CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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CALIFORNIA FISH AND GAME

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CALIFORNIA FISH and GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 37 ISSUED APRIL 27, 1951 NUMBER 2

TABLE OF CONTENTS

STUDIES AND NOTES ON SOME CALIFORNIA MARINE FISHES[1]

By John E. Fitch
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A number of rare or seldom-taken fishes came to the attention of the California State Fisheries Laboratory in 1949 and 1950. The specimens listed here have not been reported previously.

Electrona crockeri Bolin. Lanternfish.

On May 16, 1949, a single specimen was taken from the stomach of a chilipepper *(Sebastodes goodei)* which was killed in the course of seismic exploration for offshore oil deposits. The fish was collected in 810 feet of water between Santa Barbara city and Santa Cruz Island (Lat. 34° 12′ N, Long. 119° 40′ W). In addition to the *Electrona*, the stomach content included one *Cyclothone signata* and some 20 to 25 hake *(Merluccius productus)* up to two inches in total length. The lanternfish was identified by Dr. Rolf L. Bolin of Stanford University.

Eleven more of these small lanternfish were collected by Dr. Gordon Tucker, San Diego State College, during the summer of 1950. Dr. Tucker was engaged in deep trawling in the San Diego Trough some 17 miles off Point Loma using a net six feet in diameter made of one-inch stretched mesh. These important catches were made as follows: July 13, one in a horizontal haul at 900 feet; August 8, one in a horizontal haul at 1,450 feet; August 23, one in each of three oblique hauls from 1,200 feet to 900 feet, 1,500 to 1,200 feet and 1,800 to 1,500 feet respectively; September 6, one in an oblique haul from 900 to 600 feet; and September 7, one in an oblique haul from 1,200 to 900 feet and four in an oblique haul from 1,500 to 1,200 feet. The specimens have been sent to Dr. Bolin. Very few of these fish have been taken or recorded previously.

Hygophum reinhardtii (Lütken). Lanternfish.

A number of *H. reinhardtii* collected recently have come to the attention of the laboratory. These fish were taken at scattered localities well off the Southern and Baja California coasts and at the mouth of the Gulf of California. Listed in order of their capture they are:

1. March 13, 1950: One specimen dipped at the surface under a light at N. B. Scofield Station 911, Lat. 31° 32′ N, Long. 130° 16′ W.
2. March 31, 1950: 34 specimens ranging from $\frac{3}{4}$ inch to $1\frac{1}{2}$ inches in total length were dipped from under a light by Walter Richards of San Pedro at Lat. 22° 53′ N, Long. 107° 48′ W.
3. April 10, 1950: Five specimens collected at N. B. Scofield Station 927, Lat. 33° 00′ N, Long. 127° 30′ W. One was dipped under a light together with other lanternfishes including one *Myctophum*

[1] Submitted for publication September, 1950.

affine, five *Myctophum californiense*, and one *Centrobranchus nigro-ocellatus*. Four were taken from the stomach of a jack mackerel (*Trachurus symmetricus*) caught during the same night. The stomach contained two *M. affine* as well.

4. April 14, 1950: Two dipped under a light at N. B. SCOFIELD Station 934, Lat. 34° 20′ N, Long. 140° 11′ W.

Bolin (1939) lists but one record of this species from the Pacific Coast and that from the Gulf of California. The specimens discussed here will be deposited in the Stanford University collection.

Albula vulpes (Linnaeus). Bonefish.

A 12-inch bonefish was hooked and landed by Mr. William Graham on October 9, 1949. He was fishing in the upper bay at Newport Harbor and using clam for bait. These fish seldom wander as far north as this and are particularly unusual during the fall and winter months.

Lactoria diaphana (Bloch and Schneider). Boxfish.

Mr. George A. Beane snagged a small boxfish while fishing in the surf at Corona Del Mar on November 8, 1949. These fishes are distributed in tropical seas throughout the world but have only been recorded from California by two authors (Hill, 1932; Bolin, 1933). During November and December, 1932, at least 10 of these fish up to seven inches in length were collected between Santa Barbara and San Juan Capistrano, a little over 115 miles of coastline. The present specimen has been sent to Scripps Institution of Oceanography, La Jolla.

Verrunculus polylepis (Steindachner). Triggerfish. (Figure 53.)

A 15-inch triggerfish was taken on January 5, 1950, in a drag net in 120 fathoms of water about eight miles east of Anacapa Island by the boat JUBILEE, skipper Mark Mullenary. This tropical species is a not too infrequent visitor to Southern California but to the author's knowledge has not previously been recorded so far north. The specimen has been deposited in the collections of the University of California at Los Angeles.

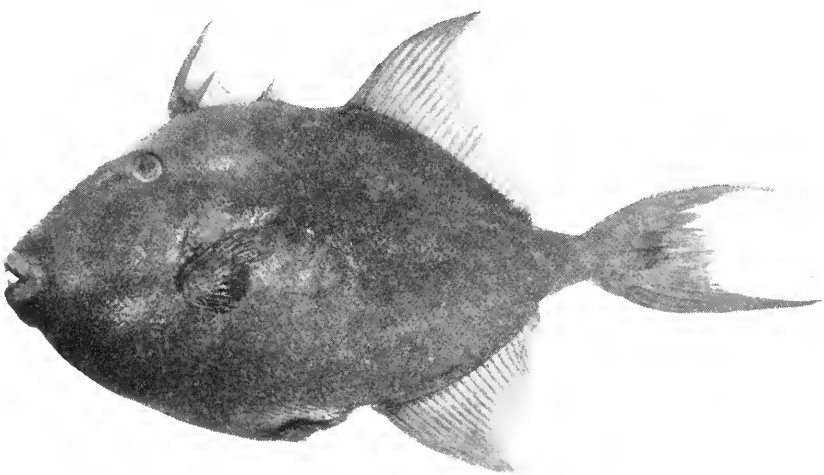


FIGURE 53. Triggerfish, *Verrunculus polylepis*. Photograph by Al Johns for Haden & Carpenter, San Pedro.

Alepisaurus borealis (Gill) Wolffish. (Figure 54.)

On February 11, 1950, a four-foot wolffish was noticed swimming feebly in the surf near the mouth of Oso Flaco Creek just south of Pismo Beach. It snapped viciously at a youngster who was attempting to catch it. Mr. Harold Foster of Pismo Beach, who was digging clams nearby, finally captured the fish by throwing it onto the beach before it could bite him. This specimen has been deposited in the collection of the University of California at Los Angeles.

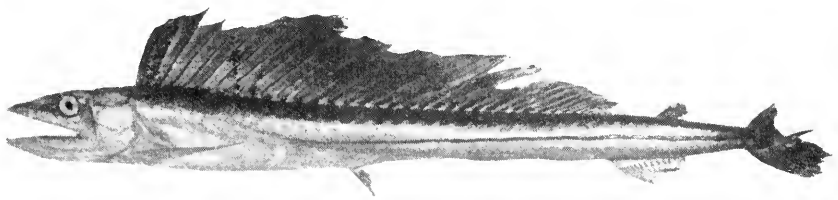


FIGURE 54. Wolffish, *Alepisaurus borealis*. Photograph by Al Johns for Vernon M. Haden, San Pedro.

A previously unrecorded specimen four feet long was picked up dead on the beach at the mouth of Oso Flaco Creek during March 1945. A photograph of the fish was sent to the California State Fisheries Laboratory by Fish and Game Warden R. E. Jeffries. During the summer of 1950, a 53-inch wolf fish was taken from the surf near Pt. Sal (just south of Oso Flaco Creek) by Mr. John W. Taylor of Los Angeles. This third *A. borealis* was reported to the laboratory by Warden H. L. Lantis of Santa Maria. The most recent capture was made by the crew of the California Division of Fish and Game research vessel N. B. SCOFIELD some 240

TABLE 1

Measurements in millimeters and counts on two Alepisaurus borealis

	Oso Flaco Creek Feb. 11, 1950	240 miles off San Pedro Sept. 9, 1950
Measurements		
Standard length	1,160	723
Total length	1,260	857
Head length	205	124
Upper jaw	142	83
Dorsal base	727	452
Anal base	111	71
Pectoral base	36	
Ventral base	18	
Snout	81	46
Fleshy orbit	36	25
Bony interorbital width	34	20
Tip of snout to dorsal insertion	202	124
Tip of snout to ventral insertion	520	322
Tip of snout to anal insertion		558
Pectoral length	170	130
Ventral length	78	53
Counts		
Gill rakers outer arch, total	24	21
upper limb	5	5
lower limb	19	16
Dorsal rays	40	39
Anal rays	17	16
Pectoral rays	15	14
Ventral rays	8	8
Total vertebrae		51
Weight	7¾ pounds	

miles west of San Pedro (Lat. 33° 05′ N, Long. 123° 40′ W). This fish was caught on a set line during daylight hours at a depth of about 15 fathoms on September 9, 1950.

The stomach contents of these fishes proved extremely interesting. The specimen taken on February 11 contained 17 small octopi one to three inches in total length; two rockfish (*Sebastodes*) eight and three inches long respectively, one hake (*Merluccius productus*) seven inches long and two lanternfish (*Tarletonbeania crenularis*) each three inches long. The wolffish caught September 9 contained 15 to 20 coelenterates about a half-inch in diameter. The 53-inch fish from Pt. Sal had in its stomach, according to Mr. Taylor who furnished drawings and descriptions, "three eels 18 inches long and four eels eight inches long" (*Otophidium?*); four rockfish (*Sebastodes*) five to six and one-half inches long; one 2-inch alligatorfish (family Agonidae); and 21 squid and octopi up to three inches in length.

A number of these fish have been picked up (usually in the surf) throughout the years from San Diego northward to Alaska. Three species have been described from the Pacific Coast; however, the other two, *A. serra* and *A. aesculapius*, are regarded as synonyms of *A. borealis*.

Leuroglossus stilbius Gilbert.

On the night of February 21, 1950, about 30 of these fish up to seven inches in total length were collected in an experimental mid-depth trawl by the crew of the Division of Fish and Game research vessel YELLOWFIN. The school from which these fish were collected was quite dense as evidenced by the "show" on the tape of the recording fathometer. It was spread over a wide area 60 fathoms beneath the surface in 300 to 600 fathoms of water three miles east of Santa Barbara Island. The catch indicated that this school consisted of about a 50-50 mixture of *Leuroglossus stilbius* and *Lampanyctus leucopsarus*, a lanternfish. Other lanternfish present included *Diaphus theta* and *Tarletonbeania crenularis*.

The following counts were made on several specimens cleared and stained by C. R. Clothier: Dorsal rays 9 to 10, anal rays 11 to 12, gill rakers on outer arch 7-9 + 19-21 = 26-29, vertebrae 39 to 42 (20 to 21 precaudal, and 19 to 21 caudal).

Prionotus stephanophrys Lockington. California searobin.
Prionotus ruscarius Gilbert and Starks. Searobin. (Figures 55 and 56.)

On March 15, 1950, Roy McCoy and George Davis caught one *P. stephanophrys* on a hand line in 60 fathoms of water while fishing from the boat IDA MAY about one mile west of the Pt. Fermin buoy. This is the first *Prionotus* from Southern California taken outside Santa Monica Bay. Some of the measurements in millimeters were: standard length 260, total length 320, head length 90, maxillary 35, first four dorsal spines 30, 38, 40, 38, respectively, and pectoral 106. Gill raker counts on the outer arch were 5 + 17 = 22.

Two *P. stephanophrys* and eight *P. ruscarius* were caught in gill nets set by the YELLOWFIN in five fathoms of water at Santa Maria Bay, Lower California (Lat. 24° 47′ N, Long. 112° 16′ W) during the night of April 14, 1950.

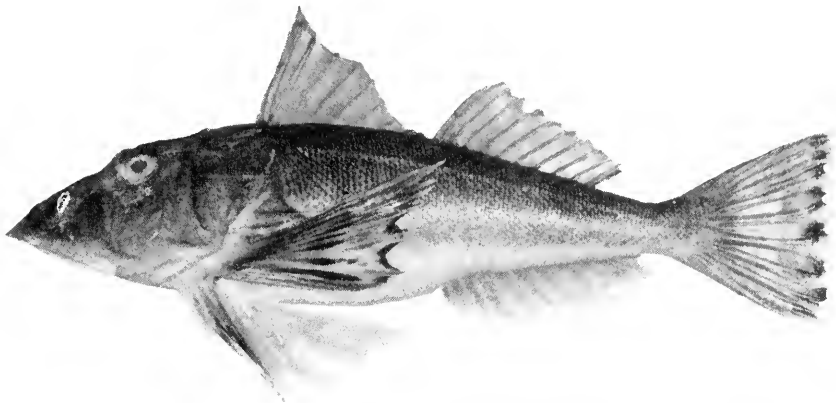


FIGURE 55. Searobin, *Prionotus ruscarius*. Photograph by Al Johns for Vernon M. Haden, San Pedro.

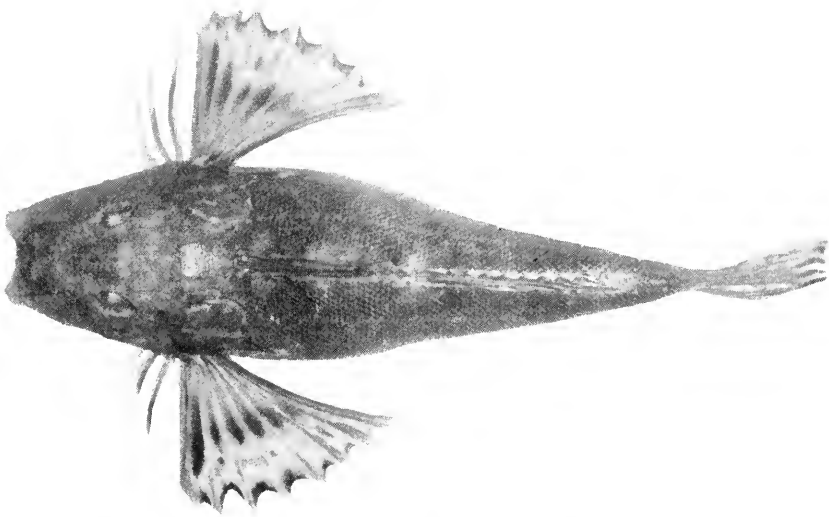


FIGURE 56. Dorsal view of *Prionotus ruscarius*. Photograph by Al Johns for Vernon M. Haden, San Pedro.

Regalecus glesne (Ascanius). Oarfish. (Figures 57 and 58.)

On the afternoon of March 29, 1950, a surf fisherman, Thomas De Garmo of Wilmington, noticed a very large and peculiar fish swimming feebly just off a point of rocks at Cabrillo Beach near San Pedro. Several successive waves brought the fish within a few feet of the rocks where Mr. De Garmo was fishing and he jumped into the waist-deep water, grabbed the fish and pulled it ashore. It proved to be an oarfish $10\frac{1}{2}$ feet long, 15 inches deep and weighing about 130 pounds. The head was badly cut and battered as if it had been rammed by some vessel or struck by the screw. An old injury to the tail which was healed and pigmented over indicated that more than a foot of that portion of the anatomy was missing. A cast was made of this fish by the Scripps Institution of Oceanography, La Jolla, a short time after it was taken.

FIGURE 57. The 1950 oarfish (*Regalecus glesne*). Note the missing portion of the tail and the long dorsal fin rays in the head region. Photograph by Herb Phillips Photo Salon, San Pedro.

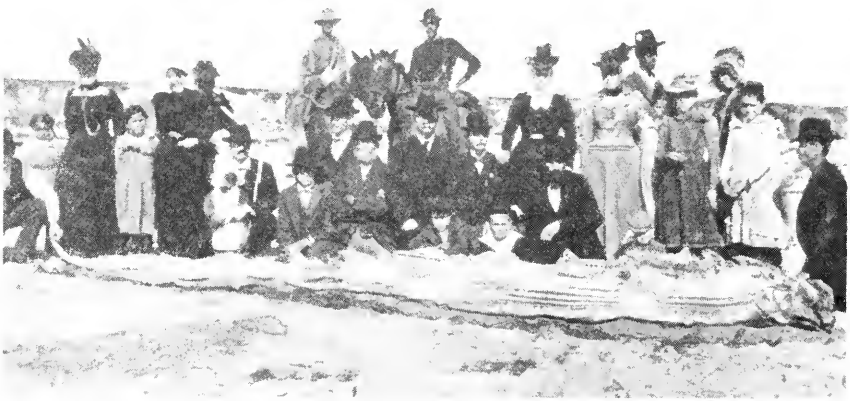


FIGURE 58. The 1901 oarfish. It was mutilated by the man who first found it on the beach. Photograph courtesy Charles F. Crawford, San Pedro.

This represents the second record of *R. gloriae* from the California coast. The first specimen was washed ashore near Newport Beach (about 20 miles southeast of Cabrillo Beach) in 1901. It was about 20 feet long with an estimated weight of 500 pounds (Figure 58).

These fishes, world-wide in distribution, are not infrequently cast ashore along the Scandinavian coast. There it has been found that the flesh is very unpalatable. Even dogs will not eat the meat whether offered raw or cooked. The name oarfish is derived from the shape of the two long and blade-like ventral fins. The fish is also known as the king-of-the-herrings because in some localities it was thought to precede or accompany the herring shoals.

Trichiurus nitens Garman. Pacific Cutlassfish. (Figure 59.)

A 30-inch cutlassfish was taken near San Pedro on the morning of June 21, 1950, by the bait boat PEER skippered by Charles Whiteley. It was skeletonized by C. R. Clothier and found to have 148 vertebrae (36 precaudal and 112 caudal). The stomach contained two anchovies, *Engraulis m. mordax*.

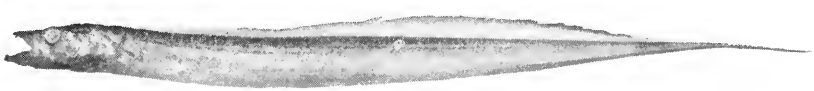


FIGURE 59. Pacific cutlassfish, *Trichiurus nitens*. Photograph by Al Johns for Vernon M. Haden, San Pedro.

During the 1930's considerable numbers of these fish were brought into the San Pedro fresh fish markets where they were sold mostly to Japanese who consider the flesh quite a delicacy. On several occasions loads from a few hundred pounds to around a ton were sold for 7 to 10 cents per pound. Old-time fishermen around San Pedro state that about 1915 large cutlassfish weighing several pounds apiece were commonly taken on "rock cod" set lines in some 600 feet of water between San Pedro and Santa Catalina Island.

Trachypterus rex-salmonorum Jordan and Gilbert. California Ribbonfish.

A 29-inch ribbonfish was caught by the seiner NEW SAN ANTONIO, Frank Iacono, captain, on the night of June 21, 1950. A smaller individual was caught by another seiner on the same night. Both vessels were fishing several miles off the west end of Santa Catalina Island. Stomach contents of a large specimen included remains of two small rockfish, *Sebastodes*, one myctophid, *Tarletonbeania crenularis*, several small squid and octopi and numerous small crustaceans. Gill rakers on the outer arch totaled 15 (5 + 10). Vertebral counts of two specimens gave a total of 92 each (35 and 37 precaudal, respectively).

Lampris regius (Bonnaterre). Opah. (Figure 60.)

Several opahs have been landed by sportfishermen during the summer of 1950. The first of these to come to the attention of the laboratory was caught by R. W. Langenberg, Huntington Park, California, about nine miles off Newport Beach on July 18, 1950. He was fishing for albacore near Fourteen-mile Bank when the opah struck and was landed after a short battle. This fish weighed 34 pounds 9 ounces and was 30 inches long and 17 inches high.

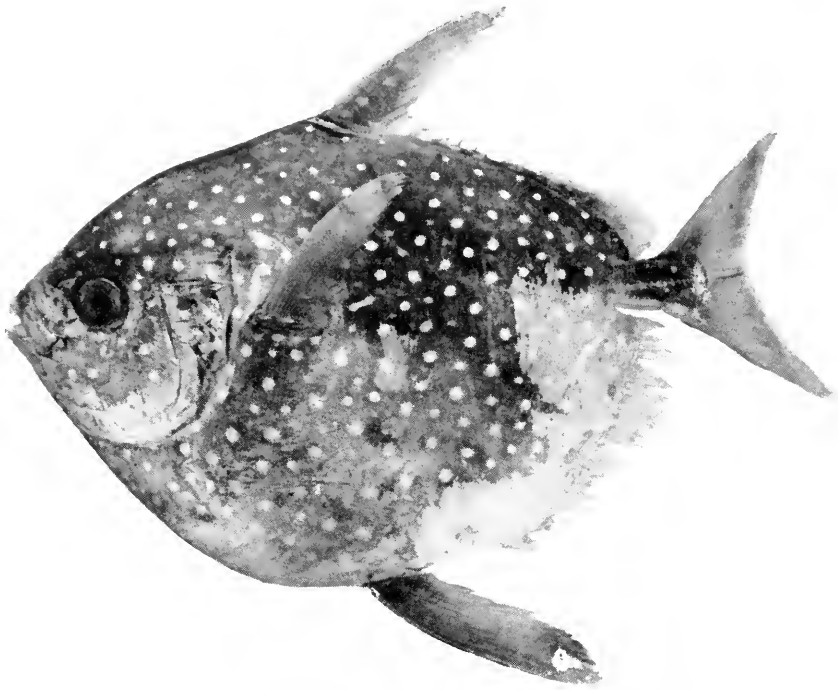


FIGURE 60. The 24-pound opah, *Lampris regius*, caught off Monterey on September 25, 1950. Photograph by J. B. Phillips.

A second opah was caught in the Los Angeles harbor area a short time later and was estimated to weigh around 80 pounds. The Scripps Institution of Oceanography, La Jolla, made a cast of this second fish. On August 2, 1950, a 40-pounder was caught by a Los Angeles fisherman (R. Smith) at almost the same place as was the July 18 specimen. Two of these opahs had identical vertebral counts, 20 precaudal and 24 caudal, while the third had 20 precaudal and 23 caudal. Another was caught in the paddle wheel of a glass-bottom boat at Santa Catalina Island in early September. This fish was gaffed and pulled aboard the boat. Its weight was estimated at 60 to 70 pounds.

A fifth opah was caught off Humboldt County in a drag net by a commercial fisherman some time during the summer of 1950. Mr. H. S. Barnes of Fortuna, California, sent a snapshot of this specimen to the laboratory for identification. Further information concerning this capture is not available; however, Mr. Barnes did volunteer information on two other *L. regius* which were taken by salmon trollers. The first was caught during July, 1945, by Mr. Paul Pellegrini on the troller SEA GULL and the other by Mr. "Bud" Peters on the troller PANDORA during 1946 or 1947. Both of these fish weighed 9 or 10 pounds and were caught on salmon spoons in the Eel River Canyon about 16 miles southwest of Humboldt Bar.

Mr. J. B. Phillips, California Division of Fish and Game, wrote as follows concerning still a sixth opah:

> "[It] was caught about 30 miles west of Monterey on September 25, 1950, by A. B. Lindstrom. Mr. Lindstrom was trolling for albacore on his 45-foot fishing boat, the LOYAL, when the Opah struck a jig and was hauled in. It was delivered with a load of albacore to the Regal Seafood Company, Monterey. Mr. Howard Low of that concern turned the specimen over to the Division of Fish and Game.
>
> "This specimen was 28¼ inches total length, and weighed 24¼ pounds. The greatest depth of body, exclusive of dorsal and ventral fins, was 15½ inches and the greatest thickness of body was 3½ inches."

This species is distinguished by the deep, ovate, much compressed body, the dorsal fin which is high and falcate in front, the long ventral fins, the silver spotting on body and the bright red fins. Teeth are absent in the jaws.

The color is steely blue to dark bluish gray on the dorsal surface, shading to silver, flushed with light red on the ventral surface. All the fins are brilliant red. The reddish tinge to the ventral surface of the body disappears after the fish has been out of water for a period, and the brilliant red of the fins fades when the specimen is placed in preservative. The silvery spots are uniformly scattered over the body.

The opah is an inhabitant of the open waters, usually of the warmer seas, and is of world-wide distribution though nowhere very common. It attains a length of six feet and a weight of 500 or 600 pounds. The food consists of crustaceans, squid and small fishes.

The name "opah" was given by the natives of the west coast of Africa who esteem it as a food fish. On the island of Madeira according to Herald (1939) the opah is held in such high regard "that every specimen taken was required by law to be carried to the governor of the island, without whose license it could not be sold in the market."

Along the Pacific Coast, occasional specimens have been taken between Southern California and Alaska. Herald recorded 24 from California up to 1939.

REFERENCES

Barnhart, Percy S.
1936. Marine fishes of Southern California. Berkeley, Univ. Calif. Press, 209 p., 290 figs.

Bolin, Rolf L.
1933. New fish records from Southern California. Copeia, no. 1, p. 35-36.
1939. A review of the myctophid fishes of the Pacific Coast of the United States and of Lower California. Stanford Ichthyological Bull., vol. 1, no. 4, p. 89-156, 29 figs.

Fitch, John E.
1950. Life history notes and the early development of the bonefish *Albula vulpes* (Linnaeus). Calif. Fish and Game, vol. 36, no. 1, p. 3-6, 2 figs.

Fraser-Brunner, A.
1949. A classification of the fishes of the family Myctophidae. Proc. Zool. Soc., vol. 118, p. 1019-1106, 167 figs., 1 plate.

Herald, Earl Stannard
1939. The opah (*Lampris regius*) and its occurrence off the California coast. Calif. Fish and Game, vol. 25, no. 3, p. 228-232.

Hill, Howard R.
1932. A new record of *Ostracion diaphanum* Bloch and Schneider from California. Copeia, no. 4, p. 181.

Hubbs, Carl L.
1945. California searobin (*Prionotus stephanophrys*), a fish new for the fauna of Southern California. Calif. Fish and Game, vol. 31, no. 4, p. 195-200, 1 fig.

Hubbs, Carl L., and Clark Hubbs
1941. Pacific cutlassfish, *Trichiurus nitens* Garman. Calif. Fish and Game, vol. 27, no. 1, p. 29-30.

Roedel, Phil M., and Howard McCully
1939. Occurrence of the wolf-fish *Hepisaurus aesculapius* (Bean) in Southern California. Calif. Fish and Game, vol. 25, no. 1, p. 35-37.

LAMPARA NET-PULLING GURDIES[1]

By J. B. Phillips
Bureau of Marine Fisheries
California Division of Fish and Game

During the past three and one-half years the small lampara net boats at Santa Cruz have been operating with half as many men in a crew because of the installation of net-pulling gurdies. In the spring of 1947, John Cecchini, captain of the lampara boat Anna Alma, hit upon the idea of mounting two modified shark gill net gurdies aboard his boat, each to pull in a wing of the net. This innovation proved successful and soon other Santa Cruz boats using lamparas installed similar gurdies.

The basic part of these net-pullers is the rear axle assembly from an old car placed upright on the deck with a wheel six to eight inches thick and about 16 inches in diameter mounted to the upper or free end (Figure 61). The edge of the wheel is concave like a sheave and lined with rubber to accommodate and grip the net. Power to turn the axle and wheel is applied to the lower end of the axle through a power takeoff from the main engine. The net-pulling gurdies are not stock models but are made

[1] Submitted for publication September, 1950.

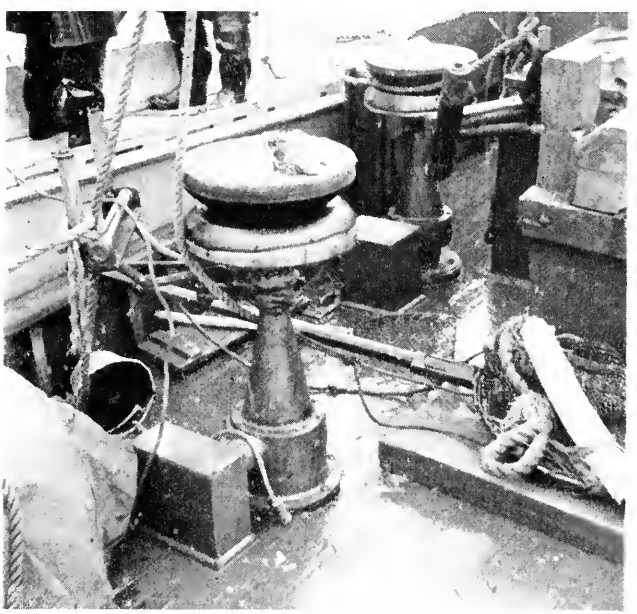


Figure 61. The two capstanlike net pullers aboard the 35-foot Santa Cruz fishing boat Sal Boy. Photograph by J. B. Phillips, September 18, 1950.

FIGURE 62. Unloading sardines from the barge of the lampara boat SAL BOY, at a Moss Landing cannery. The fifth man of the crew, not in photo, is operating a hoisting winch. Note the net-pullers mounted on the deck of the powerboat. Photograph by J. B. Phillips, September 18, 1950.

to order by a machine shop in Santa Cruz and are installed by the crews of the boats. The average cost of the parts and other modifications necessary on each boat is about $500, exclusive of installation.

Originally, Mr. Cecchini tried the two net-pulling heads in a vertical position, similar to rope-pulling gurdies, but this did not prove nearly as satisfactory as the present arrangement.

The boats on which net-pullers have been installed vary from 29 to 40 feet in length. Their engines range from 90 to 165 horsepower; most of them are gasoline-powered. Except for one vessel which is constructed to carry about 25 tons in the hold, these boats tow barges that carry 20 to 40 tons of fish. Most of the barges are war-surplus steel lifeboats although one is a plywood landing barge. The lampara nets are 120 to 172 fathoms in length along the cork line and 20 to 25 fathoms deep at the bag. The cost of the materials is $1,000 to $1,500.

One of the larger lampara nets used by Santa Cruz fishermen is 172 fathoms around the cork line. Each wing is 65 fathoms long and the bag is 42 fathoms long. The depth of the bag is 25 fathoms. The tapered wings are composed of eight-inch mesh (stretched), nine-thread webbing. The bag is made up of seven-eighths-inch webbing, six-thread. In the central section of the bag, next to the wings, is a square section of four-inch mesh, nine-thread, called the apron. In the central portion of the bag, next to the cork line, is another square section of webbing of one-inch mesh, nine-thread. This latter section of webbing, sometimes called the "sack," is the portion into which the catch is concentrated for brailing.

Nearly all boats have an extra lampara, in case the net in use is badly damaged and cannot be repaired in time for the following night's fishing. When fishing is good the nets are tanned every two weeks. Only four or five men, including the captain, compose a crew of a boat equipped with the two net pullers. Before the net pullers were installed, eight to ten men were needed. The crews work on a share basis as do the purse seine crews at Monterey. Because of the smaller investment in boat and net, only two shares are reserved for them and each of the crew receives one share. With a five-man crew this makes a total of seven shares by which the proceeds of the catch are divided. With larger purse seine boats, the number of shares will total about 20.

When a set is made with a lampara net, it takes about 15 minutes to pull in the wings with the aid of the net-puller. Since the wings taper to an apex at the ends and are of eight-inch mesh, they pull through the water readily. By the time the wings are in, the lead line, which is shorter than the cork line, is also in, thus cutting off the escape of the fish below. The bag portion of the net in which the fish are trapped is pulled in by hand until the fish are concentrated in the sack, from which they are brailed. If no fish are caught, it takes about one-half hour to set and haul the net. For 10 tons of sardines it will take about an hour to haul the net and load the catch; for 30 tons it will take about two and one-half hours.

None of the few lampara boats at Monterey has these double net-pullers installed (September, 1950). At Santa Cruz, 11 lampara boats had net-pullers in 1950. In 1949, three boats now fishing with other gear were using a lampara with the aid of the mechanical net-pullers.

THE INTRODUCTION OF KOKANEE RED SALMON (*ONCORHYNCHUS NERKA KENNERLYI*) INTO LAKE TAHOE, CALIFORNIA AND NEVADA[1]

By J. C. Fraser and A. F. Pollitt
Bureau of Fish Conservation, California Division of Fish and Game

Ever since Lake Tahoe's vast area ceased to produce the once fabulous population of cutthroat trout, fisheries workers have sought to re-establish a satisfactory game fish population.

At the present time this interstate water provides some fishing for the introduced lake (mackinaw) and rainbow trouts. Neither species has lived up to its original expectations as regards production of angling in keeping with the lake's size and recreational importance. Reduction in spawning areas for rainbow through summer use of water from tributary streams is probably one of the factors limiting the production of that species, and shortage of forage fish in the open and deeper waters of the lake may be a limitation on the production of lake trout.

In recent years, attention has been given to the kokanee, a landlocked form of the red salmon, native to waters of the Pacific northwest, which was first introduced into California waters on an experimental basis in 1941.

The decision to introduce the kokanee into such an important body of water as Lake Tahoe was based on several factors, after the habits and requirements of the fish had been studied in other waters. Briefly, these factors are as follows: (1) The kokanee is an open-water lake fish and a feeder on minute plants and animals. Thus, it does not compete seriously with shoal or bottom feeding types of game fish for food, nor is it carnivorous in relation to other species of fish. (2) It is a desirable game fish and has excellent eating qualities. (3) It is a good reproducer, utilizing both gravelly shore areas and tributary streams for spawning. The abundance of good shore spawning areas in Lake Tahoe should be a contributing factor to satisfactory population increase. (4) The kokanee prefers cool water and Lake Tahoe's temperatures are very suitable in this respect. (5) Indications are that the kokanee itself may provide a source of food for other game fish if it becomes sufficiently abundant. In summary, it may be said that the kokanee is not a predator, that it appears to be well suited to the environment of Lake Tahoe, and that there is reason to hope it will become sufficiently abundant to prove a real asset to the lake's fishery.

Kokanee were first introduced into Lake Tahoe in 1944 through accidental escapement from the Tahoe Hatchery. Returning spawners from this escapement appeared in the hatchery outflow stream in 1946; these fish averaged 14½ inches in length.

[1] Submitted for publication October, 1950.

The first phase of the program to establish a large population of kokanee started in 1949, with the planting of 90,000 fingerlings in three tributary streams on the California side of Lake Tahoe. It should be noted at this point that the Lake Tahoe kokanee introduction program received the full sanction and support of the Nevada Fish and Game Commission before its inception.[2]

In 1950 a total of 613,475 fingerling kokanee was planted directly in the lake and in suitable tributary streams in Nevada and California. These fish were hatched from eggs obtained by California from the Idaho Department of Fish and Game. Approximately 338,900 of these salmon were raised in the Idlewild Hatchery of Washoe County, located in Reno, Nevada. The remainder were raised in the Basin Creek and Tahoe State Fish Hatcheries, in California.

Planting in the lake itself was accomplished by power boat and barge. A regular 150-gallon fish planting tank was mounted on a barge and the fish thus transported were planted in suitable shore spawning areas along both the California and Nevada shore lines. Planting in these shore spawning areas was made to take advantage of the homing instinct of the kokanee, so that maximum utilization of available spawning areas could be obtained. These shore planting areas were predetermined on the basis of surveys made by personnel of both the Nevada and California Fish and Game Divisions. Many areas were not accessible by land routes

[2] The authors wish to acknowledge the work done by Messrs. S. S. Wheeler, Director of the Nevada Fish and Game Commission during the program's inception; Thomas J. Trelease, Nevada Fish and Game biologist; and other personnel of the State of Nevada Fish and Game Commission, who played an important role in all phases of the program.

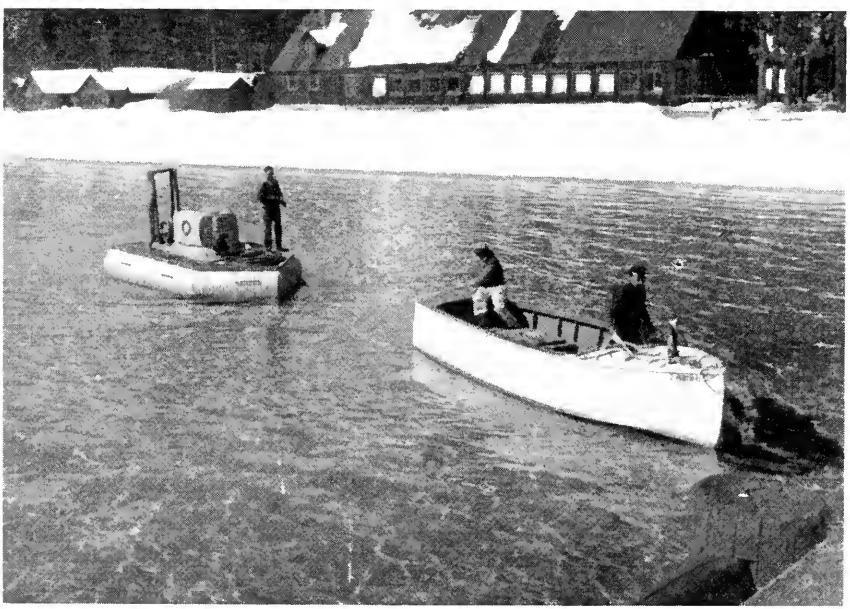


FIGURE 63. View of 150-gallon planting tank mounted on barge used in distribution of kokanee to snowbound shore areas of Lake Tahoe in April, 1950.

during April, May, and early June, when the plantings were made, because of deep snows or lack of roads. Thus, the use of this barge proved to be a very satisfactory method of transportation whereby maximum distribution of the fish could be obtained in suitable areas. All of the tributary streams to Lake Tahoe suitable for spawning were stocked from trucks.

This entire stocking program is directed at producing an initial population, which in subsequent years should gradually build itself up to a satisfactory level through natural reproduction. It is tentatively planned to continue this artificial stocking program through 1953. Stream improvement work in the way of barrier removals, stream flow maintenance, and spawning area improvement is being carried on in streams tributary to Lake Tahoe to increase the success of natural reproduction. Careful follow-up studies on the spawning runs and success of spawning when this activity starts are also planned.

Although the kokanee has excellent possibilities for improvement of the Lake Tahoe fishery, it should not prematurely be considered as a panacea for all of the lake's problems. In the few other waters in California in which the kokanee has been introduced (Curtis and Fraser, 1948) its success has not been uniformly good: growth has been limited in Echo Lake and survival to maturity low in some years in the other waters. Its ability to improve the fishery picture of Lake Tahoe will depend largely upon its spawning success in the years to come.

REFERENCE

Curtis, Brian, and J. C. Fraser
1948. Kokanee in California. Calif. Fish and Game, vol. 34, no. 3, p. 111-114, 1 fig.

THE EMBRYONIC AND EARLY LARVAL STAGES OF THE TUI CHUB, *SIPHATELES BICOLOR* (GIRARD), FROM EAGLE LAKE, CALIFORNIA[1]

By Robert R. Harry
Stanford University

INTRODUCTION

The complete early development has not been described for any native western North America cyprinid. The postembryonic development of one species, the venus roach, *Hesperoleucus venustus* Snyder, has been discussed in detail by Fry (1936), but its embryonic development is completely unknown.

The present study on the tui chub, *Siphateles bicolor* (Girard), was made by the writer while in the employ of the California Division of Fish and Game. It was carried out at the suggestion of Mr. Harry A. Hanson of the Division and forms an integral part of an investigation into the entire life cycle of the species in Eagle Lake, Lassen County, being conducted by Mr. J. Bruce Kimsey, also of the Division of Fish and Game.

Fertilized eggs of the tui chub were obtained at Eagle Lake by Mr. Kimsey and the writer and their development studied by the latter from 70 hours after fertilization to 12 hours after hatching. It is unfortunate that circumstances caused the development of the eggs under conditions that did not lead to unquestionably normal results and that there was no chance to repeat the work under more normal conditions. However, since there is so little recorded on the early development of fishes, the publication of the present study, even if incomplete, seemed worthwhile.

METHODS

Ripe adults were caught in a gill net on the western side of Eagle Lake near Webb's resort (formerly Spaulding's) over their spawning grounds, which were approximately six feet in depth. The females were stripped into a bowl containing plants and the eggs were artificially inseminated at 8 a.m. on June 24, 1949. Approximately 20,000 eggs were obtained and immediately transported to the Lake Almanor State Fish Hatchery on Clear Creek, Lassen County. They arrived at noon the same day and were placed in quart jars partly submerged in a trout hatching trough. The eggs were kept in the highly mineralized Eagle Lake water at all times. The water was partially changed at frequent intervals and most of the eggs were kept at an even temperature of 45 degrees F., approximately 20 degrees below that normal for the development of *Siphateles* eggs in Eagle Lake.

[1] Submitted for publication October, 1950.

All eggs developed normally for the first 100 hours, forming the blastodermal cap and the segmentation cavity. After the latter stage the eggs at 45 degrees either remained dormant or continued growth with irregular cell development. Some of the eggs clumped together in large masses and these eggs formed the blastodermal cap, but developed abnormally thereafter. The yolk became granular and shrunken, and after about 100 hours these eggs also seemed to become dormant, without further organized development. However, they did not die or appear to be more susceptible to fungus than the properly developing eggs.

Three days after stripping 100 eggs were removed and allowed to stay at room temperature, which varied from 34 degrees to 84 degrees F. These eggs developed rapidly and appeared to be almost fully formed within six days. At this time most of the eggs died from fungus. The remaining embryos continued to develop, and formed the pigment pattern characteristic of this species. It is possible that the embryos were so weakened by abnormal conditions for development that they were unable to break out of the eggs at the proper time.

In the following description of embryonic development the eggs at 45 degrees are used for the first 100 hours. The remainder of the description is compiled from embryos kept at room temperature. Only one larva hatched and the description of the early larval stages is from this specimen.

DESCRIPTION OF EGGS

The freshly stripped eggs of *Siphateles* are translucent, yellowish, spherical, adhesive, and rather large for cyprinid eggs, measuring 1.8-2.0 mm. in diameter. Their specific gravity is considerably more than that of fresh water and the free eggs sink quickly to the bottom. The membrane is thick and tough but fairly smooth. The surface is covered with minute crenulations, which at first are hardly visible under 160x power, and which become covered with the floating matter in the water as development progresses. The yolk is filled with numerous oil globules and appears to be separated into small cells, but is so opaque that it is impossible to determine whether or not the divisions are limited to the surface.

The eggs are emitted as a sticky, fluid mass and adhere to each other or other objects soon after coming in contact with fresh water. This adhesive character is soon lost. The membrane becomes flattened over a wide surface wherever the eggs come in contact with each other.

EARLY EMBRYONIC DEVELOPMENT

By 70 hours the fully developed blastodermal cap (Figure 64, A) has become a symmetrical dome. It is very large and its outer surface forms a gentle curve almost continuous with the outline of the yolk. Its irregular inner surface pushes into the yoke. At this time the cells are so small as to be indistinguishable. During all stages of development the perivitelline space is small.

The segmentation cavity (Figure 64, B), partly developed beneath the central area of the blastodermal cap, is formed by the thinning of the central blastodermal wall. This cavity could be distinguished by looking down on the upper surface of the blastoderm in the early stages (Figure 64, C).

At about 100 hours the segmentation cavity is narrower and slightly eccentric. This is the first indication of the main axis of the future embryo; the thicker area marks the posterior pole.

Continued growth and development of the segmentation cavity causes a thinning of the central portion of the blastodermal cap and a

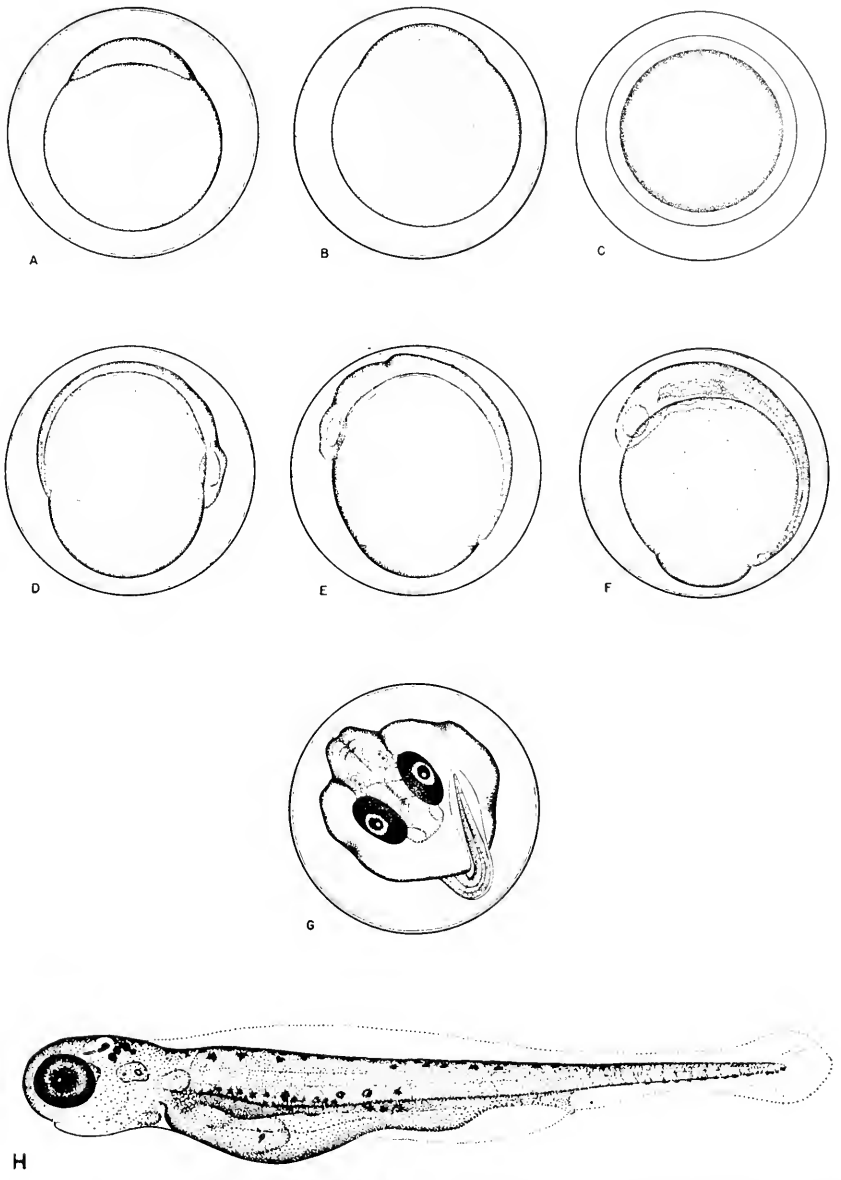


FIGURE 64. Development of *Siphateles bicolor* (Girard). A. 70 hours after fertilization. B. 85 hours. C. 100 hours. D. 120 hours. E. 136 hours. F. 152 hours. G. 170 hours. H. Larva about 6 hours after hatching.

thickening of the peripheral germ ring, which is very difficult to distinguish and appears as a broad, slightly darker ring surrounding a more translucent area. From the time of its origin until the closure of the blastopore it marks the advance of the blastoderm over the yolk sphere. The embryonic shield is fairly narrow and somewhat wedge-shaped. During the formation of the embryonic axis the blastoderm covers half of the yolk sphere at about 120 hours (Figure 64, D).

At about the same time that the germ ring forms an equatorial belt, Kupffer's vesicle appears imbedded in the yolk at the posterior end of the embryo and metameric segmentation is detected at the middle of the body. The notochord also becomes apparent.

LATE EMBRYONIC DEVELOPMENT

Near the time of the closure of the blastopore at 136-140 hours (Figure 64, E and F) the eyes become visible. Metameric segmentation is well developed caudally and the heart begins to pulsate below the middle of the left eye (viewed from the dorsal aspect). Immediately behind the eyes the auditory capsules are barely visible as small oval vesicles. Kupffer's vesicle now appears to be obsolete.

At 170 hours (Figure 64, G) the blastopore is closed and the head as a whole has increased markedly in size. The pupils and lenses in the eyes are visible and the otoliths are formed. The tail twitches from side to side at frequent intervals and passes over the snout and eyes. The continuous fin fold is clearly visible.

About the ninth day pigment begins to appear in the form of several rows of conspicuous melanophores on the dorsal side, particularly on the head. The eyes are heavily pigmented. The extent of pigmentation increases during the remainder of embryonic development. The yolk becomes reduced to less than half its original size.

EARLY LARVAL DEVELOPMENT

After hatching, which took place during the night of the twelfth day, the larva was exceptionally active and was able to swim rapidly and effectively (Figure 64, H). The yolk was almost completely absorbed. The auditory capsules were enlarged and the cells of the notochord could be seen along its entire length. The tail had begun to develop rays (ceratotrichia) and to change shape. Chromatophores were concentrated along the ventral midline of the body, exclusive of the gut. Two irregular longitudinal rows of large melanophores extended along each side of the dorsal midline. A large triangular blotch of giant melanophores was present on the nape. The eye and lens were solid black. The pectoral fins were very small and the rays only slightly developed. The anus was far posterior in position.

The only larva that hatched died approximately 12 hours after it emerged. So far as could be seen, it had no special structures on the head for breaking the egg membrane.

REFERENCE

Fry, Donald H., Jr.
1936. Life history of *Hesperoleucus venustus* Snyder. California Fish and Game, vol. 22, no. 2, p. 65-98, 8 figs.

THE M.V. YELLOWFIN, AN ADDITION TO CALIFORNIA'S MARINE FISHERIES INVESTIGATIONS[1]

By Robert C. Wilson
Bureau of Marine Fisheries
California Division of Fish and Game

INTRODUCTION

The close of World War II saw a resumption of full-scale investigation of our marine resources by the California Division of Fish and Game. This made more evident the need for additional research facilities at sea to augment and speed up the collection of data about pelagic fish and the environment in which these species live. To meet this need plans were made to acquire a second research vessel to supplement the work of the N. B. Scofield, in service since 1938. Before a second vessel could be obtained the failure of the sardine fishery in 1946-47 brought home to the industry the necessity for increased research, to find the reasons for such a failure. The backing of the industry served as a further stimulus to establish the need for additional research vessels of a size sufficient to carry out a high seas investigation.

Funds were made available by the Legislature to the Division of Fish and Game for the purchase and conversion of one additional research vessel, and the F. S. 64 was purchased May, 1948, and renamed Yellowfin for conversion into a marine research vessel.

The F. S. 64 was constructed for the U. S. Army in 1943, at Stonington, Maine, from a design prepared by H. C. Hanson, Naval Architect. She was planned for interisland freight and passenger service. The vessel subsequently saw service in Pacific waters until the close of the war, when she was laid up and declared surplus.

DESCRIPTION

Basic construction of the vessel is wood, with four transverse bulkheads of steel. All tanks are of steel.

Construction is to the following specifications:

Length over-all	113 feet, 8½ inches
Length between perpendiculars	107 feet, 3 inches
Molded beam	26 feet 6 inches
Beam over planking	27 feet 0 inches
Depth to bottom of keel amidship	14 feet 7 inches
Mean draft, full load	11 feet 3¼ inches
Light displacement tonnage	417.53
Gross tonnage	272
Net tonnage	112

[1] Submitted for publication November, 1950.

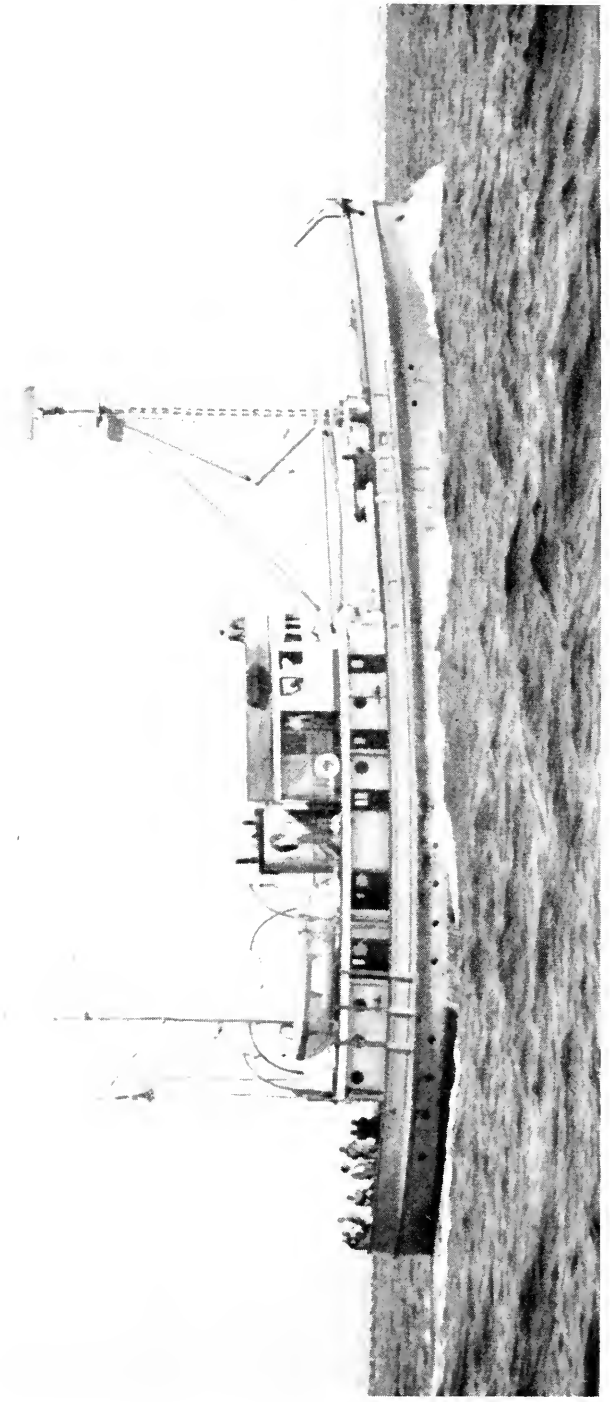


FIGURE 65. The M. V. YELLOWFIN. Photograph by Leo Pinkas, October, 1948.

Main propulsion	twin 320 hp. 325 RPM single acting, four cycle, solid injection, six cylinder Atlas Imperial model 6 HM 155S diesel engines.
Auxiliary power	two Hercules model DJXC $3\frac{3}{4}$x$4\frac{1}{2}$ diesel engines, each driving a 20 KW 125 volt DC generator.
Cruising speed	10 knots
Maximum speed	11.2 knots

Extensive repair and conversion were necessary to adapt the vessel for scientific work. Plans were drawn up and work was supervised by G. Bruce Newby, Naval Architect. Repair and conversion was accomplished at the yard of the Long Beach Marine Repair Company, Long Beach. It was attempted to make the vessel as versatile as possible, from a fishing point of view, without a major modification of the hull. However, the N. B. SCOFIELD, which was constructed especially for marine fisheries research was already well adapted to tuna and trawl investigations, so emphasis in conversion of the YELLOWFIN was placed upon utilization in high seas sardine and mackerel work, together with oceanographic observations.

In the conversion, additional fuel and water tanks were installed, together with additional refrigeration space, to create total capacities as follows:

Diesel fuel	20,000 gallons
Fresh water	2,500 gallons
Cruising radius	6,000 miles at 10 knots
Refrigeration, food, frozen	127 cubic feet
Refrigeration, food, chilled	100 cubic feet
Refrigeration, specimens, frozen	30 cubic feet

Stateroom accommodations are provided for 13 persons as follows:

Master, fisheries vessel	1
Motor vessel engineman	1
Netman and boatswain	1
Assistant motor vessel engineman	1
Radiotelegraph operator and assistant engineman	1
Ship's cook	1
Deckhand	4
Scientific personnel	3

In addition, emergency accommodations for four persons are installed in the forecastle.

Certain equipment was installed to aid in navigation of the vessel, as follows:

Radio	Transmitting side: radiotelephone 500-100 watts power, 7 crystal controlled channels, CW section power output 180 watts; 9 crystal controlled channels. Receiver side: 6 receiving coils, reception 30 megacycles to 180 kilocycles.
Radar	Mariners pathfinder, Raytheon model 1197, with wheelhouse-mounted plan position indicator. Maximum range 40 miles, with 20, 8, 4, 2, and 1 mile scales.
Automatic pilot	Sperry magnetic compass pilot, in wheelhouse, with Sperry electric nonfollowup controller and rudder angle indicator mounted on top of house for maneuvering.
Echo sounding	Submarine Signal model 710-M 20 KC indicator, maximum depth 2,500 fathoms.
Remote control	Engine speed may be controlled from both wheelhouse and top of house through a hydraulic throttle system.

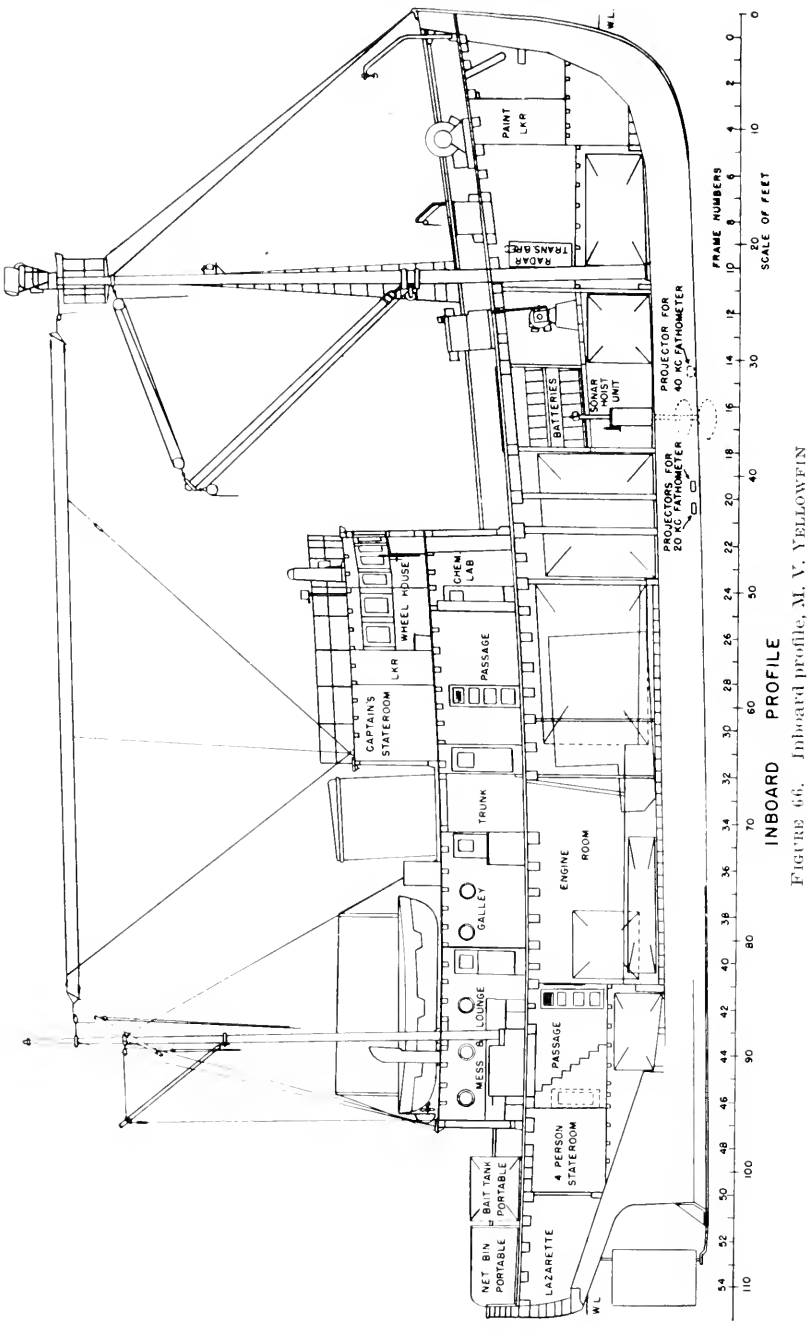


FIGURE 66. Inboard profile, M. V. YELLOWFIN

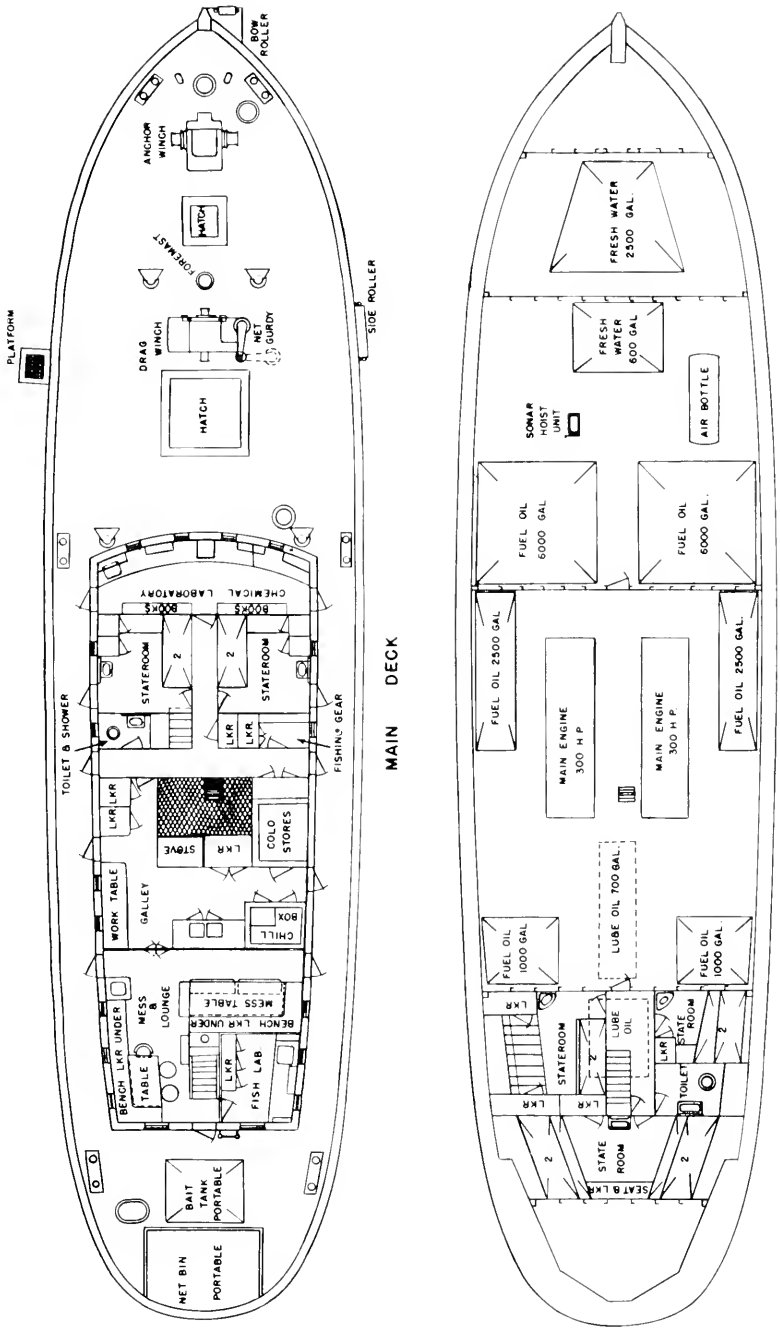
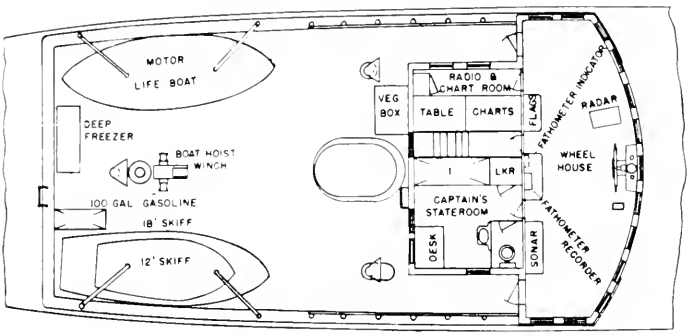
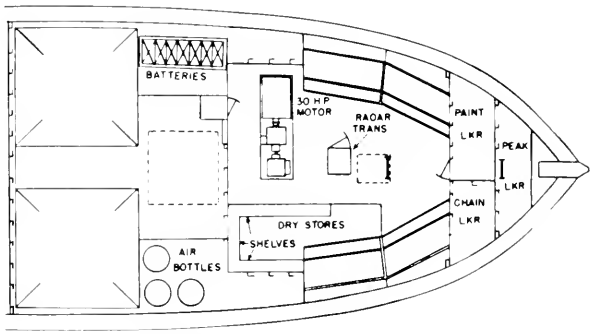


FIGURE 67. Maindeck and hold plans, M. V. YELLOWFIN



BRIDGE DECK

FIGURE 68. Bridge deck, M. V. YELLOWFIN



PLATFORM DECK

FIGURE 69. Platform deck, M. V. YELLOWFIN

Certain special equipment was installed to aid in locating schools of fish:

Echo ranging	Model WEA-2a sonar, approximately 23 KC, maximum range 5,000 yards, with neon-tube indicator and Sangamo recorder wheelhouse-mounted.
Echo sounding	Submarine Signal Co. model 1215A recording fathometer, maximum depth 500 fathoms, with 500-foot scale, and variable chart feed rate. Frequency 40 KC.

Other equipment was installed to aid in fishing operations, and in scientific observations:

Winch	Northern Dragger model 200-D, 2-drum trawling winch, with gill net gurdy and longline gurdy attachments. Driven by 30 hp electric motor through a hydraulic torque converter. May be utilized for plankton tows and Nansen bottle casts as well as trawling and other fishing operations.
Winch	Standard high speed bathythermograph winch, capacity 2,000 feet $\frac{3}{32}$-inch cable.
Bait tank	Portable, $6\frac{1}{2}'x5\frac{1}{2}'x4\frac{1}{2}'$, supplied with salt water by 2-inch vertical bait pump. Capacity about 40 scoops of bait.
Rollers	Side roller for hauling gill nets and bow roller for riding warp when gill nets are set.

The YELLOWFIN was placed in service September 20, 1949. To December 1, 1950, she had completed 16 cruises in waters from Northern California to Cape San Lucas, Baja California. The vessel has been utilized for work on the following problems:

1. Development of rapid methods for locating and identifying pelagic schools of fish.
2. Measurement of environmental conditions where sardines (*Sardinops caerulea*) are found.
3. Measurement of the relative abundance of the sardine 1950 year class.
4. Collection of jack and Pacific mackerel (*Trachurus symmetricus*, *Pneumatorphorus diego*) for population studies.
5. Collection of material for an analysis of food of jack mackerel.
6. Tagging sand and kelp bass (*Paralabrax nebulifer*, *P. clathratus*).

The vessel has proved quite suitable for the uses to which she has been put, and is a valuable addition to the pelagic fishery research program of the Division of Fish and Game.

EFFECTS OF HUNTING PRESSURE AND GAME FARM STOCKING ON PHEASANT POPULATIONS IN THE SACRAMENTO VALLEY, CALIFORNIA, 1946-1949[1]

By Harold T. Harper, Chester M. Hart and Dale E. Shaffer
Bureau of Game Conservation, California Division of Fish and Game

INTRODUCTION

Most of California's pheasant populations (*Phasianus colchicus*) are found in the Sacramento Valley, and consequently the heaviest hunting pressure on these birds occurs here. To supplement the breeding stock and the kill of pheasants, game farm stock has been released in increasing numbers each year. In order to study the effects of heavy hunting pressure and game farm stocking, two pheasant study areas were established in typical Sacramento Valley pheasant habitat. From this study, information was gathered that will be valuable in the management of the ring-necked pheasant in California.

THE STUDY AREAS

These two areas, the Sartain and McManus, were selected as they were similar in size, readily accessible to hunters, and planted to the same crops. Both were located in the rice growing section of the Sacramento Valley. Annual precipitation averages 24 inches, with little or no rainfall during the summer; winters are mild and snow is unusual.

The Sartain study area was a corporation ranch located 12 miles west of Gridley in Colusa County, under the direction of Mr. Terrill Sartain. It contained 6,920 acres composed of rice, barley, and pasture or waste land interspersed with numerous tule-filled sloughs and canals.

The McManus area, in Glenn County, consisted of a group of ranches owned by nine individuals. This area included 7,800 acres of rice, fallow rice, barley, and pasture or waste land, again interspersed with many tule-filled sloughs and canals. In 1949, 130 acres were planted to milo maize.

The areas were only three and one-half miles apart, but the land from the north boundary of Sartain's to the south boundary of the McManus area was dry, unirrigated grain land with a comparatively light pheasant population. This acted as a barrier to the movements of birds between the two study areas. Table 1 gives the acreages of crops grown and Figure 70 shows the location of each area.

[1] Submitted for publication June, 1950. Federal Aid in Wildlife Restoration Act, Project California 22-R. The authors wish to acknowledge contributions to this study made by Project 22-R Assistants Jack Hiehle, John F. Davis and Fred Jones, and former 22-R Project Leaders Carol M. Ferrel and Howard Twining; also, to Wallace Macgregor, John Cowan and Gordon Bolander, former Project 22-R Assistants. Appreciation is expressed to the numerous bureau personnel who served as hunter interview officers during the years of study.

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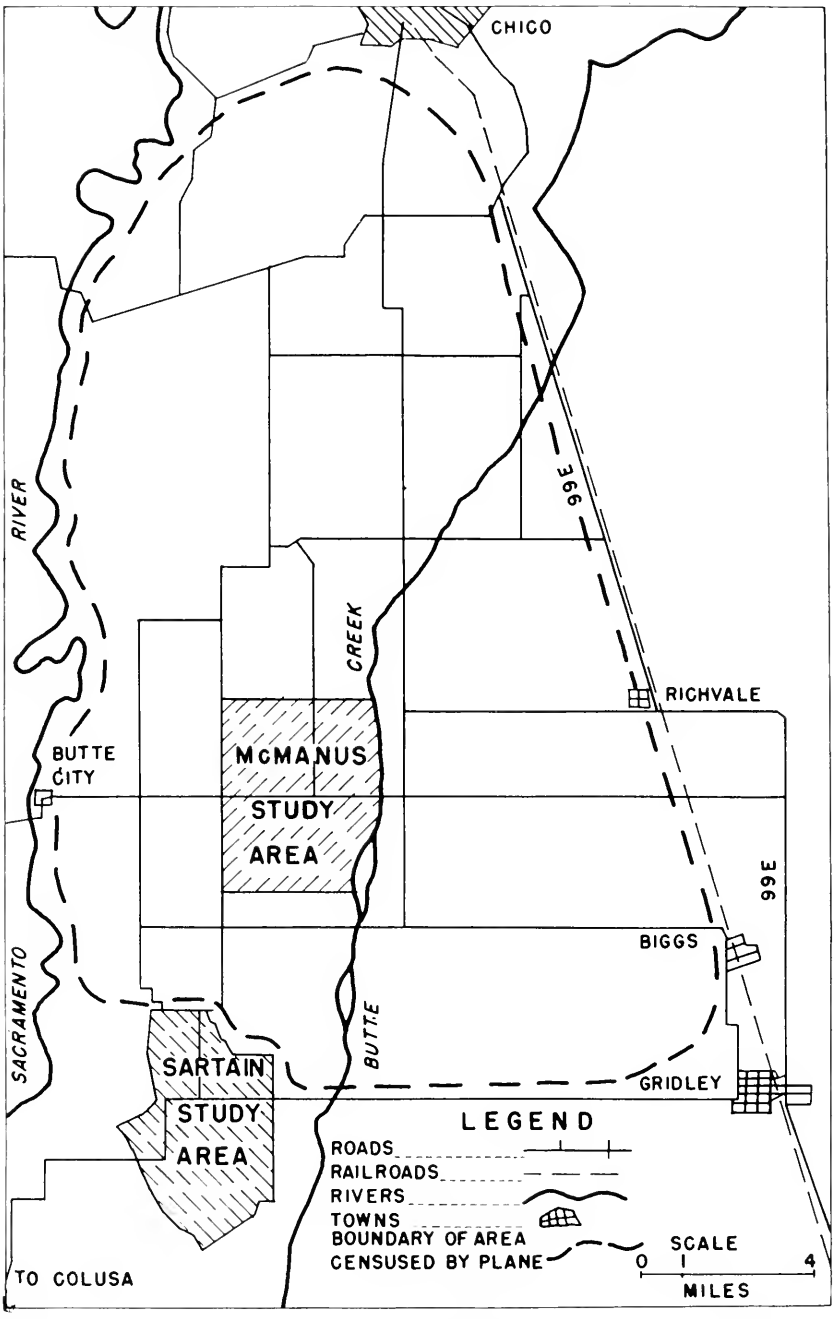

FIGURE 70. Location of the Sartain and McManus study areas and the area censused by airplane in the Sacramento Valley

TABLE 1

Crop Acreages, 1947-1949

	Rice	Fallow rice	Barley	Pasture	Milo maize	Total
Sartain						
1947	3,160	0	3,720	40	0	6,920
1948	2,535	0	4,155	230	0	6,920
1949	2,535	0	4,155	230	0	6,920
McManus						
1947	3,360	80	3,560	800	0	7,800
1948	2,722	603	3,966	509	0	7,800
1949	2,560	155	4,225	430	130	7,800

During the hunting season both areas contained plowed and leveled ground where the barley stubble had been turned under in prepration of the soil for the next season's crop production. The rice was harvested before the hunting season but the stubble remained and provided both food and cover.

Game farm birds, both cocks and hens, were released on the Sartain area from 1946 through 1949. Various age groups were liberated at intervals before the hunting season. In 1949, a sample of the wild resident population on Sartain's was trapped and banded, and some additional wild-trapped cocks were transplanted from local refuges. The McManus was used as a comparative check area, and no pheasants were liberated there during the years of the study.

Preseason and postseason sex ratio counts were made on both areas from 1947 through 1949. This was done by hiking through the areas, counting cocks and hens flushed.

HUNTING SEASON CHECKS

The dates of the hunting season each year were as follows: 1946, December 6-15; 1947, November 21-30; 1948, November 19-28; and 1949, November 18-27, all dates inclusive. Daily shooting time started at 10 a.m. in 1946 and at 8 a.m. in 1947, 1948, and 1949. Shooting was stopped at one-half hour after sunset from 1946 through 1948 and at sunset in 1949. A daily bag limit of two male birds and a seasonal limit of 10 was in force during each of the four years.

In 1946, the check on the Sartain area was conducted with the use of two road blocks during the first three days and last two days of the season. During the intervening five days an attempt was made to contact hunters in the field. This method proved unsatisfactory and in following years a system giving a more complete check was used. No check was made on the McManus area in 1946. In 1947 and 1948, roads leading from both areas were either blocked or had checking stations on them. In 1949, one road on the McManus and two roads on the Sartain area were not blocked as these received very little traffic and the loss of hunter information was considered to be insignificant.

In 1947, a 1,680 acre tract on the Sartain ranch was restricted to hunting by Mr. Sartain's numerous personal friends. After the sixth day this was reduced to 260 acres immediately surrounding ranch headquarters. In 1948 and 1949 the restricted area consisted of 1,280 acres. Hunting on this section of the ranch was moderate. Permission to hunt

on unrestricted land was granted by Mr. Sartain in 1946 and 1947. In 1947 and 1948 the California Division of Fish and Game posted the land with signs advising hunters that the ranch was open to hunting and that it was an experimental pheasant study area. Written permits to hunt were issued by the Division in 1948. The Sartain area was operated under both the cooperative hunting area plan and the pheasant planting policy [1] in 1949. A 1,680-acre block was placed under the pheasant planting policy and liberations of both game farm and wild-trapped birds were made there. Hunting on this area was free. The remaining 5,240 acres of the study area was operated under the cooperative hunting area plan and a fee of $2 per day per hunter was charged. The Division limited the number of hunters to one per five acres at any one time, but not once during the season was the quota filled. Mr. Sartain was responsible for issuing permits for the cooperative hunting area, while the Division of Fish and Game issued permits for the pheasant planting area.

The McManus area was not posted with Division signs and permits to hunt were granted solely by the landowners. A commercial hunting club containing 960 acres was located inside the west boundary in 1948 and 1949. In 1948 and 1949, a trespass fee was charged on approximately 1,140 acres lying inside the east border. Hunting on these two areas was only moderate and was comparable to pressure on the restricted tract on the Sartain ranch.

An airplane census of hunter's cars was made during the 1947, 1948, and 1949 seasons. Both study areas were censused and a count was made which included 269 square miles of pheasant habitat in the Sacramento Valley.

Data procured during the four-year hunting season check included: information regarding the area, number of hunters, number of automobiles, county of hunter's residence, number of hours hunted for day interviewed, total number of days hunted, number of birds bagged, kill of game farm birds, kill of transplanted wild birds, age ratios of birds killed, and samples of pheasant weights.

HUNTING SEASON RESULTS

Airplane Census of Cars

Cars were counted by airplane on the first three mornings of the 1947 and 1948 seasons from 8.30 a.m. to 10 a.m., and from 9.30 a.m. to 11 a.m. in 1949.

The area covered, by flying parallel courses, was bounded on the south by the Gridley-Colusa Road, on the west by the Sacramento River, on the east by Highway 99E, and on the north by a line from the outskirts of Chico west to the Sacramento River (Figure 70). These boundaries enclosed approximately 269 square miles. The same area was censused in 1947, 1948, and 1949. All cars, except farm trucks, whether on or off the road, were counted. Results of this census are included in Table 2.

The figures for total cars counted indicate that in 1948 there was an increase in hunting in the Sacramento Valley over that in 1947. This was followed by a nearly proportionate decrease in 1949.

[1] Under this policy state reared pheasants are released on land which is open to free public hunting with verbal or written permission from the landowner.

TABLE 2

Composite Census of Hunters in 269 Square Miles of the Sacramento Valley, 1947-1949

	Total cars[1]	Average number hunters/car[2]	Total hunters	Cars per square mile	Hunters per square mile
1st day					
1947	1,713	2.6	4,437	6.4	16.5
1948	2,198	2.6	5,649	8.2	21.0
1949	1,478	2.6	3,843	5.5	14.3
2d day					
1947	1,349	2.6	3,507	5.0	13.0
1948	2,056	2.7	5,551	7.6	20.6
1949	1,416	2.7	3,823	5.2	14.2
3d day					
1947	1,149	2.5	2,895	4.3	10.8
1948	1,507	2.7	4,039	5.6	15.0
1949	1,286	2.6	3,344	4.8	12.4

[1] Does not include cars counted on Sartain and McManus areas.
[2] Computed by averaging the number of hunters per car for both Sartain and McManus areas and applying to the entire region.

TABLE 3

Percent of Daily Totals of Cars That Were Counted by Airplane

	Sartain		McManus	
	1948	1949*	1948	1949
1st day	74.5	112.0	46.1	45.2
2d day	76.2	120.0	50.2	43.0
3d day	67.6	84.1	46.8	40.3

* These high percentages result from the fact that all cars parked on the boundary roads were counted. Many of these hunters were hunting off the study area and their cars were not tabulated at checking stations. Nearly all of this land was closed to hunting previous to 1949.

The constancy of the average number of hunters per car from year to year suggests that in future years hunter censuses of any large area in the Sacramento Valley can be made through car counts by airplane. A comparison of checking station counts with airplane counts is shown in Table 3. From these comparisons it is evident that airplane censuses are not accurate for small areas. Hunters move from one site to another during the day, and for a small area too low a count will result from a flight of short duration. Additional errors are caused by the impossibility of determining accurately from the air where a hunter is hunting from the position of his parked car. It is further evident that such counts cannot be accurate on areas where pheasant hunting is light, for too high a percentage of cars counted would belong to nonhunters.

Hunting Pressure

The basic information acquired from each year's check is given in Table 4.

The number of hunters on each area varied from year to year. In 1948 considerable publicity was given to the areas by San Francisco and Los Angeles newspapers. This brought about a decided increase of hunters which was somewhat greater on the Sartain than on the McManus

TABLE 4

Composite Summary of Hunter Checks, 1947-1949

Area	Cars checked	Hunters checked	Total kill	Hunters per car	Birds per hunter
Sartain					
1947	1,029	2,592	1,023	2.5	0.39
1948	2,225	5,836	3,230	2.6	0.55
1949	1,175	2,848	1,697	2.4	0.60
McManus					
1947	906	2,375	958	2.6	0.40
1948	1,686	4,223	2,656	2.5	0.63
1949	1,630	4,174	1,420	2.6	0.34

area. In 1949 the fee charged on the Sartain Cooperative Hunting Area turned some hunters away. Five other cooperative hunting areas, operated on a nonfee basis and located closer to large cities, attracted hunters who formerly went to the Sartain ranch (Harper *et al.*, 1950). There was only a slight decrease in numbers of hunters from 1948 to 1949 on the McManus study area.

Daily and seasonal numbers of hunters per 1,000 acres are given in Table 5. The general increase in the number of hunters on both study areas in 1948 was a reflection of an over-all increase in hunting throughout the Sacramento Valley.

TABLE 5

Hunters Per 1,000 Acres Per Day, 1947-1949

Area	Day of Season										Season total
	1	2	3	4	5	6	7	8	9	10	
Sartain											
1947	112	84	59	12	13	11	14	12	30	27	374
1948	229	207	136	30	34	28	27	27	67	58	843
1949	123	100	73	14	17	16	16	13	18	22	412
McManns											
1947	85	63	67	7	9	8	17	5	20	25	306
1948	149	134	102	24	17	17	16	16	31	35	541
1949	170	176	101	12	16	6	14	8	16	17	536

TABLE 6

Average Hours Hunted Daily Per Hunter on Study Areas, 1947-1949 (Season Total)

Area	1947	1948	1949
Sartain	3.2	3.5	4.2
McManus	---	3.4	3.8

The average number of hours hunted daily by each hunter increased each year as is shown in Table 6. There is no single explanation for the increase in time spent in hunting each year. The large increase noted in 1949 on the Sartain ranch was probably stimulated by the $2 fee. Hunters had an incentive to stay in the field longer when they had to pay this fee.

Two methods of expressing hunting pressure are gun hours per 1,000 acres and gun hours per cock in the field. The latter is calculated by dividing total gun hours by the preseason cock population. It is a measure of hunting pressure exerted on the bird. Table 7 shows the two.

TABLE 7

Measures of Hunting Pressure

	Sartain		McManus	
	Gun hours per 1,000 acres	Gun hours per cock in field	Gun hours per 1,000 acres	Gun hours per cock in field
1947	1,198	5.3	...	...
1948	2,949	4.2	1,835	3.6
1949	1,722	5.0	2,009	6.8

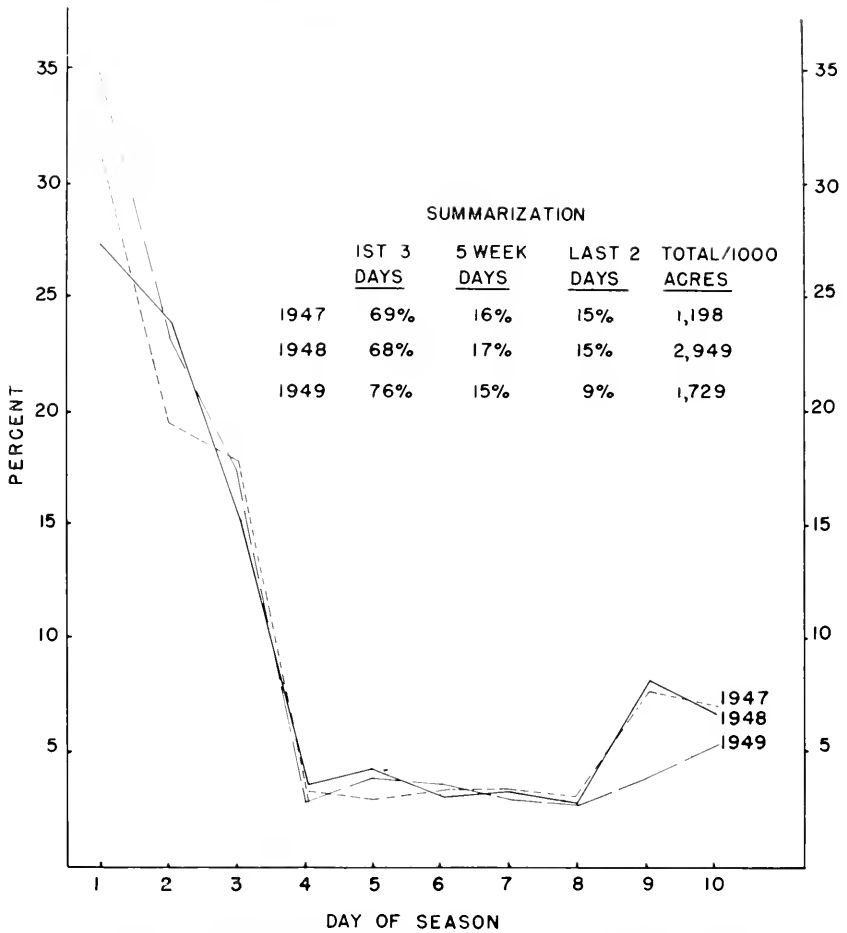

FIGURE 71. Daily percentage of total gun hours on the Sartain Ranch

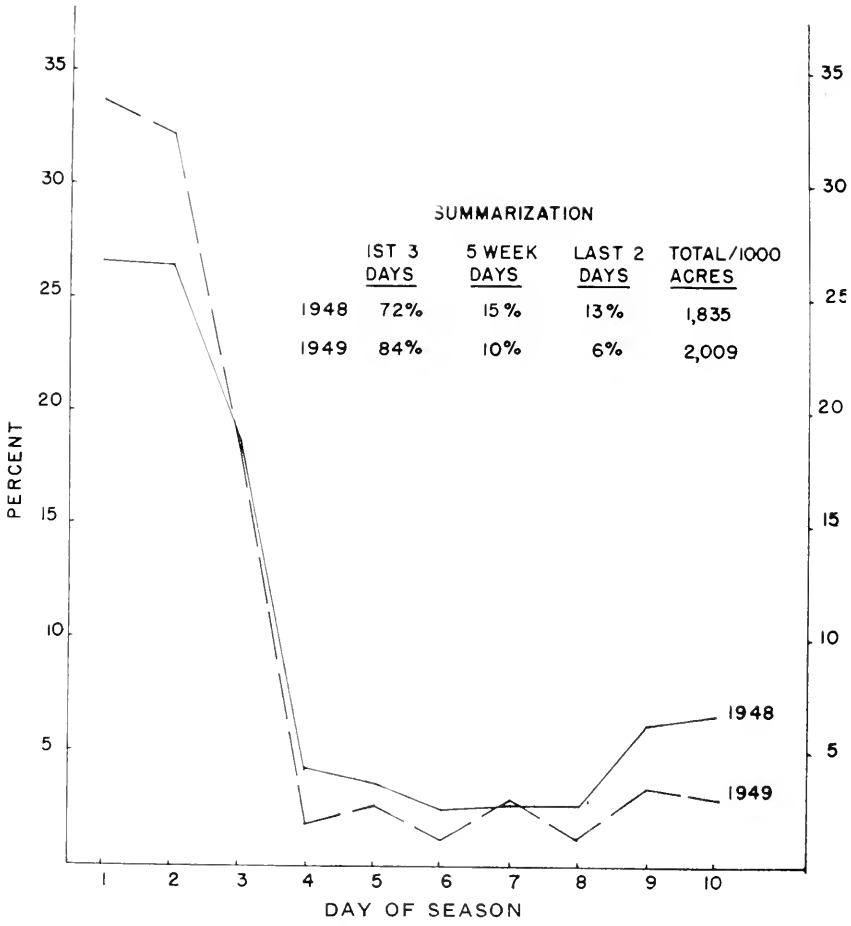

FIGURE 72. Daily percentage of total gun hours on the McManus area

Daily percentage of gun hours is shown for the Sartain area in Figure 71 and for the McManus area in Figure 72. Distribution of hunting pressure throughout the season has been similar each year with the heaviest pressure being exerted during the first three days. Week days have had light pressure followed by an increase on the last two days.

Residence of Hunters

In order to evaluate the importance of pheasant hunting in the Sacramento Valley to the State as a whole, the region of residence of hunters was recorded (Table 8).

As considerable publicity had been given to the Sartain ranch, it received greater nonlocal pressure than adjacent areas. In each year of the study the bulk of the hunting during the entire season was done by residents of the San Francisco Bay area. Hunting by local people was second in importance, while relatively small numbers of hunters were from other regions.

TABLE 8

Percentage of Hunters by Region of Residence—1947, 1948 and 1949 Seasons

	McManus Area									Sartain Area								
	Opening 3 days			Weekdays			Final weekend			Opening 3 days			Weekdays			Final weekend		
	1947	1948	1949	1947	1948	1949	1947	1948	1949	1947	1948	1949	1947	1948	1949	1947	1948	1949
Local	50.5	49.5	39.3		58.0	60.0	66.8	56.5	53.4	29.7	29.2	21.6	58.2	35.5	26.2	39.3	26.8	34.0
San Francisco Bay Region	27.9	29.0	37.9		19.6	18.6	17.0	24.2	32.0	43.3	17.0	47.4	19.6	37.4	39.2	37.7	59.2	47.6
Southern California	5.3	3.8	6.8		7.5	3.6	2.3	1.5	1.2	6.2	6.7	11.2	6.9	9.8	13.8	0.0	0.6	1.1
San Joaquin Valley	3.4	5.1	3.3		4.0	5.0	1.2	3.9	0.1	6.1	3.9	6.0	2.6	3.2	4.7	3.5	1.5	3.7
Other Sacramento Valley	5.0	3.5	3.3		2.8	2.4	4.6	3.5	3.6	6.0	6.7	6.2	6.7	7.1	4.7	14.4	4.7	7.0
Other	7.9	9.1	9.4		8.1	10.4	8.1	10.4	9.5	8.7	6.5	7.6	6.0	7.0	11.4	5.1	7.2	6.6

Local—Plumas, Butte, Colusa, Glenn, Sutter, Yuba, Nevada Counties.

San Francisco Bay Region—Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Sonoma, Napa Counties.

Southern California—Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.

San Joaquin—San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Kern, Tulare, Mariposa, Tuolumne Counties.

Other Sacramento Valley—Placer, El Dorado, Amador, Sacramento Counties.

Other—All other counties, and out of state.

The situation on the McManus area was somewhat different. The greatest number on this area were local hunters and hunters from the San Francisco Bay area were second. Again, hunters from the other regions were few.

Kill

The kill of wild resident birds on the Sartain area in 1949 was 1,073. This is 347 less than were killed on the unplanted McManus area. In 1948, there was a kill of 290 more wild birds on the Sartain ranch than on the McManus area. The higher kill on the McManus area in 1949 can be attributed partly to a hunting pressure estimated to be 45 percent greater than that on Sartain's. Further, the immediate preseason and inseason

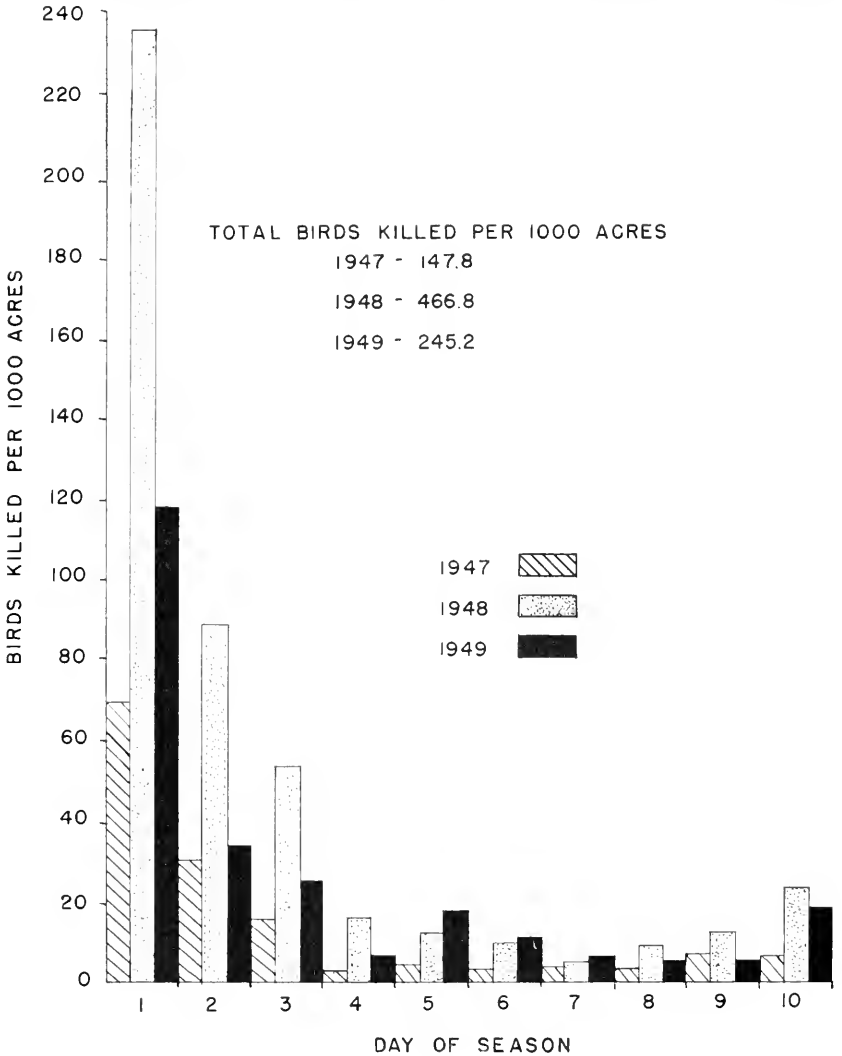

FIGURE 73. Kill per 1,000 acres per day on the Sartain Ranch

releases of game farm birds on Sartain's would have tended to reduce hunting pressure on the wild stock there.

Birds Killed Per 1,000 Acres

Figures 73 and 74 show the number of birds killed per 1,000 acres each day of the season on the Sartain and McManus areas from 1947 to 1949. On the Sartain area the total kill, which included both wild and

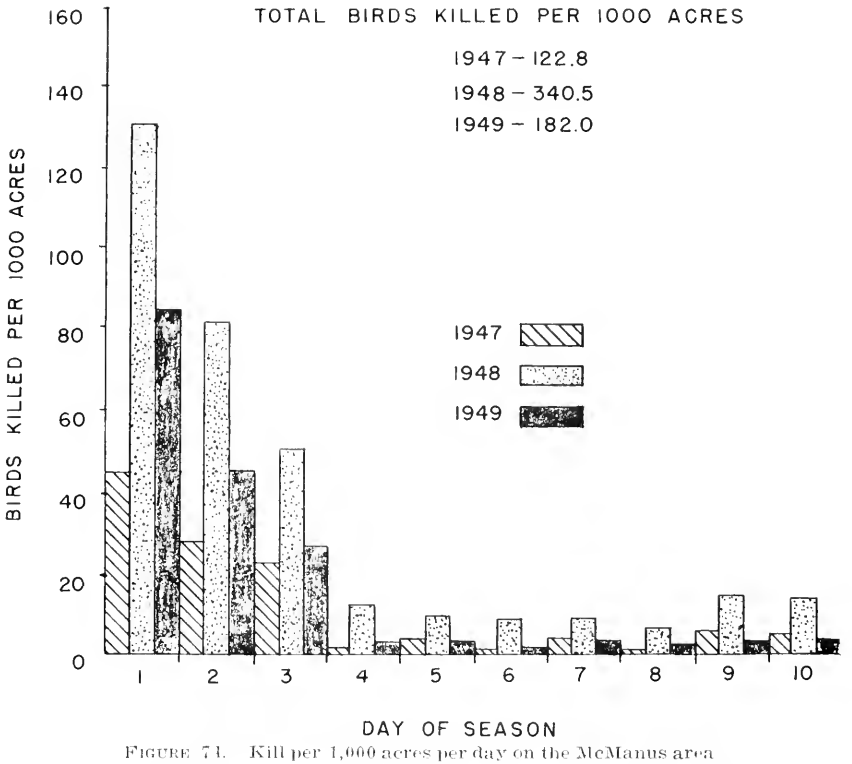

FIGURE 74. Kill per 1,000 acres per day on the McManus area

game farm birds, was 147.8 per 1,000 acres in 1947, 466.8 in 1948, and 245.2 in 1949. On the McManus area, where no game farm birds were planted, the kill was 122.8 per 1,000 acres in 1947, 340.5 in 1948, and 182.0 in 1949. The kill per 1,000 acres on the Sartain area has exceeded that on the McManus for every year, but the hunting pressure, with the exception of 1949, has also been greater. Also, the kill of stocked birds on Sartain's increased the take per 1,000 acres. Total resident wild bird kill on Sartain's in 1949 was 1,073; this would give a bag of 155.5 birds per 1,000 acres which is 26.5 less than for the McManus.

The rise in kill on the last day of the season on Sartain's in 1948 and 1949 was due to shooting in the restricted zone (Figure 73). Hunting on the 1,280 acres in this zone was negligible until the last day of the season and consequently it acted as a refuge until that time.

Kill by Day

Day by day take on both areas followed the same general trend each year. On Sartain's the percentage of total kill by days is shown in Figure 75; the same data for the McManus area are given in Figure 76. The percentage of kill for the first three days, the five week days, and the last two days of the 1947-1949 seasons for both areas is shown in these figures. The rise in the daily percentage of the total kill on the fifth and sixth days of the 1949 season on Sartain's was due to the planting of 193 game farm cocks on the evening of the fourth day. These birds made up 65.0 percent of the total bag on the fifth day and 17.9 percent of the bag on the sixth day of the season (Figure 80). This also had the effect of decreasing the percentage of the total kill made on the first day and first three days of the season by increasing the percentage of kill made during midseason.

The increased percentage of the total kill occurring in the early part of the season on the McManus area in 1949 can be explained on the basis of hunting pressure. In 1949, 84.0 percent of the season's gun hours was expended in the first three days, whereas 72.0 percent of the hunting was done in this same period in 1948 (Figure 72). This increased hunting

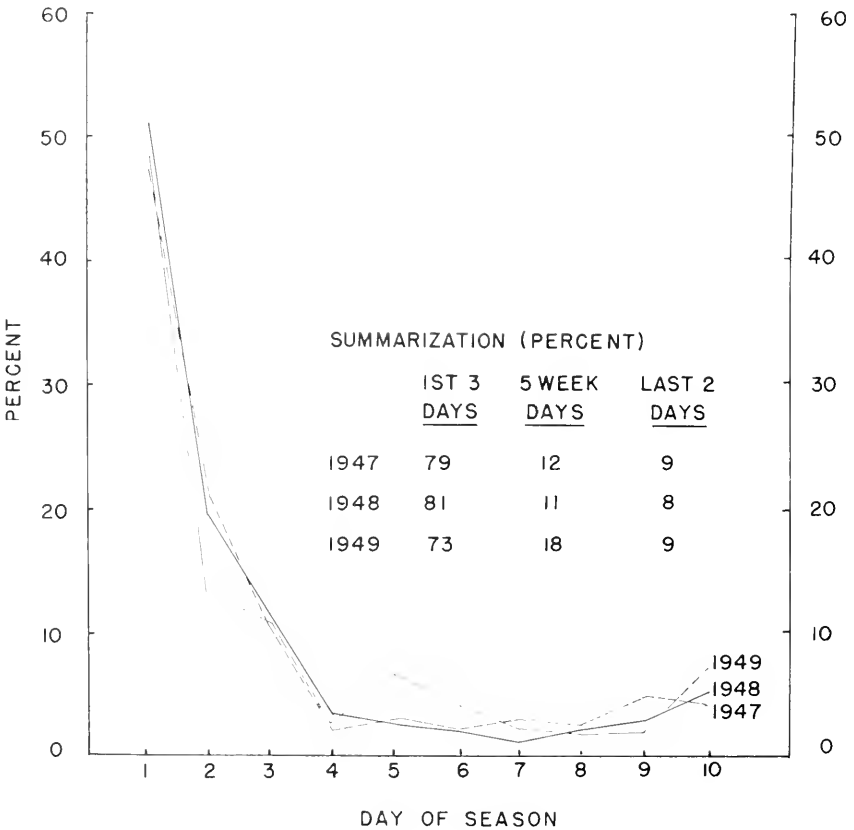

FIGURE 75. Daily percentage of birds killed on the Sartain Ranch

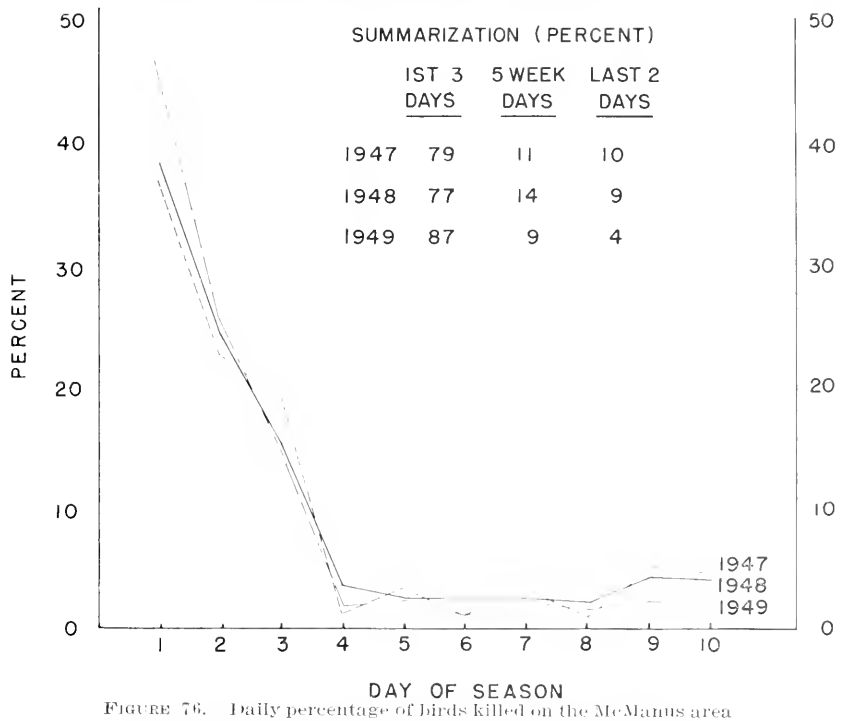

FIGURE 76. Daily percentage of birds killed on the McManus area

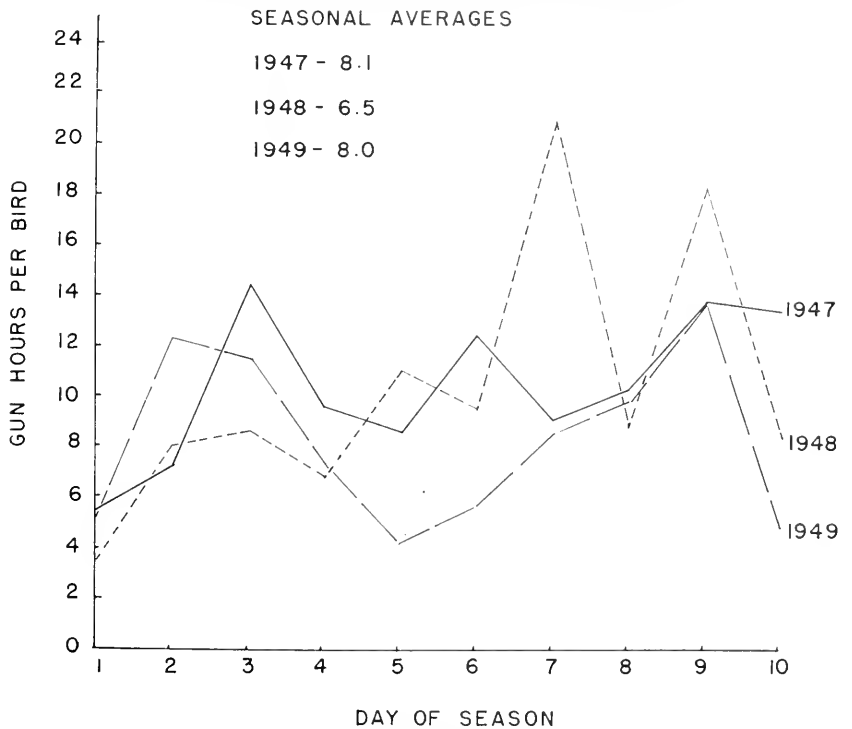

FIGURE 77. Hunter success as measured by gun hours per bird on the Sartain Ranch

pressure on a smaller cock population resulted in a larger percentage of the total kill being made early in the season.

Hunting Success

Hunting season success can be expressed as birds killed per hunter or gun hours per bird bagged. Birds per hunter are given in Table 4 for 1947, 1948, and 1949, and gun hours per bird are shown day by day for each year in Figures 77 and 78. Figures 84 and 85 show the relation of

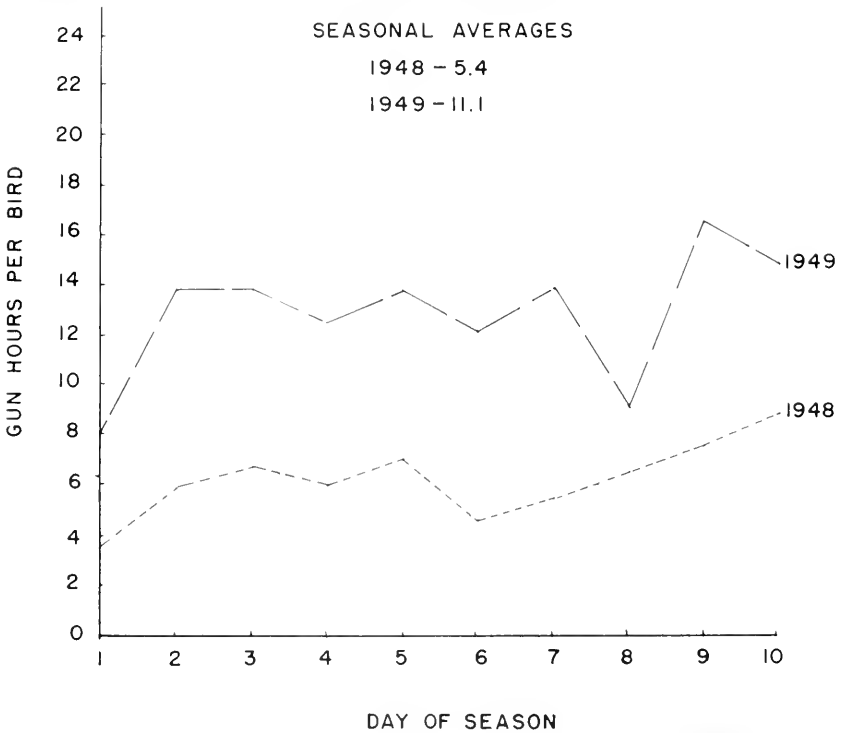

FIGURE 78. Hunter success as measured by gun hours per bird on the McManus area

pressure and cock population in the field to success each year. The high success ratio in 1949 on Sartain's as compared with McManus is undoubtedly due to the heavy plant of game farm and wild birds before and during the season. If the kill of these is deducted from the total kill, the success per hunter drops from 0.60 to 0.38 birds per hunter, which is comparable to the McManus for 1949. In other years, success on the two areas was similar. Table 9 shows the birds per hunter for each day of the season for both areas during 1949.

TABLE 9

Birds Per Hunter Day, 1949

	Day of season										Season's average
	1	2	3	4	5	6	7	8	9	10	
Sartain	.96	.32	.36	.19	.98	.63	.38	.36	.27	.84	.60
McManus	.50	.26	.27	.29	.25	.29	.27	.34	.25	.23	.34

Success is highest on the first day and decreases considerably on the second and third days. More hours are required per bird bagged on each successive day. After the third day, when heavy pressure drops off, success increases slightly as fewer and more persistent hunters are in the field. Success reaches a low point on the last two days although pressure increases. However, the heavy kill in the restricted zone on the Sartain ranch on the last day of the 1948 and 1949 seasons increased the hunter success over the entire area for the day. Of the 125 birds killed that day in 1949, 88 were taken in the restricted zone by 60 hunters.

Higher success per hunter on the fifth and sixth days of the 1949 season on Sartain's is due to the inseason release of 193 game farm cocks on the evening of the fourth day.

Pressure, success, and total population are closely interrelated. Figures 84 and 85 depict these factors graphically. The year of highest cock population on Sartain's was 1948. It supported the greatest pressure (gun hours per 1,000 acres) and gave the highest success (the lowest gun hours per bird). Furthermore, a greater number of cocks was left after the season than in any other year. The pressure in 1949 on McManus was greater than in 1948 and the population was less. Poorer success resulted although the percentage of cocks taken was comparable. Less pressure would have resulted in approximately the same kill. It appears that there has been more pressure each year than was necessary for a satisfactory harvest.

It seems evident that after the first three days of the season the cock population is so reduced that further kill will be slight regardless of additional hunting pressure. A means of closely determining the point of diminishing returns is to compute the number of gun hours expended each year in bagging 80 percent of the kill. These figures are given in Table 10.

TABLE 10

Point at Which 80 Percent of Kill Was Bagged

Year	Sartain		McManus	
	Gun hours/ 1,000 acres	Day of season	Gun hours/ 1,000 acres	Day of season
1947	840	4		
1948	1,965	3	1,381	4
1949	1,475	4	1,526	3

Figures 75 and 76 show that between 40 and 50 percent of the total kill occurs on the first day and between 70 and 85 percent on the first three days. By comparison, 25-35 percent of the pressure comes on the

first day and 70-85 percent on the first three days (Figures 71 and 72). Comparatively few hunters are in the field after the first three days.

The rate of decreasing success throughout the season indicates that a longer season would have little effect in increasing the total kill. Conversely, a shorter season would still yield about the same bag.

Kill of Stocked Birds vs. Resident Wild Birds

The kill on Sartain's was increased by planting game farm stock, and in 1949 by transplanted wild birds. Figure 79 gives the relative importance in 1948 and 1949 of stocked and resident birds in the daily and seasonal kill. In 1947 the kill from 300 game farm birds made up 9.6 percent

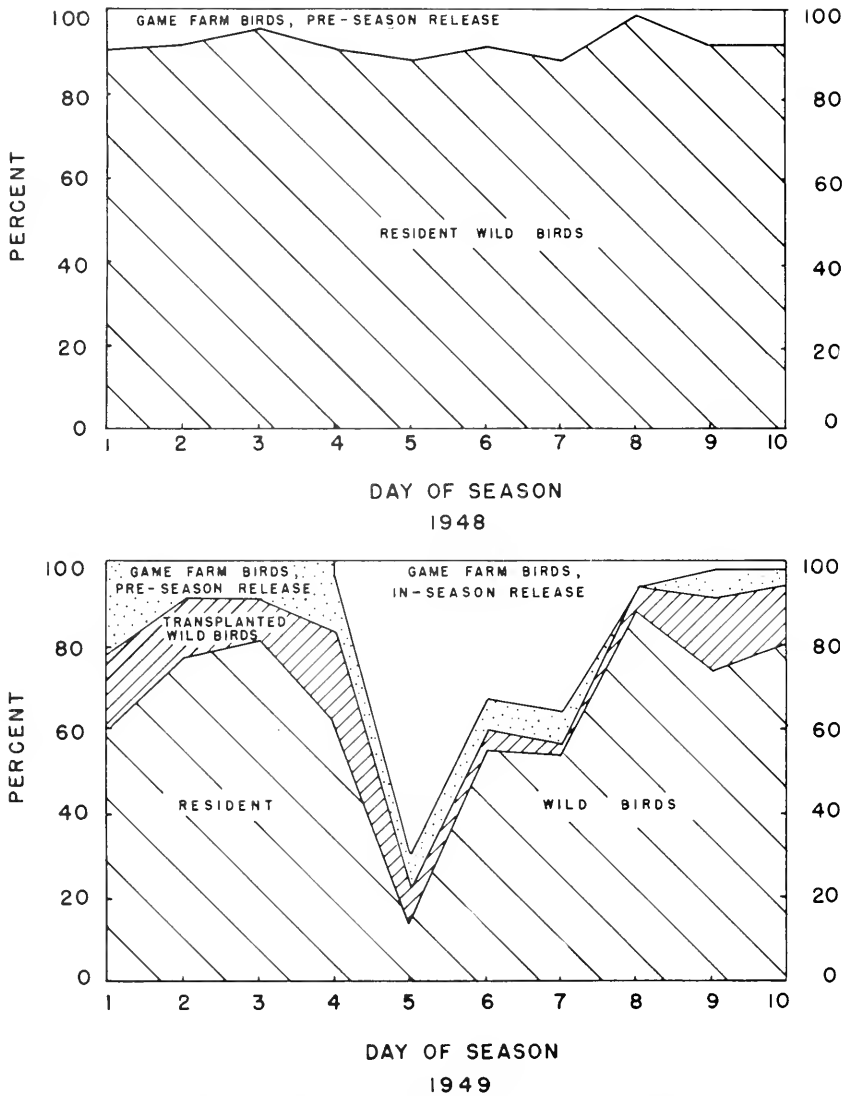

FIGURE 79. Daily composition of kill on the Sartain Ranch

of the total bag. The bag from 799 game farm birds released in 1948 made up 8.7 percent of the seasonal kill. However, 36.8 percent of the kill in 1949 was from 1,515 birds stocked during the year. Of this, the kill from the 1,041 game farm birds was 22.5 percent of the total seasonal kill and the kill from 474 transplanted wild birds was 14.3 percent. Thus it can be seen that the bag of game farm birds in relation to numbers released was of little importance in the total kill in 1948, but in 1947 and 1949 the kill of stocked birds was more significant. The percentage of stocked birds in the bag is a reflection of the population level of wild birds for the year.

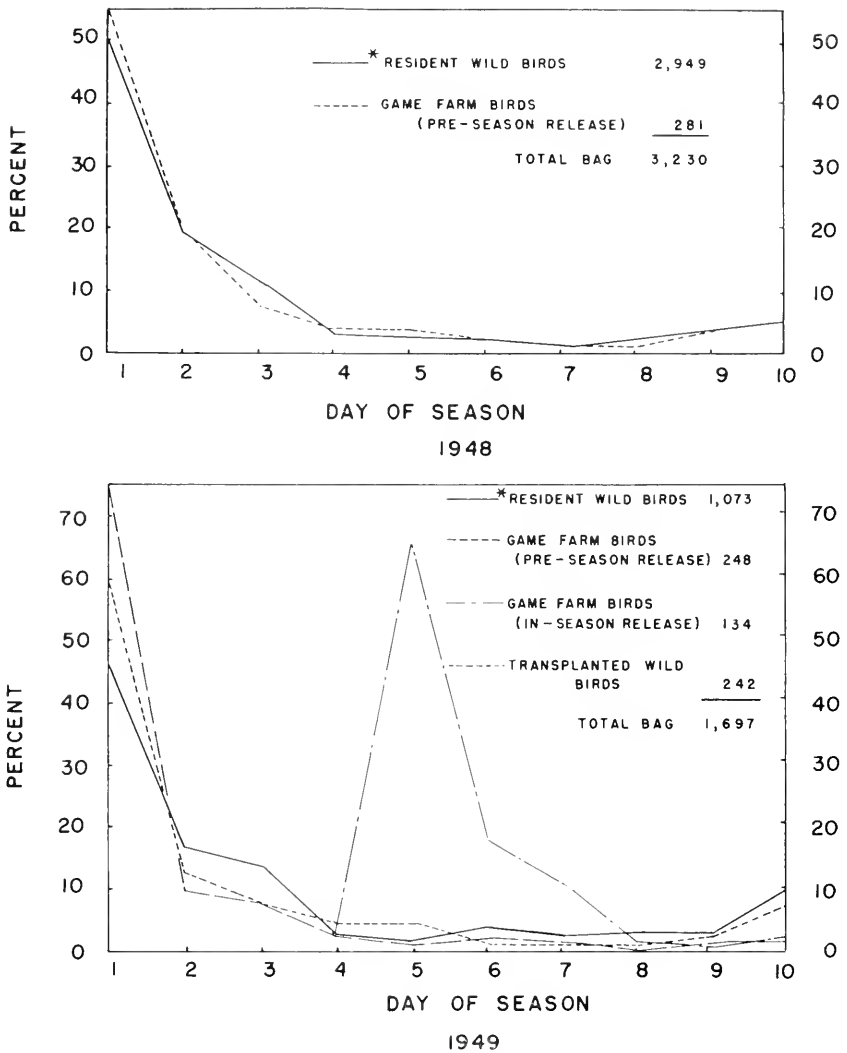

FIGURE 80. Daily percentage of total seasonal wild bird and game farm bird kill on the Sartain Ranch. "* Resident wild birds" includes game farm birds from previous years; 1948—3, 1949—9.

In 1948 the number of pheasants, especially cocks, in the Sacramento Valley was considerably greater than in either 1947 or 1949.

Of the total seasonal kill in 1949, 45.9 percent of the wild residents, 75.0 percent of the preseason game farm release, and 59.5 percent of the transplanted wild birds were taken on the opening day (Figure 80). In contrast to this, 50.4 percent of the total kill of wild resident birds and 54.6 percent of the bag of game farm birds were taken on opening day in 1948. The higher take of game farm and transplanted wild birds on opening day in 1949 was due to the location where these birds were liberated. As stated previously, all releases of birds were made on a 1,680 acre tract under the pheasant planting policy. Hunting pressure on this and closely adjacent areas was considerably higher than on any other part of the ranch. This resulted in the take of these birds in a higher proportion to wild resident cocks than occurred in 1948, when the game farm cocks were more evenly distributed over the ranch and hunting pressure on the first day was not concentrated in the areas of release.

Age Ratios

The method employed in aging birds in 1947, 1948, and 1949 was by probing the bursa of Fabricus. The results obtained are considered to be accurate, if the validity of bursa measurements for age determination can

TABLE 11

Age Groups of Kill

Year	Sartain						McManus					
	Adults		Indeterminate		Young		Adults		Indeterminate		Young	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1947	12	11.7	2	1.9	89	86.4	36	15.9	7	3.1	183	81.0
1948	11	4.1	3	1.1	252	94.7	41	13.1	9	2.9	257	83.7
1949	46	17.5	8	3.0	209	79.5	54	23.5	12	5.2	164	71.3

be relied upon, as all probing was done by experienced personnel and a sample of each day's kill was taken. Table 11 shows the age groups of the kill from 1947 to 1949. The 1949 data indicate a decrease in percentage of juvenile birds in the populations on both areas from 1947 and 1948. The spring nesting and brood count studies indicated that there would be a decreased number of young birds in 1949.

Figure 81 shows the frequency distribution of bursa depths of birds killed on the Sartain area. Comparable data for the McManus area are given in Figure 82. Each year these data have been distributed in the form of a bimodal curve with gaps at the 6-8 mm. class. This class has been considered to be birds of indeterminate ages rather than adult or juvenile. It is believed that these birds are either adults that have retained deep bursae or juveniles that have had a more rapid shortening of bursae than others. However, in 1949 there was an indication that bursa measurements for age determination are not as reliable as was once believed.

It has been said that the kill of adult birds rises during the last part of the season and that a larger percentage of the immature birds are shot during the first days of the season. The percentage kill of young birds in each day's kill in 1949 is shown in Figure 83. The curve reflects a fairly equal kill of adults and young in each day's take. Although there are variations from day to day, there is no indication that young birds are taken in higher proportion in any particular part of the season.

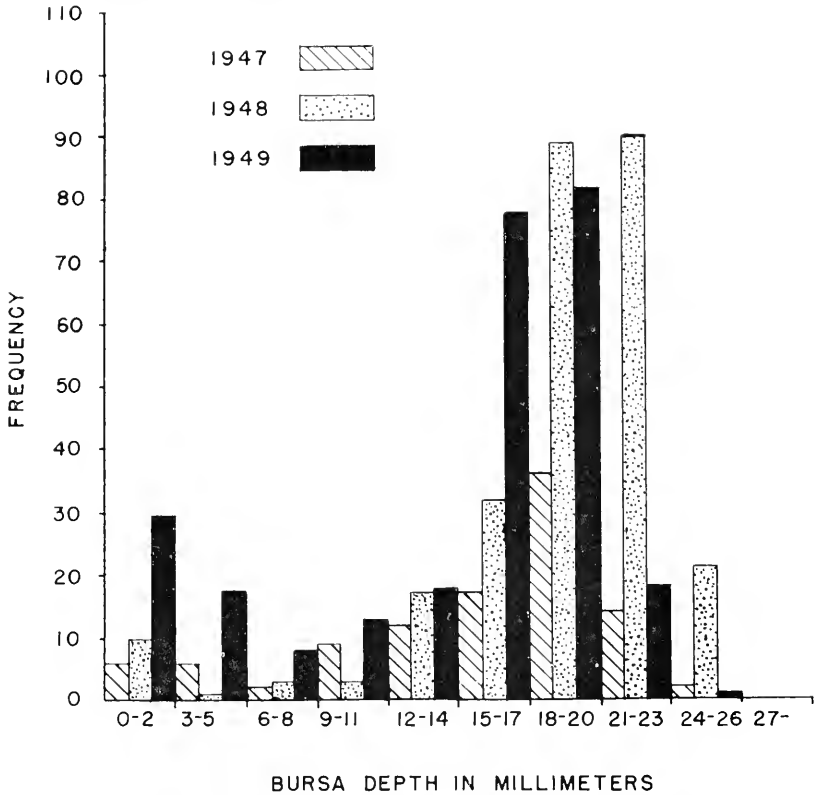

FIGURE 81. Frequency distribution of bursa depths, Sartain area

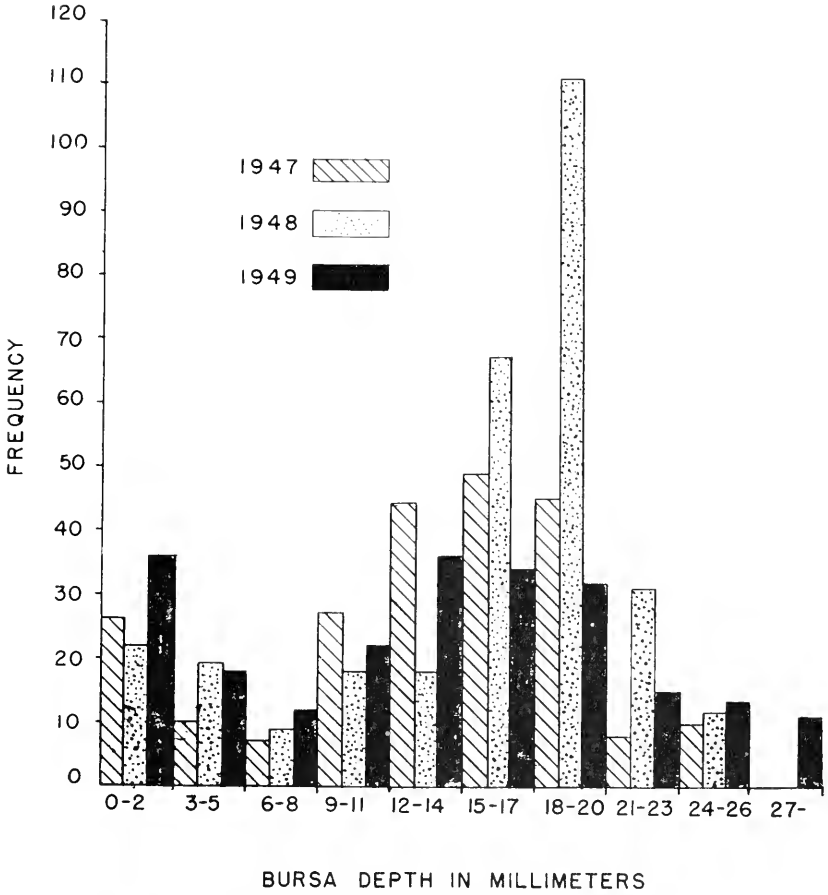

FIGURE 82. Frequency distribution of bursa depths, McManus area

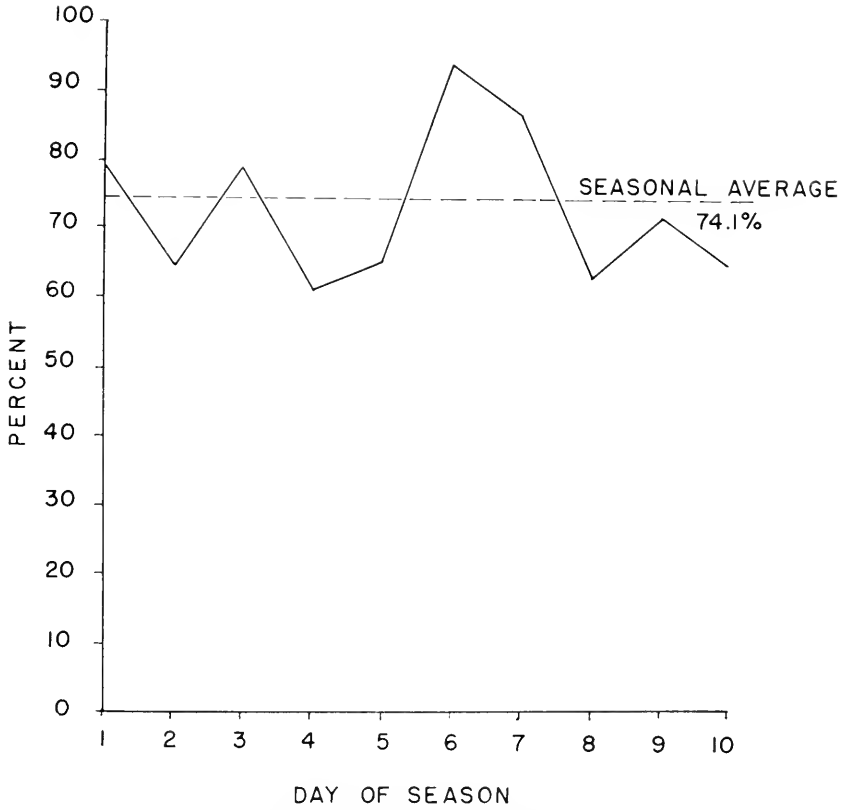

FIGURE 83. Percentage of young birds in each day's kill of wild birds, Sartain and McManus areas combined, 1949

POPULATIONS

Information on cock-hen ratios needed for satisfactory reproduction in the wild was obtained in the course of this study. Extremely high hunting pressures each year reduced the cock population on the study areas to 15 or less cocks per 100 hens. The postseason sex ratios on the Sartain area were 3.4:100 in 1946 and 5.4:100 in 1947. Each year these ratios resulted in apparently normal reproduction. Low sex ratios on both areas were probably increased before the breeding season by an influx of cocks from surrounding areas in which the density of cocks was higher. A count on Sartain's, early in the spring of 1947, showed that the sex ratio had increased to 22:100.

The density of the hen population was probably another factor contributing to high fertility that occurred with low sex ratios. From 1947 to 1949 the average acres per hen varied from 1.1 to 1.7 on the two areas, making it possible for a cock to collect a large harem from a small area.

With habitat conditions that exist in the Sacramento Valley, it does not appear that hunting pressure can reduce the cock population to the point where fertility will be endangered. Stocking of cocks to provide apparently favorable sex ratios for breeding is, therefore, unnecesary.

Population Indices

Differential Sex Ratio Method

The approximate total populations of the two experimental areas can be computed by use of the Kelker Index, using preseason and postseason sex ratios and total kill in the following formulae:

$$\frac{\text{Preseason sex ratio times hen kill minus total cock kill}}{\text{Postseason sex ratio minus preseason sex ratio}} = \text{Postseason hen population}$$

Postseason hen population plus hen kill = Preseason hen population

Preseason hen population times preseason sex ratio = Preseason cock population

Preseason cock population minus total cock kill = Postseason cock population

Crippling losses must be added to the checked cock kill to obtain total cock kill figures. In 1947 and 1948 the crippling loss was estimated at 30 percent of the number of cocks bagged, and illegal kill of hens was estimated at 5 percent of the cock bag. Crippling loss of cocks in 1949 was estimated at 20 percent of the bag, based upon hunter questionnaires.

TABLE 12

Yearly Values Used in Calculating Total Populations by Use of the Kelker Index

	Sartain			McManus		
	1947	1948	1949	1947	1948	1949
Preseason sex ratio[1]	.34	.88	.57	.37	.70	.36
Postseason sex ratio[1]	.05	.15	.15	.10	.10	.10
Checked kill of cocks	1,023	3,150	1,481	958	2,656	1,420
Crippling loss of cocks[2]	307	945	296	287	797	284
Hen kill	51	158	74	48	133	71

[1] Males per female.
[2] Considered to be 30 percent of cock bag in 1947 and 1948, and 20 percent in 1949.

Table 12 gives the data that are needed to use the Kelker Index. Sex ratios are given as cocks per single hen, as used in the formula. Kill of the game farm birds released on Sartain's after preseason sex ratios were taken are not included in the checked kill of cocks. Harvest of these releases of game farm birds was so complete that the survivors were considered to have little effect upon postseason sex ratios.

The above sex ratio formula differs slightly from the one used in 1947 and 1948 hunting season reports. For comparison, populations for

TABLE 13

Approximate Total Pheasant Populations and Percent of Cock Kill

	Preseason			Postseason			Percent cock kill
	Hens	Cocks	Total	Hens	Cocks	Total	
Sartain							
1947	4,600	1,550	6,150	4,500	230	4,730	85
1948	5,600	4,900	10,500	5,400	810	6,210	83
1949	4,200	2,400	6,600	4,100	620	4,720	74
McManus							
1947	4,600	1,700	6,300	4,500	450	4,950	74
1948	5,700	4,000	9,700	5,600	560	6,160	86
1949	6,500	2,300	8,800	6,400	620	7,020	73

all three years have been calculated using the same method. Table 13 gives rounded-off population figures and the percentage of the cock population killed each year.

There is a direct proportion between the cock population before the season and the number of cocks left after the season. When the preseason population is high, the postseason is high, although the percentage remaining is closely similar from year to year (Figures 84 and 85.)

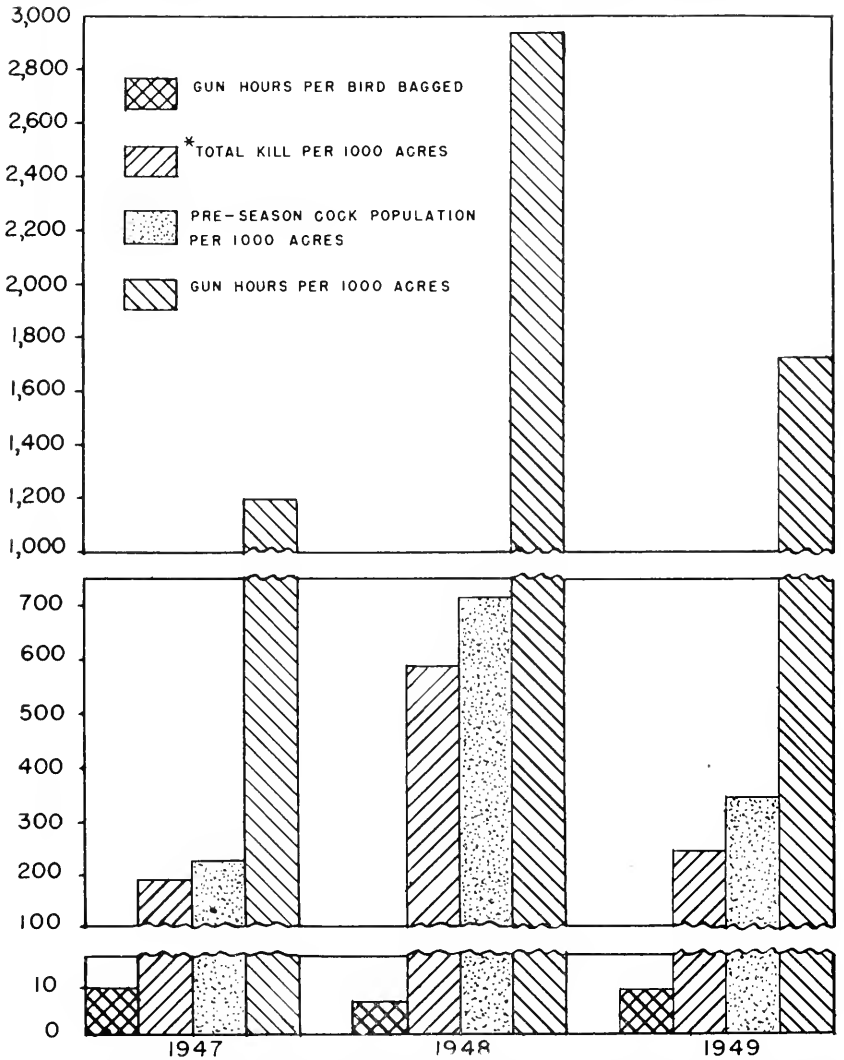

FIGURE 84. Pressure-success-population relationships on the Sartain Ranch. "* Total kill per 1,000 acres" includes crippling loss, but not the kill from game farm releases made after October.

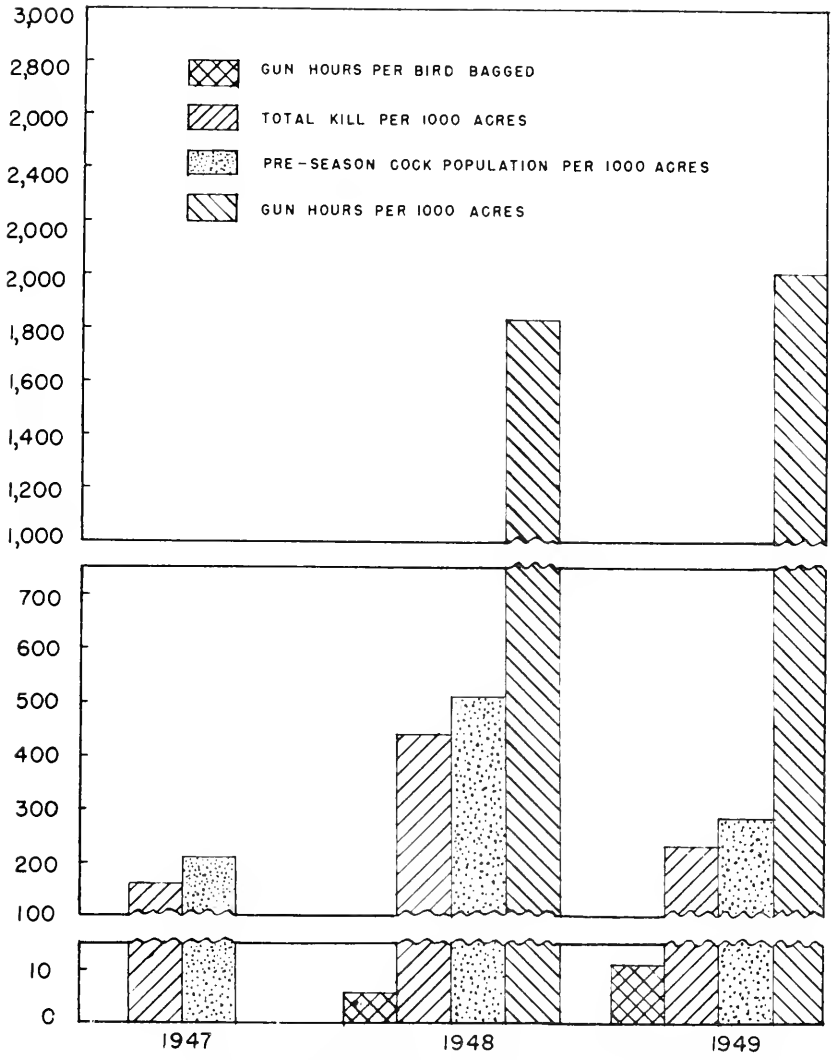

FIGURE 85. Pressure-success-population relationships on the McManus area

Lincoln Index

This method involves a simple proportion:

$$\frac{\text{Cocks present before season}}{\text{Total cocks killed}} = \frac{\text{Total number banded birds}}{\text{Number banded birds killed}}$$

In computing the pheasant population in 1949 on the Sartain area, returns from wild transplanted birds were used. A total of 98 bands was returned from 150 adult and juvenile wild cocks released on Sartain's during September and October. The total checked kill on the area,

subtracting the kill of game farm birds released after October, was 1,481. The above data substituted in the Lincoln Index give:

$$\frac{X}{1{,}481} = \frac{150}{98}, \text{ and}$$

$$X = 2{,}267 \text{ cocks before the season.}$$

Rounding this figure off in the same manner used with Kelker Index figures gives a preseason cock population of 2,300. This compares very closely with the figure of 2,400 obtained by use of the Kelker Index.

There was no basis for using the Lincoln Index to check on population figures of the McManus area because no birds were banded.

Effect of Game Farm Hens on Total Population

Calculated total population figures show that the over-all effect of heavy stocking of game farm birds as a means of increasing the total population by breeding was at best slight and possibly of no significance. Reproduction by 500 hens released in 1947 and by 560 hens released in 1948 on Sartain's would have affected the 1948 and 1949 population figures if the effect were of measurable extent. The 650 hens released in 1949, of course, could not yet have affected the population by breeding. However, as shown in Table 14, the population per unit area was greater on Sartain's in 1947, increased over the McManus area somewhat in 1948, but was less in 1949.

TABLE 14

Approximate Pheasant Populations Per 1,000 Acres Before the Hunting Season

	1947	1948	1949
Sartain	890	1,520	955
McManus	805	1,245	1,130

It should be borne in mind that population figures on Sartain's include survivors of game farm releases made before November of each year. These include 220 birds in 1946, 800 in 1947, 1,259 in 1948, and 1,399 in 1949—a total of 3,658 game farm birds. Yet, even with these game farm birds, the population on Sartain's, which was 22 percent greater than that on the McManus area in 1948, was 15 percent less in 1949.

The question arises as to what happened to the game farm hens released on the Sartain area, if their release made no noticeable effect on the pheasant population. Follow-up searches made soon after liberations, near release sites, showed that mortality of game farm birds of both sexes was often great. All birds were released in good condition before the heat of the day, with time spent in crates less than four hours and hauling distances not more than 35 miles.

During live trapping operations using spotlights at night in the summer of 1949, 277 adult hens were caught on Sartain's. These included only four game farm hens from 1948 releases, while there were none from 1947 releases. Thus game farm hens, making up approximately 6 to

10 percent of the hen population when released, made up only 1.5 percent of a sample of the same population one year later, and had disappeared entirely two years later.

SURVIVAL AND RETURN OF GAME FARM BIRDS

Banded game farm birds were released on the Sartain study area from 1946 to 1949. Birds from 6 to 12 weeks of age were stocked to determine the best age to plant for survival from summer releases. All age classes in a release were liberated at the same site. Older age groups were stocked to measure return in relation to length of time in the field before the hunting season. In 1949, the various age classes were released on dates corresponding as closely as possible to the 1948 release dates. A summary of 1948 and 1949 plants with hunting season returns is presented in Table 15.

TABLE 15

Return of Game Farm Birds From Sartain Releases by Age Classes and Days in the Field, 1948 and 1949

Age released (weeks)	Number released	Date of release	Days in field (before season)	Percent return	
				1948	1949
6	50	June 11	159–161	8	10
8	50	11	161	10	--
6	50	24–25	146–147	4	4
8	50	24–25	146–147	22	16
10	50	25	147	50	--
6	50	July 15	125	--	2
8	50	15	125	--	22
9	50	15	125	--	36
6	50	August 5–18	93–106	0	0
8	50	5–18	93–106	14	22
10	50	5–18	93–106	28	12
12	100*	12–18	93–99	35	24
11	100	September 11	66	13	--
14	100	13	65	--	16
14	100	October 14	34	--	56
16	100	18	32	55	--
16	99	November 17	2	81	--
18	99	16	2	--	84
Sub-totals 1948	799			35	32
1949	848				
20	193	November 21	In season	--	69
Grand totals 1948	799			35	39
1949	1041				

* 99 birds in 1949.

Mortality Soon After Release

Following liberation of 1,399 birds of both sexes in 1949, 109 dead birds (7.8 percent) were found. In 1948, 20 dead birds (1.7 percent) were found from a total of 1,160 liberated. More thorough follow-up searches were made in 1949 which accounted for the greater number of dead birds found. Numerous additional remains were found in the vicinity of release, but were not counted in the total as bands could not be located. Actual losses were greater as only small areas about release sites were searched. Consequently, birds moving away before dying were not found. Figure 86 shows immediate mortality of game farm birds released

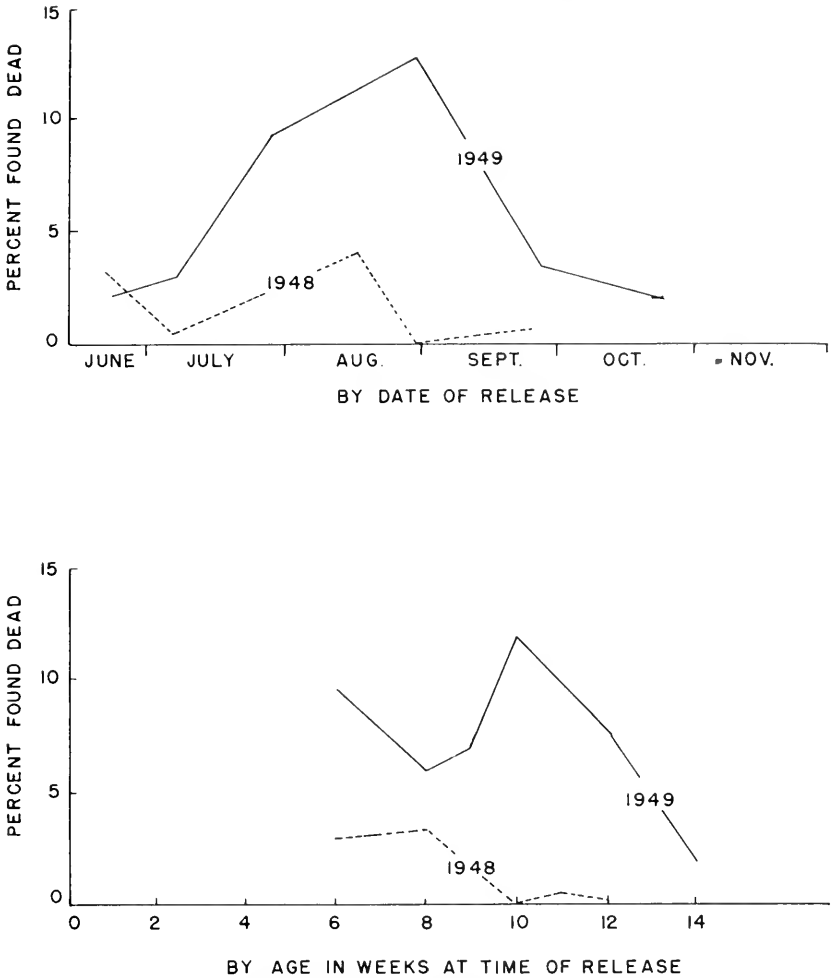

FIGURE 86. Known mortality of game farm birds soon after release on Sartain Ranch

on different dates and at various ages. August releases of both 1948 and 1949 appear to be subjected to greater mortality than those of any other single release. This is further reflected in fewer hunting season returns from these releases (Figure 87).

There appears to be a relation between ages of birds at release and subsequent mortality. In general, more birds of younger age classes were found dead than of older classes, perhaps because older birds disperse more readily. Younger birds (6 to 10 weeks old) were found flocked even after several weeks in the field. This increased the possibility of a single predator killing a large number. Releasing birds in small groups throughout the area to be stocked may reduce the possibility of large number of birds being killed while they are concentrated near releasing points.

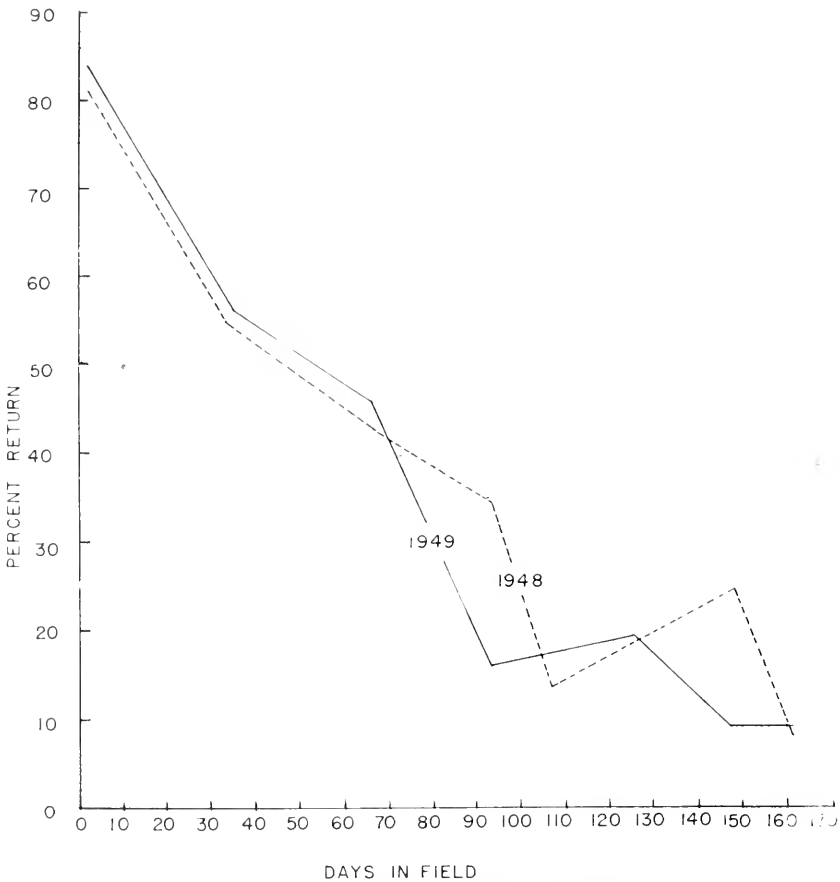

FIGURE 87. Comparison of returns from preseason releases of game farm cocks on the Sartain area

Feral house cats are by far the greatest cause of mortality of game farm birds in the Sacramento Valley. Many of the birds listed as dead from unknown causes apparently were unable to make the transition from game farm conditions to surviving in the wild and died of shock or other unrecognizable causes. Table 16 presents known mortality data.

TABLE 16

Mortality Factors of Game Farm Birds on Sartain's 1948-1949

	House cat	Automobile	Unknown
1948	2	3	15
1949	68	7	34
Totals	70	10	49
Percent	54.3	7.7	38.0

Hunting Season Returns

Of the 848 game farm cocks released before the season in 1949, bands from 31.9 percent were returned. This compares closely with the 35.0 percent return from 799 cocks planted in 1949 and the 32.7 percent return from 300 males stocked in 1947. The 1947 plant consisted of 14-week-old cocks liberated September 10-12. In 1946, 220 cocks, 18 weeks old, released in mid-October produced a 37.7 percent return.

The return of game farm cocks in 1949 was comparable to the 1948 return for similar age classes and days in the field before the season. When two or more age classes were released at the same time, older birds gave greater returns, as shown in Table 15. The single exception to this occurred in returns from 8- and 10-week birds released in August, 1949, when a greater percentage of eight-week birds was returned.

Returns from birds in the field longer than 66 days before the season were variable and, with one exception, less than 40 percent. Cocks in the field 66 days or less yielded returns tending to be inversely proportional to the length of time in the field. Greatest returns were approximately 81 and 84 percent from birds released two days before the season. Cocks liberated 65-66 days before the season yielded returns of 43-46 percent, while those in the field approximately half that time gave returns of 55-56 percent, which is only 10-12 percent greater. An inseason release of 193 game farm cocks (age 20 weeks) in 1949 gave a return of 69.4 percent. These figures show that releases should be made during a short period of time before the season opens if maximum returns are the primary objective.

In 1949, lower returns from the inseason release than from the release made two days before the season demonstrates that hunting pressure, in addition to survival, is an important factor in the kill return of game farm birds. The inseason release was subjected to a minimum hunting pressure of 379 gun hours per 1,000 acres (last five days of season) to yield a return of 69.4 percent. The immediate preseason release had a pressure of 1,722 gun hours per 1,000 acres (all 10 days) and gave a return of 83.8 percent, which is 14.4 percent greater. In contrast to this, returns from game farm birds in the field 66 days or less in 1948, when hunting pressure (10 days) was 2,949 gun hours per 1,000 acres, corresponded closely with returns in 1949. Assuming that survival of these birds was approximately the same for both years, the lower but still intensive seasonal hunting pressure exerted in 1949 was sufficient to harvest maximum returns.

The relationship of hunting pressure to returns of game farm birds is not clearly understood, but the data indicate intensive hunting pressure as well as liberating birds a short time before the hunting season is necessary to harvest maximum returns of game farm birds.

Survival of game farm birds from releases made in June and July was evidently greater than that of birds liberated in the first half of August, even though their period of time in the field before the season was a month or more longer (Figure 87). Releases of six-week birds in early August were the only ones which resulted in no returns during 1948 and 1949. This indicates that conditions in early August were generally unfavorable for the liberation of pheasants on the Sartain area and possibly throughout the general rice growing section.

Returns of game farm cocks in the field longer than one year were very low. In 1949 a total of nine birds, representing a 1.1 percent return, was killed from game farm releases made in 1948 on the Sartain ranch. A total of three, or 1.0 percent return, was killed in 1948 from birds liberated before the previous (1947) hunting season. These birds made up a minute percentage of the total kill on the area, and it is evident that returns from game farm cocks on a heavily hunted area are insignificant after the first hunting season following their release.

Game farm birds in the field a month or more before the hunting season evidently are not killed any more readily than are wild birds on a heavily hunted area. In 1948 the daily percentage of the total seasonal wild bird kill and kill of all game farm birds was remarkably constant throughout the season, as shown in Figure 80. In 1949 the percentage of the total seasonal kill made on the first day of the season was nearly 30 percent greater for game farm birds than for wild birds. This increase was due to very heavy hunting pressure in the preseason release area, as discussed before. The percentage of the total seasonal kill of game farm birds made on the first day of the 1949 season was greatly increased by the take of game farm stock released two days before the season. For this group of birds, 84.4 percent of the total kill was made on the first day, and 96.4 percent in the first three days of the season. The kill of inseason-released game farm birds occurring on the first day after release was 64.7 percent of their total kill, and 95.5 percent was taken by the end of the third day. It is evident that game farm birds released in season or a few days before the season are harvested more readily by hunters than are other birds.

Information gained in the course of the study shows that failure to recognize game farm or other banded birds in the bag because of loss of bands was not an important factor. Birds less than nine weeks of age were wing banded, and in 1949 all cocks nine weeks of age or older were both wing and leg banded. The use of both types of bands provided a check on loss of each. During the 1949 hunting season on the Sartain area, a total of 563 birds was checked that were known to have been both wing and leg banded. Of this group, four leg bands and 11 wing bands were missing. This is a loss of less than 1 percent for leg bands and approximately 2 percent for wing bands; loss of both bands from a bird would be very rare. Loss of wing bands is in part due to faulty technique of the bander in clipping the wing band through the patagium.

Game farm birds showed little tendency to move off the area. Returns from 405 cocks released in 1949 revealed that 98.3 percent were taken on the study area or along its borders within a radius of two miles from the point of release. One game farm bird released four months before the season was reported killed 14 miles away. All other returns were within a five-mile radius of the release site.

SURVIVAL AND RETURN OF WILD BIRDS

Considerable information on the survival and bag of wild banded pheasants was obtained during the 1949 hunting season on the Sartain area. A total of 763 wild cocks of various age classes was banded and released on Sartain's between July and October. Of these, 474 were transplanted cocks removed from state and federal waterfowl refuges,

and 289 were resident males caught on the Sartain ranch. Age classes of these birds, days in the field before season, and returns are shown in Table 17 for resident birds and Table 18 for transplanted birds. Juvenile

TABLE 17

Returns From Resident Wild Banded Cocks on the Sartain Area, 1949

Age banded (weeks)	Number banded	Date of release	Average number of days in field (before season)	Percent return
5	8	July 27–31	113	62.5
6–8	15			6.7
8–10	38			18.4
10–12	27			29.6
Adult	14			64.3
5	3	Aug. 11–28	90	0.0
6–8	8			25.0
8–10	29			27.6
10–12	96			29.2
12–14	12			33.3
Adult	39			51.3
Total juveniles	236			26.7
Total adults	53			54.7
Grand totals	289			31.8

TABLE 18

Returns From Transplanted Wild Banded Cocks on the Sartain Area, 1949

Age banded (weeks)	Number banded	Date of release	Average number of days in field (before season)	Percent return
6–8	15	July 27–31	113	20.0
8–10	28			42.9
10–12	39			48.7
Adult	21			47.6
6–8	1	Aug. 11–28	90	100.0
8–10	5			40.0
10–12	40			15.0
12–14	14			42.9
Adult	36			61.1
8–10	2	Sept. 7–8	72	50.0
10–12	20			35.0
12–14	39			18.7
Adult	54			63.0
6–8	1	Sept. 22–29	55	0.0
8–10	2			0.0
10–12	8			50.0
12–14	28			67.9
Adult	56			62.5
14–16	21	Oct. 5–11	41	42.9
Adult	44			70.5
Total juveniles	263			45.6
Total adults	211			62.6
Grand totals	474			53.2

wild birds were aged by the moult pattern of the primary wing feathers; bursa probing was necessary to segregate a few juveniles from adults in late September and October.

The hunting season return of 31.8 percent for banded resident birds appears low when compared to returns from other classes of banded

birds. Most of these were caught and banded in the restricted zone of the Sartain Cooperative Hunting Area incidental to the process of developing techniques and equipment for catching pheasants in California at night with the use of spotlights. Hunting pressure was comparatively light on the restricted area and consequently a low return of birds in this area would be expected.

Total returns from transplanted wild birds were 53.2 percent, with juveniles yielding a 45.6 percent return compared to 62.6 percent from adults.

TABLE 19

Comparison of Band Returns From Transplanted Wild Birds and Game Farm Birds on the Sartain Area, 1949

Type of bird	Age released (weeks)	Number released	Date released	Average days in field before season	Percent return
		Comparable Age Groups			
Wild	6–10	43	July 27–31	113	34.9
Game farm	6 & 8	100	July 15	125	12.0
Wild	8–12	45	Aug. 11–28	90	44.4
Game farm	8, 10 & 12	199	Aug. 16	93	20.6
Wild	10–14	59	Sept. 7–8	72	44.1
Game farm	12	100	Sept. 13	65	45.0
Wild	12–16	49	Sept. 22–Oct. 11	48	57.1
Game farm	11	100	Oct. 14	34	56.0
		All juveniles released July 15 - October 14			
Wild	6–16	263			45.6
Game farm	6–14	599			28.9

A comparison of the returns of game farm stock and wild transplanted stock, of comparable age classes and days in the field before the hunting season, is shown in Table 19. The return from 6- to 10-week-old birds released in July is almost three times as great for transplanted wild stock as for game farm birds. Wild birds transplanted in August yielded a return more than twice that of comparable game farm birds. Returns from liberations made in September and October were similar for game farm birds and wild transplanted stock. This indicates that survival of juvenile wild birds was considerably greater than game farm birds of similar age released before mid-August, but almost equal for September and October releases.

Daily percentages of the total seasonal kill of transplanted wild birds were in general comparable to those of resident wild birds (Figure 80). The somewhat greater percentage of kill occurring on the first day among transplanted birds was caused by greater hunting pressure being exerted on these birds which were released in the pheasant planting policy area.

Wild banded birds showed little tendency to move any appreciable distance. Of a total of 344 band returns from wild birds, 96.1 percent was from the Sartain study area or along its borders. None of the adults were taken off the area; all outside returns were from juvenile cocks. A resident juvenile cock banded 3½ months before the season was taken 15 miles away; all other returns were from six miles or less. Transplanted juvenile cocks evidently did not move as much as resident juvenile males,

and adult cocks, both resident and transplanted, did not move off the area after liberation.

MISCELLANEOUS DATA

Aging Methods Used—1946-1949

Birds were aged by three methods during the four-year check. In 1946 and 1947 aging was accomplished by examination of spur lengths and by testing the hardness of the lower mandible. In 1947 the bursa of Fabricius was also used. The first methods were found to be inaccurate and in 1948 and 1949 probing the bursa of Fabricius was employed to determine old-young ratios.

A discrepancy was found in bursa measurements of adult wild birds in 1949. The bursa depths of 35 wild adult birds trapped and banded in the summer of 1949, and killed during the 1949 season, had a variance from 0 to 19 millimeters. The bursa measurements of the 35 adults varied as follows: ten from 10 to 19 mm.; six from 6 to 10 mm.; six between 2 and 6 mm.; and thirteen with no bursa.

Juvenile wild cocks, which were banded in the summer of 1949, were all found to possess a bursa depth of greater than 10 mm. when taken during the hunting season. Further work on banded wild birds will test the validity of measuring the bursa of Fabricius for age determination of wild birds. As stated previously, all measurements were taken by experienced personnel.

Weights

Samples of the birds killed during the 1946-1949 hunting seasons on both the Sartain and McManus areas were weighed in grams on triple beam balances. The weights of wild birds converted to pounds and ounces are given in Table 20.

TABLE 20

Weights of Wild Cock Pheasants From Sartain and McManus Areas, 1946-1949

	Number of birds	Average	Maximum	Minimum
1946	37	2 lbs. 11 oz.	3 lbs. 3 oz.	2 lbs. 2 oz.
1947	197	2 lbs. 11 oz.	3 lbs. 9 oz.	2 lbs. 1 oz.
1948	938	2 lbs. 11 oz.	3 lbs. 6 oz.	1 lb. 13 oz.
1949	461	2 lbs. 10 oz.	3 lbs. 9 oz.	1 lb. 14 oz.
Over-all	1,633	2 lbs. 11 oz.	3 lbs. 9 oz.	1 lb. 13 oz.

The average weight of wild birds was 2 lb. 11 oz. in the first three years and 2 lb. 10 oz. in 1949. In 1949, 44 game farm birds killed had an average weight of 2 lb. 8 oz. which was the same as in 1947 and 1948. The reason for the lower average weight of game farm birds was that the main kill consisted of late-hatched birds released shortly before the season.

CONCLUSIONS

Heavy hunting pressure and game farm stocking have had little effect on pheasant breeding populations in the Sacramento Valley. Under present habitat conditions, regulation of hunting pressures or numbers of hunters per unit of area to preserve male breeders is not necessary. However, controlled hunting reduces the possibility of damage to property and accidents to hunters. The study areas had extreme hunting pressures, probably not exceeded anywhere in the State during the four year

check, yet reproduction by wild stock was satisfactory for maintaining a sustained yield of cocks.

Little is gained by planting game farm birds year after year in high quality pheasant habitat supporting optimum pheasant populations. Very small percentages of game farm cocks and hens live until spring and thus do not measurably increase the breeding population.

The seasonal kill has not been greatly increased by the kill of game farm birds except when they have been released against the gun, which is expensive shooting. Small benefit can be realized from further plantings of game farm pheasants in the Sacramento Valley. However, game farm production has been increased each year in California. The best utilization that can be made of these birds is to plant them for the gun immediately prior to or during the hunting season. Under the present system of obtaining maximum production from game farms, the pens are filled twice during each hatching season. The early-hatched birds must be liberated during the summer to provide space for the late-hatched ones. If no system can be provided to hold them until fall, these birds can best be utilized by releasing them at the age of 10 to 12 weeks in July. At best the returns are low. Most of these birds contribute nothing to increasing either hunting success or breeding stock and, therefore, are considered to be a total loss.

Limited stocking may be desirable where pheasant habitat has been developed through changes in land use, or on areas of decimated populations. Birds for these plants can probably be obtained more economically and efficiently by removing wild stock from inviolate refuges.

Opening areas to hunting that have heretofore been closed will make more birds available to the hunter than any other single management method. Recent management efforts have been directed toward this end. Attempts to increase pheasant production are impractical in the Sacramento Valley, where the present production remains largely unavailable to the hunter.

The 1947 and 1948 hunting seasons on the Sartain ranch were conducted and regulated through the cooperation of landowner, sportsmen, and the California Division of Fish and Game. The success of controlled hunting on this area led to the adoption of the cooperative hunting area plan, and in 1949 six areas were established on which the Division regulated the hunting. These were deemed a success by both landowners and sportsmen, and plans were made to expand the number of these areas in succeeding years.

SUMMARY

A four-year pheasant hunting study was made on two comparable areas in the rice belt of the Sacramento Valley from 1946 to 1949. One area, the Sartain, received plants of pheasants, while the other, the McManus, was not planted. Hunter checks were made at stations on roads leading off the areas each year except 1946. Additional data were obtained from airplane counts of pheasant hunter's cars in a 269 square mile portion of the Sacramento Valley, which included the study areas, from 1947 to 1949. A 10-day season with a limit of two cocks per day and 10 per season was in force during the four-year study.

Local hunters were more in evidence on the McManus area than on Sartain's. San Francisco Bay region hunters constituted the largest single group on Sartain's.

Fewer hunters were in the field in 1949 than in 1948. Hunting pressure in 1949 on the Sartain area was almost half that of 1948 and was comparable to 1947. However, the McManus area had only a slight reduction in numbers of hunters in 1949. Both areas had a decided increase in hunters in 1948 over 1947.

On the first three days of the season, 70 to 85 percent of the seasonal hunting pressure is exerted and approximately 70 percent of the total kill is taken. Hunting success is highest on the first day, decreases by about one-half on the second day, and remains at a generally low level for the remainder of the season.

Before heavy game farm planting began on Sartain's in 1947, the total population per unit area was greater than on the McManus area, and the kill of wild birds was correspondingly greater. Although there was a heavy planting of hens on the Sartain area in 1947, the increase of both total population and kill in 1948 was only slightly greater than on the McManus area. Continued heavy planting of hens on Sartain's in 1948 failed to result in further increases in 1949. Instead, both total population and kill per unit area decreased to less than that of the McManus area. It is evident that the planting of game farm hens has no measurable lasting or cumulative effect in increasing pheasant production where optimum pheasant populations already exist.

The greatest benefit to be derived from game farm pheasants is to plant cocks shortly before or during the season in areas where hunting pressure is high. This planting method has resulted in the greatest bag of birds released and in years of low wild populations has considerably increased the total kill.

Returns from game farm birds released before the season in 1949 averaged 32 percent. This is remarkably comparable to the 1948 return which was 35 percent. The greatest returns, 81 to 84 percent, were realized from liberations of mature birds made two days before the season. Older birds gave higher returns than younger birds released on the same dates three months or more before the season. August proved to be the most unfavorable summer month for liberations.

Returns from transplanted wild birds were considerably greater than from game farm birds when both were liberated at comparable ages three months or more before the season.

Losses of both leg and wing bands were negligible.

Bursa measurements made on wild pheasants in 1949 indicate that this age determination criterion may not be as reliable as once thought. A high percentage of the wild adult cocks banded in the previous summer had bursas measuring from 6 to 19 millimeters in depth when taken during the hunting season.

Heavy hunting pressures have resulted in low cock populations after the season each year. However, the normal reproduction that has resulted each year has shown that the numbers of wild cocks have been ample for breeding purposes without supplementary stocking of males.

Opening areas closed to pheasant hunters has been the most pressing management problem in increasing the kill of pheasants. The success of hunting controlled by the Division of Fish and Game on the Sartain ranch led to the adoption of the cooperative hunting area plan in California in 1949. Six areas were operated under this plan in 1949. The favorable reception of these by landowners and sportsmen has led to plans for increasing the program in future years.

REFERENCE

Harper, Harold T., George Metcalfe, and John F. Davis
1950. Upland game cooperative hunting areas. California Fish and Game, vol. 36, no. 4, p. 404-432.

FOOD HABITS OF FERAL HOUSE CATS IN THE SACRAMENTO VALLEY[1]

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INTRODUCTION

The house cat, *Felis domesticus*, is widely recognized as a predator of various farm game species and song birds, while at the same time it is known to take many rodent pests. The economic status of the free-hunting cat is a moot question that must be solved for each area by local food habits studies. Such a study is here presented.

The area under consideration is the rich, agricultural valley of the Sacramento River, 150 miles long and 50 to 60 miles wide, lying between the north coast ranges and the northern Sierra Nevada of California. The land is relatively flat—most of it less than 100 feet above sea level and much of it under irrigation. Rice, other cereal grains, various fruits, and livestock are the main crops. The pheasant is the only upland game bird present in abundance, but myriads of waterfowl and shore birds winter in the valley. A sparse population of ducks stays to breed on the irrigation ditches, flooded rice fields and few permanent sloughs. Song birds, small rodents, cottontails and black-tailed jack rabbits are numerous. Under these conditions feral house cats have an abundant, year-long selection of prey species, and the purpose of this study has been to ascertain the seasonal food habits of cats with special emphasis on their relations to game species.

Acknowledgments are due Dr. A. Starker Leopold of the University of California under whose guidance the study was conducted. I am likewise indebted to Daniel Tillotson, John Chattin, Carol Ferrel and Howard Leach of the California Division of Fish and Game for generously making available materials and equipment of the Food Habits Laboratory in Berkeley, and for personal aid in pursuing the study; to field personnel of the Division and others for assistance in the collection of stomachs; and to personnel of the Division of Entomology and the Museum of Vertebrate Zoology, University of California, for aid in identifying materials.

FERAL CAT POPULATIONS

In this report the terms "feral" and "vagrant" shall refer to all the cats examined in the study. Though all were taken in the field at considerable distances from human habitation, it is acknowledged that many doubtless were wanderers from farm buildings and were not permanently resident in the wild. However, some cats in the Sacramento Valley are known to breed in the field and to be truly feral. On February 22, 1948, A. S. Leopold and Ward Russell killed a pregnant female in the mouth of her den on the Conaway Ranch, Yolo County. She contained six embryos almost ready for birth. Presumably they would have been deposited

[1] Submitted for publication October, 1950.

in the ditch-bank den which was nearly two miles from the nearest farm building. A week previously an employee of the Conaway Ranch had killed a female with eight young kittens in a similar den nearby. A lactating female was taken November 24, 1949, in the same general area. Such records of house cats breeding in the field are quite numerous in the valley. The percentage of cats examined in this study which were actually wild bred is unknown, but such differentiation is somewhat academic since vagrant cats probably are similar in feeding habits, whether they were born in a barn or under a ditch bank.

In the North Central States, Leopold (1931) found little evidence of house cats breeding in the wild, and he states that field populations must be regularly replenished by "drift" from places of human habitation. Nilsson (1940), in his study of house cats in the Willamette Valley of Oregon, found no indications of kittens being produced in the wild and he agrees with Leopold's conclusion. It is probable likewise that most of the animals taken in the Sacramento Valley were barnyard strays, but in this mild climate there seems to be more tendency toward wild breeding than in areas of higher latitude.

Leopold states further that there is a general scarcity of wild females, a fact which would preclude much breeding in the wild. Nilsson found that 77.5 percent of 147 house cats taken in his study were males and considers this an indication that wild females are scarce, or that farm females do not wander as much as the males. The sex ratio of the cats taken in the Sacramento Valley does not support this conclusion. Of 219 animals examined, 104 were males, 95 females, 17 immatures and three were unclassified. In this area the sex ratio seems to be very nearly balanced.

Only scattered figures are available which indicate actual densities of vagrant cat populations in the valley. On the Gray Lodge State Waterfowl Refuge near Gridley, Butte County, 82 cats were taken in 1949 on 2,600 acres, which gives a minimum population of a cat per 32 acres. This take was accomplished in 34 days of trapping and doubtless did not result in complete elimination of the population. A rancher near Colusa killed 650 cats on his 14,000 acre rice ranch between January, 1949, and January, 1950—a removal of one cat per 21 acres through a calendar year. This operation, which was conducted with dogs and guns, was more intensive than the trapping on Gray Lodge Refuge. It is probable that in many parts of the valley, where ground cover is dense, populations of a cat per 20 acres are not unusual. Doubtless lesser densities exist on the more open lands.

House cats in the Sacramento Valley have few natural enemies except men and dogs. Coyotes, once common in the area, are known to kill cats (Bond, 1939; Sumner, 1933), and so also do bobcats (Grinnell *et al.*, 1937). However, both of these wild predators are now scarce due to intensive agricultural development. Internal parasites found in the stomachs did not suggest that parasitism is an important controlling factor on populations. In the 219 stomachs examined, I found tapeworms in six and nematodes in 43, which probably is no higher a rate of infection than would be found in an equal sample of well-kept tabbies.

In summary, the vagrant cat population existing in the Sacramento Valley consists of some animals raised in the wild and doubtless many strays from farms. Densities up to 32 animals per square mile (one per

20 acres) are known, but over most of the valley actual densities probably average much lower. Populations presumably are controlled by man and dogs directly and are limited indirectly by the available food supply, since natural predators of house cats are scarce and parasitism seems to be light.

FOOD HABITS MATERIALS

In all, 219 cat stomachs were examined in the study. Thirty-five were empty or contained only debris so were not used. The stomachs, which were collected from 1940 to January, 1950, were sorted by months with no regard to the year taken. The heaviest take was in the spring months of March, April and May when 119 animals were collected; 38 were taken in the summer months—June, July and August; 17 in the fall—September, October and November; and 45 in the winter—December through February. Table 1 gives the number of stomachs examined from each month.

TABLE 1

Distribution of Sample of Cat Stomachs, by Months

January	11	May	18	September	10
February	29	June	5	October	3
March	56	July	20	November	4
April	45	August	13	December	5
				Total	219

One hundred and sixty-nine of the cats were captured in Butte County (71 of these on Gray Lodge Refuge), 15 in Colusa County, 29 in Glenn County and six in Yolo County (Figure 88). Collections were made by three methods: shooting (133), trapping (66) and dogs (18). Two additional road-killed cats were recovered. Shooting or capture by dogs seems to be a better method than trapping for obtaining animals for use in food studies, because the stomachs of nearly one-half of the trapped animals contained nothing or so little that they could not be used. It appears that after about 12 hours most of the contents of a cat's stomach have been passed.

The data presented in this report were compiled from stomach analysis findings only. The methods of analysis and compilation here followed are those in use by the California Division of Fish and Game Food Habits Laboratory. After the animal is killed in the field the stomach is preserved in 10 percent formalin and shipped to the laboratory where the contents are measured volumetrically by water displacement. The material is then oven-dried and the contents identified, an approximate percentage of the total content being recorded for each food item found in the stomach. The number of individuals of a given prey is also determined when possible. Mammal and bird remains are usually identified by bones or by general appearance of fur or plumage. When this proves impossible one must resort to microscopic hair and feather analysis.

Species identification was checked by consulting geographic ranges in Grinnell and Miller (1944) for birds and Grinnell (1933) for mammals.

Of the 219 stomachs here considered, 153 were analyzed by the author during the study, 66 having been analyzed by Fish and Game personnel prior to the commencement of my work.

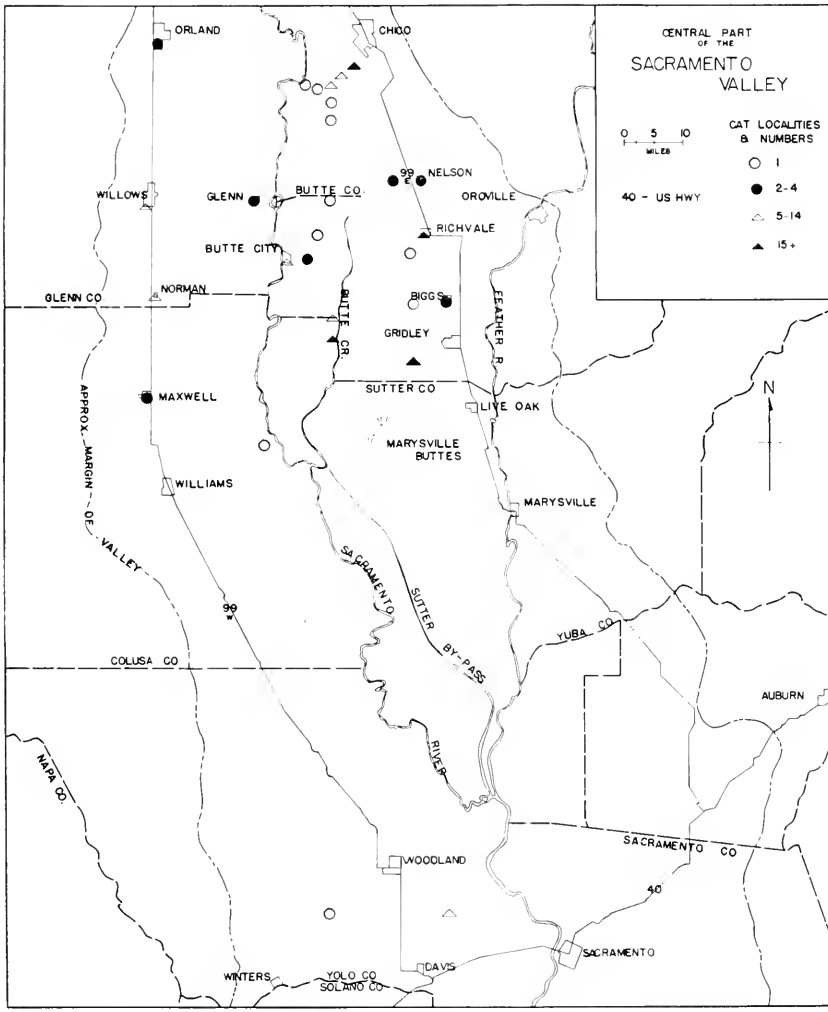

FIGURE 88. The central part of the Sacramento Valley, showing localities of house cat captures

The results are summarized by the aggregate percentage method as described by Martin *et al.* (1946). This method, in general use in the California Food Habits Laboratory, is preferred since it tends to reduce distortion caused by a few overstuffed stomachs and gives a better indication of the number of meals of the different food items than do aggregate gross volume or frequency of occurrence.

Table 2 gives the percentages of each food item by month, yearly total, frequency of occurrence in the total sample, and the minimum aggregate of prey numbers. Figure 89 presents in graphic form the percentages of the main types of food occurring in the whole sample. Figure 90 pictures the shifting seasonal food pattern of the house cats.

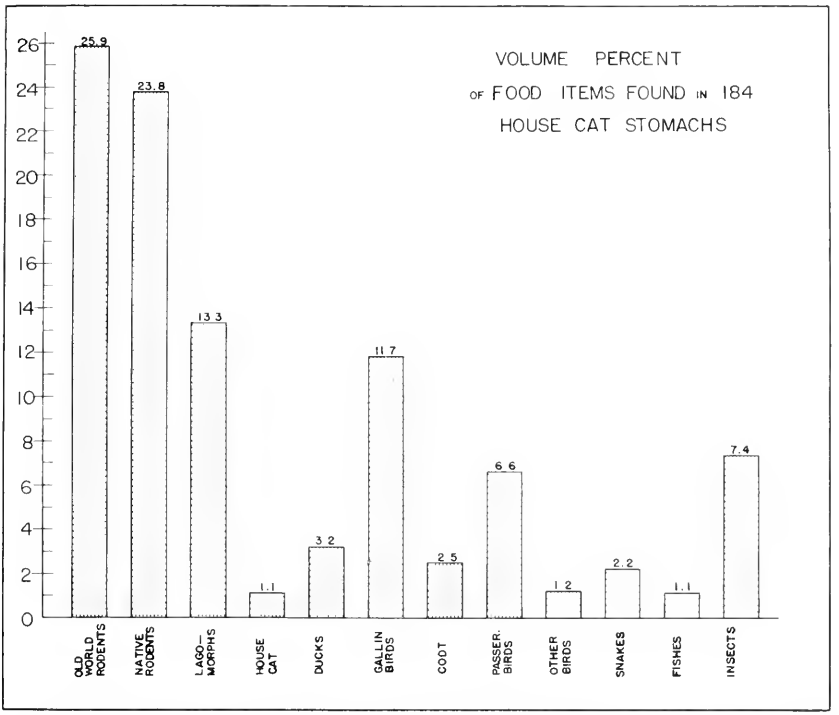

FIGURE 89. Relative amounts of various classes of food consumed throughout the year by Sacramento Valley house cats

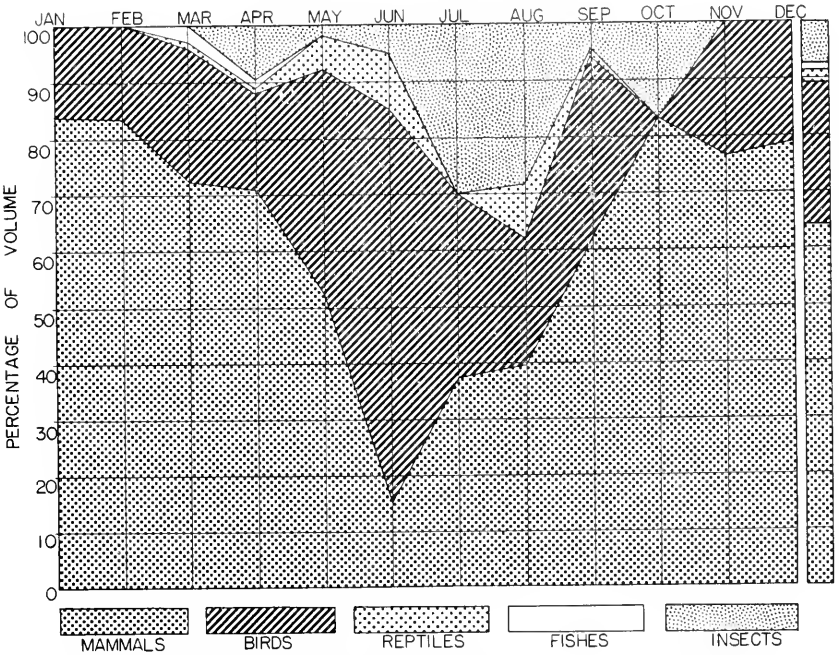

FIGURE 90. Seasonal consumption of main classes of food by Sacramento Valley house cats

TABLE 2

Percent Volume of Food Items, by Month

Item	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Number stomachs containing each item	Total numbers each item
Mammals															
Domestic rats (*Rattus* sp.)			Tr	1.3			3.3	8.3		10.0	25.0	1.0	1.8	8	8
House mouse (*Mus musculus*)	74.0	57.4	34.8	9.6	2.3		7.6	Tr	23.5	10.0	31.0	53.6	24.1	86	216
Ground squirrel (*Citellus beecheyi*)								5.8					0.4	1	1
Pocket gopher (*Thomomys bottae*)	5.7		2.7		16.7		4.3	0.8		33.0		20.0	4.1	11	16
Pocket mouse (*Perognathus californicus*)							3.9						0.4	1	1
Harvest mouse (*Reithrodontomys megalotis*)								2.9	10.0				0.7	2	3
White-footed mouse (*Peromyscus maniculatus*)			0.3	3.0					8.0				1.0	4	5
Wood rat (*Neotoma fuscipes*)							3.6						0.4	1	1
Field vole (*Microtus californicus*)	4.3	20.9	18.1	28.9	21.7		7.1	3.7	5.0	30.0	20.5		16.7	69	89
Unidentified rodent								Tr					Tr	1	1
Black-tailed jack rabbit (*Lepus californicus*)			1.9	5.4						7.0			1.9	6	6
Cottontail rabbits (*Sylvilagus* sp.)		5.1	14.4	20.4	9.2		6.6	3.8	8.1				10.5	27	27
Unidentified rabbits				0.1		15.0	1.1	5.8					0.9	4	4
House cat (*Felis domesticus*)				1.8	2.8			8.3					1.1	3	3
Totals	84.0	83.4	72.2	70.5	52.7	15.0	37.5	39.4	61.6	83.0	76.5	74.6	64.1	152	381
Birds															
Green heron (*Butorides virescens*)								8.8					0.4	1	1
Ducks			5.8	7.9	1.6								3.2	10	10
Chicken (*Gallus gallus*)					3.3								0.4	1	1
Ring-necked pheasant (*Phasianus colchicus*)	0.3		5.8	5.0	12.2	70.0	25.3	13.9	28.6			9.8	10.8	31	33
California quail (*Lophortyx californica*)			2.0										0.5	1	1
American coot (*Fulica americana*)	5.7	5.8	3.3	3.1	2.2								2.5	8	8
Meadowlark (*Sturnella neglecta*)					5.4		5.4						1.0	2	2
Red-wing (*Agelaius phoeniceus*)	10.0			0.9	5.6								1.1	3	3
Brewer blackbird (*Euphagus cyanocephalus*)					7.8								0.7	2	2
Savannah sparrow (*Passerculus sandwichensis*)									2.0				0.1	1	1
White-crowned sparrow (*Zonotrichia leucophrys*)		3.5	1.0										0.9	2	2
Golden-crowned sparrow (*Zonotrichia coronata*)					1.1								0.1	1	1
Song sparrow (*Melospiza melodia*)?		0.8											0.1	1	1
Unidentified sparrows			0.1						0.5			12.6	0.4	3	3
Unidentified passerine birds		6.5	2.3	0.1	Tr		1.9		1.5	Tr	23.5	3.0	2.2	14	14
Unidentified birds			2.2	Tr				0.2		Tr		Tr	0.5	12	12
Bird eggs					0.6								0.3	2	2
Totals	16.0	16.6	23.4	17.0	39.8	70.0	32.6	22.9	32.6	Tr	23.5	25.4	25.2	74	97

Reptiles			1.4	1.5	5.5			2.5	1.5				1.4	7	7
Gopher snake (*Pituophis catenifer*)						10.0	Tr	7.2					0.7	3	3
Yellow racer (*Coluber constrictor*)								Tr					Tr	1	1
Garter snake (*Thamnophis ordinoides*)					0.3								0.1	2	2
Unidentified snake															
Totals			1.4	1.5	5.8	10.0	Tr	9.7	1.5				2.2	13	13
Fishes			2.9										0.8	3	3
Carp (*Cyprinus carpio*)							0.2						Tr	1	1
Unidentified fish				1.6									0.3	3	3
Trap bait															
Totals			2.9	1.6			0.2						1.1	7	7
Insects		Tr	Tr	Tr	0.2					Tr			0.4	12	
Carrion insects				Tr	Tr	Tr	1.4	Tr					0.1	6	
Grasshoppers			0.1	4.4	1.4		15.4	15.1	3.0	6.7			3.7	29	
Field cricket (*Gryllus assimilis*)				2.6		5.0	12.9	12.6	0.3	10.3			2.9	18	
Jerusalem cricket (*Stenopelmatus* sp.)									1.0				Tr	1	
Locust (*Trimerotropis* sp.)					Tr			0.3					Tr	2	
Dragonflies			Tr										Tr	2	
Water beetle (Hydrophilidae)						Tr							Tr	1	
Ant (*Formica* sp.)			Tr		0.1								Tr	2	
Lepidopteran larvae				2.4			Tr						0.4	4	
Spiders								Tr		Tr			Tr	2	
Centipedes															
Totals		Tr	0.1	9.4	1.7	5.0	29.7	28.0	4.3	17.0			7.4	51	
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	184	498

FINDINGS

The food preferences of house cats in the Sacramento Valley were found to shift seasonally, mammals being most numerous in the fall and winter samples while birds were more frequently taken in the late spring and summer. Insects, reptiles and fish were all more common in stomachs taken during warmer seasons. This seasonal variability of the cat's diet suggests a constant adjustment to availability of various types of prey and is not necessarily a direct reflection of preference.

Considering the yearly diet as a whole, mammals, particularly small rodents, make up the majority of both individuals and bulk taken. It is often stated that birds constitute the heaviest part of the house cat's diet. This contention, usually based on casual observation, is not borne out by my findings nor by those of other investigators who have actually analyzed stomach contents. Nilsson found that 86 cats taken in the Willamette Valley contained 61.8 percent mammals and only 18.9 percent birds by volume. Errington (1936), in his study of the food habits of Wisconsin house cats found 57 mammals and only nine birds in 50 stomachs. McMurry and Sperry (1941) studied 84 cat stomachs from several areas in Oklahoma. Mammals made up 55 percent of the bulk and birds only 4 percent. Bradt (1949) records the prey brought in by one tame kitten in Michigan. In a period of 18 months it caught 1,623 small mammals, 1600 of them being mice, and only 62 small birds. Results from the study of Sacramento Valley cats showed that mammals constituted 64 percent of the total food and birds 25 percent.

Mammals

Three hundred eighty-one individual mammals appeared in 152 of the 184 stomachs and accounted for 64.1 percent of the total bulk as shown earlier. Twelve species, representing three orders—Rodentia, Lagomorpha and Carnivora—were identified.

The rodents were subdivided into Old World and native forms as the two groups played separate roles in the cat's diet. The Old World rodents (domestic rats, *Rattus norvegicus* and *R. rattus*, and house mouse, *Mus musculus*) were found almost exclusively in the fall and winter and the native forms largely in the warmer periods. This is as would be expected, for most of the native forms are at a low ebb in the winter months whereas the "overflow" of domestic rats and mice from farmsteads usually reaches a peak in late fall.

Domestic rats are fairly numerous in the valley, around buildings and to some extent in the fields. But they do not contribute importantly to the diet of cats. There is a widespread belief that not many house cats kill and eat rats. The study bears this out as only eight individuals were taken. Errington's study in Wisconsin revealed seven rats in 57 mammals. Kuo (1930) has shown experimentally that cats must be taught to kill rats, and that not all cats learn naturally.

On the other hand, 216 house mice were found in 86 stomachs. The house mouse was the most numerous single prey species and constituted 24.1 percent of the total yearly food. Many of them had no marks on their bodies, apparently being swallowed whole. In the Sacramento Valley these imported pests are found abundantly in granaries and grain fields.

The cats undoubtedly hunt them intensively as shown by the high frequency of occurrence and the large numbers of mice found in many individual stomachs.

Native rodents appeared 92 times and had a combined total of 23.8 percent. Eighty-nine field voles (*Microtus californicus*) were taken, mainly in the spring. They made up nearly two-thirds of the native rodent bulk and four-fifths of the total number. The pocket gopher (*Thomomys bottae*) was the only other native rodent taken in any quantity. Sixteen were found in 11 stomachs. Along with the voles they were the only American rodents caught in the winter months. Five white-footed mice (*Peromyscus maniculatus*), three harvest mice (*Reithrodontomys megalotis*), one Beechey ground squirrel (*Citellus beecheyi*), one wood rat (*Neotoma fuscipes*), and one pocket mouse (*Perognathus* sp.) were found and totaled 2.9 percent of the material.

Rabbits and hares were found in 37 stomachs, never more than one per cat. Twenty-seven were *Sylvilagus* sp.—probably mostly cottontails (*S. audubonii*), although a few may have been brush rabbits (*S. bachmani*). The remainder consisted of six black-tailed jack rabbits (*Lepus californicus*) and four unclassified individuals. Probably most of the jack rabbits were eaten as carrion on the roads, though some may have been captured. Lagomorphs totaled 13.3 percent of the volume and were taken most frequently in the spring months.

Remains of house cats appeared in three stomachs. One trapped animal contained part of a foot, perhaps its own. An adult female contained the remains of a nestling kitten, probably representing a case of maternal cannibalism. The third sample seemed to be carrion.

The total absence of insectivores supports the belief that they are distasteful to carnivores. McMurry (1945) found three shrews (*Cryptotis parva*) in one of 223 stomachs from Oklahoma. Bradt, in his account of the Michigan kitten, reports that 15 shrews were brought in but were not eaten. Errington reports only one shrew (*Blarina* sp.) from the 50 Wisconsin stomachs. On the other hand, Nilsson found six shrews (*Sorex vagrans*) and two moles (*Scapanus* sp.) in 86 Oregon stomachs.

Birds

Birds were found in 74 stomachs, totaling 25.2 percent of the total bulk. Fifty-two of the 97 individuals were of game species. These results differ considerably from those of Nilsson in Oregon. In 86 house cat stomachs he found 26 birds, only three of them being of game species. For 63 cat samples he gives a figure of 22.2 percent for nongame birds and only 6.3 percent for game birds.

Ten adult ducks were found in the spring samples. This relatively heavy take of ducks, making up 3.2 percent of the total bulk, was somewhat surprising for there is little reference in the literature to cat predation on adult ducks. Eight of the birds were hens. Many or all of them may have been mallards (*Anas platyrhynchos*) which breed in the valley in fair numbers. However, many closely related female ducks are so similar that no positive identification of the plumage fragments could be made. It is unlikely that these hens were cripples, for the dates when they were eaten were long after the California waterfowl season. It seems more probable that they were killed on their nests. Earl (1950), working on mallard production in the Sacramento Valley, lists the domestic cat as

a major predator on mallard nests but makes no direct reference to attacks on the hens. The two remaining ducks were both male pintails (*Anas acuta*).

Thirty-three ring-necked pheasants (*Phasianus colchicus*) were found in 31 stomachs, accounting for 10.8 percent of the total sample. The ages represented were not quite as expected. It is generally thought that the heaviest drain is on the chicks, but only four birds were identified as immature, two of them being found in the same stomach with remains of an adult hen. The majority of the pheasants were identified as adult hens. Einarsen's (1942) work in Washington bears out these findings. He found that of 21 pheasants killed by cats, three were cocks, seven hens, one young and 10 were "unclassified."

Undoubtedly some of the pheasants had been dead some time when eaten. Two were accompanied by carrion insects. However, there seem to have been few cripple losses represented in my sample, for most of the pheasants appeared several months after the hunting season. In fact, there was no increase in pheasant remains during the fall hunting season.

All but five of the pheasants were taken between April and September, the period covering nesting and brood development. They were most numerous in late spring and early summer which represents the peak of nesting. It is probable that cats impose quite a heavy pressure on the nesting hens in some areas. Such predation would be a more serious drain on the population than a heavier take of chicks alone. McAtee (1945) agrees that nesting hens are especially vulnerable to house cats.

In addition cats may destroy pheasant nests without killing the hens. Current pheasant studies in the Sacramento Valley, being conducted by the California Division of Fish and Game, indicate that cats are one of the predators frequently causing nest destruction, although they are of less importance than raccoons or skunks.

It is quite obvious that cats do not restrict their hunting to hens, chicks and nests, for several observations have been made of cats catching cock birds. Nilsson tells of a cat stalking a flock of pheasants and pouncing on a full grown cock and killing it. On the Conaway Ranch a cat was seen to flush a cock from the tule margin of an irrigation ditch and pull it down from the air.

Other gallinaceous birds were scarce in the sample. There was one occurrence each of the California quail (*Lophortyx californica*) and the domestic chicken (*Gallus gallus*).

Eight stomachs contained remains of the American coot (*Fulica americana*). This game bird would be easy prey for a vagrant cat as it does much wandering about on land. It is not known whether the coots were captured or were eaten as road kills, for many are found dead on the roads in the valley.

House cats have a particularly unsavory reputation as killers of song birds. McKenny (1939) sets the annual kill of small birds in Pennsylvania at 50,000,000 with the house cat as the major cause, and Forbush (1916) states that rural cats killed 7,000,000 birds in Massachusetts in 1913. Reed (1906) claims that a horde of cats were eating three-fourths of the song birds hatched. Undoubtedly house cats kill many song birds, but the findings of this study tend to discount these extravagant claims as do most other detailed food habits studies. Only 29 passerine birds were

found, accounting for 6.6 percent of the material. Fourteen undetermined song birds, two meadowlarks (*Sturnella neglecta*), three red-wings (*Agelaius phoeniceus*), two Brewer blackbirds (*Euphagus cyanocephalus*), and eight sparrows were found. The take of passerine birds was generally scattered throughout the year.

One green heron (*Butorides virescens*) was eaten. This species is one of several herons found fairly commonly in the study area.

Remains of bird eggs were found in only two stomachs—a small sample in the light of all the nest destruction attributed to cats. However, when a cat raids a nest it usually eats the contents of the eggs and does not ingest much shell which is the only traceable part to be found later in stomach analysis. Nilsson found no sign of eggs in the 86 Oregon house cat stomachs he examined. Stomach analyses probably do not accurately reflect the consumption of eggs by cats.

Reptiles

The remains of 13 snakes were found in the spring and summer material. Seven Pacific gopher snakes (*Pituophis catenifer*), three yellow racers (*Coluber constrictor*) and one garter snake (*Thamnophis ordinoides*) were identified. The remaining two were of undetermined species. At least one of the snakes was probably carrion, as dirt was found pressed into the scales and meat.

Fishes

There was a general scarcity of fish remains. Teale (1948) cites many instances of cats fishing in ponds, but states that most cats, despite their love for fish, do not like to get wet. The cat's dislike for water can not explain the lack of fish in my sample, for many fish are stranded when the flooded rice fields dry in the summer. Fish were found in only seven stomachs, four times as trap bait. The common carp (*Cyprinus carpio*) was the only species identified.

Insects

Insects appear to be an important item in the summer diet. Field crickets (*Gryllus assimilis*) and Jerusalem crickets (*Stenopelmatus* sp.) accounted for nearly 100 percent of the insect bulk. These insects are common during the summer and could easily be caught by a prowling house cat. One stomach contained 80 cc. (almost $\frac{1}{2}$ cupful) of field crickets and nothing else. Carrion insects (several types of flies and beetles) were taken 12 times, probably indirectly with carrion. Other invertebrates included: Grasshoppers, one locust (*Trimerotropis* sp.), dragonflies, water beetles (family Hydrophilidae), ants (*Formica* sp.), lepidopteran larvae, spiders and centipedes.

McMurry and Sperry give a figure of 12.5 percent for insects, mainly grasshoppers and crickets, in their studies of cat food habits in Oklahoma. Errington reports that five of the 50 Wisconsin house cats were high in grasshoppers, crickets, and June beetles. In my sample, insects constituted 7.4 percent of the total food.

Debris

In addition to the food itemized, debris was found in 77 of the stomachs. Included in this category were: Grass, sticks, dirt and cat hair. Approximately one-third of the stomachs contained small quantities of green grass. The loose cat hair was undoubtedly ingested as a result of

licking the fur. The sticks and dirt were found mostly in the stomachs of trapped animals.

DISCUSSION

The results of this study indicate that feral house cats in the Sacramento Valley have a shifting seasonal diet, comprised mostly of rodent pests but including also significant numbers of ducks, pheasants, song birds and rabbits at certain seasons of the year. Because they take such great numbers of rodents, house cats can be considered of real benefit to farmers in the valley.

Yet where game production is of primary concern, cat control certainly is warranted—particularly on breeding grounds of pheasants and ducks. The 184 stomachs examined in the study actually represented 184 cat meals distributed throughout the year. Forty-one of the meals included pheasant or duck which means that a vagrant cat will average one game bird about every fifth day over the entire year, discounting the factor of carrion. In spring, when most of the game bird kills occur, the frequency must be much greater. With densities as high as a cat per 20 to 30 acres, the total loss to breeding pheasants and ducks may be locally serious. In addition there is the drain on coots and cottontail rabbits which are game species of lesser importance.

Control measures must be handled on a local basis. On primary game areas, all cats should be eradicated if possible. The State of California provides by law for the destruction of these predators on game refuges. Though it is advisable for farmers to maintain some house cats on their premises, limited control or restraint is necessary to keep the population of cats at a moderate level to avoid "drift" to game production areas. However, actual control of cat numbers is expensive and is complicated by sentiment and prejudice. Some people are violently opposed to any form of cat killing. Likewise control operations are sure to remove some wandering pets along with truly vagrant animals, an event which arouses additional adverse reaction. Sentiment further causes people to abandon unwanted cats rather than kill them, thereby augmenting already existing vagrant populations. These considerations will always make cat control difficult in the Sacramento Valley.

REFERENCES

Bond, Richard M.
1939. Coyote food habits on the Lava Beds National Monument. Journ. Wildlife Management, vol. 3, no. 3, p. 180-188.

Bradt, G. W.
1949. Farm cat as predator. Michigan Conservation, vol. 18, no. 4, p. 23-25.

Earl, John P.
1950. Production of mallards on irrigated land in the Sacramento Valley, California. Journ. Wildlife Management, vol. 14, no. 3, p. 332-342.

Einarsen, Arthur S.
1942. Specific results from ring-necked pheasant studies in the Pacific Northwest. Trans. 7th North American Wildlife Conf., p. 130-146.

Errington, Paul L.
1936. Notes on food habits of the southern Wisconsin house cats. Journ. Mammal., vol. 17, no. 1, p. 64-65.

Forbush, E. H.
1916. The domestic cat. Massachusetts State Board Agric. Econ., Bull. no. 2, 108 p.

Grinnell, Joseph
1933. Review of the recent mammal fauna of California. Univ. Calif. Publ. Zool., vol. 40, no. 2, p. 71-234.

Grinnell, Joseph, Joseph Dixon and Jean M. Linsdale
1937. Fur-bearing mammals of California. Berkeley, Univ. Calif. Press, 2 vols., 777 p.

Grinnell, Joseph, and Alden H. Miller
1944. The distribution of the birds of California. Pacific Coast Avifauna, no. 27, 608 p.

Kuo, Zing Yang
1930. The genesis of the cat's response to the rat. Journ. Comp. Psychol., vol. 11, no. 1, p. 1-35.

Leopold, Aldo
1931. Report on a game survey of the North Central States. Sporting Arms and Ammun. Manufacturer's Inst., 299 p.

Martin, A. C., R. H. Gensch and C. P. Brown
1946. Alternative methods in upland gamebird food analysis. Journ. Wildlife Management, vol. 10, no. 1, p. 8-12.

McAtee, W. L., editor
1945. The ring-necked pheasant and its management in North America. Washington, American Wildlife Inst., 320 p.

McKenny, Margaret
1939. Birds in the garden and how to attract them. New York, Reynal and Hitchcock, 349 p.

McMurry, Frank B.
1945. Three shrews, *Cryptotis parva*, eaten by a feral house cat. Journ. Mammal., vol. 26, no. 1, p. 94.

McMurry, Frank B., and Charles C. Sperry
1941. Food of feral house cats in Oklahoma. Journ. Mammal., vol. 22, no. 2, p. 185-190.

Nilsson, N. N.
1946. A study of the domestic cat in relation to game birds in the Willamette Valley, Oregon. Master of Arts thesis, Corvallis, Oregon State College.

Reed, Elizabeth A.
1908. Protecting young birds from cats. Bird-Lore, vol. 10, no. 5, p. 215.

Sumner, E. Lowell, Jr.
1935. A life history study of the California quail, with recommendations for its conservation and management. Pt. 2—Conservation and management. Calif. Fish and Game, vol. 21, no. 4, p. 275-342.

Teale, Edwin W.
1948. Days without time: adventures of a naturalist. New York, Dodd, Mead and Co., 283 p.

TOXICITY OF ZINC FOR RAINBOW TROUT (*SALMO GAIRDNERII*)[1]

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INTRODUCTION

Difficulty in maintaining exhibits of rainbow trout (*Salmo gairdneri*) in the Steinhart Aquarium led to the suspicion that zinc from galvanized pipes might be present in the water in sufficient concentration to be toxic to these fish. Other species of trout, including eastern brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and lake trout (*Cristivomer namaycush*), appeared able to withstand the concentration of zinc present in the aquarium waters, although their resistance may have been due to a gradual conditioning over an undetermined period of time. Actually, the concentration of zinc was not high, but it was found to be present in greater amounts than either copper or lead.

The effect of zinc on fish had been noted by Abbott (1924) when he studied a case of almost total mortality of the fish in Devils Lake, North Dakota. At the time of his investigation the brook stickleback (*Eucalia inconstans*) was the only surviving species and many were dying. This lake had no outlet and the total salt content was higher than normal for fresh-water lakes, but not sufficiently high to eliminate all fish on the basis of osmotic effects. However, the lake did contain 15 parts per million of zinc. Abbott tested small (unspecified) fish in a solution containing 15 parts per million of zinc (using $ZnCl_2$). All fish died within eight hours.

More recently Grindley (1946) found that rainbow trout (*Salmo gairdneri* var. *shasta*) lost their sense of equilibrium in 133 minutes in a solution of $ZnSO_4$ containing 25 parts per million of zinc and died very shortly even when transferred to fresh water.

Analysis of the Steinhart Aquarium water showed a concentration of zinc of from 8 to 11 parts per million. It was decided to determine experimentally whether such concentrations would be fatal to rainbow trout, and if possible discover the minimum fatal concentration.

METHOD

Fingerling *S. gairdneri* approximately three inches long were used in all experiments unless otherwise noted. The fish were placed in all-glass aquaria, each containing approximately 17 liters of tap water. It was necessary to maintain optimum constant temperature and a high oxygen

[1] Submitted for publication October, 1950.

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content. Therefore, each aquarium was aerated by compressed air finely dispersed by a diffusion ball, and all were partly immersed in a tank of running water maintained at 11 degrees C.

Inasmuch as the water in each aquarium was not circulated through a filter or allowed to be continually exchanged with fresh water, it seemed advisable to place a time limit on the measure of the toxic effect of the zinc in order that the effect of accumulative toxic waste products would be minimized. For this reason 48 hours was taken as the time limit of the evaluation. However, numerous experiments were continued for five or six days before the survivors were returned to the stock tank.

Varying known amounts of zinc (as $ZnSO_4$) were added from a stock solution which had been made sufficiently acid with sulfuric acid to prevent any zinc precipitate. Because the acid was used the pH of the test mixture was noted in the early experiments and found to vary from pH 7.4 to pH 7.8, while the solutions of zinc near the minimal lethal concentration usually had a pH of 7.6. A solution of $ZnCl_2$ of similar zinc concentration was used on one run, and produced results nearly identical to those obtained with the $ZnSO_4$.

Samples were taken from all solutions before the fish were added, and from almost all solutions after the fish had been removed. Zinc analyses were made on all these solutions to determine the total amount of zinc as well as to check the amount added. The dithizone method of analysis described by Hibbard (1934, 1937, and 1938) was followed. However, the dithizone was first purified by extraction with chloroform from acid solution (Offic. Agri. Chem. Assoc., 1935).

RESULTS

In a preliminary experiment three groups of 10 fingerlings each were placed in tap water (2 p.p.m. Zn) for control and in solutions containing 25 and 50 p.p.m. Zn, respectively. All fish exposed to 25 and 50 p.p.m. were dead in two hours. There were no fatalities in the control tank and after 48 hours these fish were returned to stock. This is in close agreement with Grindley's (1946) report that 25 p.p.m. Zn stunned and killed rainbow trout in 133 minutes.

Table 1 shows the results of a second series in which 10 trout were used per aquarium. Six parts per million was fatal.

TABLE 1

Survival of Three-inch Rainbow Fingerlings

Zn p.p.m.	Number alive out of 10 original at—		
	14 hours	18 hours	24 hours
2	10	10	10
6	3	0	0
10	0	0	0
14	0	0	0

In a third group fish which were about six months old and approximately five inches in length were used. They had been in the aquarium water system for about 40 days. At that time the aquarium water tested 2 p.p.m. Zn. As these fish were a little larger, only five specimens were placed in each tank. Table 2 shows that some of these survived 6 p.p.m.

TABLE 2

Survival of Five-inch Rainbow Fingerlings

Zn p.p.m.	Number alive out of 5 originals at		
	12 hours	24 hours	48 hours
2	5	5	5
6	4	2	2
10	1	0	0

It is realized that the increase in tolerance over that shown in Table 1 could have been due to 40 days' acclimatization in the aquarium at 2 p.p.m. Zn or to the larger volume of water per fish.

A series of experiments was run to determine whether the young fish developed a tolerance with increasing age. For this purpose eyed eggs were obtained, and were hatched in the aquarium in water which tested 1 p.p.m. Zn. Table 3 shows the effect on trout 10 days to two weeks old. At this age they had just completed the absorption of the egg sac. Under these conditions 4 p.p.m. was fatal to 90 percent and 3 p.p.m. fatal to 55 percent.

TABLE 3

Survival of 10-14-Day-Old Rainbow Fingerlings

Zn p.p.m.	Number alive out of 20 originals at		
	16 hours	40 hours	48 hours
1	20	20	20
3	19	13	11
4	16	2	2
6	5	0	0

TABLE 4

Survival of Four-Week-Old Rainbow Fingerlings

Zn p.p.m.	Number alive out of 20 originals at			
	18 hours	24 hours	42 hours	48 hours
1	20	20	20	20
2	20	18	15	15
4	19	18	6	2
6	18	6	3	1

TABLE 5

Survival of Eight-Week-Old Rainbow Fingerlings

Zn p.p.m.	Number alive out of 20 originals at —			
	18 hours	30 hours	45 hours	66 hours
1	20	20	20	20
2	20	20	19	19
4	20	20	19	18
6	18	15	7	4

TABLE 6

Survival of 10-Week-Old Rainbow Fingerlings

Zn p.p.m.	Number alive out of 20 originals at—			
	22 hours	27 hours	30 hours	48 hours
1	20	20	20	20
2	20	20	20	20
4	20	20	20	20
6	15	11	9	2

At four weeks their tolerance had increased as shown in Table 4, while the tolerance of fish from the same batch of eggs at 8 and 10 weeks (Tables 5 and 6) had increased so that all the fish eventually survived in 4 p.p.m. Zn for 48 hours.

Many of the survivors of the 4 p.p.m. Zn solution showed strong toxic symptoms and could be picked up by hand. Some of these subsequently died, even though they were transferred to fresh water.

Many of the young fish that died in this series of experiments developed bent backs while in the zinc solutions. Sometimes this would occur as a single 90-degree bend; sometimes it took the form of a "crick" or a more pronounced "S" shape. Both the young fry and the fingerlings in many instances acted as though they were in a stupor and could easily be picked up by hand. They would often have tremors or pronounced twitching when handled. At other times they were highly excitable and at the least disturbance would dart head-on against the wall of the aquarium. They would do this even in the larger tanks with opaque walls, indicating that such behavior was not due to the invisibility of the glass aquaria.

Some fish were noted to have a marked fading of color along the lateral line. This and the other symptoms tend to suggest that the nervous system was being affected by the zinc.

CONCLUSION

Zinc at a concentration of six parts per million was fatal to fingerling rainbow trout (*Salmo gairdneri*) on exposures of 48 hours or less.

Young fish two and four weeks old could not tolerate concentrations of four parts per million, but with increasing age showed a tendency to develop a tolerance to solutions of this concentration.

LITERATURE CITED

Abbott, G. A.
1924. A chemical investigation of the waters of Devils Lake, North Dakota. Indiana Acad. Sci., Proc. 40th Ann. Meet., vol. 34, p. 181-184.

Grindley, J.
1946. Toxicity to rainbow trout and minnows of some substances known to be present in waste water discharged to rivers. Annals of App. Biol., vol. 33, p. 103-112, 4 figs., 3 tables.

Hibbard, P. L.
1934. Micromethods for determination of zinc. Indust. and Eng. Chem., vol. 6, anal. ed. no. 6, p. 423.
1937. A dithizone method for measurement of small amounts of zinc. Indust. and Eng. Chem., vol. 29, no. 11, p. 127-131.
1938. Estimation of copper, zinc and cobalt (with nickel) in soil extracts. Indust. and Eng. Chem., vol. 30, no. 39, p. 615-618.

Official Agricultural Chemists Association
1935. Official and tentative methods of analysis of the Association of Official Agricultural Chemists, 4th ed., p. 378.

TOXICITY OF THE ROE OF THE CABEZON, *SCORPAENICHTHYS MARMORATUS*[1]

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An unhappy gastronomic experience of the senior author and his wife and laboratory experiments by the junior author indicate rather definitely that there is some toxic constituent in the roe of the cabezon, *Scorpaenichthys marmoratus* Girard, a large cottid fish of western North America.

On January 14, 1923, a ripe adult female cabezon, 440 mm. in standard length, caught during the day in a tidepool on Point Lobos, Monterey County, California, was eaten for supper. The senior author and his wife partook of the roe while her parents and a young child ate the flesh. Those who ate the flesh were not discomforted in the least, nor have we heard of anyone having been poisoned by eating this common food and game fish. The two who ate the eggs awoke in misery about four hours afterward and were violently ill throughout the rest of the night, with rapidly alternating chills and fever and with frequent vomiting and diarrhea. There was, however, no marked prostration, fainting, dizziness, or paralysis. Both were left very weak in the morning but gradually recovered during the day, with no residual or recurrent symptoms. No medical attention was received.

This experience, related to fellow ichthyologists, was the basis for the statement by Walford (1931, p. 127), that "although the flesh is of excellent quality the roe is said to be poisonous," and for the following remarks by Schultz (1948, p. 68):

> "Also, it is definitely known that the eggs of certain fishes are poisonous, although the fishes themselves are not. (Dr. Hubbs became very sick after eating some eggs of a United States Pacific Coast marine sculpin.)"

When a very large female collected at the Scripps Institution reef by Jack Prodanovich on December 23, 1949, was found to be full of nearly ripe roe, a long desire for an experimental test of the toxicity of the roe was reactivated. The ovaries were promptly hard-frozen. They were kept in that condition for nine months, until the experiments were run.

The experimental results (Table 1) confirmed the experience recounted above. A portion of the roe (77 g.) and 50 ml. of water were homogenized for five minutes in a Waring Blendor. The mixture was fed orally to 12 male albino rats and to two guinea pigs. The animals had in addition their regular food at all times. Four rats and one guinea pig

[1] Contribution from the Scripps Institution of Oceanography, New Series, No. 506, and from the Scripps Metabolic Clinic. Submitted for publication, November, 1950.

TABLE 1

Data on Toxicity of Cabezon Roe to Rats and Guinea Pigs

Animal	Weight of animal	Weight of roe administered		Death time (hrs.)
		Grams	Percent body wt.	
Rat	330	7.7	2.33	22
	420	7.7	1.83	22
	272	1.43	0.53	84
	291	1.43	0.49	..
	314	1.07	0.34	..
	318	1.07	0.34	..
	326	0.71	0.22	76
	343	0.71	0.21	..
	292	0.36	0.12	..
	302	0.36	0.12	..
	338	0.18	0.05	..
	350	0.18	0.05	..
Guinea Pig	355	1.43	0.40	30
	400	1.43	0.36	..

died. All the animals exhibited diarrhea and nasal discharge, but these conditions diminished in intensity as the dose was decreased.

It would obviously be unwise to eat the roe of the cabezon, but there is no indication that the flesh of this fish is in any way harmful.

REFERENCES

Schultz, Leonard P. (with Edith N. Stern)
1948. The ways of fishes. D. Van Nostrand Co., Toronto, New York, London. xii +264 p., illustr.

Walford, Lionel A.
1931. Handbook of common commercial and game fishes of California. Calif. Div. Fish and Game, Fish Bull. 28. 181 p., illustr.

YIELD OF HATCHERY TROUT IN CALIFORNIA LAKES[1]

By Brian Curtis [2]

INTRODUCTION

What happens to hatchery trout after they are liberated? How many survive to be caught by fishermen?

It is recognized that lakes as a class produce different results from streams, and also that there are differences between lakes and between streams. In California, stream investigations have not yet reached the point where they provide a broad picture, but lake studies have been in process for the last 10 years. Some of these have been published in this periodical, but others have seen the light of day only in the form of administrative reports. Most of them are, for one reason or another, now terminated, and the time has come to bring all this material together and make it available to sportsmen and conservationists.

In a state as large and as geographically diversified as California, experiments of this nature must be performed in different areas, under different conditions of climate and fishing intensity, and with different kinds and sizes of trout. For this reason the results are sometimes confusing. Having had general supervision of most of this work, and being therefore more familiar with the interrelationships of its different phases and with their relative strength and weakness than any other one person, it has fallen to me to undertake the task of evaluation and synthesis; but major credit belongs to the men who were directly in charge of the various projects, and especially to J. H. Wales, Elden H. Vestal, Harry A. Hanson, Garth I. Murphy, J. C. Fraser, and Scott M. Soule, all of the Bureau of Fish Conservation of the California Division of Fish and Game.

The period covered by this report is approximately the decade from 1940 to 1950. The number of lake studies is nine, of which six are considered important enough to be reviewed in some detail here, while the other three are treated together in one section. Most of these lakes have no, or insufficient, natural spawning facilities. The method throughout has been to plant a known number of trout, and to find out, by complete catch records, by sampling the catch, or in other ways, how many of these fish were caught.

Marking through the removal of one or more fins has been relied on to a large extent for identification of the fish. In earlier years it was assumed that fish with one or two fins missing suffered on the average no greater mortality than intact ones. More recently this assumption has come to be doubted, and experiments on salmon fingerlings have supported this doubt. However, the life history of most trout is quite different from that of salmon, and two experiments in California on marked

[1] Submitted for publication October, 1950.

[2] Formerly of the Bureau of Fish Conservation, California Division of Fish and Game.

trout have produced conflicting results. Pending further evidence, we shall have to withhold judgment, and stick to the assumption that fin marking does not significantly impair the viability of trout, at least in lakes in California.

It must be remembered that throughout this report we are dealing with *yield to the angler*, which is quite different from true survival. The latter is inevitably higher: from any group of planted fish there remain in any year an undetermined number still in the water after the anglers' total catch has been counted. And it must be remembered that two factors having nothing to do with survival affect the yield to the angler. One is stocking intensity, the other fishing pressure. Heavy stocking in a lightly fished lake will result in low yield combined with high quality of fishing (measured in terms of numbers of fish caught by each angler). Light stocking in a heavily fished lake will produce high yield combined with poor fishing. Optimum results from the point of view of both yield and angling quality are obtained when stocking and fishing pressure are properly balanced.

We shall proceed now to review the experimental work on the different lakes in as brief a manner as possible while at the same time including the details and the circumstances necessary for an understanding of the results, and then shall try to fit the various pieces together into a generalized picture.

CASTLE LAKE, SISKIYOU COUNTY

This Northern California lake has been the subject of one of the longest intensive creel counts carried out on any body of trout water in the United States. Two reports have already been published (Wales, 1946, 1947) and more will undoubtedly follow. Its features are:

Elevation: 5,200 feet.

Area: 47 acres.

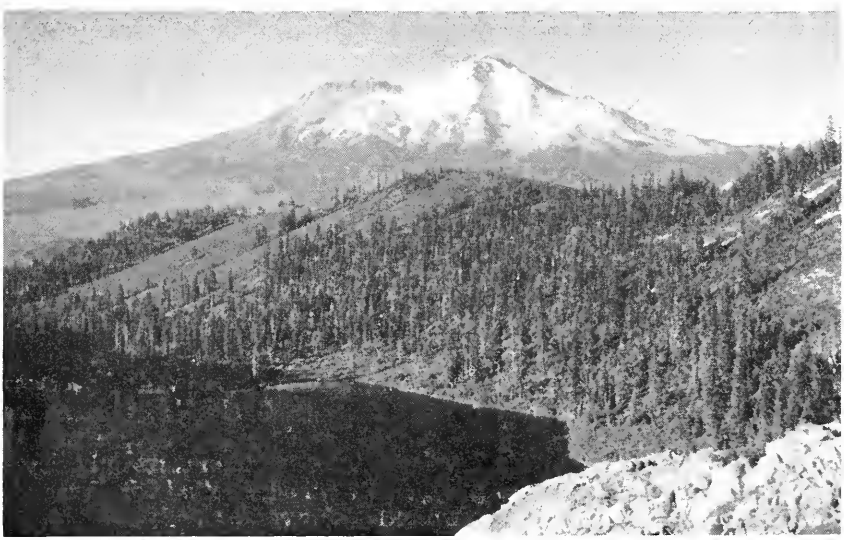

FIGURE 91. Castle Lake, looking northeast toward Mt. Shasta. Photograph by J. H. Wales.

Depth : 120 feet.
Volume : approximately 1,800 acre-feet.
Winter conditions : snow and ice for five to six months.
Spawning : successful only for lake (mackinaw) trout, and for eastern brook trout in bottom spring seepages.

There are no permanent camps on the lake and only one access road. A full-time employee was stationed there throughout the major part of each season, with the work on a part-time basis only in the very early and late days, when little fishing is done. The record, therefore, is to all intents and purposes a complete creel census.

The experiment has two distinct parts. During the first, fingerlings of three species, rainbow trout (*Salmo gairdnerii*), brown trout (*Salmo trutta*), and eastern brook trout (*Salvelinus fontinalis*) were planted in equal numbers to study their relative merits. Occasional small plants of larger trout were made to improve the fishing and thus bring in more anglers. Also present in the lake was a small population of lake trout (*Cristivomer namaycush*), remnants of a stock introduced in 1924; a small population of the western golden shiner (*Notemigonus crysoleucas auratus*), presumably introduced at about the same time as the lake trout; and a few speckled dace (*Rhinichthys osculus*), first noticed in the lake in 1945 and presumably brought in by anglers as bait. This part of the project came to an end when all fish were killed through chemical treatment of the lake in October, 1946. Since then only one species has been planted, the eastern brook trout.

Each year class of trout was identifiable either because fins had been removed before planting, or because it was left unmarked and was the only significant group of such fish in the lake during its lifetime. It was thus possible to follow the progress of each year class through the fishery, and observe the percentage yield of each in relation to the size of the fish when planted. Fish stocked as yearlings showed, as is to be expected, a much higher yield than fingerling plants; but as between different sizes of fingerlings the correlation between yield and size at planting was poor. For example, rainbow planted at 37 per ounce (about 1½ inches) yielded 4.2 percent, while those planted at 7 per ounce (3 inches) yielded only 2.6 percent; still another year class planted at 10 per ounce yielded 7.2 percent. These records have been published in detail (Wales, 1946, 1947) and will not be reprinted here, where we shall try to give consideration only to the major outlines.

Wales has shown that in the first phase of the Castle Lake project fingerling plants of brook and rainbow trout played their most important part in the catch as yearlings. Since catch records did not begin here until 1941, plantings of these species prior to 1940 are eliminated from Table 1, as are also, of course, catches of fish from these year classes. Since brown trout, as shown by Wales, continue to enter the catch in significant numbers for as long as six years, brown trout plantings as far back as 1938 are included in Table 1.

In considering the 3.6 percent average yield for the first phase (Table 1a) it must be remembered that when the lake was chemically treated in October, 1946, it still contained many fish which would have been caught in succeeding years. This is especially true of the brown trout, of which 1,960 individuals were by actual count picked up after the chemical treatment. Based on the detailed records of the earlier years

TABLE 1

Castle Lake Fingerlings

a. Catch Records from 1941 to 1946, Inclusive (First Phase)

Species	Trout planted				Numbers caught from 1941 to 1946, incl.	Yield (percent)
	Size		Years "(incl.)"	Number		
	Number per ounce	Length in inches				
Eastern brook	6 to 34	1½–3	1940–45[1]	48,000	817	1.7
Rainbow	5 to 37	1½–3	1940–45[1]	48,300	1,834	3.8
Brown	6 to 31	1½–3	1938–45	61,500	2,968	4.8
				157,800	5,619	Average: 3.6

b. Catch Records from 1947 to 1949, Inclusive (Second Phase)

Species	Trout planted				Numbers caught through July 31, 1950	Yield (percent)
	Size		Years	Number		
	Number per ounce	Length in inches				
Eastern brook	5.0	3	1947	20,000	5,419	27.1
Eastern brook	12.5	2	1948	20,000	4,686	23.4
				40,000	10,105	Average: 25.3

[1] Plants before 1940 not shown because not entering catch records in significant numbers.

(Wales, 1947), it is conservative to estimate that if the lake had not been chemically treated at least 600 more fish would have been caught from the plantings listed, which would have brought the over-all yield up to approximately 4 percent. This is with stocking at the average rate of 20,000 fingerlings per year, and fishing pressure at 596 angler-days, equivalent to 425 fingerlings and 13 angler-days per acre per year. Fishing success, including the yearlings and the lake trout, averaged close to 0.6 fish per hour over the period.

For the second phase of the experiment (lower part of Table 1) the records available at this writing carry us only through July 31, 1950. The yield of 27.1 percent from the five-per-ounce (three-inch) brook fingerlings is extraordinarily high even after making allowances for the fact that the only other fish in the lake at the time of their planting were the six-inch yearling brooks planted in July of the same year (Table 2). For the smaller brook fingerlings planted in 1948 the yield already reaches 23.4 percent, and if their pattern at all follows that of their predecessor class their yield may be even higher. At present, average yield for the two year classes stands at 25.3 percent. It is of interest to note here the difference between the first, three-species phase of the experiment, with lake trout also present, when the brook fingerlings furnished their best fishing as yearlings, and the second, single-species phase, when they still play an important part in the fishery in their fourth year. The increase in over-all yield is nothing short of phenomenal.

Fishing pressure in the first three years of the second phase averaged 1,051 angler-days per year (22 angler-days per acre), and fishing success over 1.6 trout per hour—very markedly above the first phase. The high rate might be attributed in part to the 20,000 yearlings planted in 1947 to make fishing possible the first season after the chemical treatment; but in 1949, when this group provided only 8 percent of the catch, trout were caught at the rate of 1.8 per hour—higher than in 1948 when the yearlings formed 66 percent of the total. Stocking of fingerlings was at the rate of 20,000 per year in 1947 and 1948—425 per acre—the same as in the first phase of the experiment.

TABLE 2

Castle Lake Yearlings

a. Catch Records from 1941 to 1946, Inclusive (First Phase)

Species	Trout planted			Numbers caught	Yield (percent)
	Size	Years	Number		
Eastern brook	6 to 16 per lb.	1942 1943 1946	3,100	719	23.2
Rainbow	24 per lb. to 1.4 lbs. each	1942 1943	3,300	905	27.4
Brown	10 to 24 per lb.	1942 1943	2,700	865	32.0
			9,100	2,489	Average: 27.4

b. Catch Record from 1947 to 1949, Inclusive (Second Phase)

Species	Trout planted			Numbers caught	Yield (percent)
	Size	Years	Number		
Eastern brook	13.3 per lb.	1947	20,000	9,541	47.7

To turn to the yearlings (Table 2), their over-all yield of 27.4 percent in the first phase of the project is low. This may be due to their small numbers, running from 2,000 to 4,000 in the years when they were planted; to the comparatively light fishing—averaging from three to four fishermen per day on the lake throughout the six years; and to the numbers of fingerlings planted at the same time. In any case, the yield of 47.7 percent from the 20,000 yearling brooks stocked in 1947 at the beginning of the second phase comes close to what one may be permitted to consider the norm, in spite of two unfavorable factors: an abnormally large number of these fish were found dead in the lake during the first season, and at its end over 1,000 of them are known to have gone out of the lake into the outlet stream, presumably not to return.

FROG LAKE, NEVADA COUNTY

Frog Lake, like Castle Lake, lies in a granite cirque basin. Although at a higher elevation, it is some 200 miles farther south and subject to

much the same climatic conditions. It is some 12 miles from the town of Truckee, and has only one access road. Its features are:

Elevation: 7,900 feet.
Area: 33 acres.
Depth: 45 feet.
Winter conditions: snow and ice for five to six months.
Spawning: successful for brook trout only in bottom spring seepages.

The experiment began with an incomplete catch record in 1938. From then through 1948 records were maintained on a careful basis through the courtesy of the late Mr. Felix Smith, owner of the lake, who had his caretaker do this work; but since the man had other duties to perform he could not be expected to cover all anglers. It is estimated that the records are not over 80 percent complete. Since they have not been published before they are printed in summary here (Tables 3, 4, 5).

TABLE 3

Frog Lake Stocking Record, 1937-1947

(All Fish Were Fingerlings)

Year	Number planted			
	Eastern brook	Rainbow	Brown	Totals
1937	5,000	4,500[1]		9,500
1938	5,000	5,000		10,000
1939	4,000	4,000	4,000	12,000
1940	5,000	5,000	5,000	15,000
1941	7,000	7,000	7,000	21,000
1942	5,000	5,000	5,000	15,000
1943		15,000		15,000
1944		15,000		15,000
1945		14,000		14,000
1946		15,000		15,000
1947		15,500		15,500
Totals	31,000	105,000	21,000	157,000

[1] Steelhead stock.

TABLE 4

Summary of Trout Caught in Frog Lake, 1938-1948

Year	Eastern brook		Rainbow		Brown		All species
	Number caught	Percent of total	Number caught	Percent of total	Number caught	Percent of total	Total number
1938	183	65	9	3	89	32	281[1]
1939	572	73	50	6	160	21	782
1940	515	72	72	10	125	18	712
1941	305	65	64	13	103	22	472
1942	221	42	65	12	246	46	532
1943	122	24	106	21	284	55	512
1944	88	22	49	12	263	66	400
1945	65	18	80	22	221	60	366
1946	91	25	62	17	210	58	363
1947	128	30	85	20	218	50	431
1948	99	22	130	29	216	49	445
Totals	2,389	45.1	772	14.5	2,135	40.4	5,296

[1] Catch record in 1938 was only partial.

TABLE 5

Frog Lake: Yearly Comparisons of Fishing

Year	Number of reporting anglers	Total reported catch	Average catch per angler-day	Average catch per hour
1938[1]	53	281	5.3	0.93
1939	286	782	2.7	0.81
1940	271	712	2.5	0.58
1941	190	472	2.5	0.68
1942	221	532	2.4	0.58
1943	166	512	3.1	0.61
1944	134	400	3.0	0.64
1945	183	366	2.0	0.51
1946	280	363	1.3	0.37
1947	203	431	2.1	0.56
1948	266	445	1.7	0.44

[1] Catch record in 1938 was only partial. Many "zero catches" went unrecorded, thus bringing up the catch per angler-day and per hour.

It will be seen (Table 3) that from 1939 through 1942 three species of fingerling trout were planted in equal numbers, as at Castle Lake. Thereafter only rainbow fingerlings were planted, but quantities of eastern brooks and browns still remained in the lake. That an unauthorized plant of brown trout was made prior to 1939 is evident from their appearance in the catch in 1938 and 1939 (Table 4). Because there is no record of these fish they do not appear in Table 3.

A few hundred trout were marked in 1940 for age-length assessment, and some in 1947 which played almost no part in the total catch, but the great majority of the planted fish were left unmarked because of the fact that the caretaker did not have time to examine and record marks.

To arrive at a valid approximation of the yield in Frog Lake certain adjustments must be made. With regard to the eastern brook, we must adjust for the not inconsiderable natural spawning. In the first phase at Castle Lake brook trout played no significant part in the catch beyond their third year after the year of planting. Since none were planted in Frog Lake after 1942, we must assume that those caught after 1945 were naturally produced, and eliminate them from the count before computing the yield. Furthermore, we know that some of the brooks caught in the earlier years were naturally produced. From 1946 through 1948 naturally produced brooks were caught at the rate of around 100 a year; we can therefore hardly do otherwise than assume that *on the average* the same was true from 1938 through 1945, and that some 800 nonhatchery brook trout were caught in those years. The recorded catch for those years was 2,071 brooks. From this must be deducted 800 nonhatchery fish, leaving 1,271. Therefore, the total hatchery stocking from 1937 to 1942 of 31,000 eastern brook fingerlings yielded 1,271 fish to the angler, or 4.1 percent. Since a higher yield (4.4 percent) would be obtained by applying the same process to the assumption that all brooks caught after 1944 were naturally produced, the figure of 4.1 may be considered to be on the conservative side.

For the rainbow, with no natural spawning, no adjustments are necessary. From 1937 through 1947, 105,000 of them, including the 4,500 steelhead of 1937, were planted; 772 were caught from 1938 through

1948; yield was 0.7 percent. That the rainbows which were placed in this lake did not do well here is an inescapable conclusion, and there is some reason to suspect that the fall-spawning stock largely used here is not well suited to fingerling planting in high mountain lakes.

For the brown trout, adjustments again are necessary, even though successful natural spawning did not occur. We have no record of stocking prior to 1939, and we know from the Castle Lake work that browns play their most significant part in the catch as two-year-olds. If, then, we eliminate from the catch all browns caught in 1938, 1939, and 1940, we are certainly on the conservative side, for any survivors of the earlier unauthorized plant lingering on to be caught in 1941 and thereafter would be more than offset by survivors of the hatchery plants lingering to be caught after the records were brought to a close in 1948 (and the length of life of the browns here, corroborating the experience in Castle Lake, is noteworthy). Total catch of browns from 1941 through 1948 was 1,545; total plantings were 21,000; yield to the angler 7.7 percent. This seems a high figure for brown trout in a mountain lake, and perhaps not to be expected unless other species are present for them to feed on.

Summarizing our adjusted figures, we have the yield shown in Table 6.

TABLE 6

Frog Lake: Yield of Fingerling Trout, Adjusted Figures

Species	Number planted	Number caught	Yield (percent)
Eastern brook	31,000	1,271	4.1
Rainbow	105,000	772	0.7
Brown	21,000	1,545	7.7
	157,000	3,588	2.3

With regard to the over-all yield of 2.3 percent, two observations must be made. The first is that this figure is based on an estimated 80 percent catch record, so that the figure for 100 percent of the catch would be 2.9 percent. The second is that, included in this figure and pulling it down, is the abnormally poor showing of the rainbows, which constituted the bulk of the plantings.

The stocking over most of the period has run about 15,000 a year, or at the rate of 450 trout per acre; the fishing pressure has averaged 220 angler-days per season, or about seven anglers per acre; and the catch has run from a high of 0.8 to a low of 0.4 fish per hour, with a mean of less than 0.6.

JUNE LAKE, MONO COUNTY

The principal features of June Lake, on the east slope of the Sierra, are:

Elevation: 7,600 feet.
Area: 310 acres.
Depth: 140 feet.
Winter conditions: snow and ice for four to five months.
Spawning: none successful for rainbow trout.

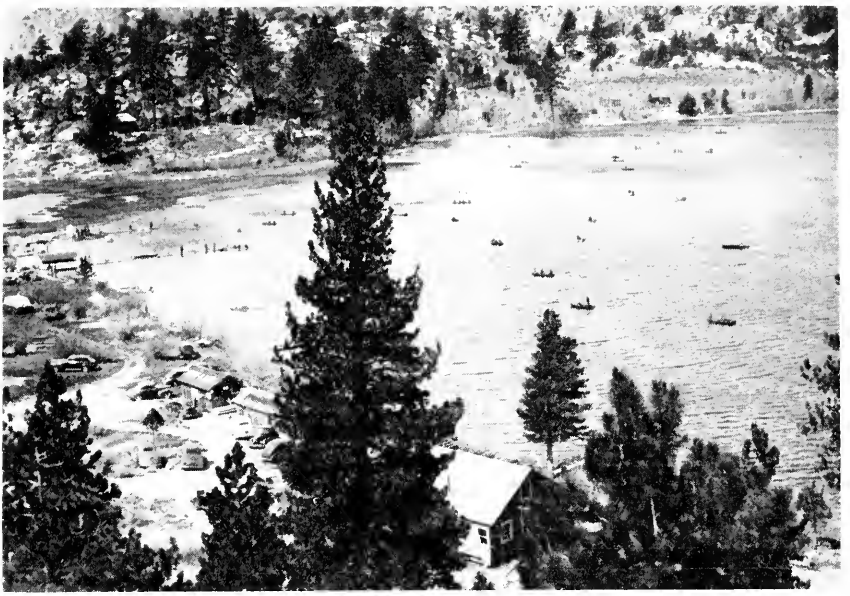

FIGURE 92. Fishing boats on June Lake, May 30, 1940. Photograph by Elden H. Vestal.

This lake is much more accessible than either Castle or Frog, is surrounded with resorts and homes, and is therefore not susceptible to a complete creel count. Records, however, have been complete enough to permit reliable estimates. From 1939 through 1941 the creel counts were made under professional supervision by CCC boys, ERA assistants, and boat concessionaires; in 1942 reliance was placed on intensive sampling of the catch.

The methods whereby estimated total catches were derived from partial records and samples have already been printed (Vestal, 1943), and we shall therefore limit ourselves to setting forth the results.

Fishing in June Lake, once excellent, had declined until "catchable-sized" rainbow of fall-spawning stock were planted in 1937. Remnants of these fish and of the similar 1938 plant undoubtedly contributed to the 1939 catch; but, by the same token, remnants of the fish planted from 1939 through 1942 undoubtedly still remained in the lake to be caught in later years after this experiment ended. The two groups thus compensate for each other, and the yield obtained by dividing the total number of fish planted in the four years by the fish caught is if anything on the low side due to the heavier plantings in the later years.

It will be noted (Table 7) that the number of fish actually counted during the first three years, 64,699, gives a yield of some 31 percent of the number planted. This is a rock bottom figure. If we take the *estimated* catch for the three years, a figure derived in perhaps a somewhat arbitrary manner, we get a yield of nearly 45 percent. If with this is combined the estimate for 1942, very carefully derived from a very careful sample, the yield is about 48 percent. We have, therefore, from spring plantings of catchable rainbow trout at the average rate of 250 per acre

in a lake where fishing pressure averages 40 angler-days per acre each season and the catch 0.6 fish per hour, a yield of not less than 31 percent, and of probably as high as 48 percent.

TABLE 7

Stocking and Catch Records in June Lake, 1939-1942, Inclusive

(All Fish Were Rainbow Trout of Fall-spawning Stock)

	Stocking	Catch	
		Recorded	Estimated total
1939	70,000 at 2.6 per oz. (4 in.) stocked 5-26-39	16,452	26,000
1940	70,000 at 1.3 per oz. (5 in.) stocked 6-19-40	19,476	29,000
1941	70,000 at 1.2 per oz. (5 in.) stocked 5-22-41	28,771	39,000
	210,000	64,699	94,000
Yield (percent)		30.8	44.8
1942	100,000 at 13.5 per lb. (6 in.) stocked 4-29-42	Sample only: 3,536	56,000
	310,000		150,000
Yield (percent)			48.4

GULL LAKE, MONO COUNTY

Gull Lake adjoins June Lake. Its features are:

Elevation: 7,600 feet.
Area: 68 acres.
Depth: 64 feet.
Volume: 2,500 acre-feet.
Winter conditions: snow and ice for four to five months.
Spawning: successful for eastern brook trout in small tributaries.

The lake was treated with rotenone in 1940 (Vestal, 1942) to eliminate an enormous population of rough fish (*Siphatcles bicolor obesus*). It was to evaluate this operation and the subsequent stocking with eastern brook trout that creel counts were made. With no natural spawning before the fall of 1941, all fish caught through 1942 were inevitably hatchery trout.

TABLE 8

Gull Lake Stocking and Catch Records, 1940-1942

Stocking:
Yearling brook trout, 1.3-1.1 per oz. (about 5 in.)—Nov. 1940: 78,000
Fingerling brook trout, 3 per oz. (about 3½ in.)—Aug. 26, 1941: 20,000

Catch	Yearlings		Fingerlings	
	Recorded	Estimated	Recorded	Estimated
1941	5,113	10,000–15,000		
1942	10,327	17,000	46	530
	15,440	27,000–32,000		
Yield (percent)	19.7	34.6 41		2.7

FIGURE 93. Gull Lake looking southwesterly. Photograph by Elden H. Vestal, July, 1940.

The estimate of the yearling catch in 1941 (Table 8) does not rest on a very firm foundation, and to be on the safe side the lower figure, 10,000, should be used. The estimate of 17,000 of these fish caught in 1942 may be taken with considerable confidence, thus giving 27,000 as a conservative estimate of the total number caught in two years, and a yield of about 35 percent. This seems far from satisfactory in view of the heavy stocking—at the rate of 1,150 yearlings per acre; but it must be remembered that these 78,000 brook trout were planted in November at a size of five inches in a lake which, having just been chemicaly treated, was low in fish food, whereas "catchable fish" as we usually think of them are planted at a size and time when they will enter the fishery almost immediately.

The estimate of the catch of the fingerlings planted in 1941 is based on examination of a sample of 1,524 fish caught in 1942. These were allocated to year-classes: 1,405 to the 1940 yearlings and 119 to the 1941 fingerlings, by sight classification based on length. However, only 23 of the observed fish were fin-marked, and one-half of the 1941 fingerlings had been so treated. On this basis it is logical to suspect that only about 46 of the "fingerlings" actually belonged to that class, and that the rest of the 119 were small fish of the 1940 yearling group. To be on the conservative side, this is the assumption which has been adopted here, and results in the estimate of 530 of the 1941 fingerling plant having been caught in 1942 for a yield of 2.7 percent. If the pattern of Castle Lake after treatment recurred here, there would be at least as many of these fish caught the following year, with a yield of over 5 percent. Unfortunately, record-taking had to be suspended due to the war.

In 1941 estimated fishing pressure averaged in the neighborhood of 30 anglers per acre and catch 1.3 per hour; in 1942 the respective figures were 50 per acre and 1.2 per hour. Stocking in 1940 was at the rate of 1,150 yearlings per acre; in 1941 at the rate of nearly 300 fingerlings per acre.

CRYSTAL LAKE, LOS ANGELES COUNTY

This project had fewer complicating factors than any of the others, and its results are therefore the easiest to interpret. Its features are:

Elevation: 5,500 feet.
Area: 10 acres.
Depth: 48 feet.
Volume: 335 acre-feet.
Winter conditions: snow and ice for several months.
Spawning: none.

Close enough to Los Angeles to attract multitudes of fishermen, this lake had provided a satisfactory fishery until introduced goldfish (*Carassius auratus*) and chubs (*Gila orcuttii*) overran the trout. In the fall of 1941 all fish were killed with rotenone. Restocking took place in January and February, 1942, with 14,000 rainbow trout averaging from 9 to 13 to the pound. The season opened May 1. Fishing pressure was intense, and from May 15 to August 21 close to 26,000 additional rainbows, averaging from six to the pound to 24 to the pound, were placed in the lake.

Due to the interest and the excellent work of William E. Conner, owner of the single camp and boat concession at the lake, the catch records are highly reliable and about as complete as is practically possible. They show that 28,500 trout were caught, out of the 39,800 planted, making the yield 71.6 percent.

Fishing pressure of 6,822 angler-days is at the prodigious rate of 682 angler-days per acre for the season; and in spite of the fact that the catch averaged just under one fish per angler per hour—a very satisfactory figure—28 percent of all the angler-days produced no trout! About 10 percent of the angler-days resulted in catches of over 15 trout—the limit at that time being 25.

Stocking averaged 3,980 catchable fish per acre. This would, of course, not have been possible but for the fact that the fish were being constantly removed and replaced throughout the season. In fact, this was purely a "put-and-take" proposition; but that such a system, although expensive, does yield to the angler a high percentage of the trout planted is clearly demonstrated.

LAKE ALMANOR, PLUMAS COUNTY

This power storage reservoir in Northern California inundates a small natural lake and a large forested meadow from which the trees were not removed when the dam was built. Its features are:

Elevation: 4,500 feet.
Area: 28,000 acres at maximum allowable level.
Depth: 120 feet in one spot, but not more than 30 feet over most of the lake bottom.
Volume: 1,600,000 acre-feet at maximum allowable level.
Winter conditions: frozen for four months.
Spawning: excellent for rainbow in many tributaries.

Ever since the dam was completed this lake has been noted for the rapid growth and large size of its rainbow trout. Even now when, according to old-timers, fishing is no longer what it used to be, the rainbows average from $2\frac{1}{2}$ to $2\frac{3}{4}$ pounds. Water temperatures become high in summer, and the trout then concentrate in the cold sub-surface springs. Largemouth black bass (*Micropterus salmoides*) have found their way into the lake; the noticeable increase in their numbers in the last two years leads to the surmise that this may become a good bass lake.

In spite of the excellent spawning tributaries, there has always been a strong demand for the planting of fingerling trout here. Marking experiments have been undertaken, mainly in the hope of finding out what contribution these hatchery fish were making to the catch. Returns have been difficult to obtain because of the number of boat landings and of the road which encircles the lake. Marked fish planted in 1942 and 1943 gave no usable returns. In June and July of 1946, 100,000 marked rainbow were planted at 12.8 per ounce (two inches), and in August and September of 1947, 73,800 at 6.6 per ounce (three inches). 114,000 unmarked rainbow were also planted in 1947 at 25 per ounce (one and three-quarter inches), but play no part in this project. From the 1946 plant, 64 returns have been officially recorded; from the 1947 plant, seven. It is the carefully considered opinion of the trained men in charge of this work that the total catch numbers about six times the officially recorded catch. On this basis the 1946 plant of 100,000 has contributed 384 fish to the creel for a yield of 0.4 percent; the 1947 plant of 73,800 has contributed 42 fish to the creel for a yield of 0.06 percent. Average yield for the two plants is therefore 0.23 percent. But even if we disregard the 1947 fish on the theory that something went abnormally wrong with them either before or after planting, we are faced with a yield in the order of magnitude of one-half of one percent from the 1946 fish as the best known contribution of hatchery fingerlings to fishing in Lake Almanor. That fingerling planting has helped fishing very little in a lake so large and so well furnished with natural spawning facilities as this one will not come as a surprise to those who have studied such matters.

The number of fisherman-days on Lake Almanor is estimated at around 30,000 in 1948 and 1949, with the total catch each year in the neighborhood of 10,000—mostly wild fish, needless to say.

OTHER LAKES

Creel counts on the three lakes in this section have been much less intensive than in the six previously discussed, and the yield figures can not therefore be considered to have the same degree of reliability.

Conn Valley Reservoir, Napa County, impounds the waters of Conn Creek and its tributaries which, prior to the construction of the dam in 1945, received runs of steelhead trout from the ocean via Napa River and San Francisco Bay. When full, at an elevation of 315 feet, it contains 31,000 acre-feet, with an area of about 800 acres and a depth of 110 feet. Winters are comparatively mild, with much rain but no ice. Good gravels in which steelhead formerly spawned exist in the very small tributary streams, but the latter become extremely low and often intermittent in late summer.

Although planted exclusively with rainbow trout because of local sentiment centering around the now defunct steelhead runs, Conn is not a favorable trout habitat. The surface water becomes warm in summer—as high as 78 degrees—and the lower levels with cooler water become deficient in oxygen. Green sunfish (*Lepomis cyanellus*), strayed into the reservoir from ponds higher in the watershed, and Pacific lampreys (*Entosphenus tridentatus*) which appear to have become landlocked, are not helpful to the trout population.

The City of Napa, owner, has restricted the daily catch to 10 fish, and in some years has imposed a shortened season. A creel count has been made by the Division of Fish and Game at the opening of the season each year since fishing started in 1947, and the city employees at the boat landing have kept excellent records of fish brought in throughout the season. These two sources, plus an estimate arrived at by the city and division employees of the ratio between total boat catch and total shore catch, form the basis for the estimates of total catch. The planting record is given in Table 9.

TABLE 9

Rainbow Trout Planted in Conn Valley Reservoir From Its Construction to End of 1949 Fishing Season

Date	Number	Size
1946, April	100,000	25 per oz. (2 inches). Unmarked.
1947, May	100,000	22 per oz. (2 inches). Unmarked.
Summer	43,000	Fingerlings rescued from tributary streams and placed in reservoir. Unmarked.
1948, March	20,100	6 to 10 per lb. (6 to 8 inches). 1,000 marked.
1949, April	41,400	12 to 16 per lb. (5 to 6 inches). Unmarked.

Catch recorded during the 61-day 1947 season was 5,515; total catch was estimated at not less than 7,000 as an absolute minimum, with 11,000 considered a more probable figure. Study of 100 scale samples indicated that 30 percent of the fish were of hatchery origin. Applying this figure to the estimates, not less than 2,100 and more probably about 3,300 hatchery fish were caught from the 100,000 fingerlings planted in April 1946, making a yield of 2.1 to 3.3 percent—or, if one wishes to average the two estimates, the yield could be called 2.7 percent.

Number of fish recorded in the 1948 season (May 1 to October 31) was 5,716; total catch was estimated at not less than 10,000 with 15,000 a more probable figure. Observed ratio of marked to unmarked fish indicates that 96 percent of all fish caught came from the March, 1948, plant, making the yield from 48 to 72 percent. The 143,000 fingerlings placed in the reservoir in 1947 yielded practically nothing to the 1948 anglers. This, and the scarcity of naturally spawned fish in 1948, may be ascribed in large part to highly unfavorable conditions both in the reservoir and in its tributaries during the late summer of 1947.

Number of trout recorded at the boat landing in 1949 (season May 1 to July 15) was 2,373 (Murphy and Pintler, 1950). Total catch was estimated at not less than 4,700, with 7,100 a more probable figure. Analysis of 121 scale samples indicated that approximately two-thirds of these came from the plant of April, 1949, or from 3,130 to 4,730, giving a yield from the 41,400 planted 5- to 6-inch trout of 7.6 to 11.4 percent.

These low figures are due in part at least to the low fishing pressure (and perhaps also to the greater amount of water in the reservoir). Not only was the season shorter than in 1948, but in the same period only half as many boat-anglers fished the lake. Of carry-over of the 1948 plant there was no evidence; not one of the 1,000 fish marked then was seen in 1949 among the more than 600 trout examined by professional workers.

Average of all figures for plants of catchable fish—48 to 72 percent yield for the 1948 catchable fish, 7.6 to 11.4 percent for the 1949—gives a mean yield for all plants of catchable fish in Conn Valley Reservoir of 35 percent. In the opinion of those who carried on the work, the probability is that the true figure is considerably higher than this estimate.

Hume Lake, Fresno County, was formed by a dam in 1909 some 70 miles from the City of Fresno. At an elevation of 5,300 feet, it has when full a surface area of 94 acres, a volume of 1,800 acre-feet, and a depth of 45 feet. Winter conditions include snow and ice for about four months. Spawning has been practically impossible during the period covered by the census. A naturally good trout habitat, although too warm for good fishing in midsummer, Hume twice has been overrun by rough fish, and has had its entire fish population destroyed by chemical treatment in 1940 and again in 1947. Since then a basic policy of stocking approximately 30,000 subcatchable (4½- to 5-inch) rainbow trout each autumn has been followed.

None of these fish have been marked, but since natural spawning has been almost nil, the number of fish caught which did not come from the hatchery plants may be assumed to have been negligible. Creel counts made on eight days, all either Sundays or holidays, spaced at fairly regular intervals throughout the 1949 season, the first on May 1 and the last on October 30, form the only basis for an estimate of the total catch. To quote from the unpublished report (Soule, 1950):

"There is no means by which a reliable estimate as to the total catch can be made from the foregoing facts. It is possible however to compute a total catch figure if certain assumptions are made. The total harvest computation so obtained can be used to advantage *if the user clearly understands the fragile and possibly inaccurate framework upon which it rests.* The writer has taken into consideration his knowledge of the lake and of the people who fish it as a basis for estimating the season's total catch from the creel census data. At best the result is merely an informed guess and is open to argument on many points."

By the most careful and detailed methods, weighted for Sundays, holidays, week-days, monthly variations, etc., an estimate of 17,000 for the total catch is arrived at; and it is pointed out that a number of other methods were tried and gave estimates varying from 13,000 to 20,000. Never forgetting that what we have here is "merely an informed guess," it seems worth while using as, at least, a directional signpost. With an annual planting of approximately 30,000 as the denominator, a catch of 17,000 gives a yield of 57 percent for the season of 1949. In view of the nature of the data, it is probably wise to say, for the purposes of this paper, that the yield was "not less than 50 percent."

Total fishing was estimated at 7,000 angler-days, making an average of nearly 75 per acre for the season. Catch ran as high as 0.75 per hour on May 1, as low as 0.13 on Labor Day—September 5—with the average estimate at 0.5. Stocking has averaged about 320 fish per acre.

Crowley Lake, Mono County, part of the Los Angeles water supply, holds 183,000 acre-feet of water. Its elevation is 6,780 feet, surface area 5,284 acres, depth 115 feet. There is some spawning in the tributaries. Plantings of rainbow trout averaged around 110,000 annually for the four years 1946-1949, but variations both in numbers and in sizes from year to year were so great as to make it inadvisable to try to derive yield figures for this species from the periodic creel counts held in 1947 and 1949.

However, the situation is different with cutthroat (*Salmo clarkii*). Between August 24 and September 28, 1946, some 817,000 fingerlings, ranging from 15 to 32 per ounce (1½ to 2 inches long) were introduced into the lake. None of these fish could have produced natural offspring big enough to enter the catch prior to 1950, and no more of this species were planted until late 1949. It is therefore certain that all cutthroat in the 1947 and 1949 creel counts came from the 1946 fingerlings. Estimates based on these creel counts, with observations and interpolations for 1948, give the figure of 8,500 as the total harvest through 1949 from 817,000 fingerlings, for a yield of 1.04 percent. Giving all benefit of doubt to the fish which still remain in the lake, the yield from this planting by the time it reaches the end of its life in the fishery could not exceed 1.5 percent. Again we find fingerlings planted in a large lake, where other fish are present, producing a very small yield.

COMPOSITE PICTURE OF THE YIELDS

We are now in a position to view with understanding the contents of Table 10. All scientific work attempts to avoid the subjective, and yet that element is present in parts of this table. In some cases it is nonextant. In Crystal Lake an objectively counted number of fish were caught from an objectively counted number planted to give a purely objective yield of 71.6 percent. The same thing is true of the Castle Lake work, even though, in the fingerling part of the first phase, the purely arithmetic figure of 3.6 percent has been raised to 4.0 percent; for this has been done by projecting known results obtained from repeated experience in the past into a very near future. But in Frog Lake the observation that 20 percent of the catch went unrecorded, and the adjustment of the yield figure from 2.3 to 2.9 percent to compensate for this, is based largely on the opinion of the creel-counter; it may be presumed to be on the conservative side, but it partakes of the subjective. From here on, this element enters more and more into Table 10. The last column is to some extent an attempt to indicate its importance in each case, but this column is in itself subjective in that it records the opinion of the writer.

The yield figures given in the table are sadly inconsistent. One way to deal with them is to average them. There are two objections to this: the varying degree of subjectivity—of reliability—in the various cases; and the variation in the environmental conditions. If one does insist on an

TABLE 10

Yields of Hatchery Trout in California Lakes

Name of lake	Elevation in feet	Surface in acres	Depth in feet	Fish stocked		Fishermen days per acre per year, mean	Catch per hour, mean	Creel counts		Yield in percent	Degree of reliability
				Species	Mean number per acre per year			Number of years	Portion of season		
Fingerlings											
Castle											
1st phase	5,200	47	120	3	425	13	0.6	6[1]	All	4.0	Excellent. Includes estimate of fish which would have been caught if not killed by chemical treatment in 1946.
2d phase	5,200	47	120	EB	425	22	1.7	3[1]	All	25.3	Excellent. Makes no allowance for fish still to be caught after July 31, 1950.
Frog	7,900	33	45	3	450	7	0.6	10	All	2.9	High. Estimate makes allowance for 20% of catch unrecorded.
Gull	7,600	68	64	EB	295			1	Periodic	2.7	Fair. Estimate makes no allowance for fish still to be caught after end of creel count.
Almanor	4,500	28,000	120	RT	3 (marked)			4	All	0.2	Fair. Estimate is based on counts at several stations.
Conn	315	800	110	RT	125			2		1.4	Fair. Yield figure is based on mean of 2.7 for high and low estimates for 1946 plant and on complete failure of 1947 plant. Boat records combined with estimate of shore catch.
Crowley	6,780	5,284	115	CT	155			2	Total of 33 days	1.5 or less	Low. Based on estimates for 1947 and 1949, with 1948 interpolated, and allowing for fish still to be caught.
Catchable Fish											
Castle											
1st phase	5,200	47	120	3	32	13		6	All	27.4	Excellent.
2d phase	5,200	47	120	EB	425	22	1.7	3	All	47.7	Excellent.
Crystal	5,500	10	48	RT	3,980	682	1.0	1	All	71.6	Excellent.
June	7,600	310	140	RT	250	40	0.6	4	All	48±	High. Actual count for 3 years is 31%. 48% is estimate of total harvest for 4 years.
Gull	7,600	68	64	EB	1,150	40	1.2	2	Periodic	35±	Good. Estimate is based on partial counts.
Conn	315	800	110	RT	38			2		35±	Fair. Yield estimate is mean of high and low estimates for 2 years, based on boat records and estimate of shore catch.
Hume	5,300	94	45	RT	320	75	0.5	1	8 days	50±	"Informed guess."

[1] Castle Lake creel counts have extended over a total of 10 years, since under "Catchable Fish" the first of the 3 years in the 2d phase comes between the 6- and 3-year periods of the 1st phase under "Fingerlings."

Species Symbols: RT—rainbow
EB—eastern brook
BN—brown
CT—cutthroat
3—first three planted together

average, one obtains 5.4 percent for the fingerlings, and 44.9 for the catchable fish. These are not unreasonable-looking figures, but to me they are unsatisfactory. They are objective combinations of figures of varying degrees of subjectivity. To me it seems better, since subjectivity is an unavoidable element here, to use it, aided by the best of our intelligence and our experience, in interpreting the results.

Considering fingerlings first, available evidence from all over the country tells us that their yield when planted in large lakes, especially where other fish are present, is low. The first step, then, in obtaining a clear understanding of the results to be expected from fingerlings in small lakes—under 100 acres—is to forget Almanor, Conn Valley, and Crowley, where yields average 1 percent, and to consider only the first four items in Table 10. Average of the yields in these is 8.7 percent. This is obviously distorted by the unusually high figure of 25.3 for Castle Lake second phase. Setting this aside as due to especially favorable conditions, we have the 4.0 percent of Castle Lake first phase based on six years of what might be called normal conditions except for the simultaneous stocking of three species; the 2.9 percent of Frog Lake under the same kind of conditions with the exception that the unsuitability of rainbow there probably lowered the figure; and the 2.7 percent of Gull Lake which made no allowance for the fish still remaining in the lake when creel counts had to be terminated, and which would undoubtedly have been higher if they could have been continued another year. The figure of 4 percent stands in the mind of the writer as the yield to be expected over the long run in normal conditions.

When we come to catchable fish, the distribution of figures does not cover so wide a range. The low yield in Castle Lake first phase might be attributed to low stocking and fishing intensity; in Conn Valley to low stocking and unsuitable environment; in Gull to overstocking of an impoverished environment. The high yield in Crystal is certainly due to the continuous pouring all season long of catchable fish into a small, extremely heavily fished lake—an uneconomic procedure unless special fees are charged. There remain Hume, Castle Lake second phase, and Hume. The results here are so closely grouped that they cannot help bringing to mind the figure of 50 percent as the yield to be expected in the long run from the planting of catchable fish.

From the arithmetic averages of 5.4 percent and 44.9 percent, the subjective figures of 4 percent yield from fingerling plants and 50 percent from catchable fish plants do not differ greatly. The reader is at liberty to accept either; but, most important, he is at liberty to reject both and, with the figures and the qualifying circumstances set forth here, to determine for himself his own idea of the most probable values for the respective yields.

SUMMARY

1. This paper brings together information obtained over 10 years from hatchery trout yield experiments on nine California lakes, of which six are considered of primary and three of secondary importance. Most of these lakes have no or insufficient natural spawning. It is emphasized that lakes produce very different results from streams.

2. Figures are given for the yield in each lake: number of fish caught as a percentage of the number planted. Stocking intensity and fishing pressure are also given.
3. The results of the different projects vary widely. From fingerling plants, three large lakes (800 acres and up) produced low yields in comparison with three small lakes (33 to 68 acres). Average yield from the former was 1 percent with a range of 0.2 to 1.5; from the latter 8.7 percent with a range of 2.7 to 25.3. In all combined, fingerling plants averaged a yield of 5.4 percent.
4. Extraordinary improvement in yield from fingerling plants occurred in one 47-acre lake when a population of three planted trout species plus resident lake trout (mackinaw) was eliminated and replaced by one species.
5. Plants of catchable trout in seven lake experiments in which areas ranged from 10 to 800 acres gave an average yield of 44.9 percent with a range of 27.4 to 71.6.
6. It is suggested that the arithmetic average yields of 5.4 percent from fingerlings and 44.9 percent from catchable trout take too little account of the variations in the reliability of the figures from which they are formed, and of the nonquantitative factors involved. Knowledge and consideration of these lead to the proposal that the figures which best interpret the results obtained in these experiments are: yield from fingerling plants (in lakes under 80 acres), 4 percent; yield from plants of catchable fish, 50 percent.

REFERENCES

Murphy, Garth I., and Herbert E. Pintler
1950. The 1949 fishery of Conn Valley Reservoir, Napa County. Administrative report to the Bureau of Fish Conservation, Calif. Div. Fish and Game, 9 p., submitted July 12, 1950 (mimeographed).

Soule, Scott M.
1950. Occasional creel censuses at Hume Lake, Fresno County, during 1949. Administrative report to the Bureau of Fish Conservation, Calif. Div. Fish and Game, 31 p., submitted April 7, 1950 (mimeographed).

Vestal, Elden H.
1942. Rough fish control in Gull Lake, Mono County, California. Calif. Fish and Game, vol. 28, no. 1, p. 34-61.
1943. Creel returns from hatchery trout in June Lake, California. Calif. Fish and Game, vol. 29, no. 2, p. 51-63.

Wales, J. H.
1946. Castle Lake trout investigation. First phase: Interrelationships of four species. Calif. Fish and Game, vol. 32, no. 3, p. 109-143.
1947. Castle Lake trout investigation: 1946 catch, and chemical removal of all fish. Calif. Fish and Game, vol. 33, no. 4, p. 267-286.

NOTES

A NOTICEABLE ABSENCE OF BLADDER WORMS IN CATALINA DEER

The intermediate stages, or cysticerci, of various tapeworms are commonly known as bladder worms. These white cysts occur most frequently on the mesenteries, but are encountered in the liver, thereby causing the disease *Hepatitis cysticercosa*. The usual species found in California deer is *Cysticercus tenuicollis*. One case of *Echinococcus granulosus* was observed at the laboratory.

Several hundred deer from practically every part of the State have been examined by the staff of the Disease Research Laboratory. More than 90 percent of the deer observed at post mortem contained one or more cysts.

During the past special hunting season on Santa Catalina Island opportunity was afforded the author to examine or observe the viscera of 93 deer. Not one of these deer had any observable cysts present. The lack of cysts was immediately apparent as compared with all of the deer previously autopsied on the mainland of California.

The original stock of 22 mule deer were planted on the island some 20 years ago. One buck and two does probably from Modoc County and 19 deer from Los Angeles County comprised the introduced herd. With the introduction of the deer, the bladder worms were undoubtedly also introduced.

The final host for the tapeworm is a carnivore, usually the coyote. A reasonable explanation for the disappearance of the tapeworm cysts on Santa Catalina Island could be the absence of the coyote, thereby breaking the chain of the life cycle.—*Morton N. Rosen, Bureau of Game Conservation, California Division of Fish and Game, August, 1950.*

COMPOSITION OF DEER MILK

On June 10, 1949, a female black-tail deer (*Odocoileus hemionus columbianus*) was brought into the California Division of Fish and Game disease laboratory within a few minutes after it had been killed. The doe had been suckling a fawn and had a large supply of milk. By massaging the milk into an exposed milk well, 25 cc. was collected and frozen for later analysis at the College of Agriculture at Davis. The following table

compares the composition of this sample of deer milk with the average composition of milks of antelope, goat and cow:

Animal	*Specific gravity*	*Total solids per cent*	*Ash per cent*	*Fat per cent*	*Authority*
Deer	1.046	20.4	1.44	8.3	Present analysis
Antelope		24.9	1.3	13.0	Einarsen, A. S., 1948. The Pronghorn Antelope. Wld. Mgt. Inst., Wash., D. C., p. 110.
Goat	1.0305	13.2	.85	4.07	Heineman, P. G., 1919. Milk. W. B. Saunders Co., Phil. & London, p. 70.
Cow	1.0313	12.73	.72	3.68	Heineman

Chemically the milk of deer proves to be rich in total solids, ash and fat, much like antelope milk. By contrast, goat and cow milks are much lower in solids, fats and in nutrient value.—*Herbert L. Hagen, Museum of Vertebrate Zoology, University of California, Berkeley, October, 1950.*

OBSERVATIONS ON FAILURE OF GAMBEL QUAIL TO BREED

The failure of quail to nest during dry years has been reported by many people. Leopold (Game Management, c1933, p. 28) states: "... during periods of drouth Gambel quail coveys fail to pair off and nest. Apparently in such instances the disposition to breed is inactive for lack of some stimulus associated with normal weather, food and cover, but the abnormal condition does not visibly affect the health of the adult birds. No one has proved that drouth is actually the cause of failure to breed, or through what deficit in food, cover, vitamin, or mineral it operates to this end."

The reports in the literature are usually for isolated areas and represent isolated observations. During the spring of 1950 it became evident to the fish and game personnel working in the Colorado and Mojave Desert region that throughout most of this area the Gambel quail (*Lophortyx gambeli*) were not nesting. The birds did not pair off and remained in the large winter coveys. As the spring progressed there was a noticeable absence of young chicks or paired-up birds. During this period several birds were collected from different localities throughout the desert. Some of the male birds possessed slightly enlarged testes, but there was no sign of development of the female reproductive organs. The crop contents were analyzed by the Division of Fish and Game food habits laboratory and showed that seeds and insects were making up the diet of the birds but that no green feed was present.

Throughout most of the Colorado and Mojave Desert there was less than 2 inches of rain during the 1949-1950 season. Almost all of this precipitation fell during December and January when the weather was too cold for any growth to occur.

On July 6, 1950, heavy rains fell in the Piute Mountains in the vicinity of the Lazy Daisy Well. Sprouting annuals appeared shortly following this rain. There were a few light showers in August and early September and green feed was plentiful from a few days after the rain on July 6th until September 10th. Young quail 10 to 14 days old were observed during the middle of September.

Normally the quail in this area start to mate the first of April, so the breeding season was delayed approximately four months. Up until this time there had been no young birds observed in this area. The only places in the Mojave-Colorado Desert where young birds were found were adjacent to spots where green feed occurred, around the border of the desert, and at a few locations at higher elevations in some of the desert mountain ranges. From these observations it would seem that a lack of green feed and the vitamins it contains is responsible for the birds failing to pair off and nest. Evidently if green feed is supplied during the breeding season the birds are stimulated and begin to breed.—*Wallace Macgregor, Jr., and Manley Inlay, Bureau of Game Conservation, California Division of Fish and Game, November, 1950.*

IN MEMORIAM
SAM R. GILLOON

Assistant Chief of Patrol S. R. Gilloon, in charge of the Sacramento Division of the Bureau of Patrol, passed away on October 27, 1950, at the Veterans' Hospital, Fresno. He had suffered for some time from an unidentified ailment.

Sam Gilloon entered state service on April 1, 1925, as a deputy in the patrol department. He was stationed in Siskiyou County, and was promoted to captain in 1928, with headquarters at Mt. Shasta. In 1935 he was transferred to the Fresno District, where he served as captain until 1948, when he was promoted to assistant chief, in charge of that district. Upon the retirement of Assistant Chief C. S. Bauder, Gilloon was placed in charge of the Sacramento patrol district.

Sam Gilloon was a very active and most capable enforcement officer, well liked and respected by his men. He had many friends and associates who join the department in extending sincere sympathy to Mrs. Gilloon. —*L. F. Chappell, Chief of Patrol, California Division of Fish and Game, January, 1951.*

REVIEWS

Handbook of Freshwater Fishery Biology

By Kenneth D. Carlander; William C. Brown Company, Dubuque, Iowa, 1950; v + 281 p., 5 charts; $4.50.

This book is without question an outstanding contribution to the literature on fresh-water fishery biology. It is the first major compilation summarizing a vast wealth of previously scattered data into a convenient form for comparative and reference purposes. The title may be misinterpreted by those who think of a fisheries handbook in terms of a manual or textbook; instead, this actually is a handbook or source book for quick reference to data on fresh-water fishes. Periodic supplements to the handbook are planned to keep the compilations up to date.

Contents of the present volume are divided into several sections as follows: Introduction and Instructions for Reading the Tables; Suggestions for Conducting a Simple Age and Growth Study; Life Histories (by species); Population Data; Conversion Tables; Literature Cited; Index; and Appendix of Alinement Charts and Nomographs.

The section on Life Histories (by species) represents the monumental task of compiling ". . . as completely as possible all data on growth, length, weight, and various length relationships on all species of fresh-water fishes found in the United States and Canada," and then assembling this data in a standard form for easy comparison. This work alone will save fisheries workers untold hours of duplicating each other's work in compiling the same material. Mr. Carlander admonishes his readers quite clearly, however, that "These summaries will not serve as a substitute for reference to the original papers in any detailed life history study." He also cautions that "Not all of the data in the tables are of equal value" as "Some represent careful, detailed studies and others are mere chance observations."

The section on Population Data includes creel census figures of catch per hour, annual yield per acre, and standing crop. These data were accumulated in connection with other bibliographical work and no particular effort was made at a complete coverage. Nevertheless, much valuable information is included and, of greater importance, a start has been made in the compilation of comparative statistics for creel census data evaluation. If fish management work is to be carried forward in an intelligent fashion there is a definite need for evaluating yardsticks by which the results of the use of stocking, environmental control and various other methods of improving fishing can be compared and analyzed.

Conversion tables are included for inches by tenths and by eighths to the nearest millimeter, for ounces to grams, for pounds by tenths and by hundredths to the nearest gram, and for ounces by tenths to hundredths of a pound. There are tables for converting lengths and weights of preserved fish to live lengths and live weights. In addition there is a table of the reciprocal method of calculating the condition index whereby the factor from the table corresponding to the length of the fish in millimeters when multiplied by the weight of the fish in grams gives the condition index. The same table can also be used to determine the condition index from English measurements.

An idea of the scope of the book can be had from the fact that there are 1,112 references listed in "Literature Cited." These include waters and fish from all sections of the United States, much of Canada and many from other countries as well. Carlander deserves a rousing cheer from all fresh-water fishery workers for the magnitude of this work.

In my opinion this book will make a worthwhile and very useful, if not indispensable, addition to the library of all biologists, conservationists, and research workers dealing with fresh-water fishes.—*Scott M. Soule, California Division of Fish and Game.*

The Pursuit of Plenty: The Story of Man's Expanding Domain

By A. G. Mezerik; Harper & Bros., New York, xi + 209 p. $2.50.

Here is an interesting, highly recommended book concerned with the struggle between the people's right to a fuller life and the private interests which seek to exploit for profit while preventing the full development of resources. The criticism is directed at such groups as the "professional economizers" who will pollute the water or the air in preference to slightly reducing the annual dividend. The answer given by Mezerik is the extension of agencies such as the TVA or similar, stronger regional planning organizations which, by national and international integrated resource development, will meet the problem of the expanding population. This book is good for the professional wildlife worker whose perspective is clouded by the maze of petty details. We could well adopt as a motto one of Mezerik's basic concepts that ". . . nowhere can natural resources be evaluated as materials separated from the social organization of the people who are to use them."—*R. M. Paul, California Division of Fish and Game.*

Name That Animal

By Ernest C. Driver, drawings by Olive Driver; The Kraushar Press, Northampton, Mass., 1942, revised 1950, 558 p., 113 p. of line drawings, $6.50.

This is an initial attempt to combine under one cover and by one author the means by which the student and the curious can identify the more common land and fresh-water animals found in the United States. That there is a need for such a book is beyond dispute.

As acknowledged by the author, emphasis has been placed on the species occurring east of the Rockies. This is quite noticeable for one finds that certain species indigenous to California are missing and that notable California references are absent from the bibliography.

The author has arranged the 11 phyla of land and fresh-water animals into 14 groups in consequent chapters. There is a general introductory discussion of each group. This is followed by line drawings of individual species or labeled plates showing morphological characteristics of the group and by a key to the identification of animals included in that group. Two chapters are devoted to egg and track identification. Accompanying each chapter is a list of references. It is felt that many of the line drawings are too sketchy and that considerably more time should have been spent on the illustrations.

One should find that with this book he can key an unknown animal down to species or at least to a point where he will know where to look in available literature for such identification. A zoologist desiring the finer details of classification will undoubtedly find the book's value limited but to the amateur it is recommended.—*Howard R. Leach, California Division of Fish and Game.*

Field Book of Seashore Life

By Roy Waldo Miner; G. P. Putnam's Sons, New York, 1950, xv + 888 p., 251 black and white + 24 colored plates, $6.

This is truly an excellent volume. Dr. Miner, who is now curator emeritus of living invertebrates, American Museum of Natural History, has drawn upon a lifetime of observations in preparing it, and this is reflected in the complete descriptions and natural history notes. The book includes more than 1,300 species of marine invertebrate animals commonly found in the waters of the Atlantic from Nova Scotia south to Cape Hatteras; from the upper tide limit to the edge of the Continental Shelf at a depth of 600 feet. Each species discussed is represented by an accurate line drawing and in addition many are illustrated in color.

In the introduction the author gives a brief explanation of scientific classification. There are as well short sketches telling where and how on the seashore one may find many of the common forms. Quick and easy methods of capture and preservation are suggested.

The geographical area covered in the scope of the book is relatively small and many of the animals discussed are endemic to it. This should not detract, however, from the value of the book as a reference for biologists in other localities.

Very early in the text occurs the statement, "The book is intended first of all for the layman . . ." but common names, which the nonscientist can understand and then use himself in telling a friend of a particular seashore find, are noticeably lacking throughout with the possible exception of the section on shells. Dr. Miner excuses this lack of common names with several statements including, ". . . the

so-called popular name may seem easier to remember, but it is loosely applied, and often includes different species under the same current appellation." While this is unquestionably true, the use of scientific names in a book for the layman seems to be carried to extremes in this case. There are many places in the text where for fifty or more pages no popular name occurs.

A man of Dr. Miner's qualifications should be the logical person to set up a system of acceptable common names for these invertebrates and what better place than the present volume to inaugurate such a plan. However, any slight disappointment which the layman may experience over lack of common names will probably be more than compensated by the thoroughness of the text.

This volume is definitely recommended to anyone who has even the slightest interest in the seashore and the animal forms which may be found there.—*John E. Fitch, California Division of Fish and Game.*

Streamer Fly Fishing in Fresh and Salt Water

By Joseph D. Bates, Jr.; D. Van Nostrand Company, Inc., New York, 1950; xvii + 402 p.; $5.

Apparently this is the first book to be devoted exclusively to streamer and bucktail fishing. By the author's definition, each is a type of "fly" which does not represent an insect but "whose shape and intended action is to represent a baitfish." The streamer possesses a predominantly feathered wing; the bucktail a predominantly haired wing. Such flies are well known especially as early season lures and as takers of big fish.

The first part of the book deals with definitions, the development of streamer fishing, the reasons why fish take them, methods of fishing, and tackle. It includes chapters on fast and slack water fishing, and on salt water fishing in the west, east, and south. The chapter on western salt (and brackish) water fishing discusses salmon (especially silvers), cutthroat, steelhead, striped bass, and shad.

The second part, almost half of the book, is a detailed account of the history and "authentic" dressing of more than two hundred streamers and bucktails. Wherever possible, Bates has described the flies directly from original patterns and much of their history has been obtained from the originators. Californians will find special interest in the development of such Klamath River steelhead flies as Peter Schwab's wire-bodied bucktails, C. Jim Pray's opties of Eel River fame, and the older flies such as the Railbird and Improved Governor. Incidentally, one fly in the series, the "Leech Streamer" is unique in representing a leech or bloodsucker instead of a minnow. (The term "fly," it will be seen, is a very inclusive one today. Flies have now been tied to imitate insects, crustaceans, worms, and fish; and at least one pattern purports to represent a gob of salmon eggs.)

The sections on methods of use are easy to follow and should be helpful to most anglers. However, the detailed discussions of streamer design, and the reasons for such designs and their selection, tend to bog down in minutiae which will have appeal only to the extremely technical angler and fly-tier. The book is obviously written for such men. The neophyte or more casual fisherman will probably read only the more general sections, and will do well to keep in mind the author's own conclusion: "Of all that this book contains, the very essence of its teaching is to suggest that the angler select patterns of a size and type similar to the prevalent baitfish; and then to fish his fly as that baitfish habitually swims . . ."

There are two good color plates by Ellen Wagstaff and attractive line drawings by Milton J. Weiler. The book is indexed.—*William A. Dill, California Division of Fish and Game.*

Natural History of Marine Animals

By G. E. MacGinitie and Nettie MacGinitie; illustrated by the authors, Marcella Carter, and Lucina Stanford; McGraw-Hill, New York, 1949, 473 p., 282 figs. $6.

The MacGinities' book is an introduction to the ecology and classification of marine animals. The emphasis is placed on the animal life of the North American Pacific shores, but the discussion is carried to all oceans. On the whole the book does what it is aimed to do—answer questions of a general nature about the animals of the water and beach worlds. Much of the material was obtained from field work done along the shores of Southern California, but substantial information is drawn from standard texts of the marine sciences.

It will become obvious that liberal use of the authors' own field observations elevates this book above many zoology books. This valuable feature is designed to show research students that animals can be studied in their environment and that conclusions

about animal conduct should be made from such observations and not those made in the laboratory. There are numerous references to field methods which will be interesting to those ready to study or obtain specimens in the wild. Simple definitions and explanations keep this book from being truly technical. Withal the book can be useful to the professional biologist, although it is not intended for him, by summarizing the classification of animal groups and the principal aspects of marine ecology. This latter subject is discussed under the topics of food, growth rates, sense organs, comparisons between sea and land animals, relationships of animals, and the ocean as an environment.

The format of this book is similar to others in the well-known series by the publishers. The figures are good and supplement the many excellent photographs. Some irregularities occur. The remora is called a pilot fish on page 14, but on page 432 it is referred to as a shark sucker. On page 7 there is a statement that marine animals need less food than land animals; this astonishing fact is not explained until page 21. The discussion on succession hardly applies to marine groups. A series of fish definitely not in the category of flatfish is included under that heading.

It will behoove students and teachers of zoology, one group for whom the book is intended, to read it carefully. They will discover that irrelevancies, some discontinuity, and carelessly worded statements detract from the book's value.—*Robert L. Eberhardt, California Division of Fish and Game.*

A Modern Dry-Fly Code

By Vincent Marinaro; G. P. Putnam's Sons, New York, 1950; 269 p. $4.

There is a tendency among American dry-fly fishermen today to scorn the Halford theory of "exact imitation" and the necessity of having a multiplicity of flies each designed to match a particular natural. We find numerous authors decrying wings as useless appendages and a growth in the use of the impressionistic and the "attractor" flies. Part of this may be due to the continued influence of such writers as LaBranche, with his emphasis on presentation rather than pattern, or Hewitt, who advocated the use of hackle flies alone. An even more probable reason is the fact that good success can usually be achieved on most American streams by using only a few patterns (or sizes) of flies. This is especially true on many rapid western streams where there are few large hatches of insects, where one merely fishes the water, and where—in the reviewer's opinion—trout will often strike at almost any fly if it is properly presented. Hence we find some very successful one-fly fishermen.

Marinaro admits this general premise. However, he then proceeds to call attention to the peculiar problem of the hatch, and the failure at times of even the best fisherman to succeed in taking fish despite a host of surface-feeding trout. It is at such times that he feels that the exact imitation is indispensable. Or again when one fishes ". . . the clear calm waters, the slow smooth currents, the long glides and flats . . ." such as one finds on the limestone streams of Pennsylvania. These are the stable, spring-fed, weedy streams resembling the English chalk streams. They are rich in food, produce large trout, and offer difficult fishing. We can probably find similarities in some of the northeastern California rivers. At any rate it is here that we find the selective trout, and it is for the angler for such trout that Marinaro expounds his theories. Among them are his ideas that the body of an imitation dun is superfluous but that the wing is its most important part, and that rises to extremely minute floating insects are often mistaken for nymphing patterns.

This book is not for the "chuck and chance" fisherman. It is written by an angler-entomologist, a man to whom hooks larger than No. 14 are "outrageous," who speaks glibly of the "rise-form," and who discusses taking three-pound trout on 8 X gut (less than ¼ lb. test) or on No. 22 flies. Obviously the book will have appeal to only a limited audience, but it will be interesting reading to the scientific and unhurried angler. It has something of the style of the English writers and at times seems stilted or overly formal. As compensation for this, Pearce Bates' frequent marginal illustrations have a quiet humor that relieves the formality of the text.

The forepart of the book is devoted almost entirely to the theory of exact imitation and the presumed vision of the trout. The latter chapters discuss specific flies, their life histories, and methods of dressing the artificials. The book delves fairly deeply into entomology, but there has been an unfortunate capitalization of the specific name of every insect mentioned.—*William A. Dill, California Division of Fish and Game.*

Flies

By J. Edson Leonard; A. S. Barnes and Company, New York, 1950; xii + 340 p.; illustrated. $5.00.

The subtitle of "Flies" reads: "Their origin, natural history, tying, hooks, patterns and selections of dry and wet flies, nymphs, streamers, salmon flies for fresh and salt water in North America and the British Isles including a dictionary of 2,200 patterns." There are chapters on hooks, tools and materials. Separate chapters describe the design and methods of dressing the major types of flies listed above; an additional one covers the construction of the larger fly-rod lures such as the hair and cork bugs. In the penultimate chapter the author discusses natural insects and crustaceans. Two charts show the recognition characters of both immature and mature forms. There are descriptions of many of the best known naturals, notes on their life-histories, charts showing emergence dates (eastern), and correlations of the naturals with artificials. Several charts on the feeding habits of trout and other fishes are reproduced from fisheries papers. The last chapter is a very inclusive listing of fly patterns, most of it in tabular form and cross-indexed. The book contains eight color plates and 30 black and white drawings by the author, and 24 photographs by Jack Leonard and the Cameo Studios. An appendix includes letters from numerous fly-tiers discussing original or favorite patterns for specific localities. There is a bibliography and an index.

This, then, is the plan of the book and it is a good one. What has it omitted? The chapter on fly design begins with the interesting history of the development of artificial flies, but it is a spotty account and terminates abruptly. One wishes that the author had a fuller discussion of the many contributors to basic fly theory and design. One also wishes that the dictionary of patterns had included the name of the originators and something of the pattern's history whenever known. Of course, this would be an encyclopedic task but the blurb indicates that the book has this scope. There are other omissions. One wonders why an otherwise thorough chapter on hooks does not even mention the double hooks often used on salmon flies, nor the "over and under" hook, nor give a comparison of the American and the British "new scale" of hooks. It is a surprise to see flies of the "Irresistible" or "Rat-faced McDougal" type omitted, and a "complete" book on flies should surely mention some of the newer developments such as the use of Gantron, Lee Wulff's Form-A-Lure flies and the Garland bodies. The indexing is adequate although there are a number of incorrect paginations. In the tabular portion of the dictionary it would have been helpful to have the column headings repeated on each page. The table on hook eyes (p. 15) is extremely puzzling; it seems to have been entirely unedited. Among the minor errors one notes that on p. 34 the author obviously meant to refer to W. C. Stewart instead of to W. C. Prime. His statement (p. 78) that: "The Variant is purely an American version of the dry fly . . . " might well be questioned by the British. The term "compressed" (for flat-bodied nymphs) is used instead of the zoologically correct "depressed." There are a number of minor inconsistencies between text, tables, and figures.

This is such a good book that it may seem unfair to have devoted this much space to pointing out its imperfections. However, my criticism of the omissions is engendered in large part because of what one is led to believe by the publisher's description on the jacket: "Definitive, complete . . . the only comprehensive, encyclopedic treatment of flies ever published, it integrates every related aspect of the subject . . . monumental, conclusive . . ." Leonard's book does approach this description, but it does not attain it. In fact it is simply because he *has* been so exhaustive that one expects him to be completely so. His book represents a prodigious amount of detailed work, and is extremely well executed as a whole. His drawings are excellent. His descriptions are clear. I think most fly-tiers will want to own it.—*William A. Dill, California Division of Fish and Game.*

The Sandhill Cranes

By Lawrence H. Walkinshaw; Cranbrook Institute of Science, Bloomfield Hills, Mich., 1949, 202 p. $3.50.

The author spent portions of 15 years gathering data on four subspecies of sandhill cranes—the lesser, greater, Florida and Cuban—in Alaska, the United States, Cuba and the Isle of Pines. The text covers various aspects of crane behavior and life history, much of which is based on observations of a captive female greater sandhill that Walkinshaw raised from a fledgling. Several plates of excellent photographs of cranes and crane habitats are included. Two appendices follow the text, the first a key to the cranes of the world and the second a list of distribution records for each subspecies.

This book presents a great deal of valuable information on sandhill cranes, and a significant amount of the material, such as hatching dates, incubation period and

hatching success, appears to be new to crane research. In discussing populations and possible management, it is stated that protection of the Florida subspecies, which is estimated to include about 2,650 individuals, requires creation of a refuge on the largest breeding ground; and that the Cuban subspecies, which is estimated at less than 50 breeding pairs, is vitally in need of protection. The greater sandhill population is estimated at between 2,600 and 3,700 and is felt to be in a more stable condition than either the Florida or the Cuban. The lesser is by far the most abundant and, while the author makes no estimate of numbers, he states that flocks of up to 100,000 are still reported. This subspecies breeds in the far north and is in much better circumstances than are the others.

The chief criticism of this work is its mass of confusing and unnecessary detail. In many spots field notes appear to have been transcribed practically verbatim. The reader is not given the benefit of the summarizations and condensations which only the author can make. Though the book falls short of being a well-rounded life history treatise it is nevertheless valuable as a monograph of a little-known species.—*Fred L. Jones, California Division of Fish and Game.*

Conservation of Our Natural Rescurces

Edited by Guy-Harold Smith. John Wiley and Sons, Inc., New York and London, 1950; xii + 552 p. $6.00.

Conservation has been the theme of many books, books reflecting all degrees of quality and of opinion. This one grew from "Our Natural Resources and Their Conservation," first published in 1936 and revised in 1939. While it would be too much to expect everyone to agree with each of the 20 contributors, the book is, by and large, very good. Though designed primarily as a college-level text, it deserves a much wider audience, for, as Dr. Smith says in the preface, "The adult reader, whether well informed about conservation or not, will find here the essentials of the conservation movement which needs new enthusiasts and readers."

It is doubtful that anyone could fail to benefit from the story for even in the various fields of conservation itself there is a tendency for some workers to think of their particular phase without considering its relation to the whole. They seem to remain unaware of what the word "conservation" in its broad sense means. It is, then, not surprising that among the multitude of people to whom one of these phases is a hobby or a source of recreation there are many who are even more unaware. Controversy based more on emotion than reason may rise between proponents of two or more conservation groups, each sincerely devoted to its own cause and each failing to recognize that the ends all desire are reconcilable parts of a single picture. It follows that there is a great deal of misunderstanding and ignorance which must be overcome before the general public whose concern it is realizes what the word implies in terms of everyone's life. This books presents the views of competent men concerned with conservation of soil, agriculture, forests, water, minerals, wildlife and fisheries, and with the conservation of man himself. Through the stimulation of thought as well as through education it should make a lasting impression on its readers.—*Phil M. Roedel, California Division of Fish and Game.*

Fishing in Many Waters

By James Hornell; Cambridge University Press, London and New York, 1950; xv + 210 p., 44 text figures, 36 plates, $6.

This book is the epitaph of a man who spent a lifetime studying fisheries for the British government in many parts of the world. It is too bad that he did not live to see it in its final printed form.

The story is of fishing methods as practiced by a multitude of peoples from the most primitive to the most modern, with emphasis on the primitive, the unusual and the obscure. Most of the book deals with the Far East, especially India, and the south Pacific, and most of it is based on first-hand experience. The descriptions are detailed but never dull; the topics are diverse as these selected chapter titles show: "Weapons of the Chase Borrowed by the Fisherman," "Collecting and Curing the Bombay-duck," "Baiting for Crocodiles and Alligators," "The Grey Mullet Takes Evasive Action." There is a bibliography and an index.

Bits of folk-lore and tales of peoples' customs serve as added spice to the accounts of fishing, and bear out the dust jacket claim that " . . . anthropologists will find it a valuable contribution to the study of material culture."

The book is very well-written and is excellently illustrated with line drawings and photographs. I recommend it to the general reader and the student of fisheries alike.—*Phil M. Roedel, California Division of Fish and Game.*

REPORTS

FISH CASES

October, November, December, 1950

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalone: Overlimit; undersize; failure to show license; using for bait	31	$910 00	
Angling: No license; using another's license; failure to show license; transferring license to another; no out-of-state license; nonresident using resident license; making false statement to obtain license; 2 lines; 2 poles; fishing in closed waters; possession of angling gear in fish refuge; night fishing; possession of gaff on stream; possession of spear within 300 feet of river; attempting to spear on spawning bed	201	2,590 00	90
Barracuda: Overlimit on sport boat	1	50 00	
Bass, Black: Overlimit	2	30 00	
Bass, Striped: Failure to show fish; overlimit; undersize; more than one line; 2 poles; using undersize for bait; failure to show license; taking other than by angling; hiding undersize fish; possession for sale; taking in nets; taking at night	82	3,130 00	10
Bluegill: Overlimit; no license	2	35 00	
Catfish: Undersize; taking at night; 2 poles; set lines	12	355 00	
Clam, Cockle: Overlimit; undersize; no license	14	390 00	
Clam, Horseneck: Overlimit	1	15 00	
Clam, Pismo: Undersize; overlimit; taking in State clam preserve; taking at night; no license; after hours	80	2,348 00	
Commercial: Dragnet, closed season; no commercial license; no boat registration; failure to make out forms correctly; taking overlimit on commercial boat; round haul net in closed area; operating purse seine in District 118.5; illegal possession of fish in District 118.5; failure to keep trawl log; failure to keep records and issue tickets; no dealer's license; no receipt issued	103	4,230 00	
Crab: Closed season and undersize; possession and sale, undersize	7	300 00	5
Lobster: Undersize; closed season; no commercial license; snagging	21	461 50	$2\frac{1}{2}$
Pollution: Oil; fish refuse	14	950 00	
Salmon: Taking after hours, before hours, in closed area, in spawning beds, with 2 poles, with hands, by snagging; no license; gaffing; possession of spears on spawning beds; shooting in spawning area	38	935 00	150
Shad: Closed season	2	50 00	
Trout: Taking from closed stream; selling untagged commercial trout; failure to declare; overlimit; transporting untagged; transporting illegal trout in California; steelhead, closed season; 2 poles; spear; unattended rod	15	362 00	
Seizures: Sardines		900 00	
Mackerel		609 06	
Totals	626	$18,653 56	$257\frac{1}{2}$

GAME CASES

October, November, December, 1950

Offense	Number arrests	Fines imposed	Jail sentences (days)
Antelope: Illegal possession	1	$100 00	
Coot: Shooting and not retrieving; late shooting; taking from moving vehicle (powerboat); closed season; taking with .22 rifle	11	280 00	
Crane: Taking full protected bird	1	25 00	
Deer: Closed season; overlimit; overlimit doe; taking doe, spike buck, fawn, doe without permit, forked horn in District 1^3_4, 2 deer in one-deer district; taking after sunset; spotlighting; night hunting; failure to show license; no deer tags; transfer of tags; failure to return tag, to fill out tag; using No. 2 tag in No. 1 district; no nonresident license; discharging gun and taking deer in game refuge; taking with full metal-jacketed bullets; shooting from car; using rim-fire rifle	145	14,793 00	199
Deer Meat: Possession in closed season; failure to mark shipped meat; possession of parts of illegal deer; possession of unstamped meat in closed season; transporting illegal meat into California	27	3,478 00	11
Dove: Transfer of license and shipping tags; overlimit; shooting from a vehicle; unplugged gun; using another's license; overlimit brought from Mexico; after hours; no license; closed season; late shooting	75	2,380 00	
Duck: No license; overlimit; late shooting; unplugged gun; shooting from a powerboat; early shooting; closed season; hunting in refuge; failure to show license; hunting in closed area; unsigned stamp; attempting to take from auto with rifle; taking with pistol	187	6,282 00	41^1_2
Elk: Killing full protected animal	1	($250 00 suspended)	
Killing two elk	2	500 00	
Goose: Early shooting; overlimit; improperly plugged gun; offering overlimit for shipment; hunting without license; receiving and accepting overlimit for shipment; late shooting; hunting on refuge; driving with powerboat; closed season	16	448 00	
Hunting: Shooting in closed area; hunting in restricted zone; hunting on cooperative area; using unplugged shotgun; hunting from powerboat, from auto; late shooting; early shooting; destroying state and federal hunting signs; possessing and displaying another's license; no license; possession of gun on refuge; trespassing on cooperative area; no license; night hunting; spotlighting; making false statement to obtain resident license and deer tags; transferring license; transferring shipping tags; failure to fill out tag; using full metal-jacketed bullets; failure to show license on demand	349	11,233 50	87^1_2
Muskrat: Trapping in closed season and having no trapper's license	1	10 00	
Nongame Birds: Taking meadow larks, barred owl, seagull, grebes; taking from motorboat	10	365 00	
Pheasant: Having no tags; taking in restricted area; shooting from public road; early shooting; failure to tag; overlimit; taking hen; closed season; shooting from car; trespassing on closed zone; hunting with .22 rifle; failure to tag on Game Management Area; hunting pheasant with unplugged gun; possession in closed season; no license; possession of another's tags; possession of two sets of tags other than those legally issued	183	8,945 00	65
Pigeon: Taking bandtail in closed season	3	200 00	
Quail: Bringing into state quail taken in Mexico during closed season; closed season; unplugged gun; early shooting	21	715 00	
Rabbit: No license; closed season; night hunting; unplugged gun; spotlighting; failure to show license; taking cottontails in closed season; taking in refuge; early shooting, jackrabbit	60	1,225 00	8
Shore Birds: Taking plover, rail, killdeer, jacksnipe	6	195 00	
Squirrel: Taking tree squirrels, closed season; possession in closed season	4	125 00	
Totals	1,103	$51,299 50	412

SEIZURES OF FISH AND GAME

October, November, December, 1950

Fish:	
Abalone	493
Barracuda	44
Bass, Black	13
Bass, Striped (554 pounds)	354
Bluegill	38
Catfish (43 pounds)	53
Clam, Cockle	3,371
Clam, Pismo	1,226
Clam, Horseneck	44
Crab	184
Lobster	240
Rockfish	29
Salmon (800 pounds)	43
Sardines, pounds	291,000
Shad	3
Trout	120
Game:	
Coot	25
Crane	1
Deer	113½
Deer Meat (pounds)	398
Dove	838
Duck	358
Elk	1
Goose	37
Muskrat	5
Nongame Birds	19
Pheasant	141
Pigeon	14
Quail	27
Rabbit	18
Shore Birds	11
Squirrel	7

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