sketches on various families, genera, and species, and there is a quite complete list of references.

The first printing in 1949 of 3,000 copies was exhausted almost immediately. The second printing which is now available, while on a lighter grade of paper, has seemingly lost none of the quality of the original. Some of the plates are more intense and others less in certain colors than are corresponding plates in the first edition. It would be extremely difficult to say which are the more accurate colors without being thoroughly familiar with the fishes under consideration.

The first edition of this book sold in Capetown for the equivalent of $7.50. It is to be regretted that such a drastic increase in price was found necessary with the second printing.—*John E. Fitch, California Division of Fish and Game.*

Wildlife Management Bulletins

The Canadian Wildlife Service, Department of Resources and Development, Development Services Branch, Ottawa, Canada, has issued the first numbers of three new series of Wildlife Management Bulletins. Series 1 deals with mammals, Series 2 with birds, and Series 3 with fish and other aquatic matters. Requests for copies of these bulletins should be addressed to the service. No charge is made but bulletins will not be provided in quantities. Additional bulletins in each of the three series will be released periodically as information for incorporation in them becomes available. The three current bulletins are described below:

The Mammals of Waterton Lakes National Park, by A. W. F. Banfield, Series 1. Number 1, 43 p., 11 maps, 1950. The introduction presents a historical, geographical and biological description of the park. The main text accounts for the larger mammals, the numbers present, and the range conditions. The ranges of these animals are mapped. An annotated list is presented of all mammals observed by the author.

A Study of Bird Populations in the Apple Orchards of the Annapolis Valley, Nova Scotia, with particular reference to the effects of orchard sprays upon them, by John P. Kelsall, Series 2, Number 1, 69 p., 1950. Conclusions drawn from this study show that commercial orchards in general offer poor shelter, feeding conditions, and nesting sites for birds. All sources of information indicate that the use of poisoned sprays, as normally applied in these orchards, have no readily observable direct effect on the migratory bird population nesting or feeding in the orchards.

Prince Albert National Park Creel Census Analysis—Season 1948, by Victor E. F. Solman, Series 3, Number 1, 29 p., 1 map, 1950. Results of this study reveal the number of fishermen using the park lakes, the number of fish that were caught, and the type of lure used. A detailed analysis also shows the species taken and their sizes.—*Frank M. Kozlik, California Division of Fish and Game.*

Raising Game Birds in Captivity

By David B. Greenberg; D. Van Nostrand Co., New York, 1949; xiii + 224 p., illustrated. $4.95.

This book contains an extremely large amount of practical information for both beginners and seasoned game breeders. The author has consulted numerous books and outstanding individuals in the business of raising game birds. This in addition to his own experience has made for a complete guide.

The makeup of the book is ideal in that generalities are taken up first and referred to in subsequent chapters dealing with the different varieties. Clear cut drawings and photographs are abundant throughout. Many suggested and proved feed formulas are given. All operations of bird breeding, incubation, brooding and rearing are well described. The author gives the sound advice that locale and weather must be considered as no set rule is usable in detail in all areas. There is a full discussion of methods of holding birds in pens by pinioning, brailing and clipping, and methods of raising "gamey" birds are described and compared. A section on predators and their control tells of preventive measures in construction and the use of various traps. The economic aspects of game bird farming, including farm plant costs, production costs and marketing outlets are well covered.

This book is outstanding as a reference for anyone interested in game farm production of pheasants, quail, Chukar and Hungarian partridge, wild turkey, ducks and geese. Considering the size of the book, the amount of information given is unbelievable. It is well written and is very interesting to read. It should be in the library of everyone concerned with game bird production.—*Fred W. Hein, California Division of Fish and Game.*

North American Waterfowl

By Albert M. Day; illustrated by Bob Hines; Stackpole and Heck, Inc., New York, 1949; xx + 329 p. $4.75.

Day has ably presented the story of the waterfowl of the North American continent as it was in the past, as it is now and as it can be expected to be in the near future. As Director of the U. S. Fish and Wildlife Service his words ring with authority. Every phase of waterfowl management conducted by the Fish and Wildlife Service is thoroughly discussed.

The beginning chapters cover the early days when all but a very few believed that the waterfowl hordes were limitless and indestructible, and when exploitation of all natural resources went practically unchecked. The gradual transition from this

open-handed viewpoint to one of a more conservative nature is shown. The passing of the Lacey Act, the Migratory Bird Treaty Act and the formation of such conservation societies as the Audubon Society and the Boone and Crocket Club marked this era. The development of the present wide system of waterfowl refuges began soon afterward and is still in progress.

Banding as a method of studying migration and the development of the flyway concept therefrom is thoroughly discussed. The annual rounds of the flyway biologists, the Federal game management agents, refuge managers and other Fish and Wildlife personnel in waterfowl management is described. Fish and Wildlife Service activities in waterfowl management include two types of sponsored projects carried on by other personnel. These are the Cooperative Wildlife Research Units organized in certain state colleges and the Pittman-Robertson projects carried on by state fish and game departments. Through these much of the current research and management is being carried on.

Canadian and Mexican waterfowl situations are discussed in detail. The lax, to us, Mexican game laws have been heavily criticized by other writers and by many sportsmen. Day points out that few people hunt waterfowl in Mexico and that the actual kill is very low—about 5 percent of the total North American kill.

He sums up the Canadian-American-Mexican waterfowl interrelation by stating that though most of the birds are raised in Canada and great numbers winter in Mexico the American hunter sees each with a large "U.S." blazoned on its belly.

As a source of information on waterfowl in general and on the activities of the Fish and Wildlife Service toward waterfowl management this book warrants a place on every sportsman's bookshelf.—*Fred L. Jones, California Division of Fish and Game.*

REPORTS

FISH CASES

July, August, September, 1950

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalone: Overlimit; undersize; out of shell; using undersize for bait; using another's license	113	$2,792.00	----------
Angling: No license; possession of spear within 300 feet of lake; night fishing; 2 lines and poles; set lines; unattended lines; fishing in closed stream; using borrowed license; predating license; overlimit; undersize; snagging; failure to show license on demand; false statement on application; transfer of license; illegal spearing; seining; angling 1 hour after sundown; taking fish from spawning bed; fishing too near dam; operating 4 poles; angling within 250 feet of fishway	474	5,933.00	54
Barracuda: Taking with round haul net; overlimit	3	75.00	----------
Bass, Black: Overlimit; taking with spear; selling	5	175.00	----------
Bass, Rock: Overlimit	3	35.00	----------
Bass, Striped: No license; overlimit; undersize; failure to show fish on demand; sale; borrowed license; no alien license; using undersize for bait; more than one line; no non-resident license; night fishing; unattended rod; possession on commercial fishing boat	152	4,952.00	----------
Bass, White Sea: Overlimit; undersize; closed season	4	75.00	----------
Catfish: Taking by other than angling; undersize; overlimit; taking without license; taking at night	11	222.00	----------
Clams, Big Neck: Closed season; non-resident license; false statement on license; no license; overlimit	12	225.00	----------
Clams, Cockle: Closed season; overlimit; no alien license	4	250.00	----------
Clams, Pismo: Undersize; closed season; no license; overlimit; failure to return to deep water; failure to return to hole from which dug; possession of fork in clam preserve; possession of shovel in clam preserve; using another's license; digging clams in refuge; taking at night; taking before legal time	129	3,925.00	----------
Commercial: No license; half ring net in closed area; no sport boat license; no party boat log records; no wholesale license; failure to keep records; no fish receipts; failure to register commercial fishing boat; selling fish without license; causing and permitting deterioration of fish; set net; selling fish taken on sport boat; failure to procure license plates; use of drag net in less than 25 fathoms; operating set gill net in closed waters	75	2,357.00	250
Crabs: Undersize	1	200.00	----------
Crappie: Overlimit	2	10.00	----------
Croaker, Yellowfin: Overlimit	3	127.00	----------
Frogs: Overlimit; undersize	5	135.00	----------
Lobsters: Closed season; undersize; failure to show license on demand; no license; unstamped lobster	7	410.00	----------
Pollution: Oil pollution; fish refuse; creamery refuse; sulphuric acid; sawdust	15	1,650.00	----------
Rockfish: Overlimit; failure to show license	4	25.00	----------
Salmon: Undersize; 2 rods; mutilated	5	400.00	----------
Shad: Offered for sale; closed season	2	50.00	----------
Sunfish, Bluegill: Closed season; no license; overlimit; taking with seine net; set lines	6	265.00	----------
Trout: Taking from closed stream; overlimit; no license; chumming; closed season; set lines; using 2 poles and 2 lines; using more than 2 attractor blades; snagging; night fishing	58	1,830.00	----------
Tuna, Yellowfin: Undersize	2	100.00	----------
Court forfeitures: (Confiscated fish)	----------	5,467.50	----------
Totals	1,095	$31,685.50	304

GAME CASES

July, August, September, 1950

Offense	Number arrests	Fines imposed	Jail sentences (days)
Antelope: Illegal possession	1	$25.00	----------
Bear: Closed season	2	125.00	----------
Deer: Closed season; possession fawn; taking doe; taking forked horn; taking another's deer; antlers and hide not retained; no tags; no license or tags; tags not countersigned; possession of wife's tags; mutilating tag; failure to tag; making false statement in securing license; night hunting; spotlighting; shooting from car; allowing dogs to run and track deer; taking with .22 rifle; taking with shotgun; usng full metal-jacketed bullets	153	13,597.50	245
Deer Meat: Possession in closed season; taking parts of 2 illegal deer; unlawful possession; possession of unstamped meat	33	3,830.00	65
Dove: Closed season; overlimit; taking with rifle; no license; spotlighting; shooting from car; unplugged gun; taking after sunset; taking before legal time; failure to show game on demand	53	2,059.00	32
Duck: Closed season	2	250.00	----------
Hunting: Spotlighting; possession of loaded guns and light in game refuge; hunting in refuge; late shooting; making false statement in obtaining license; failure to show license; shooting from car; unplugged gun; possession of spotlight and guns in deer area; possession of another's tags while hunting; shooting from road; closed season	92	5,396.00	187
Migratory Waterfowl: Late shooting; possession of young wild mallards	2	50.00	----------
Pheasant: Taking with .22 rifle; no license; closed season; taking in refuge; keeping in pen without permit; hen pheasant; overlimit; shooting from car; unplugged gun	40	3,284.00	259
Quail: Closed season; failure to show on demand	9	460.00	----------
Rabbit: Closed season; no license; hunting ½ hour after sundown; unplugged gun; night hunting; spotlighting; taking from motor vehicles	100	5,340.00	----------
Sage Hen: Closed season; unplugged gun; taking in refuge; overlimit	6	175.00	----------
Squirrel: Closed season; taking tree squirrels	2	100.00	----------
Totals	495	$34,691.50	788

SEIZURES OF FISH AND GAME

July, August, September, 1950

Fish:	
Abalone	722
Barracuda	65
Bass, Black	36
Bass, Kelp	44
Bass, Rock	21
Bass, Striped	697
Bass, White Sea	21
Carp, pounds	25
Catfish	75
Clams, Big Neck	143
Clams, Cockle	498
Clams, Pismo	861
Clams, Razor	94
Crabs	307
Crappie	75
Frogs	63
Lobster	147
Mackerel, pounds	127,450
Rockfish	29
Salmon	13
Shad	139
Sunfish, Bluegill	320
Trout	489
Tuna, Yellowfin	96
Game:	
Antelope	1
Bear	2
Deer (582 pounds)	99
Dove	246
Duck	35
Pheasant	64
Quail	21
Rabbit	116
Sage Hen	18
Squirrel	2

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34814 9-50 7,500 *printed in* CALIFORNIA STATE PRINTING OFFICE