CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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CALIFORNIA FISH AND GAME

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THE ABALONES OF CALIFORNIA[1]

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Introduction

The initial human population of the West Coast of North America was relatively sparse; the culture late Stone Age. One store of food was the abalone, which was plentiful and easily procured. The shell supplied material for personal adornment and served as a medium of exchange. Exploitation was circumscribed by weather and natural indolence, and did not seriously affect an inherent abundance, maintained by the reproductive ability of the species. This state of affairs prevailed for thousands of years.

The first immigrants who came to the West Coast found natural resources so diverse and redundant that there was little incentive to make use of such a lowly form as the abalone, especially since most Caucasians have a bias on the subject of eating snails. In the last 50 years the human population of the West Coast has increased phenomenally, and the abalone, eulogized and promoted by civic and financial interests, has become a culinary delicacy much appreciated by epicures. Under these circumstances the supply is not equal to the demand and legal restrictions have been necessary to curb commercial over-exploitation.

The sport take, responsive to the above mentioned panegyrics, has also gradually and steadily increased. Laws have been passed to regulate the noncommercial abalone hunters, but it is difficult to enforce them effectively. Sportsmen, and so-called sportsmen, have become so numerous that they infest the coastal areas on every low tide. They are so persevering in gratifying their acquisitive propensities, and many of them are so indifferent to legal restrictions or so lacking in a sense of probity that the abalone has virtually disappeared from the beaches.

The commercial divers now work with an annual revocable permit. They may not take abalones legally in water of less than 20 feet in depth, and the abalones must conform to minimum sizes measured across the greatest diameter of the shell: Red 8 inches, green $7\frac{1}{4}$ inches, black and pink 6 inches.

The sportsmen's abalone territory is from the high tide mark to a depth of 20 feet. They may take five red abalones, or 10 abalones in the

[1] Submitted for publication May, 1948.

aggregate, in any one day. Their minimum size limits are: Red 7 inches, green 6¼ inch, pink, 6 inches, black five inches. An angling license is required. (Note: These laws in effect in 1948, subject to change in later years. Consult latest Fish and Game Regulations.)

Life History Notes

Abalones are marine gastropods or snails. Many of their anatomical features and habits resemble those of their relatives, the land snails. The abalone is a very primitive form and has an ancient lineage. Their shells are found imbedded in the rocks of the Paleozoic. They are bisexual and the sexes are readily distinguishable. The gonad, or reproductive gland, is a large horn-shaped organ, which lies against and bends around to the rear of the muscular foot. In the male the gonad is smooth and cream colored; in the female it appears grainy and is a dark green.

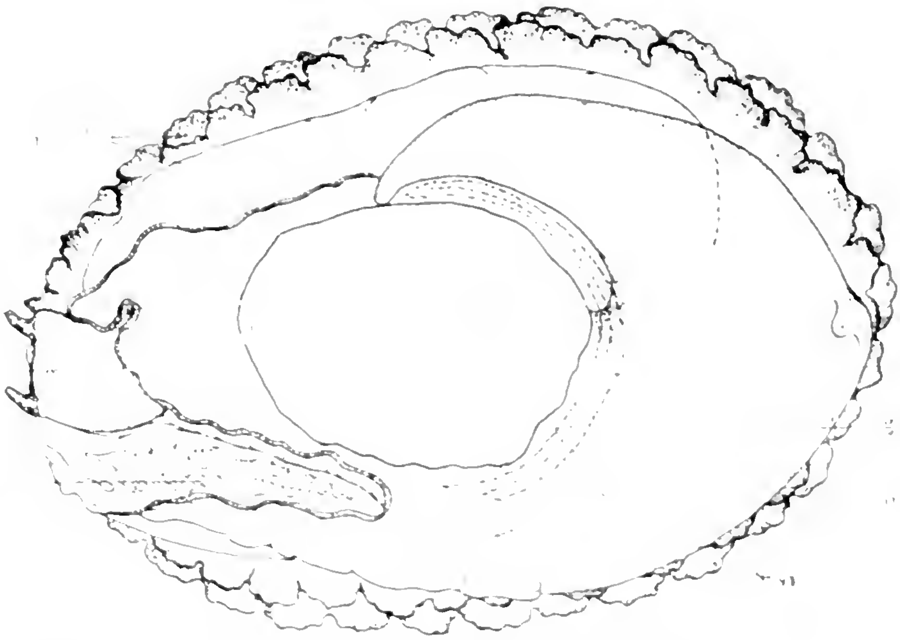

FIGURE 7. [illegible] view of abalone with shell [illegible] Drawing by [illegible] Bonnot

The gonads mature during the winter and the eggs and sperm are liberated into the water periodically, during the spring and summer. The shell is formed while the abalone is still very small. It is composed of three layers; the outer or periostracum, a thin horn-like semitransparent substance; a thick middle layer of calcium carbonate; and an inner of mother-of-pearl or nacre. The shell is secreted by glands along the edge of the mantle. The holes in an abalone shell lie directly over the gill cavity. When the shell is clamped tightly to the rock, sufficient water can be pumped in under the edge and discharged through the holes to supply the necessary oxygen and even a certain amount of food in the form of diatoms. In common with most mollusks the abalones have no eyes, but they are able to distinguish between light and dark by means of eye spots around the edge of the mantle. They are vegetarians, feeding on marine algae, and inhabit rock bottoms from the high tide line

out to a depth of about 100 feet. Beyond 100 feet there is comparatively little light. Seaweed does not flourish in the absence of light and is therefore rare or entirely absent in deep water, and abalones are correspondingly scarce. Although the abalone has survived the vicissitudes of many geologic ages, it is so delicately adjusted to its present environment that even minor changes can be fatal. An unusually large discharge of fresh water from a river or creek will kill all the abalones in the imme-

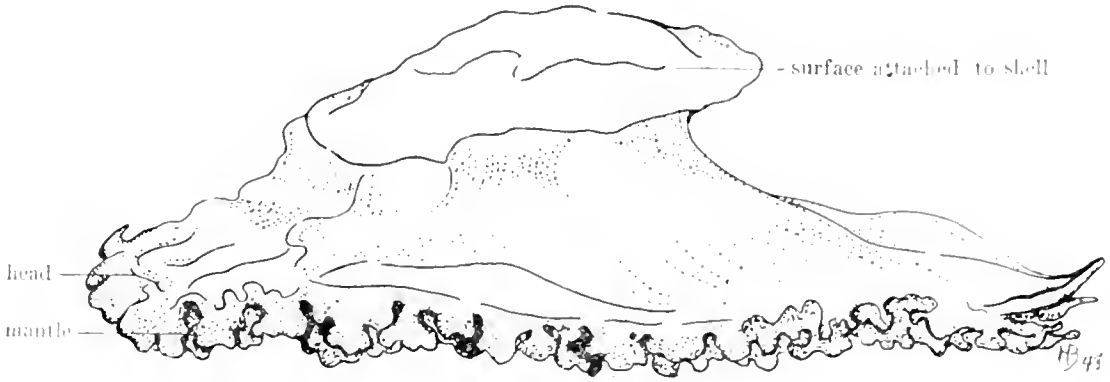

FIGURE 54. Abalone foot with viscera removed, ready for trimming. Drawing by Hester Bonnot

diate vicinity. The shifting of sand by strong bottom currents will sometimes smother large numbers. Any form of confinement or artificial restraint is usually lethal in a short time.

Our knowledge of the life history and ecology of the abalone was, until quite recently, very limited. It has been difficult for the biologist to investigate the sub-littoral zone. As a source of information, the average abalone diver is not reliable, simply because he is not a trained

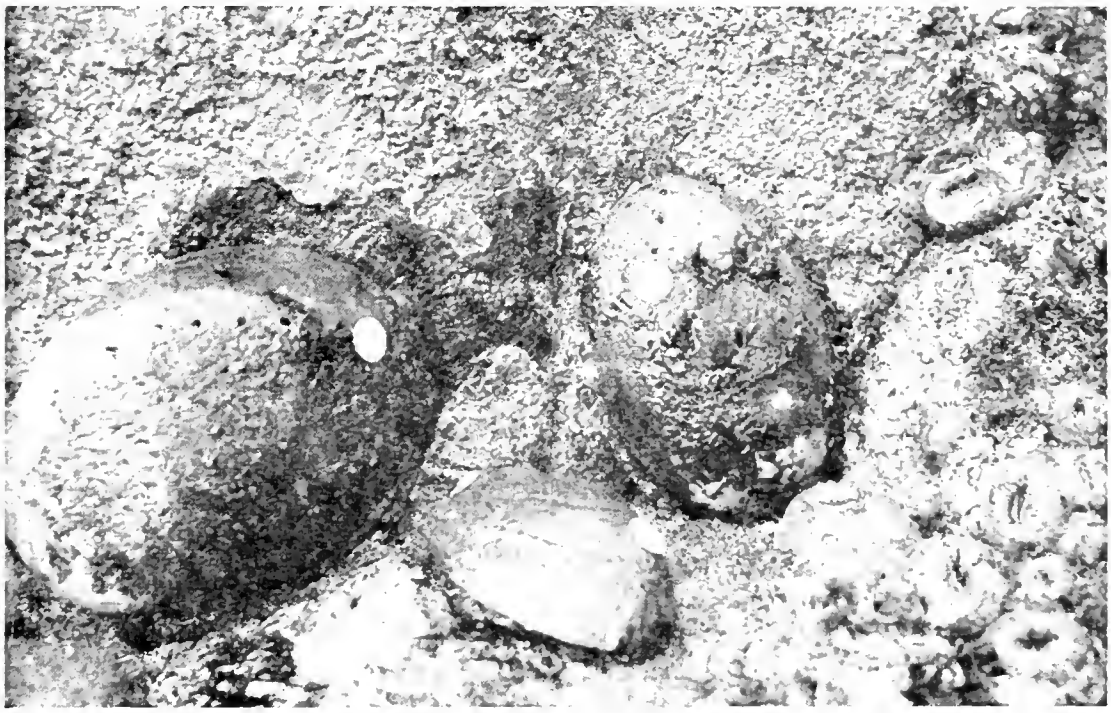

FIGURE 55. Tagged black abalones, Point Lobos State Park. Photo by W. E. Ripley

FIGURE 56. Tagged black abalones, Point Lobos State Park (Cypress Cove). The small black abalone on the left stayed on the same spot for two years. Photo by W. E. Ripley

observer and, in any case, manifests little curiosity concerning ecological principles and the efficacy with which they can and do control the destiny of the species which provides the raw material of his industry.

Several years ago, a diving program was inaugurated by the California Division of Fish and Game in an endeavor to acquire some of the deep water details of the life of the abalone. A Division biologist was instructed to learn to dive. The original survey covered the area from Monterey to Point Conception (Bonnot 1940). Subsequent surveys and spot dives have added materially to current information and have contributed an extensive knowledge of the magnitude and dispersal of the present abalone population and of the environment in which it lives.

For several years a tagging experiment has been carried on in an endeavor to learn something of the growth and movements of the abalone. Celluloid fish tags are fastened to the shell, through one of the open holes, with a German silver pin. The principal difficulty encountered in this experiment has been the inability to find sufficient abalones in the littoral zone. However, several hundred have been tagged, and a fair percentage have been recovered and checked over a period of three years. The results are as yet only tentative, but they indicate that abalones do not migrate to any extent and that the growth varies irregularly from year to year.

Abalones forage during the night, and where the surrounding terrain permits, they will sometimes travel a considerable distance, returning to their "home spot" by day break. The "home spot" area, covered by the foot, is always perfectly clean, and sometimes in soft rock a straight-sided depression an inch deep indicates that the animal has lived there a long time.

The species of abalones found along our Pacific Coast are not numerous. Some of them are rare deep water forms and are seldom seen outside of museums.

The descriptive details given here may sometimes be difficult to see. Except for the blacks the usual abalone shell supports a more or less heavy growth of algae, corralines (algae with a calcareous coating), barnacles, and worm tubes, and it may be necessary to remove some of the incrustation before it can be identified.

The outside surface of the shell can be cleaned fairly well with a wire brush. To do a good job however, it is advisable to use acid. Apply sulphuric or hydrochloric acid with a small paint brush. The acid should be allowed to work for a short time and then be washed off and another application brushed on. When the actual surface of the shell is reached, it should be washed carefully to remove all traces of the acid.

The Commercial Fishery

Among the first immigrants to arrive on the West Coast were a number of Chinese. The Chinese have been inured for ages to over population and to the consequent utilization of every available organism which appeared capable of providing any nourishment. They contemplated the abundant supply of local abalones with gustatory and mercenary satisfaction, probably indulged in laudatory vociferation—in Cantonese—and began to gather them in quantity irrespective of species or size. The meat was dried and sent to China. Because of this prodigal despoliation, minimum size limits were imposed for the various species (1911), and the drying and exporting of abalones was forbidden (1915). These several restrictions effectively curbed the promiscuous exploitation. The beaches could no longer supply a profitable quantity of legal-sized abalones, so the fishery was moved out into deep water. The Chinese apparently are not divers, so abalone harvesting was taken over by the Japanese. The original Chinese shore fishery was along the southern coast from Point Conception into Lower California. The Japanese divers worked out of Monterey and gradually extended their operations to the south. During the depression of the '30s, a number of white divers started operating at Morro and San Simeon in San Luis Obispo County, and the center of the industry gradually shifted from Monterey to the southern area (see Table 1). Few abalones were landed from the Monterey-Morro area during World War II. The Japanese were not allowed to work, and nearly all of the other divers went to Southern California to gather gelidium, the marine alga from which agar is manufactured. Agar is essential in bacteriological work. Previous to the war, 90 percent of the agar used in this country was imported from Japan, and with the advent of war it was necessary to utilize a local supply.

The canning of abalones began at Cayucos in 1905. Subsequently they were canned at Point Lobos, San Pedro, and San Diego, and by 1917 there were five plants. Because fresh abalone steaks cost less to produce and are always in demand, the canned product was never too remunerative, and the canning plants gradually dropped out. One cannery at Point Lobos, near Monterey, operated until 1931.

Red Abalone

Haliotis rufescens Swainson

Distinguishing Characters: A large abalone reaching 10 to 12 inches in diameter. Outside color of the shell dull brick red, a narrow red border around the edge of the shell. Inside, iridescent with prominent dark green markings. Holes slightly tubular, large, three or four open.

Distribution: Point Saint George in Northern California to La Paz, Lower California. The center of population is between Monterey Bay and Point Conception. This is the principal commercial species. The largest landings are at San Simeon, Morro Bay, and Monterey (see Table 1, p. 164).

FIGURE 57. Red Abalone

Black Abalone

Haliotis cracherodii Leach

Distinguishing Characters: The shell reaches a diameter of 6 inches, and is more cupped than most of the others. Color, outside greenish black, inside pearly. The shell is usually clean; not supporting a growth of other organisms. Five to eight holes usually open.

Distribution: Coos Bay, Oregon, to Santa Rosalia, Lower California. The black is a littoral zone form and is seldom found below the low tide level.

They are comparatively plentiful but are not used to any extent. They appear to be able to subsist entirely on diatoms when necessary. They will sometimes be found in cracks and holes in the rocks which they evidently entered when small and remained until they became too large to ever get out again. Such individuals would have no other source of food but diatoms, supplemented by occasional pieces of detached sea weed that might be washed in by water currents.

FIGURE 58. Black Abalone

Pink Abalone

Haliotis corrugata Gray

Distinguishing Characters: Shell round, arched, with a scalloped edge. Markedly ridged on the outside. Outside surface dull green to reddish chestnut edged with black. Grows to 7 inches in diameter. Holes slightly tubular, large, three or four open.

Distribution: Monterey, California, to San Quentin Bay, Lower California.

Taken by skin divers and commercial divers in small quantities in Southern California. Sometimes called the corrugated abalone.

FIGURE 59. Pink or Corrugated Abalone

Southern Green Abalone

Haliotis fulgens Phillippi

Distinguishing Characters: Shell reaches 8 inches in greatest diameter and is a dull reddish brown with 30 or 40 spiral ridges. Inside iridescent, marked irregularly with various shades of blue and green. The holes are small, slightly elevated and circular, five or six open.

Distribution: Farallon Islands to Gulf of California.

Taken in Southern California by both sport and commercial divers.

FIGURE 60. Southern Green Abalone

Threaded Abalone

Haliotis assimilis Dall

Distinguishing Characters: Shell thick and solid, reaches a diameter of 4 inches. Outside of shell reddish or dark greenish, etched with many fine lines; inside pearly and iridescent. A moderate furrow below the line of holes which have slightly raised edges. Five to seven open.

Distribution: Farallon Islands to San Diego, California.

This is a deep water form seen only by the divers. Occasionally a few shells are washed ashore and can be picked up on the beaches.

FIGURE 61. Threaded abalone. Photo by Al Johns, Vernon M. Haden, San Pedro

Japanese Abalone

Haliotis kamschatkana Jonas

Distinguishing Characters: Shell longer and not so round as most of the other species. It is thin, with a sharp edge and prominent spire, and reaches a length of 6 inches. There are four or five holes with raised edges and a deep channel under the line of holes. The outside color may be orange, greenish or purple or irregular combinations of these colors. Inside silvery, iridescent.

Distribution: Sitka, Alaska, to Point Conception, California. Not plentiful in California but increasing in abundance in the northern part of the range. It is also found in Japan.

This species is abundant in Alaska but has not been utilized to any extent. There are sufficient numbers to support a small commercial fishery.

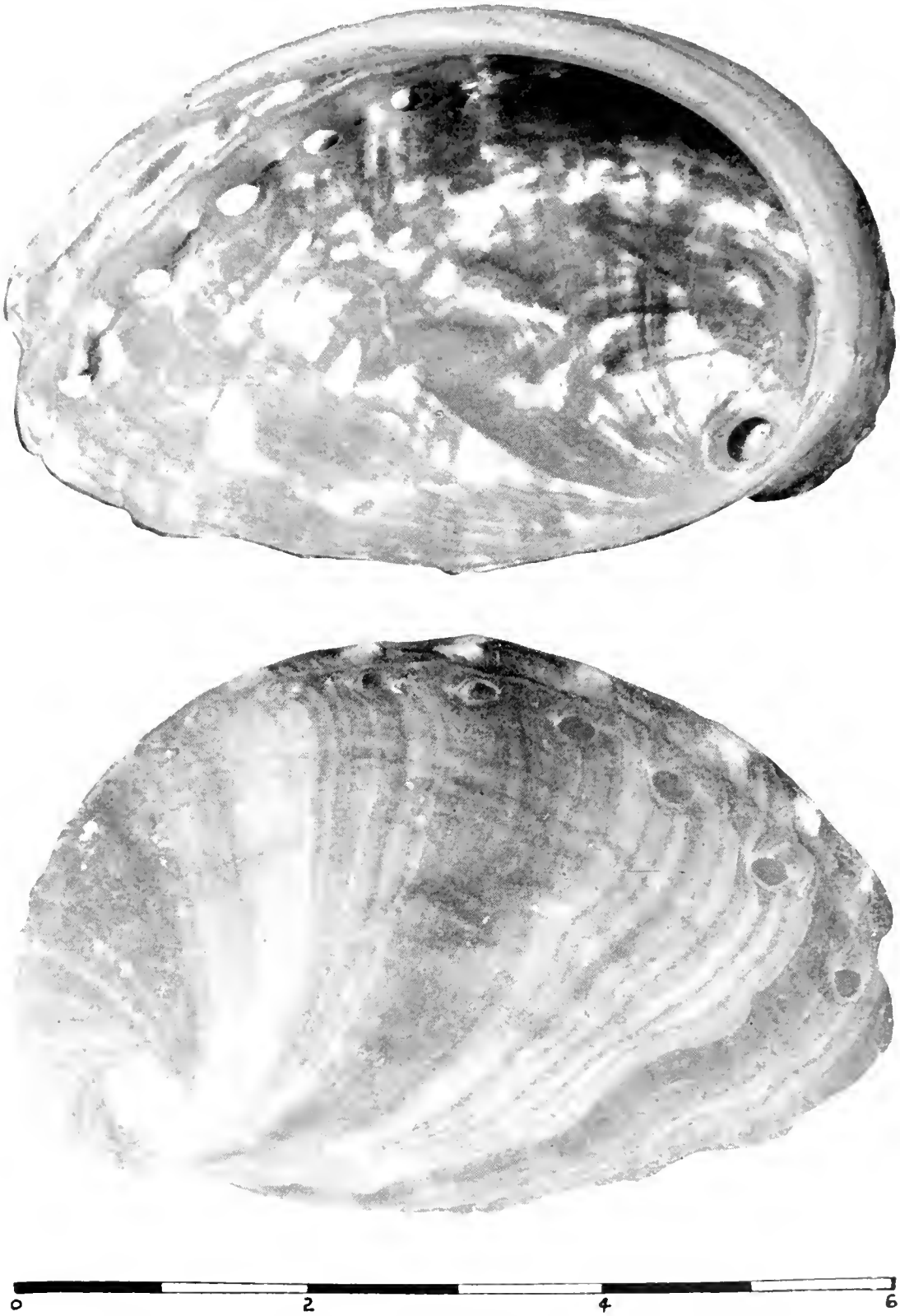

FIGURE 62. Japanese abalone, Craig, Alaska. Photo by Al Johns, Vernon M. Haden, San Pedro

Northern Green Abalone

Haliotis wallalensis Stearns

Distinguishing Characters: Resembles the southern green, but the shell is more elongated and flattened, dark brick red, mottled with pale bluish green. Not larger than 5½ inches. Edges of holes not elevated, five or six open.

Distribution: Westport, Northern California, to Point Conception. A small, relatively rare species.

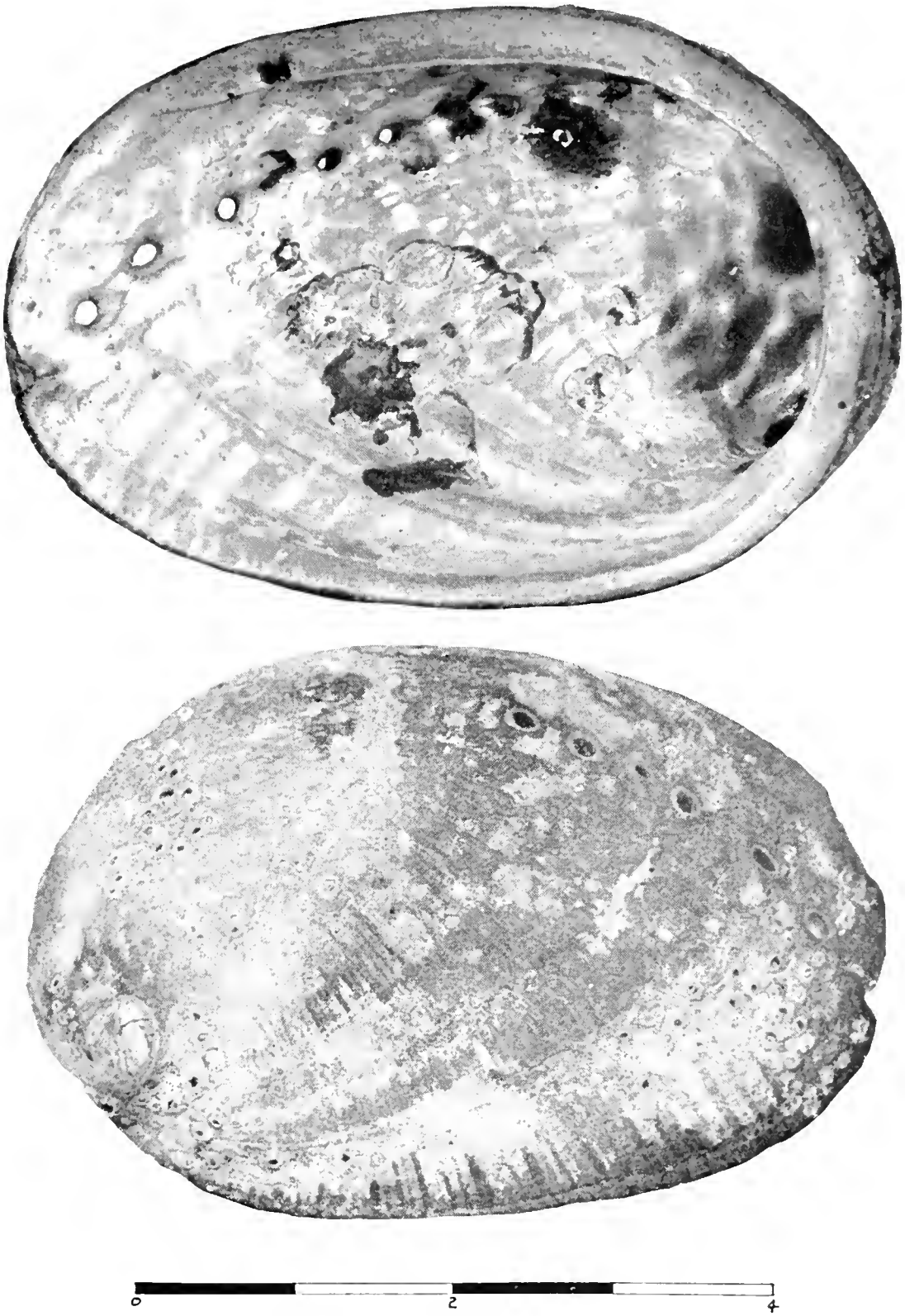

FIGURE 63. Northern Green abalone

Commercial Fishing Methods

The first abalone fishing, in quantity, was initiated by the Chinese who collected them between the tide lines. When this area became unprofitable because of legal restrictions—it had also been pretty well decimated—the Japanese introduced the diving suit and moved into deep water. They gradually reduced the number of legal-sized abalones near Monterey, and it became necessary to extend operations. A 50- to 65-foot vessel was essential to make the long runs down the coast and to provide living quarters for the five-man crew. A diving boat was towed to and from the fishing grounds, as there is no shelter for small craft along this stretch of coast. The original type of diving boat contained a stationary water-cooled gas engine and the air pump. It was propelled with oars. When the diver was down, the boat followed him about by means of a long scull. The crew member who handled the boat stood in the middle of it and worked the oar over and about a single upright wooden peg in the stern. The boat was under perfect control and could even go astern with no appreciable change in the ordinary sculling movements. The crews worked for the abalone processing companies either for wages or on a share basis. The diver received the largest wage or share—and earned it (Bonnot 1930).

The present fishery is based on diving, but there have been some changes in methods, accessory gear and financial arrangements. The contemporary divers are all Caucasians. Each diver owns his boat and hires his crew, usually two men. The diving boats are 20 to 30 feet long and are power driven. The air compressors are sometimes driven from the main engine; or they may be separate units with their own one

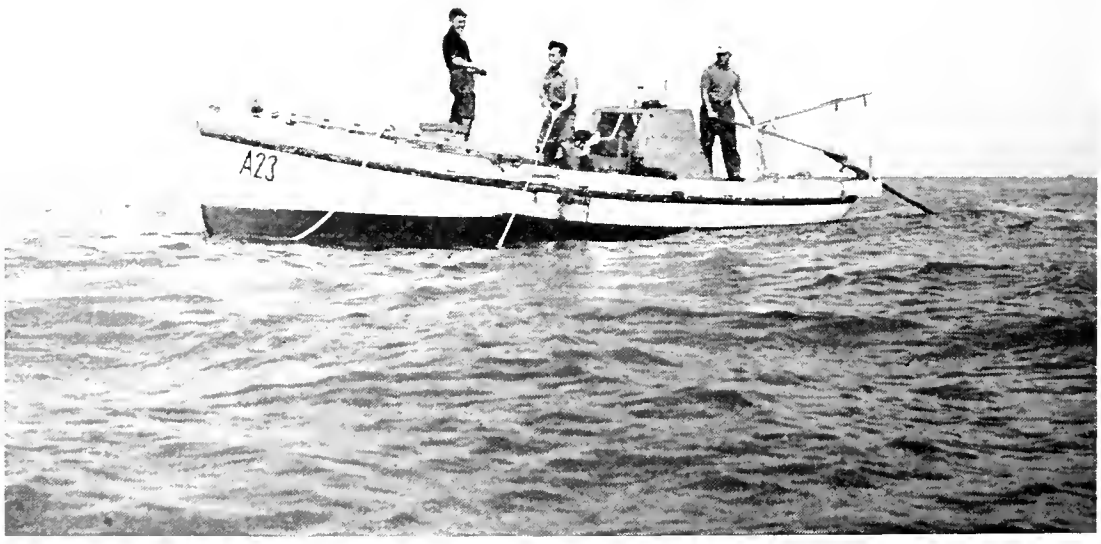

FIGURE 64. A Japanese diving boat working south of Monterey in 1939. The diver is down. Photo submitted by Roy Hattori

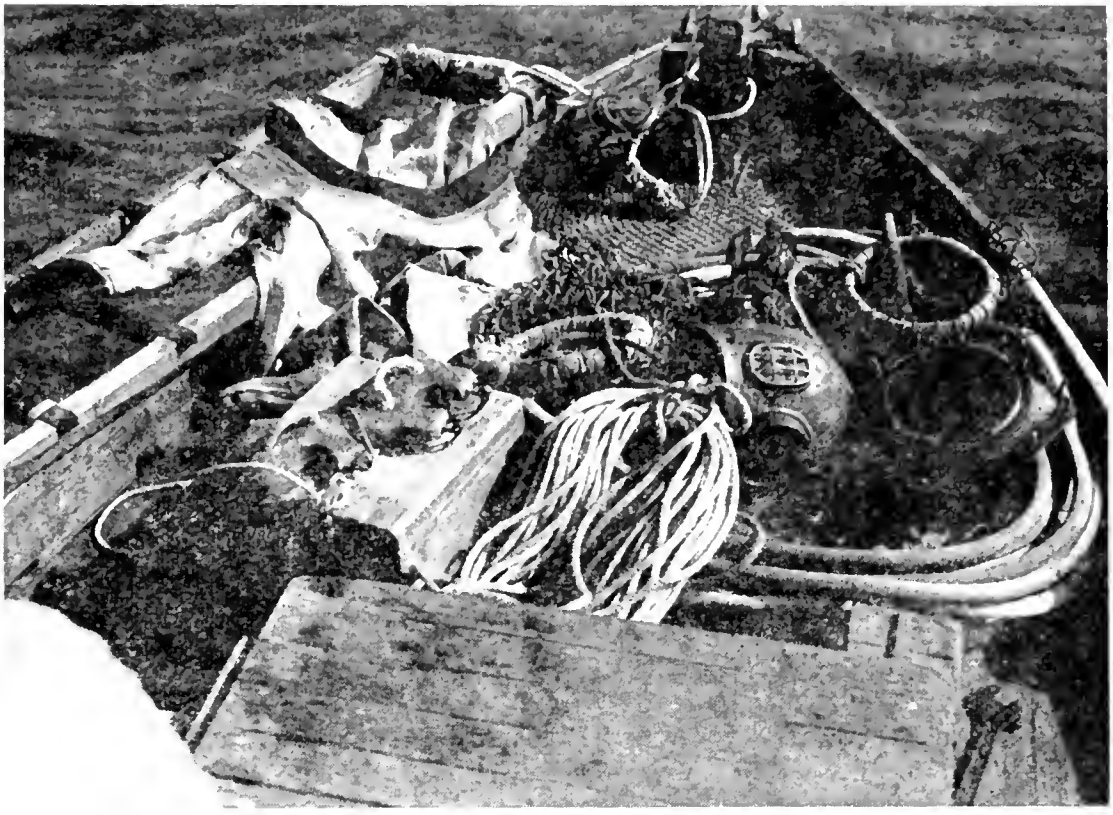

FIGURE 65. Abalone diving gear, consisting of suit, chest weights, net bag, life line, helmet, breast plate and air hose. Photo submitted by Roy Hattori

FIGURE 66. A Japanese diving crew, 1939. Roy Hattori, diver. Photo submitted by Roy Hattori

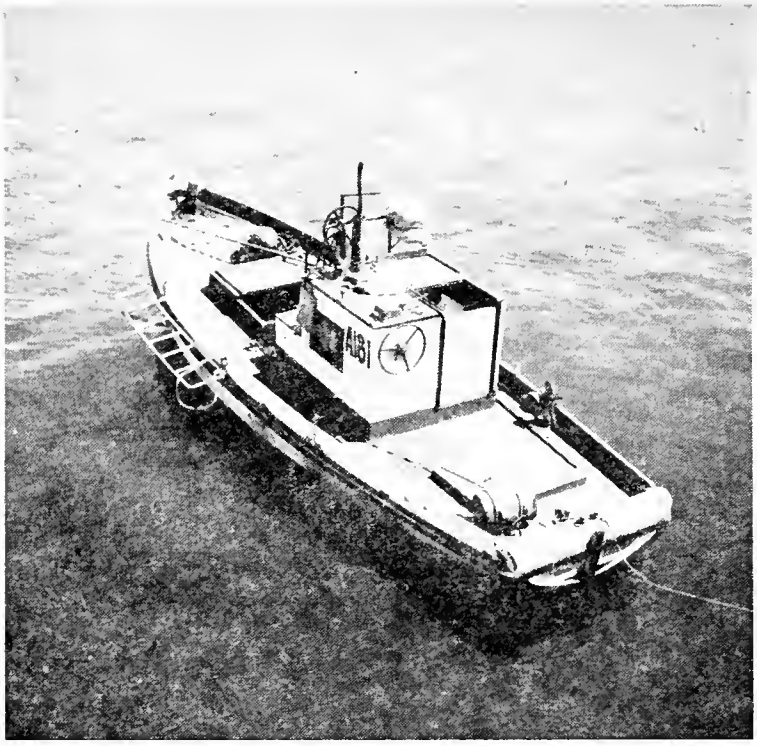

FIGURE 67. Abalone boat, 1947. Note ladder, helmet and air hose. Photo by John F. Janssen

cylinder air-cooled engines. In either case, a 30- or 40-gallon steel tank acts as an air reservoir, an innovation the Japanese divers lacked. In case of failure of the engines or of a compressor the tank contains sufficient compressed air to last the diver five or ten minutes, plenty of time to bring him to the surface. The boat follows the diver about while he is on bottom, sometimes a rather hazardous business. It is maneuvered in and out of narrow crevices, rising and falling with the surging of the sea. There are usually reefs and consequently "breaks" over the rocky bottoms where abalones are found and the boat handler must be constantly on the alert.

The diver travels along the bottom at any depth from 30 to 100 feet, prying the abalones from the rocks with a flat piece of iron. If taken unaware, abalones may be detached easily, but if disturbed they promptly increase the suction and grip the rock tenaciously. It then requires considerable effort to remove them. The diver carries a net bag, which holds about two dozen abalones, into which he drops his catch. When it is full, he signals the line tender who fastens an empty bag to the life line and the diver draws it down, coiling the line in his left hand. He detaches the empty bag, fastens the full one to the snap provided and goes on with his hunting while the tender hauls up the line and the loaded bag.

Abalone diving is one of the most exacting and physically debilitating of present day fishing methods. The diver must be mentally alert and physically able to meet any sudden emergency which could be dangerous. The boat man must hold the boat close to the diver, keeping the lines forward away from the propellor while avoiding rocks and "breaks" that might jeopardize the safety of the craft and the diver. The line tender keeps the lines slack, but it is essential that he should be

FIGURE 68. The author dressed to go down except for chest weights and helmet

able at all times to "feel" the diver and to receive and send the jerks on the life line by which they "talk" to each other. The various activities of a diving crew are few and simple, but they must be conscientiously performed—on occasion with split second timing. Inexperience, inattention, or horseplay on deck has been responsible for the deaths of several divers in the last few years. A number have been badly hurt but survived.

The first Japanese divers received $1 a dozen for the abalone they landed, which price had increased to $2.50 by 1941. The present price is $6. An average day's fishing will yield about 20 dozen, but occasionally a diver will find an area that is unusually productive or one overlooked for several seasons and will be able to take, for a short time, up to 100 dozen a day.

TABLE 1

Abalones Landed by Commercial Divers

	Monterey	*San Luis Obispo County*		*Monterey*	*San Luis Obispo County*
1926	40,860 doz.	355 doz.	1937	28,664 doz.	28,565 doz.
1927	54,249	361	1938	24,079	18,188
1928	40,997	327	1939	15,789	20,065
1929	68,249	353	1940	16,268	18,211
1930	63,179	350	1941	9,779	10,227
1931	64,216	1,027	1942	73	3,216
1932	42,707	13,636	1943	2	12,631
1933	44,430	10,693	1944	54	25,469
1934	55,736	8,710	1945	3,357	34,005
1935	53,124	23,919	1946	4,371	36,058
1936	31,513	33,843			

The red abalone is not found in commercial quantities in Southern California, and the green and pink abalones are the species utilized in that area. They are smaller than the reds and relatively less abundant. In order to make a living the divers collect both abalones and gelidium or agar weed.

Abalone diving is more dependent on weather conditions than most types of fishing. There are many days when surface conditions appear ideal, but a strong bottom surge will prohibit diving. The divers average 12 working days a month.

Commercial Processing

The divers deliver their catches daily to the processing plants and as the abolones are highly perishable, the work of preparing them is begun as soon as possible. The first step is to remove the animal from the shell by pushing a flat, stiff piece of iron up to the base of the muscle, holding the abalone in one or both hands and bringing the free end of the iron down smartly on the bench. The viscera is stripped off and the foot, or muscle, is put into a tank of fresh water and washed. The tough outer surfaces and the edges of the mantle are then removed. A very sharp knife and some experience is necessary, or trimming can be very wasteful. The trimmings of an adept worker represent about one-third of the weight of the untrimmed foot. After trimming, the muscles are left for a time on a smooth wet surface to relax and flatten and are then sliced *across* the "grain" with either a hand or power slicer into slices about one-half inch in thickness. A slice of abalone before it is pounded has the consistency of the tread of a better grade tire casing. The slices are sorted roughly as to size and are then pounded on a block with a wooden mallet to soften the hard muscle fibers. The finished product is packed in five and ten pound wooden boxes and shipped at once or placed under refrigeration. Until quite recently the trimmings were discarded as they could not be legally used. They are now sold to a number of concerns who grind them and prepare a canned chowder.

An occasional abalone in the regular catch is referred to by the trade as a "dark meat." In contrast to the usual abalone meat which is pure white, the "dark meat" is a smoky grey. There is a prejudice against it, and therefore, it is not readily saleable although it is in no way inferior to the white meat. The dark meat is usually sold with the

trimmings for chowder. Some districts produce predominantly dark meat abalones, possibly a result of the local food supply.

In 1943, T. D. Reviea, who was operating an abalone processing plant at Newport Beach, California, collected some data on the weights of the component parts of the abalone. These data are of interest as they demonstrate the yield of saleable meat from abalones of various sizes and the loss that results in trimming.

	Green (*H. fulgens*)	Pink (*H. corrugata*)
Size	8.1 inches	7.1 inches
Weights—		
Total	51.64 ounces	39.85 ounces
Shell	19.84	18.60
Animal	31.63	21.05
Foot	21.54	15.05
Gut	8.24	5.00
Gonad	3.04	2.00
Trimmings	8.32	5.85
Meat	13.16	9.75

These figures are averages of seventeen specimens in the case of *H. fulgens* and five specimens of *H. corrugata*. Both sexes are represented. By some simple calculations and the application of the rule of three the following results are obtained.

	Total Wgt.	*Foot Wgt.*	*Trimming Wgt.*	*Meat Wgt.*
1 doz. 9.0 inch abalone	40.0 lbs.	16.3 lbs.	6.1 lbs.	10.5 lbs.
8.5	37.8	15.4	5.8	10.0
8.0	35.6	14.5	5.4	9.3
7.5	33.4	13.6	5.1	8.8
7.0	31.1	12.7	4.8	8.2
6.5	26.7	11.8	4.5	7.6

There are no comparable figures, at present, for the red abalone which constitutes the bulk of the commercial catch. The processors have found that a dozen 8-inch red abalones will average 12 pounds of saleable meat. If 25 percent is added to the figures given here, a close approximation of the weights to be expected in the reds will be obtained.

One of the arguments against taking "shorts" is conclusively demonstrated by these figures. It costs the same to procure and process a dozen abalones whether they are eight inches in diameter or only six inches. It is obvious that the margin of profit to the processor precludes the use of any quantity of undersized abalones.

The Sport Fishery

The sportsman takes his abalones in the littoral zone. Originally a limit of legal-sized abalones could be obtained, at low tide, on almost any rocky beach. It could be done dryshod or perhaps by wading in ankle-deep pools. A few years ago, it became more difficult to find legal abalones on the beaches, but there were plenty of small ones. Today an abalone of any size, above the level of the minus tides is a rarity. The sportsman who gets his limit of legal abalones now is a rugged individual who wades out into the surf up to his neck and feels for them in crevices and on the under side of rocks. There are sometimes other things in the crevices and under the rocks which introduce an element of chance and adventure. As most of the good tides are during the winter and are at their best early in the

morning or late in the afternoon, it is obvious that abalone hunting has become a rigorous pastime.

The sportsmen have extended their activities, especially in Southern California, out to and sometimes beyond the twenty foot limit. It is distinctly disconcerting to a diver who is working in 35 or 40 feet of water to be suddenly hit on the back by some unknown "varmint," and it does not appreciably lower the consequent rise in blood pressure to discover, after turning about, that the unknown is a grinning young sportsman clothed in a pair of goggles and a G-string. In Southern California where the ocean water is relatively warm and clear, "skin diving" for abalones has acquired a considerable following. It is a rather dangerous amusement as the rocks on which abalones are found are usually covered with a more or less dense growth of sea weed. A "skin diver" in 30 feet of water can not afford to spend much time in freeing himself of one or more strands of sea weed that the surge has thrown around him. This is an appropriate place to mention the story, which recurs periodically, of the abalone that caught the fingers of a hunter, usually a Chinese, and held him until he was drowned by the rising tide. It's a good story. It is conceivable that a "skin diver" in fairly deep water or in the surf might be detained long enough to be drowned; but in a situation where he could breathe and get his feet under him, he would only suffer from outraged dignity and possibly some lacerated fingers.

Uses of Abalone Shell

The shell of the abalone was used originally by the coast Indians to enhance their physical charms and as currency. The first Chinese who collected abalones discarded the shells. Later, however, after some enterprising white men manufactured curios from them which had a ready sale, the Chinese saw their possibilities. Thereafter considerable quantities of shell were shipped to China to be used for inlay work or to be cut into rough blanks, which were sent back to American manufacturers to be turned into ornaments. So great was the demand for abalone shell ornaments that during the '70s the shell was worth twice as much as the meat (Edwards 1913). Abalone shell curios and jewelry, and blister pearls enjoyed quite a vogue for many years, but there is little demand at present. Until 1939, a single small manufacturer in Southern California turned out products made of abalone shell and to protect his market successfully blocked all attempts to rescind the law forbidding the export of abalone shells from the State. However, in 1941, this section of the law was changed. Now that it is legal to ship the shells outside the State, apparently nobody wants to do so. Tons of abalone shell are being used as material for retaining walls or are simply piled up and slowly disintegrating at Monterey and Morro Bay.

A few shells are cleaned and polished and sold to tourists. Some have lead plugs inserted in the open holes and are used as soup plates. They make a very colorful article but do not retain their lustre and color if subjected to much heat.

Many of the shells contain a small species of boring clam (Pholadidea parva). As the clam bores downward, it frequently breaks through the nacre or inside layer of the shell. The abalone covers the break with a layer of nacre; the clam continues to bore and more nacre is deposited.

This contest results in a blister pearl. These are cut out and mounted as pins, brooches, and ear rings, and have a small sale.

Preparation (or Processing)

A good many people, especially newcomers to the coast, gather abalones and then do not know what to do with them. The methods of preparing abalone, as practiced in the commercial processing plants, can be used by the sport fisherman with substitute equipment. A heavy knife will serve in place of the mechanical slicers and a wooden potato masher or a rolling pin will do for pounding if a wooden mallet is not available. Pounding the steaks is absolutely necessary and usually requires a little practice. The slices are slippery, and it is suggested that a fork or similar implement be used to hold them in order to keep them in place and avoid mashed fingers. If the pounding is too heavy, a pasty mass results; if too light or uneven, hard spots will remain. Pound until the steak feels soft and velvety.

There are not many methods of preparing abalones for the table. The least troublesome procedure, for those that are not too confident of their ability to satisfactorily pound the hard muscle, is to grind it with a meat grinder and make a chowder, as for clams. Having made a success of pounding the steaks, it will be a change to fry them. Season the slices with salt and pepper, dip in a beaten egg and then in fine bread crumbs or flour. Fry them in hot oil until slightly brown on both sides. Don't over do it. Cooking beyond the "slightly brown" makes them dry and tough.

A simple method of preparation has been evolved by the sportsmen along the Northern California coast. The trimmed foot is given a pounding and then browned in hot oil in the same manner as that prescribed for a slice. After browning, the foot is put in the oven or in a closed sauce pan and simmered for a half or three-quarters of an hour.

Conservation—and the Abalone

A natural resource which is expoited by both sportsmen and commercial fishermen is usually a source of discord and recalcitrant dialectics between these two diametrically opposed schools of thought. The sportsmen claim that when commercial diving is prohibited, abalones from deep water move in and repopulate the beaches which they have exhausted. This is not a valid premise. Abalones migrate very little. The occasional large abalone found above high tide, in a section previously denuded, is usually a storm-transported individual too old and weak to maintain its hold in deep water. There are plenty of "short" abalones, (under the legal commercial 8-inch minimum) on all suitable rocky bottoms in deep water; however, the beaches adjacent to territory where diving has never been carried on are no more plentiful supplied than are those where the divers work continually.

The diver works under rigid legal restrictions, and he must land his catch promptly, at specified points, as the abalone is highly perishable and must be processed immediately. A record of his catch must be kept, and he can be and is checked periodically. There are, under normal conditions, fifteen or twenty diving crews. These men are interested in a steady industry from which they can obtain a living and few of them know-

ingly break any of the legal restrictions. The present commercial regulations were, for the most part, suggested by the divers themselves or have their approbation.

For every commercial diver there are thousands of sportsmen—and so-called sportsmen. On every minus tide, they gather along the seashore and glean abalones. The real sportsmen take only abalones of legal size and within the bag limit; others take anything they can find. The game wardens check hundreds of of them but naturally can only make "spot" checks. However, even this partial policing results in many arrests and the confiscation of many thousands of undersized abalones, some no larger than a silver dollar. It is not very difficult to understand why the abalone has virtually disappeared from the littoral zone.

Administrators and biologists, entrusted by the body politic with the responsibility of managing a natural resource, endeavor to apply the approved tenets of conservation. The accepted definition of conservation is utilization to the fullest extent possible without jeopardizing the basic supply.

The abalone has been "utilized" in the littoral zone until it is practically nonexistent, while many deep water areas have not been worked at all. Having systematically stripped the beaches of abalones, some of the sportsmen would sponsor legislation to curb the activities of the commercial divers. The fable of the dog in the manger seems appropriate.

The deep water area between Monterey and Point Conception produces an average of 60,000 dozen legal abalones annually. This amount seems to be a reasonable yield for the State, from both an economic and biological standpoint. The most feasible method of administering this resource would be to open the entire coast to diving with the necessary power vested in the Fish and Game Commission to open and close districts or coastal areas as changing conditions warranted. By permitting the divers to work in one or more areas for one or two years and then shifting operations to other sections, the supply of abalones would be drawn from the whole coast instead of from only part of it. In the areas where diving is forbidden to the north of San Francisco, there are probably more abalones dying annually of old age than the divers take in the open districts.

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PROGRESS REPORT ON STUDIES OF STRIPED BASS REPRODUCTION IN RELATION TO THE CENTRAL VALLEY PROJECT[1]

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Introduction

The major California spawning grounds of the striped bass all lie within the Central Valley. The Delta Cross Channel, involving several great diversions of the waters in which these fish spawn and in which their early stages develop, constitutes an important part of the master water-control plan known as the Central Valley Project, now in the process of development. The purpose of the Cross Channel will be to transfer surplus Sacramento River water southward across the Delta to a point near Tracy, where it will then be pumped out and caused to flow along the west side of the relatively arid San Joaquin Valley through the Delta-Mendota Canal, now under construction. A continuing series of problems involving the protection of striped bass against these and other Central Valley Project water manipulations is to be anticipated. Solution of such problems will require an extensive knowledge about striped bass reproduction in the Central Valley.

Such knowledge has been slow to accumulate, although sporadic attention has been given to the matter of striped bass reproduction both in California and on the Atlantic Coast. N. B. Scofield (1910) described the general location of the areas in the Central Valley where ripe fish were taken and the months during which they were present. He noted an abundance of such fish in the vicinity of Bouldin Island (see map, figure 71) in 1903, 1904, and 1905 so great that commercial fishermen had to agree among themselves to limit their daily catches in order not to glut the market. He also indicated that the Sacramento River and certain of its tributaries were important spawning areas. All of this agrees substantially with present information. Scofield made plankton tows "at different times during the season in the river, the sloughs, the flooded islands and on the tule flats in the hope of catching a young bass just hatched, or eggs before hatching, and thus get some clue to where the striped bass spawns, but without results." As a matter of fact, nothing was known definitely concerning the specific locations of striped bass spawning grounds in California until quite recently. E. C. Scofield (1931) believed that bass spawned primarily in the flooded islands of the Delta, but information obtained subsequently does not support this view. Considerable attention was given to studies of striped

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bass reproduction in connection with the survey of the Sacramento River system and the Sacramento-San Joaquin Delta which was begun by the California Division of Fish and Game in January, 1939. The primary purpose of this investigation was to determine the effect of the Central Valley Project upon the fishes of the area. Much valuable information was obtained before the survey was interrupted by the war, but little was learned about locations of actual spawning areas. Hatton (1942), speaking of the recovery of striped bass eggs in the San Joaquin Delta, states, "At no time were eggs taken in abundance, which may indicate that the major spawning areas are to be found elsewhere."

No mention is made by any of the above workers of the very characteristic spawning behavior of the striped bass, long recognized on the Atlantic Coast (Worth 1903, Merriman 1941) under the term "rock fight" because the fish, there called "rocks," appear to be fighting at the surface of the water when they spawn. Woodhull (1947) describes a case of such spawning activity on a large scale observed in California. He showed that the fish were actually spawning by towing a plankton net through groups of splashing fish and recovering freshly-spawned eggs.

Illustrations and descriptions of the early stages of striped bass have been given by Scofield and Coleman (1910), Pearson (1938) and Merriman (1941).

It is the purpose of the present report to outline facts learned about striped bass reproduction during 1947, to propose certain theories about the movements of small striped bass within the Sacramento-San Joaquin Delta, and to discuss some of the problems anticipated in connection with the operation of the Delta-Mendota and the Cross-Channel pumping plants. These features of the Central Valley Project present the most immediate threat to California striped bass.

Methods

In 1947, field studies of striped bass reproduction were mainly exploratory. Little was known about seasonal and regional distribution and movements of the early stages of this species in Central Valley rivers. Collection of eggs, larvae and fry were made by towing conical nets of various sorts behind a launch and, less frequently, by fishing nets with the current from a stationary position. Leim (1924) had recovered large numbers of striped bass larvae in plankton tows in a Nova Scotia river incidental to studies of shad reproduction and Hatton (1940, 1942) had collected small numbers of eggs and larvae in plankton nets in the Central Valley on several occasions.

In our studies a plankton net 20 inches in diameter at the mouth with a five-foot cone of 30 mesh per inch bolting cloth was used to collect eggs and larvae.[2] A larger net with six-foot mouth diameter and a fourteen-foot cone of bobbinet about eight mesh per inch was used to collect the fry.[3]

The abundance of small particles of plant detritus present in waters of the San Joaquin Delta presented a serious obstacle to recovery of eggs and larvae. As much as two quarts of such debris was sometimes taken in a plankton net during a five-minute tow. Nets clogged rapidly

[2] Striped bass less than ½ inch in length are referred to here and elsewhere in this report as "larvae."

[3] The term "fry" is used to designate the small striped bass longer than ½ inch.

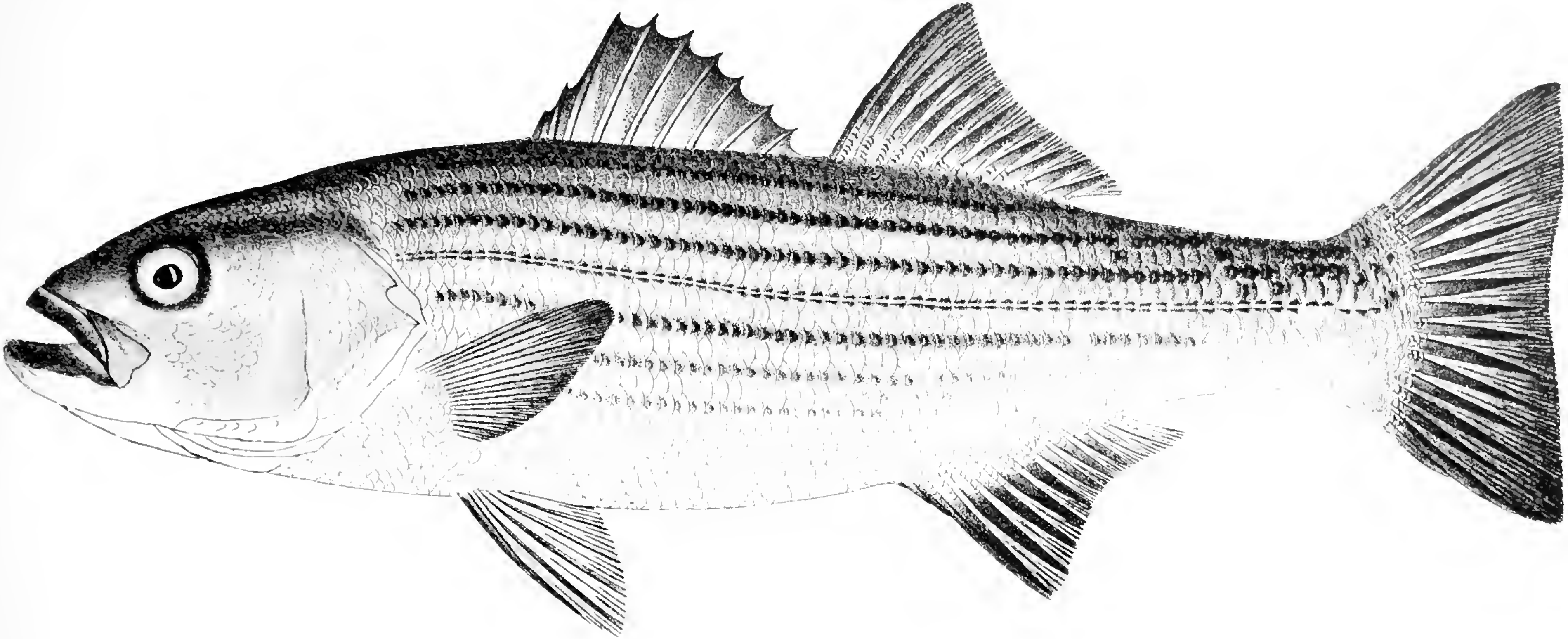

Figure 69. Striped bass (*Roccus saxatilis*)

under such conditions and adequate sampling was often impossible. The Sacramento River in the vicinity of Rio Vista generally carried much less debris in suspension. This explains in part the great success experienced in collecting larvae there.

Both eggs and newly-hatched larvae of striped bass have a distinctive appearance (Pearson 1938) and there seemed to be no reasonable possibility of confusing them with other fish eggs or larvae which might be encountered simultaneously in the Delta and immediately adjacent waters. Similarly, the fry were unmistakable at first glance. Intermediate larvae were more of a problem, however, and they required careful examination under magnification to be distinguished from other small fish in the samples. Fortunately, Pearson's drawings of series of striped bass larvae which he hatched and reared were available for reference in this connection.

All measurements of fish were from the tip of the lower jaw to the fork of the tail, recorded to the nearest tenth of an inch. An arbitrary dividing line between larvae and fry of striped bass was established at 0.55 inches for convenience in classifying and discussing samples.

1947 Recoveries of Striped Bass Eggs and Larvae

Sacramento River

Certain facts were already known about striped bass spawning in the Sacramento River. A major up-river migration occurs annually in the spring, centering in April and May, and consisting of fish which are ready or nearly ready to spawn. Its upper limits appear to fall well above Knights Landing on the Sacramento River and above Marysville on the Feather River (see Figure 70). Observations of the angling catch coupled with interviews of local residents form the basis for these statements.

Spawning behavior was reported to occur regularly each year in the Sacramento River in the vicinity of Verona and in the Feather River near Marysville (Shanghai Bend) by individuals resident in the area who appeared to be reliable sources of information.

It was difficult to understand the results of Hatton's fyke-netting operations at Hood (Hatton 1940) in the light of these reports of heavy spawning each year near Verona and Marysville. Hatton operated fyke nets more or less continuously between March and October of 1939 in the Sacramento River at Hood, but he took no striped bass fry there until August 3d, when he began to capture what appeared to be occasional stragglers. The answer seems to be that eggs and larvae flush down the river past Hood long before they are large enough to be caught in a fyke net with half-inch mesh.

Scofield (1910) indicated that in 1910 large numbers of striped bass passed through Cache Slough and Prospect Slough (see Figure 71) in the course of their spawning migration but that they apparently returned to the main Sacramento River upstream to spawn. He suggested that Prospect Slough might be an important spawning ground in most years. It is interesting to note in this connection that a large bass which had been tagged in January, 1947, in the San Joaquin Delta was caught by an angler during April of the same year in Prospect Slough, and another was taken at about the same time at Knights Landing on the Sacramento River above Verona. These two fish were almost certainly on

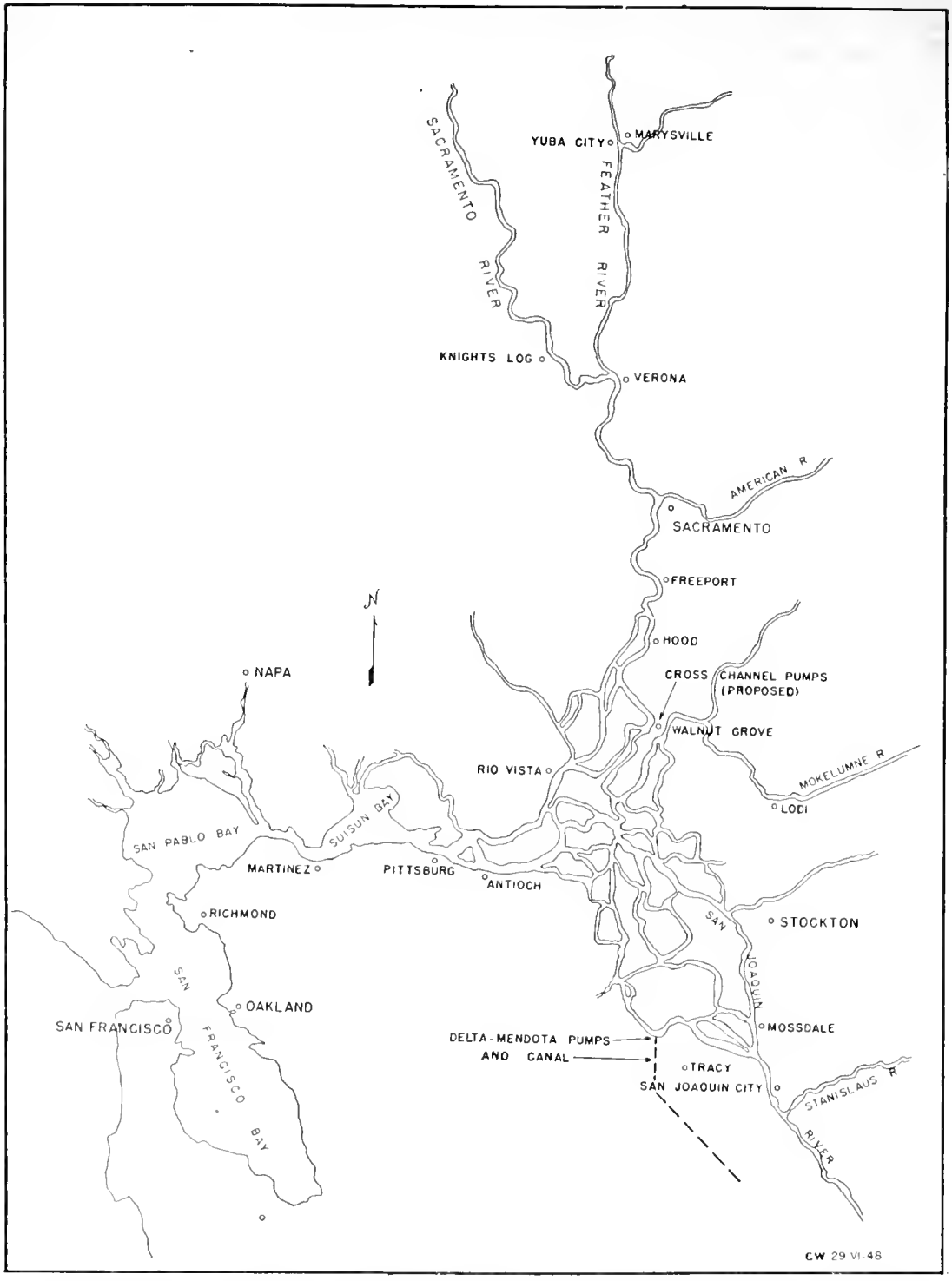

FIGURE 70. Reference map of the Sacramento-San Joaquin Delta and the Sacramento River, showing locations of the Delta-Mendota diversion and the proposed Cross Channel Pumping Plant

their spawning migration. Some of the mature striped bass which spend the winter in the southern half of the Delta must therefore cross over to the Sacramento River to spawn. However, the recovery at about the same time of another of the same group of tagged fish at Mossdale indicates that some also continue up the San Joaquin River.

Results of 1947 sampling for striped bass eggs and fry in the Sacramento River are summarized in Table 1. The discovery that considerable

numbers of eggs and newly-hatched larvae were being carried rapidly down the river past Verona in mid-April was of considerable interest. No striped bass eggs were ever taken near Rio Vista although extensive towing was carried on there and many larvae were collected. It appeared to be a reasonable conclusion that most of these larvae had come from spawning grounds some distance up the Sacramento River. This is a point of great importance from the standpoint of the Central Valley Project, and it is receiving major attention in 1948 studies. Larvae were abundant near Rio Vista in mid-May of 1947. During late May and early June they were apparently well distributed in the Sacramento River between Collinsville and Chipps Island and were still present in the vicinity of Rio Vista.

TABLE 1

1947 Sacramento River Recoveries of Striped Bass Eggs and Larvae in Plankton Nets

Date	Location	Minutes of fishing	Number of eggs	Number of larvae	Approximate age of larvae (days)*
April 17	Verona	60	39	8	2 to 4
April 22	Rio Vista		0	3	2 to 4
April 29	Rio Vista	230	0	4	4
May 14	Rio Vista	190	0	53	5 to 9
May 15	Rio Vista	330	0	248	5 to 9
May 20	Collinsville	16	0	26	6 to 14
May 28	Chipps Island	60	0	11	15 plus
June 4	Collinsville	60	0	2	15 plus
June 4	Rio Vista	60	0	9	15 plus

* Estimated roughly from Pearson's drawings.

San Joaquin River and Delta

The San Joaquin Delta has been recognized as an important striped bass spawning area for some time. There have been numerous observations of large-scale spawning activity there by Division of Fish and Game personnel (Woodhull 1947). Hatton collected striped bass larvae in plankton nets on June 8, 1939 in False River and in Washington Cut and on June 23, 1939 in Sycamore Slough (Hatton 1940). In 1940 he took striped bass eggs in Piper Slough, Three Mile Slough and the San Joaquin River below the mouth of Three Mile Slough during May, but never in abundance (Hatton 1942). Interviews with anglers and residents of the area indicated that widespread spawning occurs there each year.

Preliminary plankton-net sampling in the San Joaquin Delta during early April of 1947 did not capture any striped bass eggs or fry, but it is by no means certain that they were absent. Activities were seriously hampered by the abundance of debris in the water. Later sampling was more successful. Results are summarized in Table 2. Both eggs and larvae were recovered in some numbers in the San Joaquin River near the Antioch Bridge, and they were also taken at other stations.

An attempt was made to evaluate the importance of the San Joaquin River above the Delta as a striped bass spawning area. 1947 was an abnormally dry year, and the flows in the San Joaquin were negligible in comparison with those in the Sacramento. No eggs or larvae were recovered in the course of limited sampling at Mossdale and San Joaquin

TABLE 2

1947 San Joaquin River Recoveries of Striped Bass Eggs and Larvae in Plankton Nets

Date	Location	Minutes of fishing	Number of eggs	Number of larvae	Length of larvae
April 24	Buoy 21	10	2	0	
May 20	Antioch Bridge	34	21	33	0.2 - 0.4
May 20	Winter Island	10	0	2	0.2 - 0.5
May 20	Antioch	10	1	7	0.2 - 0.4
May 28	Antioch Bridge	82	0	14	0.2 - 0.5
June 4	Antioch Bridge	30	0	1	0.5

City. However, in years of normal rainfall the San Joaquin above the Delta is probably a spawning area of some importance, for it is known from catch records that a migration of ripe striped bass ascends the river for a considerable distance in some years.

1947 Recoveries of Striped Bass Fry

Suisun Bay

On June 13th sampling with the large tow-net was begun. The regularity with which striped bass were taken in it in Suisun Bay during the first few days it was in use, seemingly at any point where it might happen to be dropped over for a ten-minute tow, was a source of some surprise. The general picture of the distribution of striped bass fry during late June and early July, on the basis of tow-net samples, is shown in Figure 71, in which locations of tow-net stations are indicated by dots. Black dots represent stations at which fry were caught, and half-black dots represent negative stations. Striped bass fry were present throughout the Suisun Bay region at least as far west as Sealbluff Landing by the middle of June, judging from two-net catches. This area was surveyed by means of brief surface tows in mid-June, as outlined in Table 3. All such tows recovered bass fry until sampling was extended west of Sealbluff Landing. It is interesting to note in this connection that Hatton (1940) began to recover bass fry in his fyke nets at Martinez on June 14, 1939.

TABLE 3

1947 Tow Net Stations in Suisun Bay *

Date	Location	Minutes of towing	Number of fry	Number per minute
June 13	Ship channel near Pittsburg	10	15	1.5
June 13	Ship channel below Pittsburg	10	6	0.6
June 13	Ship channel below Pittsburg**	10	5	0.5
June 13	Ship channel near Mallard Island**	10	9	0.9
June 13	Ship channel near Simmons Point	30	104	3.5
June 13	Ship channel near Stake Point	15	18	1.2
June 14	¼ mile off Middle Point	20	36	1.8
June 14	Near Sealbluff Landing	30	37	1.2
June 14	Off Avon Wharf	30	0	0
June 14	Carquinez Straits, under S.P. Bridge	30	0	0
June 14	North shore Suisun Bay, opposite Avon	20	4	0.2
June 14	North shore Suisun Bay opposite Point Edith	20	5	0.2
June 14	Suisun Slough, near mouth	20	22	1.1
June 14	Suisun Cutoff, near Point Buckler	20	22	1.1
June 17	Mouth Sacramento River, near Collinsville	20	48	2.4

* All surface tows, unless otherwise indicated.
** Net about 10 feet below the surface.

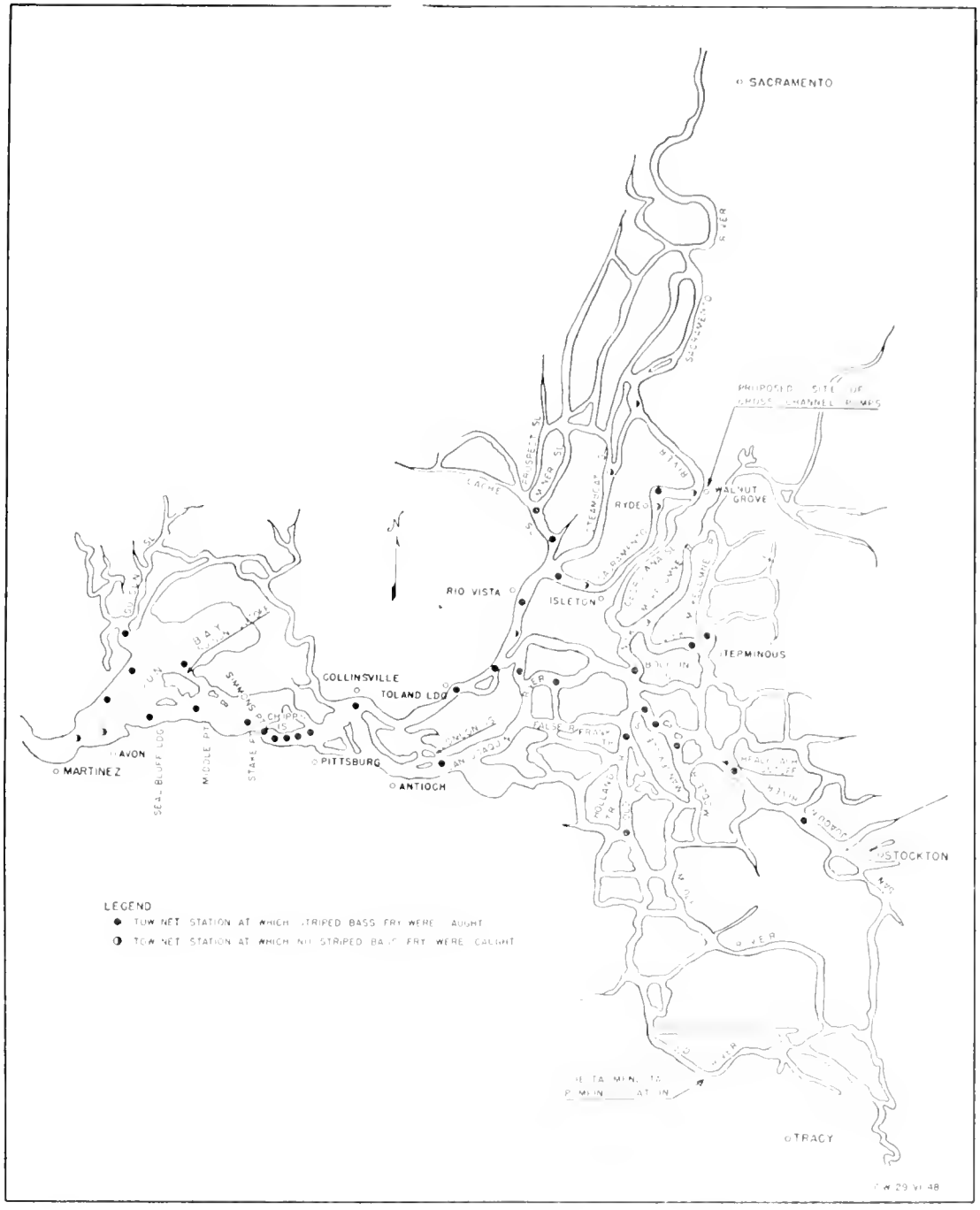

FIGURE 71. Locations of 1947 tow-net stations

Sacramento River

When tow-netting was extended up the Sacramento River above Collinsville a situation quite unlike that in Suisun Bay was found. Sacramento River tow-net samples are summarized in Table 4. Ten twenty-minute surface tows in sequence up the river from Tolands Landing to the north end of Steamboat Slough yielded a total of only nine striped bass fry. About two weeks later a series of deep tows over the same course revealed that the fry were fairly abundant in the deeper water in the vicinity of Rio Vista but were still scarce near the surface. Above Rio Vista even deep tows were negative. There appear to have been few striped bass fry left in the Sacramento River between Isleton and Ryde

TABLE 4

1947 Tow Net Stations in the Sacramento River and Its Tributaries

Date	Location	Type of tow	Minutes of towing	Number of fry	Number per minute
June 17	Sacramento River, Tolands Landing	Surface	20	1	0.05
June 17	Sacramento River, Chinaman's Cut	Surface	20	3	0.2
June 17	Sacramento River, below Rio Vista	Surface	20	0	0
June 17	Sacramento River, Rio Vista	Surface	20	1	0.05
June 17	Cache Slough, mouth of Miner Slough	Surface	20	15	0.8
June 18	Sacramento River, Rio Vista	Surface	20	0	0
June 18	Sacramento River, Rio Vista	Surface	20	2	0.1
June 18	Sacramento River, below Isleton	Surface	20	1	0.05
June 18	Sacramento River, Ryde	Surface	20	1	0.05
June 18	Sacramento River, Walnut Grove	Surface	20	0	0
June 18	Sacramento River, Paintersville	Surface	20	0	0
June 18	Steam Boat Slough, end of Sutter Slough	Surface	20	0	0
July 2	Sacramento River, Rio Vista	Surface	30	8	0.3
July 2	Sacramento River, Rio Vista	Deep	30	20	0.7
July 2	Sacramento River, Rio Vista	Deep	30	47	1.6
July 2	Sacramento River, Rio Vista	Surface	30	0	0
July 3	Sacramento River, Ida Island	Surface	30	1	0.03
July 3	Sacramento River, Ida Island	Deep	30	0	0
July 3	Sacramento River, Ryde	Surface	30	0	0
July 3	Sacramento River, Ryde	Deep	30	0	0
July 3	Cache Slough, Hamilton Landing	Deep	20	6	0.3
July 3	Cache Slough, Hamilton Landing	Surface	15	20	1.3

by the end of June. This is of considerable interest, for the Cross Channel Pumping Plant will probably be located on the Sacramento River at Walnut Grove in the center of this stretch of river.

The scarcity of striped bass fry in the main channel of the Sacramento River above Isleton can be explained readily on the basis of water flows. The flow in this region is large in relation to the size of the channel. The striped bass eggs, larvae and fry resulting from spawning in the Sacramento River and its tributaries are believed to flush rapidly down to the head of the Suisun Bay where the tidal flows dampen the carrying power of the river flow. This theory is supported by the general picture of distribution of the fry revealed by results of tow-netting, and it receives further confirmation from the fact that fry remained abundant in Cache Slough. The latter channel has a devious connection with the Sacramento River at its upper end, and appears to be comparable with the San Joaquin Delta, with respect to the behavior of its currents and flows.

Hatton's fyke-netting results at Hood, already discussed, indicated that there were few if any striped bass in the Sacramento River at Hood during late June and July of 1939 and only stragglers subsequently. Hood is only seven miles above our last station. It can therefore be inferred that the distribution and movements of striped bass fry in this area were essentially similar in 1939 and 1947. Both were relatively dry years characterized by small flows in the Sacramento River during the spring.

San Joaquin Delta

Tow-net catches in the San Joaquin side of the Delta revealed a situation similar to the one discovered in Suisun Bay, mentioned above. Striped bass fry were taken in virtually all tows anywhere the net was dropped over between June 17th and July 10th. Stations are outlined in Table 5 and Figure 71. Negative tows were almost never encountered. The fry were present in the San Joaquin River itself at all stations, in Three

Mile Slough, in Old River, in the Mokelumne River near its mouth and in the South Fork of the Mokelumne River. The regularity of positive tows seattered at random over such a wide area has led to the conclusion that striped bass fry were abundant over virtually the entire central section of the Delta. This region is undoubtedly a nursery ground of the greatest importance.

The continuing abundance of striped bass fry throughout the San Joaquin Delta well into July apparently resulted from the fact that the net outward flow there is negligible in relation to tidal flows. The Delta

TABLE 5

1947 Tow Net Stations in the San Joaquin Delta

Date	Location	Number of tows	Total minutes of towing	Number of fry	Number per minute
June 17	Three Mile Slough	1	20	46	2.3
June 17	San Joaquin River, near Kentucky Landing	1	20	31	1.6
June 20	Mokelumne River, near mouth	1	20	7	0.4
June 20	Old River, near Franks Tr.	1	20	18	0.9
June 20	Old River, near Holland Tr.	1	20	30	1.5
June 25	South Fork Mokelumne River, at mouth	1	10	0	0
June 25	South Fork Mokelumne River, below Terminous	1	10	9	0.9
June 25	South Fork Mokelumne River, above Terminous	12	120	90	0.8
June 26	San Joaquin River, above mouth Old River	10	100	207	2.1
June 26	San Joaquin River, near Mandeville Reach	4	40	58	1.4
June 28	San Joaquin River, near Headreach Cut-off	1	10	22	2.2
June 28	San Joaquin River, near Vulcan Island	4	40	16	0.4
July 10	San Joaquin River, near Donlon Island	20	300	159	0.5

Cross Channel can be expected to generate net flows toward the Delta-Mendota Pumping Plant, and bass fry may be swept along in some numbers to the diversion near Tracy. This point is discussed in detail in a subsequent section.

Several series of ten-minute tows repeated in rapid sequence over the same course resulted in surprisingly uniform rates of capture of striped bass fry. Moreover, there was a close correlation between towing time and number of fry caught in another series of comparable tows of varying duration. The fry must have been rather uniformly distributed horizontally in the San Joaquin Delta channels where these series of tows were made. Their rate of capture in the fry net promises to provide a good semi-quantitative index of abundance on the nursery grounds after methods have been standardized, judging from results obtained during 1947.

Early work with the fry net west of Pittsburg had revealed a concentration of fry at the surface of the water. However, later sampling at other places showed that vertical distribution was highly variable, and that the fry were also sometimes more or less uniformly distributed and sometimes concentrated toward the bottom.

Rate of Growth of Striped Bass Larvae and Fry During 1947

Means, standard deviations and ranges of lengths of striped bass larvae and fry collected in 1947 are given in Table 6. These data provide an index of the rate of growth which occurred during the spring and

early summer. Only eggs and very small larvae (0.2 inches) were taken in April. Eggs and larvae ranging from 0.2 to 0.5 inches were collected in May. Larger ones were also present in late May judging from the sizes of those caught in June. It was not until June 13th, when the large fry net was used for the first time, that adequate sampling of striped bass over 0.5 inches in length was possible. Frequency distributions of lengths for series of fry caught in this net between June 13th and July 10th were consistently of the "normal" type, and they were surprisingly uniform over the whole nursery area, from the upper San Joaquin Delta to the lower section of Suisun Bay. These facts coupled with other available information concerning recoveries of eggs and larvae indicate that most of the striped bass spawning which occurred in 1947 took place between the middle of April and the latter part of May.

TABLE 6

Lengths of Series of Striped Bass Larvae and Fry Collected in 1947

Date	Locality	Number of fish	Mean length (inches)	Stan. dev.	Range
April 17–29	Sacramento River, Rio Vista and Verona	15			0.2
May 14–15	Sacramento River, Rio Vista	301			0.2-0.3
May 20–28	San Joaquin River, Antioch Bridge to San Joaquin Point	82			0.2-0.5
June 4	Sacramento River, Rio Vista	9			0.2-0.4
June 13	Suisun Bay, Pittsburg to Stake Point	157	1.00	0.22	0.5-1.7
June 14	Suisun Bay, Middle Point	36	0.98	0.21	0.5-1.5
June 14	Suisun Bay, Sealbluff Landing	37	1.24	0.19	0.9-1.6
June 14	Suisun Slough, near mouth	23	1.18	0.23	0.9-1.6
June 14	Suisun Bay, Point Buckler	22	1.18	0.26	0.8-1.9
June 17	Sacramento River, Sacramento Point	48	0.93	0.24	0.5-1.6
June 17	Three Mile Slough	46	0.95	0.28	0.4-1.6
June 17	San Joaquin River, Kentucky Landing	31	0.97	0.28	0.5-1.6
June 17	Cache Slough, mouth of Miner Slough	15	0.81	0.12	0.6-1.1
June 20	Old River, vicinity of Franks Tract	48	0.97	0.21	0.6-1.8
June 25	South Fork Mokelumne River, at Terminous	99	1.23	0.23	0.6-1.8
June 26	San Joaquin River, Venice Island	304	1.20	0.25	0.6-1.9
June 28	San Joaquin River, Headreach Cut-off (below Stockton)	36	1.31	0.36	0.5-2.4
July 2	Sacramento River, Rio Vista	75	1.30	0.24	0.8-2.0
July 3	Cache Slough, Hamilton Landing	24	1.28	0.17	1.0-1.6
July 10	Antioch Bridge	155	1.53	0.27	1.0-2.6

Preliminary results of 1948 studies have borne out the belief that the time of occurrence and the duration of the spawning season will vary appreciably from year to year depending upon water temperatures during the winter and the spring. Spawning was unusually early in 1947, from all indications. In years of normal spring run-off the fry will probably be somewhat retarded in their development compared with 1947.

Striped Bass Problems Arising in Connection With the Delta Cross Channel

Description of the Delta Cross Channel and Associated Structures

In order to understand the problems of striped bass protection arising from the Delta Cross Channel and its associated pumping plants, it is necessary first of all to understand the project itself. Many aspects of the final design and operational plans of this part of the Central Valley Project still remain uncertain, but a fairly good general outline of the definitive structures is, nevertheless, emerging, and several major fea-

tures are already under construction. The purpose of the Cross Channel will be to augment the water supply of the relatively arid San Joaquin Valley, using Sacramento River water which now wastes to the ocean. The locations of the Delta-Mendota and the Cross Channel pumping plants, at the terminals of the Cross Channel, are shown in Figure 70. The name "Cross Channel" is in some respects a misnomer, for existing Delta channels will be used for whatever cross-flows are made. The primary installation will be the great Delta-Mendota Pumping Plant, already under construction, and scheduled for completion in the summer of 1950. It will be located on an intake canal leading out of Old River near Tracy. Photographs of the excavation for the intake canal and the foundations for the pumping plant as they appeared on July 8, 1948, are shown in Figures 72 and 73. The pumps will lift water 200 feet up onto the shoulder of the hills which parallel the west side of the San Joaquin Valley. From there it will flow south by gravity 120 miles through the Delta-Mendota Canal. The latter will be linked with other canal systems and will terminate at the Mendota Pool. Figure 74 shows a completed section of the Delta-Mendota Canal about one and one-half miles north of its intersection with Highway 50. The maximum capacity of the Delta-Mendota Pumping Plant will be 4,600 cubic feet per second, which is the equivalent of a fair-sized river. The only safe assumption is that this capacity will eventually be fully utilized, although 1,100 cubic feet per second is reserved for future development and will not be used until storage in addition to that provided by Shasta is available. Tentative schedules of water demands indicate that from 2,000 to almost 4,000 cubic feet per second will be removed during the initial years of operation in April, May,

FIGURE 72. Excavation of Delta-Mendota intake canal in progress, July 8, 1948. This view was taken looking toward the site of the pumping plant from the Byron-Bethany Highway

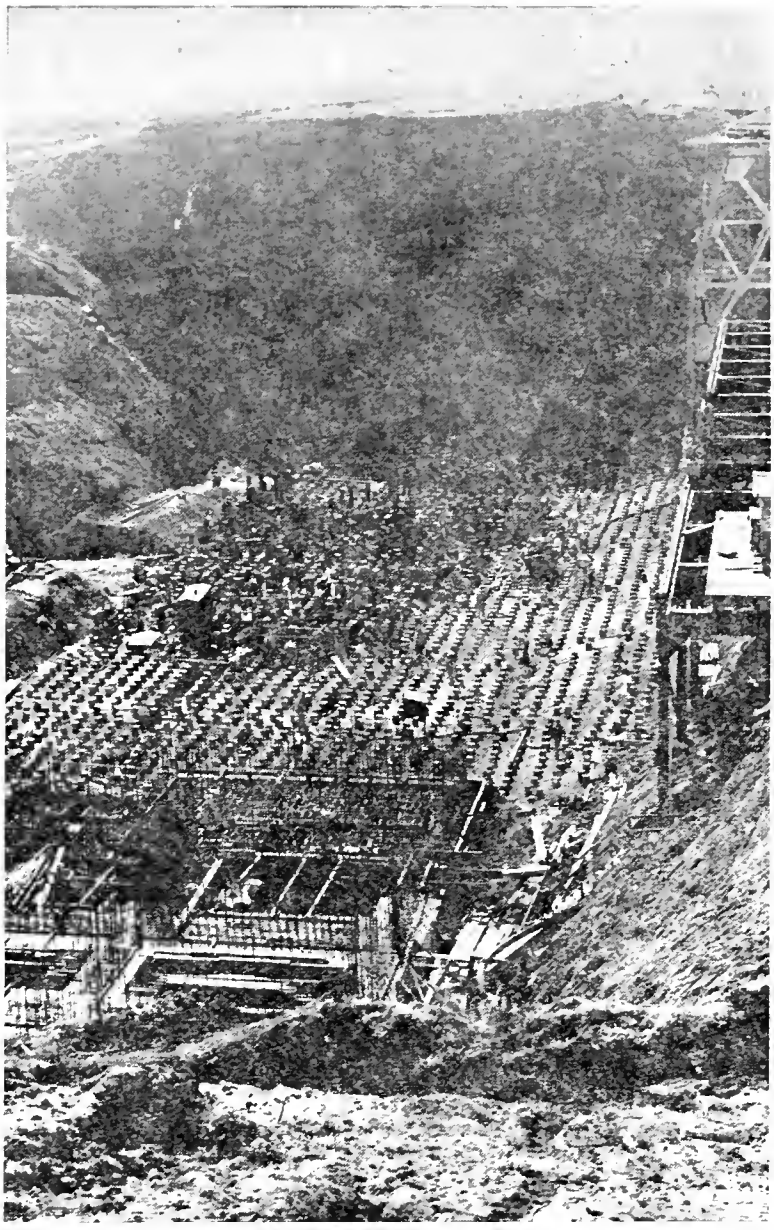

FIGURE 73. Foundation of the Delta-Mendota Pumping Plant under construction, July 8, 1948

June and July. These are the months when bass eggs, larvae and fry will be particularly vulnerable.

The source of the water which is to be removed by the Delta-Mendota pumps is a matter of great interest. The Delta itself will act as a mammoth reservoir from which the water will be drawn. Original plans for an actual canal which would have carried the water in a closed circuit from the Sacramento River near Hood directly to the Delta-Mendota Pumping Plant (Hatton 1940, Van Cleve 1945) have been entirely abandoned. As the project is shaping up, the only construction work on the actual Cross Channel will be such dredging and levee reenforcing as is necessary to enable existing channels to pass the necessary flows. Use of the San Joaquin Delta as a reservoir involves a number of uncertainties which promise to remain unresolved until operation of the Delta-Mendota Pumping Plant begins. Large transfers of Sacramento River

FIGURE 74. Completed section of the Delta-Mendota Canal near its intersection with Highway 50

water into the San Joaquin Delta in addition to those already occurring naturally through Georgiana Slough and Three Mile Slough will probably be necessary to prevent saline intrusion up the San Joaquin River. For this reason a second set of pumps, referred to as the Cross-Channel Pumping Plant, has been proposed. It would transfer water directly from the Sacramento River at Walnut Grove into the present channels of the Mokelumne River, through which the water would flow southward across the San Joaquin Delta to replace removals at Tracy. Although final decisions with regard to this feature have not yet been reached by the Bureau of Reclamation, indications are that it will become necessary in the immediate future.

The tidal currents which churn Delta waters continuously, producing flows up to 150,000 cubic feet per second in the main San Joaquin,[4] greatly complicate the over-all picture, and there is some uncertainty about what is going to happen with regard to salinity in the Delta when the Delta-Mendota pumps begin to operate in 1950.

No major changes in water temperatures are anticipated in the Delta as a result of the operation of the Cross Channel.

Preliminary Evaluation of the Cross Channel as a Threat to the California Striped Bass Population

It must be emphasized, at the outset, that available information on distribution and size of early stages of striped bass is based on studies made during 1947, a notably dry year. It is being assumed that the situation found in 1947 was fairly representative. If it develops that

[4] Maximum flows of 153,000 c.f.s. were measured in the San Joaquin River by Bureau of Reclamation engineers in August and October of 1945. Tides were normal.

such an assumption was unjustified, certain of our ideas may have to be modified.

At this point it will be well to outline briefly the over-all picture of striped bass reproduction in the Central Valley as we now understand it in order to provide a background for the discussion which follows. The spawning season centers in the months of April, May and June. Spawning occurs extensively each year over much of the San Joaquin Delta, and presumably also in the rivers flowing into it in years of normal rainfall. Spawning of major importance occurs also in the Sacramento River above Sacramento and in the Feather River between its mouth and Marysville and perhaps above the latter point. The eggs are semi-buoyant, and they develop while they are being carried along in suspension in the water. They hatch in about 74 hours at 60° F. (Merriman 1941), and take somewhat less time when the water is warmer. The small, delicate larvae which emerge are helpless and at the mercy of the currents. In typical river channels such as those of the Sacramento and Feather Rivers in which there is a one-way flow toward the ocean the eggs and larvae are swept rapidly downstream out of the spawning areas. In the channels of the San Joaquin Delta, on the other hand, in which downstream flows are negligible by comparison with the tremendous, oscillating, tidal flows, large numbers of eggs and larvae remain and develop in the actual spawning areas, flushing back and forth continually through the many channels of the Delta. The entire San Joaquin Delta constitutes a nursery area of the greatest importance for the very young striped bass. Suisun Bay is another such area.

Turning now to the various problems which arise in connection with the Cross Channel, the most serious difficulty promises to stem from the fact that the Delta-Mendota Pumping Plant will be diverting large flows of water from the main San Joaquin Delta spawning and nursery area during the period when it contains large numbers of striped bass which are too small to be stopped by fish screens. It will not be surprising if many small bass are drawn to the Delta-Mendota diversion, especially in dry years such as 1947, and perhaps also in years of normal rainfall. There are many unknown factors involved in Delta interactions of river flows, tidal currents, effects of the diversion, and movements of small striped bass in response to currents. It is therefore impossible to estimate the force of the attraction which the Delta-Mendota pumps will exert upon these fish, or the area which will be involved. It is greatly to be hoped that the attraction will be small and localized, in which case losses of small bass may not be very great. Actual losses occurring during the initial years of operation must be determined so that it will be possible to develop a fish-protection program to match them.

The possibility of screening the Delta-Mendota intake canal with a fine-mesh rotary screen is being considered by the Bureau of Reclamation.[5] A by-pass canal will also have to be built if screens are installed, for it is useless to screen fish from a channel if they have no place else to go.

A purely reconnaissance type of cost estimate made by the Bureau of Reclamation indicates a probable total cost for screens, fish pump and by-pass canal amounting to from $5,000,000 to $8,000,000 depending upon size and location of the by-pass canal. It must be emphasized that

[5] One inch is probably about the minimum length of striped bass which can be screened at such a diversion. There may even be some difficulty with fish this size.

these estimates are of very preliminary nature, and can be taken to indicate only a possible range of cost for fish protection facilities at this location.

Final decisions have yet to be reached by the Bureau of Reclamation with regard to these structures, and it is very uncertain at the present time if they will be constructed.

Serious difficulties may arise if large numbers of striped bass larvae and fry are carried to the Delta-Mendota diversion. It remains to be seen what can be done to minimize losses of such fish. A number of possibilities suggest themselves. Fish rescue within the canals supplied by the Delta-Mendota pumps may offer a partial solution, if large numbers of fish pass through the pumps and survive. Passage of the Old River Channel through a sizeable lake which could be created by flooding one of the adjacent "islands" might produce a break in the continuity of currents carrying larvae and fry toward the outlet. This in turn might retard their rate of travel sufficiently to permit most of them to reach screenable size before arriving at the diversion. The cost of such a project would be so great that it could be justified only if very large losses of small bass actually occur at the Delta-Mendota outlet. Moreover, the various agencies interested in salinity control in the Delta would like very much to eliminate existing flooded areas of this sort, such as Franks Tract and Sherman Island Lake, and would scarcely look with favor on proposals to create new ones.

Another method of reducing the gravitation of large numbers of striped bass fry toward the Delta-Mendota outlet might be to pump additional salinity-control water into the Mokelumne River at Rio Vista during early summer, assuming the Cross Channel pumps materialize. This might increase the proportion of fry flushing into Suisun Bay from the San Joaquin side of the Delta. Normally, most salinity-control water would pass down the Sacramento River. This scheme is mentioned here only as a possibility worth investigating in the event that we are faced with major losses of small bass at the Delta-Mendota outlet following operation of the Cross Channel.

The possibility of resorting to the artificial propagation of striped bass arises inevitably in any such discussion as this. It would be feasible to hatch eggs and to rear fish through the larval stage, judging from available information (Worth 1910, Scofield 1910). This should lead to no false illusions, however. The possibility of maintaining even a fraction of a fish population the size of our present striped bass population by artificial propagation can scarcely be given serious consideration. A glance at the area over which fry were abundant in 1947 (Figure 71) will emphasize this fact. Actual numbers of fry present must have been astronomical, and anything a hatchery could turn out would be insignificant by comparison. Over and above this fundamental objection are the many practical difficulties involved. These are well illustrated by Scofield's troubles in connection with attempts to operate a striped bass hatchery on the San Joaquin River many years ago. He finally abandoned the project entirely after three consecutive years of fruitless efforts to obtain ripe spawn. Attempts to hold mature fish in pens until they ripened were not successful. We could anticipate similar difficulties. Anglers could not be counted upon to supply fish with suitable eggs, for female striped bass do not bite well when the eggs are fully ripe.

In the East, where successful hatching on a small scale has been carried on over a long period, ripe fish were apparently all obtained on the spawning grounds in nets, under conditions which are not duplicated in California. We would rarely be justified in netting females for their eggs, because there would always be the possibility that they might have spawned in areas unaffected by the Delta Cross Channel. It is one of the tenets of modern fisheries biology that artificial propagation is at best but a poor substitute for natural reproduction, which it rarely approaches in efficiency. All in all, hatchery operations offer little hope of solving any of the striped bass problems which may arise from operation of the Delta Cross Channel.

On the basis of 1947 tow-net catches, it is evident that the total number of striped bass fry present that year on all the nursery grounds was very great indeed. Furthermore, a large proportion were in Suisun Bay and in other waters beyond the influence of the Delta-Mendota diversion. It therefore appears probable that even if losses at the diversion are quite large of themselves, they will be relatively small in relation to the total numbers of fry present on the nursery grounds. It should not be inferred from this that we mean to condone such losses. However, it is gratifying to be able to report that the Delta-Mendota diversion will probably not bring about any disastrous reduction in the size of the striped bass population.

The second major Cross Channel problem centers about the proposed Cross Channel Pumping Plant at Walnut Grove. While it is not yet certain that this installation will be built, indications are that it will be, and soon. Preliminary results of 1948 studies have confirmed the belief that sizeable numbers of striped bass eggs and larvae flush down the Sacramento River. From all indications, they are carried past Walnut Grove quite rapidly. Numbers of such eggs and larvae passing through the Cross Channel pumps will presumably be proportional to the volume of water pumped during the brief period while they are present. Other channels such as Steamboat Slough will carry their share of the down-stream migrants safely below the diversion. The pumps will have a low lift. Maximum clearance will presumably be provided, so that fish of some size will pass through them without injury. This installation should therefore not cause too much trouble. It can be expected to divert into the San Joaquin Delta only a minor portion of the total Sacramento River down-stream delivery of bass larvae and fry; much less, in fact, than already passes normally from the Sacramento River into the San Joaquin Delta through Georgiana Slough.

Several long-range programs have been set up to study means of protecting the striped bass and other fish against harmful effects resulting from the Central Valley Project in general and the Delta Cross Channel in particular. In addition to the striped bass investigation and the salmon investigation of the California Division of Fish and Game, an ambitious ecological study of the Delta in relation to Cross Channel problems is being undertaken by the U. S. Fish and Wildlife Service. These three programs promise to pay large dividends in helping to provide solutions to the manifold fish-protection problems which will arise as the Central Valley Project expands and matures.

Summary

Striped bass eggs were collected during the 1947 season in the Sacramento River at Verona and in the San Joaquin River at the Antioch Bridge, Buoy 21, and Antioch. Larvae were taken in large numbers in the Sacramento River at Rio Vista, and in lesser numbers at many other widely-scattered points. Fry were found to be abundant throughout most of Suisun Bay and the San Joaquin Delta in late June and early July. They had a mean length of about one inch at that time. Few fry were taken in the Sacramento River above Rio Vista, and numbers present there are believed to have been small. Vertical distribution of fry was found to be variable.

The distributional pattern of striped bass fry in the early summer of 1947 appears to have resulted from flow conditions in the various channels. The early stages of striped bass are believed to flush rapidly down and out of the Sacramento River, because of its large net flow. In the San Joaquin Delta, on the other hand, where river flows are negligible by comparison with the tremendous tidal currents, large numbers of the eggs and larvae apparently remain and develop in the general area of the spawning grounds.

The Delta-Mendota Pumping Plant, now under construction, will divert large flows of water from the San Joaquin Delta during the period when striped bass too small to be stopped by fish screens are abundant there. Sizeable losses of small bass may occur at this diversion. Actual losses occuring during the initial years of operation will have to be determined in order to evaluate the threat which this installation presents. It is impossible to predict the magnitude of losses to be expected because of the many unknown factors involved. Possible protective measures are discussed. Even if losses at the diversion are quite large of themselves, it is probable that they will be relatively small in relation to the total numbers of fry present on the nursery grounds, and they should therefore not bring about any disastrous reduction in the striped bass population.

If the Cross-Channel Pumping Plant is built, it can be expected to divert a minor portion of the total Sacramento River down-stream delivery of striped bass larvae and fry into the San Joaquin Delta. This installation does not appear to present any great threat to the striped bass population.

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A CRITICAL REVIEW OF RANGE SURVEY METHODS AND THEIR APPLICATION TO DEER RANGE MANAGEMENT[1]

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Introduction

Western deer, in their proper habitat, depend upon range vegetation for food. In order to maintain a thrifty and productive deer herd, it is necessary first to maintain a thrifty and productive deer range. Livestock production may be based on cultivated pasturage but practical deer production cannot be. Deer are a factor in the range complex and deer management must be based on range management to be successful in the long run.

As stated by Ellison and Croft (1944), the objective in range management is the sustained production of forage crops and the control of water flow to optimum capacities of range sites. This can be accomplished only where a state of balance exists among the major site factors of climate, topography, soil, and living things. In an earlier paper (Humbert and Damann, 1945) it was pointed out that while climate and topography, in a broad sense, cannot be altered by man; man can exercise some control over soil. But it is not practical to control range soils except through the medium of vegetation. It is only the plant-animal factor with which the range manager can work, practically and generally.

The deer range manager may alter the vegetation cover by thinning, pruning, weed eradication, fertilization, re-seeding, or controlled burning but the cost of such measures is usually too high for general application. Ordinarily, adjustments in the plant cover must be made through control of the degree of cropping by range animals. To maintain or re-establish a plant cover adequate to hold the soil, control water flow, and produce the optimum amount of forage possible on each site, enough of the annual growth of vegetation must be left in place to enable the plants to carry on their life processes. The range manager needs to be concerned not so much with the fraction that range animals take as with the fraction of vegetative growth that range animals leave. This fraction may be called the range maintenance reserve.

The number of animals that will take no more than the forage crop in all but poorest growth years is the maximum number a range unit will support on a sustained basis. Since range is dynamic, changing continually with fluctuations in precipitation, temperature, evaporation,

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and varying use patterns, no rate of stocking can be considered final. Changes in stocking must be made at intervals in order to balance demand with supply. The range manager needs to make periodic surveys to enable him to keep track of such vegetation trends.

The purpose of this paper is to evaluate some of the accepted range survey methods and to point out those that appear best for use in deer range management.

Range Survey Methods

Most range land surveys fall into one of three classes: (A) forage inventories, (B) range condition surveys, or (C) forage utilization checks.

A. FORAGE INVENTORIES

Forage inventories usually aim at the appraisal of the quantity and quality of forage present on a range unit in order that an estimate of its carrying capacity may be made. Carrying capacity has been defined by the author (Dasmann, 1945) as "the maximum number of foraging animals of a given class that can be maintained in good flesh year after year on a range unit without injury to the range forage growing stock or to the basic soil resource." Carrying capacity is often expressed in animal unit months of forage. An animal unit month of forage is the quantity of vegetation that will support a mature cow and her sucking calf for one month.

The Original Method: This method of appraising forage crops is still in common use under greater or lesser degrees of refinement throughout the world. It consists of examining the range unit, comparing its areas with other areas of known carrying capacity with which the examiner is familiar and arriving at an estimate of the number of animals the range unit will support. Obviously this method is subjective and open to the personal bias of the examiner. The factors that enter into the estimate will vary with individuals. The estimate will be no better than the experience, memory, and judgment of the man making the survey.

The trained range examiner will make use of a knowledge of range indicators in formulating judgments. Some of the commonly used range indicators are listed later in this paper. Indicators of range condition, range trend, and plant utilization, tell a story if the range examiner is trained to read them. (Ellison and Croft, 1944; Talbot, 1937.)

The Reconnaissance Method: Jardine originated the reconnaissance method of forage inventory and used it on the Coconino National Forest in Arizona in 1911. It is based upon the amount of forage per acre as indicated by plant density and upon the relative palatability of the different plant species represented.

Forage density is a measurement of the horizontal aspect of vegetation. It is expressed in terms of ground surface covered by vegetation. A completely covered ground surface (when viewed from directly above) is considered as having a density of ten tenths. Only the current year's available growth of browse plants is included in the measurement.

Palatability is defined by the Western Range Survey Conference, (1937) as the percent of the total current year's growth within the reach of stock to which a species is grazed when the range unit is properly utilized under the best practical range management. Palatability ratings are now more properly called Proper Use Factors.

The range examiner using the reconnaissance survey method estimates for each sub-type (a) the average density of the plant cover, (b) the ratio in per cent that each important plant species makes of that average density, and (c) the area of the sub-type. Using this information the carrying capacity is then determined in terms of forage acres as shown in Table 1.

TABLE 1

Determination of Carrying Capacity by Reconnaissance Method
Adapted From Dasmann (1945)

(In this example it is assumed the sub-type has an average density of .3, composition ratios as shown in column 1, and an area of 500 acres.)

Species	*(1) Percentage-composition*	*(2) Palatability*	*(1x2)*
Asp	.6	.70	.42
Ptr	.3	.40	.12
Lup	.1	.20	.02
			.56

Average density (.3) x .56 = .168 (forage factor)*
500 acres x .168 = 84 forage acres
84 ÷ .8 (forage acre requirement for cattle) = 105 cow months.

Under the best practice a forage acre requirement per animal is determined for each locality as follows: A grazing unit upon which desirable range conditions and proper use of forage prevails is selected and surveyed. The forage acre requirement is then computed by dividing the total forage acres on that unit by the average number of animal months of grazing per year allowed on the unit during recent years.

By substituting a definite procedure, i.e., density estimates, percentage composition ratios, sub-types, plant palatability ratings, for an undefined subjective process, the reconnaissance survey is an advancement over the older method. It has an additional advantage, also, in that the data secured under this method can be checked in the field at a later date.

The Square-foot Density Method: This method, more properly called the Point-Observation-Plot Method, of forage inventory was described by Stewart and Hutchings (1936). It differs from the older method chiefly in its technique for determining density. With the reconnaissance method the examiner must select for each sub-type a representative sample of vegetation upon which to make his density estimates. The square foot density method eliminates the need for personal selection by sampling each sub-type with small plots established along a line at predetermined intervals. These plots are usually 100 square feet in area. The amount of vegetation present on a plot is determined by estimating the number of square feet of completely covered ground surface for each of the represented plant species. The separate densities of plant species should add up to the total plant density. The total plant density plus the number of square feet of unvegetated ground should equal 100.

* The forage factor is the percent of the ground surface which is covered with a crop of available palatable vegetation of ten-tenths density.

The average of all plots falling in each sub-type is considered as representative of the vegetation present on that sub-type. Plant palatability ratings are used as in the reconnaissance method. The carrying capacity is then determined as is shown in Table 2.

TABLE 2

Determination of Carrying Capacity by Point-Observation-Plot Method (Dasmann, 1945)

Species	*(1) Average Density All Plots in Sub-type*	*(2) Palatability*	*(1 x 2)*
Asp	.18	.70	.126
Ptr	.08	.40	.032
Lup	.04	.20	.008
			.166

500 acres x .166 (forage factor) = 83 forage acres.

This method of range survey further eliminates individual bias and personal errors from the work. By spacing many small plots at mechanical intervals, it offers quantitative data as suggested by Stewart and Hutchings (1936) that is both randomized and replicated and lends itself to statistical analysis. Also, by concentrating the range examiner's attention upon a small plot, more exact and detailed observations usually are obtained.

Discussion of Above Methods: Both the reconnaissance and the square-foot density methods of forage inventory have an outstanding weakness, i.e., their use of density alone as a quantitative measure of vegetation. By making no allowance for height, density measurements ignore the three dimensional aspect of plant growth.

Schwan and Swift (1941) point out that density alone is not a true index of the amount of forage available (a) because it ignores differences in volume; (b) because "ratings of forage types * * * are necessarily in terms of ratio and do not attempt to express a physical measure of the forage present," (c) because forage acre requirements of livestock are based on studies of units presumed to have been properly grazed which element rests upon personal judgment; (d) and because of the difficulty of exact determination of the density of shrubs where part of the plant is older growth, part of the current growth is unavailable, and where many layers of twigs and leaves over-story one another.

Smith (1944) determined that there is extremely poor agreement between the amount of vegetation produced from clipping and estimates of density. He states that density is a poor index of forage yield even within a single species.

One would think that with so many weaknesses so aptly pointed out, the use of a density measurement as a sole indicator of forage yield would no longer be considered a basis for inventories. But it is still used. It is true that as a measure of the horizontal aspect of plants, and for comparisons of relative spread of vegetation on ranges of similar site and type, the density measurement has its place.

Both the reconnaissance and square-foot density methods are also weak where region-wide palatability ratings (proper use factors) are used. Palatability is defined not as the amount that *may* be used but as the amount that *is* used. This definitely involves livestock preference. But livestock preference is a fluctuating factor that varies considerably with climate, season, type, and sub-type. Where such ratings are worked out locally, or for areas of similar vegetative composition, climate, and cropping season, their use in a carrying capacity determination may be more dependable. But regional palatability ratings add to the other errors.

One way to eliminate the troublesome density element from forage inventories would be to substitute actual weight of forage on randomized plots as determined by clipping and weighing. The yield could then be expressed in poinds of forage per acre. Berndsen and Morgan, according to Pechanec and Pickford (1937b), have proved this method accurate and the method is often used for intensive studies in certain forage types. However, it is too time-consuming and hence too expensive for use on extensive surveys.

Weight Estimate Method: This method of forage inventory was developed by Pechanec and Pickford (1937b). They report that men can learn to estimate weight of vegetation on small plots and that while "weight estimates are subject to slightly more personal error than density estimates * * * they are superior to density estimates for indicating actual yield."

Schwan and Swift (1941) recommended the use of a weight-estimate method for forage surveys of big game ranges. They stressed the advantage of a method that depends on physical rather than ocular checks and pointed out that estimates can be compared directly with actual weights, instead of computing the error against the crew mean as must be done with density methods. They stated that in actual field tests, maximum error of weight estimates did not exceed 20 percent, but agree with Costello and Klipple (1939) in the need for a proportionately greater number of plots in highly important types.

Carhart and Means (1941) reported the application of a forage weight per acre method in a survey of deer and elk ranges in Colorado. They had determined that some dozen plant species furnish the bulk of forage on deer ranges in that state, and pointed out that time can be saved by limiting the survey to such key forage plants, rather than to include all vegetation in the forage inventory.

The author (Dasmann, 1945) has previously suggested that the palatability rating be eliminated from the weight-estimate method and that instead the estimated weights be reduced by the amount that must be left for the plants to carry on necessary life processes (metabolic reserve), and further reduced by the amount that grazing animals will probably leave unconsumed where the key species received no more than allowable cropping. The carrying capacity would then be determined as is shown in Table 3.

TABLE 3

Determination of Carrying Capacity by Weight-estimate Method
(Dasmann, 1945)

Species	(1) *Average Weight/Acre All Plots—Pounds*	×	(2) *Allowable Cropping Factor*	×	(3) *Preference Rating*	=	*Available Crop—Pounds*
Asp	700		.60		1.0		420
Ptr	500		.50		.8		200
Lup (6)	200		.80		.7		112
	1,400						732

Available crop per acre in pounds × surface acres ÷ monthly animal requirement = animal months of forage available.

Discussion: Pickford and Reid (1940b) reported that the weight-estimate method, on the basis of data from three experimental areas, is best suited to types running heavily to bunch grasses and to sedge meadow types. They state that the use of this method in highly variable types such as found on timbered range is questionable. Pickford and Reid further indicated that there is no question here of the greater accuracy in portraying forage production claimed for the weight-estimate method. The question, rather, is the practicability of the method for general use in range surveys due to the likelihood of excessive cost, arising out of the large number of plots needed. It should be pointed out, however, that the factor which ran up the number of plots needed to obtain a satisfactory degree of accuracy in their study was the scattered occurrence of highly productive meadows. Were the survey concerned primarily with key deer forage species and most of them shrubs, as suggested by Carhart, the accuracy for a given number of plots may have been much higher.

Until a better method is developed, the weight-estimate method appears as the most practical and dependable for making forage inventories of big game ranges, where this information is really needed. Deer managers should remember, however, that the end product of such a forage inventory will be an estimation of the number of deer that the range will safely carry. To use this information, it will be necessary to know the number of deer currently on the range.

Rasmussen and Doman (1943) tested various deer census methods on a large deer-tight fenced area in Utah upon which the actual number of deer was later determined. They tried the general reconnaissance census, strip census, airplane census, drive count, meadow and feed ground counts, and track counts. Only the drive count, with men spread at eight rod intervals, yielded an accurate estimate of the total population. This method is too unwieldy and costly for general application. The authors concluded that since methods of counting mule deer have not proved successful in determining total numbers, the value of this type of count appears to be limited to determining trends. Total populations can be determined more accurately by use of ratios and indices. Stoddart and Rasmussen (1945) emphasized even further that in the final analysis, forage utilization must form the basis for mule deer management. So far as the author has been able to determine, no new reliable

census method for determining total deer populations has been developed since 1943.

It should be considered, also, that the foraging habits of range animals vary with topography, character of soil, rockiness, density of vegetation cover, distance from water, and other factors. On well-watered ranges of soft soil, gentle topography, and constant floristic composition, distribution of cropping is most apt to be regular and uniform. As ranges recede from this pattern, distribution becomes more uneven. Sometimes large areas are used only lightly or not used at all, while forage plants in adjacent areas suffer from over-cropping. Often such use-patterns cannot be altered without heavy expenditures for range improvements. Adjustments in estimated carrying capacities based on forage inventories must, therefore, be made to allow for the local pattern of use if depletion of concentration areas is to be prevented. Thus, no matter how perfect the inventory method, the rate of stocking must finally be based on what is happening on the ground as determined by checks on forage utilization and range trend.

B. RANGE CONDITION SURVEYS

Range condition surveys seek to appraise the status of the range complex and to determine whether the trend in plant and soil development is up, down, or in approximate balance. Range condition is a reflection of the accumulated effects of past use; range trend is an expression of the effects of current use. Both condition and trend can be diagnosed by a consideration of various range indicators.

Sampson (1923) demonstrated that one of the most important indicators of condition of range is the succession stage of its vegetation. The evolution of soil from bare rock to fertile field is a process accompanied by a succession of vegetation changes. Weathered rock supports lichens which assist mechanically and chemically in developing it to a place where it will grow certain shallow-rooted, short-lived annuals. The soil supports the plants; the plants till, fertilize, shade, and hold the soil. This process goes on until we find the fully developed soil supporting a climax stage of vegetation characteristic of its particular site.

When the plant cover is subject to over-cropping the plants weaken, begin to thin out and die. The soil, receiving less protection from sun, wind, and water may bake, blow, and wash.* Lower stage plants with less rigid soil requirements move in. If the grazing load is lightened sufficiently, both soil and vegetation will recover, but if sub-climax plants in turn are over-cropped, retrogression will proceed to a still lower stage until a balance is reached.

The range examiner who knows the successional niches of certain common plant species can often learn a great deal about a range from the occurrence and abundance of such indicator plants.

There have been many lists of range indicators compiled. The lists given below present a composite of data taken from several sources, principally Ellison and Croft (1944); Talbot (1937); Pickford and

* Sampson (1944) points out that Craddock and Pearse (1938) found that wheatgrass proved 2,000 times more effective in preventing erosion than an annual weed cover and 300 times more effective than Downy chess.

Reid (1942); White, Frandsen, Humphrey, and Nelson (1942); and Handbook for Range Managers (1940).

I. Indicators of soil condition
   1. Occurrence of litter.
   2. Mineral soil between plants.
   3. Bare soil surface (consider soil salts).
   4. Absence of horizon A (dark, gritty soil).
   5. Observed movement of soil (muddy water, dust).
   6. Plants on soil pillars; soil humps on slopes.
   7. Exposure of plant roots.
   8. Soil remnants; islands or hummocks of better soil.
   9. Erosion pavement, lichen lines, old soil lines.
   10. Gullies or blow-outs, rills, shoestringing.
   11. Stream-bank cutting.
   12. Wind or water deposits of soil (dunes, bars).
   13. Terracing (from stock trails).

II. Indicators of vegetative condition
   1. Species of plants present and their relative abundance (Succession stage).
   2. Age classes of plants (Presence or absence of seedlings).
   3. Density and height of plants (consider influence of particular site).
   4. Vigor of plants (consider site and precipitation).
   5. Dead or dying plants.
   6. Presence of annuals and/or ground-hugging, top-rooted plants (Cheat grass, knotweed, etc.).
   7. Invasion of bare spaces.
   8. Patchy vegetation.

III. Indicators of utilization
   1. Close grazing of inferior species.
   2. Range uniformly close-cropped.
   3. Stones, cow dung, gopher mounds, and stock trails plainly visible.
   4. Plants close-cropped under brushy trees, low shrubs, and thickets.
   5. Hedged shrubs, browse and grazing lines.
   6. Accessibility of palatable species.
   7. Condition of timber reproduction.
   8. Dead or dying plants.
   9. Flesh condition of livestock or deer.

Range Condition—Carrying Capacity: The Soil Conservation Service makes use of a method for estimating carrying capacity based directly on range condition surveys. This agency's criteria of range condition as expressed by White, Frandsen, Humphrey, and Nelson (1942) are given as "composition of plant cover, forage density, volume growth, vigor of key species, and degree of erosion." Briefly, this method necessitates a localized study of (a) the factors that make up excellent, good, fair, poor, and very poor range condition on various types (b) a study of the rates of stocking, seasons of use, and other grazing practices that have brought about the occurrence of these conditions and (c) a correlation of (a) and (b) resulting in recommended carrying capacities and methods of management designed to maintain the best conditions and improve all others.

The study includes clipping and weighing data; forage yields are expressed in terms of pounds per acre. Emphasis is placed on pounds per acre of litter remaining at the end of the season of use; the value of litter in protecting and developing the soil, and in providing earlier growing and more vigorous herbaceous forage is stressed. From the local study, local standards are compiled. These standards can then be used by range examiners as a guide in making condition surveys and carrying capacity estimates of other range units in the vicinity.

Discussion: Because the range condition method bases carrying capacity directly upon condition of soil, vegetation cover, and plant species composition, instead of screening data through a series of ratio formulas, it appears superior to the other methods discussed above. But this approach to carrying capacity is difficult for the deer range manager to apply because of the need to determine rates of stocking (number of deer) before carrying capacities can be determined.

Condition surveys, on the other hand, are essential to sound range management and should be used in conjunction with range utilization checks to reveal the full range picture. It sometimes happens, for instance, on steep slopes or on highly erosible soils that damage occurs from a degree of use that would be classed as light to moderate elsewhere. Indicators of condition and trend will reveal such sore spots.

Condition surveys can be useful also in deer range management where it is desired to determine extensively the condition of range lands and whether they are getting worse or better.

Studies of food preferences of western deer indicate that even where grasses and weeds are an important factor in their diet, browse forage is taken to an extent that any list of key forage species will contain many palatable shrubs. Because this is so, it is believed that condition surveys of deer ranges should give more recognition to palatable shrubs than is usual.

The opportunity for using the condition standards for range types that have been compiled by the Soil Conservation Service, the Forest Service, and other agencies, should not be neglected. It should be stressed again, however, that range condition is usually a reflection of past forage utilization and that the principal factor affecting trend that man can manipulate is rates of stocking.

The question naturally arises (a) if estimated carrying capacities must be adjusted on the basis of utilization checks to allow for existing patterns of use and possible errors of survey, (b) if the effect of current rates of stocking is best determined from forage utilization checks, and (c) if the factor most indicative of future improvement or deterioration of a range is degree of cropping of vegetation, why not go directly to forage utilization checks for a base in deer management?

C. FORAGE UTILIZATION CHECKS

The most direct way to determine the carrying capacity of a range unit is to stock it with a known number of animals, watch what happens and then adjust the stocking and or the grazing season until proper use is attained. Even where the number of animals is not known, a similar procedure may be used; viz., check the use at the end of one or several of the seasons. If it is not satisfactory, add or subtract known numbers of animals until the desired result is reached.

Range administrators have used less direct methods for determining carrying capacity because of a lack of adequate sampling methods, plus a lack of personnel with the time and or training necessary to make such checks. Western ranges with their intricate pattern of grazing and browsing use posed difficult problems for the range examiner. It was thought safer to stock ranges on the basis of forage inventory surveys than to rely on judgments of local field men. As range research progressed, however, several sampling techniques were developed that gave

reliable data on utilization and trends without unwarranted expenditure of time. The development of the key plant species concept and the recognition of use patterns and resultant key (heavy use) areas, have led to some simplification of the job of making utilization checks. There remains the problem of selecting suitable sampling methods. Several of the methods are discussed below.

Methods for Estimating Degree of Cropping

General Reconnaissance Method: This method, as described by Pechanec and Pickford (1937a), estimates on the basis of general observations the total plant height or volume removed from extensive areas. A refinement leading to greater accuracy is to first estimate the percent of plants actually grazed and then the percentage cropping of this fraction. The accuracy of the estimates varies with the individual range examiner and is not subject to statistical checks.

The recognition and proper evaluation of range indicators is basic to the best type of reconnaissance check. A division of intensity of use into light, moderate, and heavy, as indicated by stubble heights, visibility of soil surface from stand-off view, degree of uniformity of cropping, and other indicators, is common practice today. There has been a shift of emphasis toward less concern with the percentage of the volume or weight of forage which has been taken and more concern with the amount of shrub growth, height of stubble, and abundance of litter (i.e., the range maintenance reserve), which has been left. The method is especially valuable in judging degree of use on complex annual type ranges and on meadows, but utilization standards based on range indicators have been developed for many western range types.

Actual Weight Method: Beruldsen and Morgan, according to Pechanec and Pickford (1937a), used sets of randomized plots or transects. On one set the full crop of ungrazed forage is clipped and weighed; on the other the stubble remaining after the season of use is clipped and weighed. This method is simple and eliminates personal errors but is time-consuming and involves protecting the first series of plots from grazing.

Stem Count Method: Stoddard, according to Pechanec and Pickford (1937a), based this method on the assumption that the percentage utilization varies directly with the percentage of the total number of stems that are grazed. The method is simple and free from personal error, but was the least accurate of those reported by Pechanec and Pickford. It is laborious and is theoretically unsound since it is based on the premise that the entire individual plant is removed by grazing.

Height-weight Method: A method estimating the degree of cropping was developed for the Forest Service by Campbell and Crofts (1938), Lomasson and Jensen (1938) and others. As expressed by Pickford and Reid (1940a), it consists in computing the average height of the grazed stubble in per cent of average ungrazed heights of plants. The average per cent height removal is converted by use of charts to percentage utilization based on weight of forage removed. Pickford and Reid after field comparisons of this with the ocular by-plot method, reported that the principal weakness of the stubble height method springs from the fact that shape of plants after grazing usually is so complicated that measurement of stubble height is reduced to an estimate and because the greatest

part of a plant's weight is near its base, a small error in measuring average stubble height may represent considerable error in the estimate of its use.

Clark (1945) determined that the variability in plant height and weight relationship within a species, resulting from site, zone, and year, indicates there is considerable error in the use of height-weight tables or scales based on averages. He quotes Campbell (1937) to point out that when the continued productivity or gradual decline and death of good forage grass may depend upon a difference in foilage removal of as little as 10 per cent, a more accurate measure of utilization is necessary.

Ocular By-Plot Method: This method, described by Pechanec and Pickford (1937a), is based on volume-weight relationship. Visual estimates of degree of cropping are made in percentages of the total weights of each species removed from small plots as shown by volume. Field men must become proficient at mentally correlating weight with plant volume and growth form. Accuracy of estimation can be checked by clipping and weighting procedures. With this method errors in personal judgment tend to be compensating. It is reasonably accurate, sensitive to fluctuations, and rapid.

Clark (1945) recommended the use of the ocular estimate by-plot method because in field comparisons, the ocular estimate by-plot method has proved not only adaptable to all classes of forage, but also sufficiently rapid for general field procedure. When employed by a trained technician it has yielded reliable estimates of use. He states that its accuracy is shown to be but little affected by the sort of variation in height-weight distribution noted in these studies, and that technicians can learn to appraise such features as difference in height, character of growth, and pattern of herbage removal, and to evaluate properly their respective effect on the relative amount of forage removed.

Ocular Estimate by Averages of Plants Method: This method, described by Pechanec and Pickford (1937a), is a refinement of the ocular by-plot method. Here, the percentage weight removal is estimated for each individual plant, instead of for all plants, on the plot and these are averaged. It is relatively free from personal error and its high correlation with volume removal adapts it to accurate range studies. It is slightly less rapid than the plot estimate method.

Twig Measurement Method: Aldous (1945) described this method as a practical and reliable means to determine the annual percentage utilization of each browse species on winter deer range. One or more lateral branches of a shrub are tagged and the current twig growth on the outside of the tag is measured before deer enter a range and again after they leave. If livestock and/or deer are on the range and crop the plant during its growing season, this method is less adequate. It then becomes necessary to estimate the average length of uncropped leaders which increases the probability of error. This method is based on the assumption that intensity of cropping is proportional to percentage of twig growth removed, which will not hold where leaves or fruits make up a considerable part of the forage taken. Also, where current growth is not readily distinguishable from the balance of the twig at the time of measurement, complications ensue. However, the twig measurement method offers a simple

mechanical technique and may prove adequate for certain shrub and tree species on fall and winter deer ranges.

Visual Estimate Method: Hormay (1943) described a method for estimating the utilization of shrubs. The average leader length of all ungrazed twigs on a shrub is estimated in inches. An estimate is made, in per cent of the total, of the number of leaders that have been cropped. An estimate is made of the percentage of the twig growth inches that have been taken from the cropped leaders. For instance, if 50 per cent of the leaders are cropped an average of 30 per cent, the average cropping for the shrub is computed at 15 per cent. Hormay suggested that such averages for individual shrubs may be weighted with the product of crown circumference × average ungrazed leader length. He pointed out that while this product is not a direct measurement of either volume or yield it serves the purpose of permitting relative comparison to be made in total production and total utilization as well as percentage utilization.

Sampling Methods

Number of Plots: Costello and Klipple (1939) reported that the laws of statistical analysis apply to range forage sampling. They found that it takes nearly as many sample plots to determine the average density or forage factor of a range type one acre in area as it does to sample a 10,000 acre type to the same degree of accuracy.* These authors pointed out that the number of plots needed for a reliable estimate of either the density or forage factor is not proportional to the area of the type to be sampled. Apparently the number of plots needed is mostly dependent upon the heterogeneity of the vegetation cover and is related to area only as heterogeneity is related to area. This is clearly shown in Table 4.

TABLE 4

Accuracy (with odds of 19 to 1) obtained by samples of 100 plots on areas of different size (adapted from Costello and Klipple (1939).

Size of Area in Square Miles	*Percentage of Accuracy Obtained For Plant Density*
1	93.23
2	92.66
4	94.01
8	90.82
12	89.26
16	91.72
20	90.60
100	89.65
10,000	91.85

Costello and Klipple concluded, among other things, (a) that the law of diminishing returns applies to accuracy of surveys by the plot method, (b) that different vegetation types require different numbers of

* "The number of plots required to give a mean density or a mean forage factor of any desired degree of accuracy was calculated by transposing the formula for the standard error of a mean to the following form:

$$\text{Number of plots} = \left(\frac{\text{the standard deviation}}{\text{the standard error of the mean}}\right)^2."$$

The standard error of the mean was given an arbitrary value depending on the accuracy desired.

plots to secure a given degree of sampling accuracy, (c) that different portions of a type generally require different numbers of plots for a given degree of accuracy, and (d) that seasonal and yearly fluctuations in floristic composition result in seasonal and yearly fluctuations in the sampling intensity necessary to survey the same area with a given degree of accuracy. While these conclusions are based on studies of forage density and forage factors, the same principles should hold for plant height, volume, and weight.

Type of Plots: According to Bauer (1943), Christidis (1931) recomended that sample plots be long and narrow to reduce the effect of heterogeneity, and Pechanec and Stewart (1940) found that long, narrow plots were generally somewhat more efficient than square ones of the same size. Bauer, after reviewing the literature on efficiency of various sizes and shapes of plots used to sample density and frequency of vegetation species, reports that in laboratory tests line transects proved superior to quadrats for sampling both percentage ground covered and numerical abundance of plant species. In his tests, known areas on which discs of various sizes and colors were used to simulate a chaparral community, were sampled and the figures obtained could be compared with true values.

It has been generally recognized that line transects are effective for sampling grasses. Bauer, after making his laboratory tests, checked this sampling method on a Chapparal area on which the density and frequency of plants had been determined by time-consuming methods. He reports the results checked very favorably with the control data and suggests that this method for sampling coverage and frequency of shrubs be used in other shrubby types.

Discussion

On the basis of the literature reviewed above, it is suggested that a reconnaissance method based on range indicators be used where rapid, extensive utilization checks are wanted. For more intensive utilization checks, it is suggested that the visual estimate method be used for shrubs, and that an ocular estimate by plant method be used for grasses and forbs, both in conjunction with line transects. For intensive studies of yield and utilization, the actual weight method is suggested.

It should be stressed, however, that no matter what method of utilization check is used, full consideration should be given to other indicators. Allowable degree of cropping may vary considerably with soil, slope, and other site differences. The intensity of use a plant can withstand can vary within species and with seasons. Reliable data must be determined for each locality on the basis of what is happening on the ground.

Aids for Sampling Forage Utilization

Key Areas: As has been pointed out before, the pattern of use by grazing and browsing is seldom even. On some ranges, it is so uneven as to create areas of heavy, moderate, and light cropping of forage plants. This is particularly true of winter deer ranges where occurrence of snow

limits the distribution of animals for extensive periods. As a result, the forage plants on mid-winter concentration areas are subject to more intensive cropping than those occurring elsewhere on the range. It follows, therefore, that where vegetation on such key areas is not over-cropped, over-cropping should not occur generally over the balance of the range. Sometimes, areas of steep slopes or light, unstable soils, may be considered keys to a range.

Key areas can serve the range examiner once they are reliably determined. Too critically important to sacrifice, field men may give such key areas the intensive examination they deserve, confident that the range will not suffer elsewhere as long as stocking does not exceed carrying capacity on areas where use is heaviest.

In contrast to key areas, there occurs on most ranges small spots, usually around water or along main passes, where vegetation must be sacrificed if the range is to be used at all. Such areas are present on all ranges. The objective should be to delimit them and not allow them to spread.

Key Plant Species: Deer, like sheep and cattle, display preference for certain foods. If present on a range, preferred plant species will supply the bulk of the forage that deer consume.

Mitchell (1941) reported that on the Umatilla National Forest in Oregon on 319 spots examined only eight of 68 plant species identified appeared on 50 or more plots and of the eight only four were utilized by deer and elk to an extent of 10 percent or more. He points out that Einarsen (1940) found that blacktail deer in western Oregon used only three plant species heavily and 19 species moderately to lightly in spite of an abundance of varied vegetation.

Carhart (1941) reported that deer in Colorado generally depend on a limited number of forage plants for their sustaining diet, and indication are that they use these consistently whether the range is overgrazed or not.

The Interstate Deer Herd Committee (1947) reported that bitterbrush, sagebrush, juniper, and grass made up over 79 percent of the volume of food taken by deer on that range as indicated by stomach samples.

Many others have published supporting data to indicate that on most deer ranges there exist a relatively few key plant species which deer prefer and from which they take the bulk of their diet. While deer may subsist on other food species, where the preferred plants are not present, the loss of key plant species from a range is generally synonymous with a lowering of carrying capacity. Mitchell reported that Forsling and Storm (1929) found that cattle lost weight after the preferred plant species were depleted, and we can safely assume that a similar preference nutrition relationship applies to deer.

It follows that such preferred plant species are critical foods on deer ranges and, like key areas, can serve to reduce the problem of making adequate utilization checks. Because they are subject to the heaviest use, it can be assumed that where these preferred plants are not over-cropped, no other plant species of significant occurrence will be

generally over-cropped. It is important that key species be determined on the ground. Once they are determined for any range unit, the range examiner can limit his utilization checks to observations of the degree of cropping of a limited number of plant species thus simplifying his job immensely.

Table 5 lists some of the forage plants preferred by deer on ranges in the west. Field men will have to determine which plants are most important on any specific range examined.

TABLE 5

Highly Rated Deer Forage Plants

(Only plant species rated high by at least one author are included in this table. Ratings are derived from the following sources:

1. Plants rated as excellent, good, fair, and poor deer forage in "A Study of the Life History and Food Habits of Mule Deer in California"; Joseph S. Dixon, California Fish and Game, Vol. 20, Nos. 3 and 4, 1934.
2. Palatability ratings from "A Study of Plants Eaten by Deer on the Santa Barbara National Forest"; Cyril S. Robinson, Region 5, Forest Service, 1936.
3. Preference ratings of from 0 to 100 based on weights of forage taken where deer had a free choice. The first figure (viz. 80/30) is the rating when plants are green; the second, the rating when cured. Taken from "The Experimental Feeding of Deer"; A. A. Nichols, University of Arizona, 1938.
4. Preference ratings based on the percentage of the species in the deer diet divided by the amount available on the range. Taken from "Colorado Deer-Elk Survey," Vol. 5, Colorado Game and Fish Commission, 1941.)

Species	Common name Shrubs and trees	Preference ratings			
		1	2	3	4
Amelanchier alnifolia	Service berry				2.09
Amorpha californica	False indigo			80/50	
Artemesia tridentata	Big sage	L			1.14
Cercocarpus ledifolius	Curl-leaf mahogany	G	20		3.36
Cercocarpus betuloides	Birch leaf mahogany	G	60		3.36
Ceanothus integerrimus	Sweet birch	E	60		
Ceanothus leucodermis	Chaparral whitethorn	E	40		
Ceanothus fendleri				90/30	
Calliandra eriophylla	Mesquitillo			99/60	
Celtis pallida	Desert hackberry			99/90	
Celtis reticulata	Mountain hackberry			99/80	
Cowania stansburiana	Cliff rose			85/25	
Ephedra sp.	Mormon tea	L	40		1.07
Eriogonum nudum	Tall buck wheat	E	20		
Eriogonum wrightii	Buck wheat			99/60	
Eysenhardtia orthicarpa	False mesquite			99/60	
Fendlera rupicola	Fendlera			99/80	
Krameria parvifolia	Cosahui			75/5	
Juniperus communis	Dwarf juniper				5.00
Odenostoma repens	Creeping holly grape				5.78
Pachistima myrsinites	Myrtle box leaf				10.88
Populus spp.	Aspen	G		99/99	
Prunus emarginata	Bitter cherry	G	60		
Prosopis chilensis	Honey mesquite	E			
Prosopis pubescens	Screw bean	E			
Pseudotsuga taxifolia	Douglas fir				1.03
Purshia tridentata	Bitter brush	E			.99
Purshia glandulosa	Bitter brush		70		
Quercus emoryii	Emory oak			90/10	
Quercus gambelii	Gambel oak			80/10	
Quercus kelloggii	California black oak	E	30		
Quercus dumosa	California scrub oak	E	20		
Quercus vicinifolia	Huckleberry oak	E			
Quercus spp.	Scrub oaks				1.93
Rhamnus crocea	Redberry		70		
Sambucus glauca	Elderberry		80		
Vitis arizonica				90/60	

Species	Common name Forbs	Preference ratings			
		1	2	3	4
Artemesia mexicana	Sage			80/10	
Astragalus nothoxys	Loco weed		20	80/—	
Amaranthus palmeri	Careless weed			99/—	
Atriplex wrightii	Salt weed			75/—	
Calandrinia caulescens	Calandrina			95/—	
Chenopodium fremontii	Lambsquarter			99/—	
Erodium spp.	Filaree	G		—/99	
Ipomoea cordifolia	Morning glory			75/—	
Lotus wrightii	Buck clover			85/—	
Lotus mollis	Birdsfoot trefoil			95/—	
Lotus americanus	Spanish clover	E	30		
Medicago hispida	Bur clover	G	90		
Oenothera hookeri	Evening primrose	G	20	95/—	
Polygonum aviculare	Yard weed	E			
Portulaca lanceolata	Purslane			99/—	
Sonchus oleraceus	Sow thistle			99/—	
Talinum patens	Talinum			99/—	
Trifolium obtusiflorum	Creek clover	L	80		
Vicia americana	American veteh	G	60		
Vicia sativa	Common vetch		60		
Vicia exigua	Vetch			85/15	

Species	Common name Grasses and grasslike plants	Preference ratings			
		1	2	3	4
Festuca elatior	Meadow fescue	E	40		
Triodia mutica	Slim triodia			85/—	

On most ranges there occur some plants which are not generally abundant but which are eagerly sought and cropped by deer wherever they are present. Not offering sufficient volumes of forage to become a practical base for carrying capacity, such species can only be favored by extremely light use or by rotation use practices not applicable to deer. Further research may reveal that such plants offer trace elements important to the well being of deer.

Conclusions

Sound deer management involves the production of deer on a sustained cropping basis. As a crop, deer are indirectly a product of the soil and directly a product of the palatable vegetation the soil sustains. Where deer out-balance the forage supply, they over-crop range vegetation. Plants are damaged and start to thin out. This depletion of the vegetation cover lowers carrying capacity and exposes soil to the action of sun, wind, and water. It takes nature 300 to 1,000 years to produce one inch of top-soil. Where soil is lost at a rate faster than that, fertility declines and the better types of forage plants can no longer flourish. Thus a vicious circle of destruction starts to revolve. If corrective measures are not taken in time the process must end inevitably in depletion of deer numbers as well as damage to watersheds.

A basic problem in deer management is to balance the number of deer on each range unit with the carrying capacity of that unit. The

deer range manager should aim at adjustment of stocking to a level at which the vegetative cover and/or the soil mantle will not be damaged in any but the poorest growth years. It is believed the most direct and reliable method of deer population control is one based on utiliziation checks of intensity of cropping key plant species on key areas (where they occur), strongly supplemented by observations of general range condition and trend as shown by indicators as discussed in this paper.

The deer range manager, by controlling consumption of forage, works to maintain (or re-establish) a balance among range site factors. His standard in setting up range carrying capacities is to limit the animals to that number which will take no more than the allowable crop of forage, and will have a range maintenance reserve adequate to protect the soil, regulate waterflow, and produce an optimum amount of forage year after year.

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FERTILITY OF EGGS OF THE RING-NECKED PHEASANT[1]

By Howard Twining,[2] Henry A. Huebsman, and Wallace MacGregor
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Investigators who have worked with wild pheasants are aware of the importance that sportsmen attach to the existence of an optimum cock-hen ratio. Hunters fear that intensive hunting pressure may reduce the number of cocks below the point at which all hens will be successfully mated.

Standard textbooks on poultry, such as Lippincott and Card (1946), recommend a ratio of one rooster to as high as 25 hens for Mediterranean type chickens. Byerly and Godfrey (1937) found that of 65 laying pullets mated to a light Sussex male, 62 laid some fertile eggs. Tegetmeyer (1911, p. 109) representing the point of view of the old English gamekeeper recommends one cock pheasant to six hens. Nestor (1948, p. 49) states that in pheasants a ratio of one cock to five or six hens is desirable for coverts in England. James Ashley, biologist of the California Division of Fish and Game, tells of talking with a keeper of a shooting preserve in Norfolk, England. This man considered the optimum ratio of cocks to hens to be 1 to 13, provided the cock distribution through the coverts was uniform. If he found that there were too many cocks just before nesting season, he would shoot the wandering cocks that seemed to be attached to no territory until the 1 to 13 ratio was reached. Beebe (1926, p. 52) observed a harem size of four to eight hens for the Chinese pheasant in its native range. Randall (1941, p. 6), working in Pennsylvania on an area with a sex ratio of one cock to seven hens, found "fertility" was 94.1 percent. Einarsen (MS) describes the actions of a cock that had been placed in a field pen with 12 hens. The bird was observed mating 31 times during the month the birds were under observation. Some matings were probably not observed. "Fertility" was 89.8 percent in this field, where brailed birds were being studied.

Shick (1947) found that pheasant hens on a game farm produced "fertile" eggs for an average maximum of 22 days after the cock bird was removed from the cage. He cites experiments made at game farms in Iowa which showed 75 percent fertility of eggs collected from a pen with one cock and 50 hens. He points out that the spring sex ratio on the Prairie Farm in Michigan has averaged one cock to seven hens but data resulting from studies on nesting in this area have shown a normal

[1] Submitted for publication May, 1948. Federal Aid in Wildlife Restoration Project California 22-R. The Life History and Management of the Ring-necked Pheasant in California.

Dr. Lewis Taylor, of the Poultry Research Laboratory, University of California, has been kind enough to furnish numerous references in the literature on the subject of fertility of hens' eggs and has assisted greatly by applying his knowledge of poultry to problems related to pheasants.

[2] Resigned May 31, 1948.

production of "fertile" eggs. He concludes that it appears reasonable to assume that a single cock easily could service 10 to 12 hens in a breeding season.

Investigators on the subject heretofore commonly have determined fertility by incubating the eggs and observing the development of the eggs. Those that are candled out after a few days of incubation and show no sign of development are called "infertile." Field workers studying pheasant nesting habits have made a practice of breaking intact eggs left in a nest after the brood has hatched. Those eggs that show no sign of development have been called "infertile" and the blame is usually placed on unsuccessful mating.

Investigators of reproduction in game birds so far have used the word "fertile" to apply to those eggs that are capable of hatching, and in so using the word are in accord with definitions given in dictionaries. Embryologists would prefer that this term be reserved for eggs in which fertilization has taken place, whether or not the fertilized ovum is capable of embryonic development. Thus, if development of a fertile egg is stopped by some early zygotic lethal (or inherent death factor), the egg would be classified as one with *dead germ* but still would be classed "fertile." Henceforth in this article the term fertile will be used according to the embryologist's definition.

Fertility of eggs can be established quickly and easily by examination of the germinal disc. For a person doing field research on game birds the technique is simple and invaluable in establishing percentages of fertile eggs to be found in the wild or on the game farm. In early June of 1947, for example, 45 percent of the eggs at a California state game farm failed to develop. Examination of samples of fresh eggs, however, showed 100 percent fertility. It was found that the hot sun had killed the germ before any visible sign of development. A comparison of fertility and hatchability of chicken eggs has been reported by Munro and Kosin (1945).

Description of Fertile and Infertile Eggs

The infertile germinal disc is whiter than the fertile and its margins are irregular. There are many clear vacuoles (lacunae) usually concentrated around the edge of the disc. Pandor (1817) made drawings of fertile and infertile discs and described each briefly. Prevost and Dumas (1827) described in detail the gross appearance of germinal discs. Kosin (1945) in describing the infertile blastodisc, points out that the most conspicuous feature "* * * is the presence of varying numbers of large lacunae, in extreme cases giving the surface a reticular appearance. These lacunae are nothing more or less than gaps on the protoplasm of the disintegrating blastodisc. When these gaps are deep enough, they reach to the underlying yolk, which then can be seen through them." Drawings of fertile and infertile germinal discs depicting general differences are shown in Figure 75.

The fertile germinal disc of both pheasant and chicken eggs can be quickly and easily distinguished without the aid of a glass. The area opaqua (outer ring) is not an intense white. The disc is round or nearly so and the margins are clean cut. The area pellucida (central core) is often clear but frequently is invaded by greater or lesser amounts of

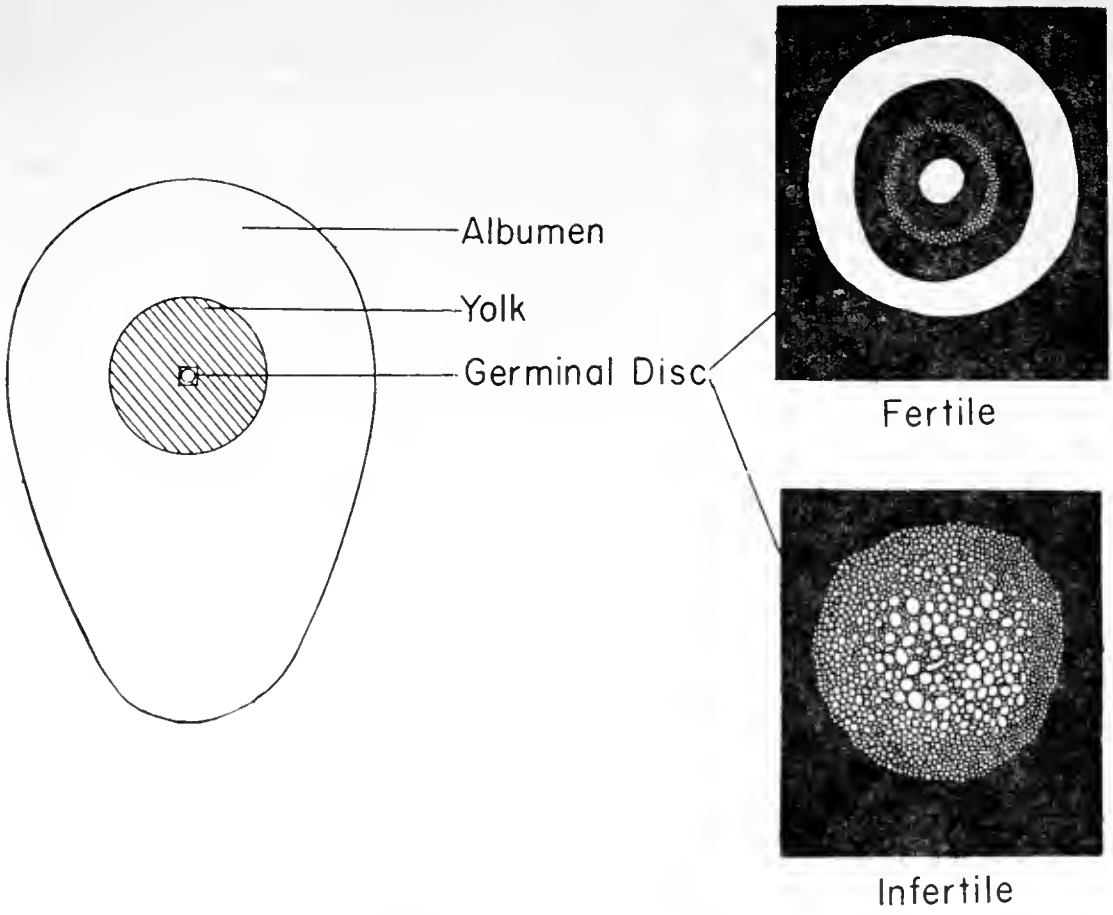

FIGURE 75. Germinal discs of unincubated ring-necked pheasant eggs

white material. One or more small vacuoles may occasionally occur on the periphery of the blastoderm. Kosin (loc. cit.) shows that the fertilized blastoderm at the time of laying consists of several thousands of cells in contrast to the unfertilized egg which undergoes no cell division. Byrd (in litt.) in an investigation of fertility of chicken eggs has segregated fertile germinal discs into four types according to the appearance of the white material in the area pellucida. He has found that an infertile disc may occasionally superficially resemble a fertile one. Close examination, however, will reveal many inconspicuous vacuoles in the disc. Examination, by us, of 105 pheasant eggs disclosed only one of this type.

Kosin (1945) classified eggs as infertile and fertile, then incubated the yolks and watched for development. He found that "* * * the macroscopic method of detecting fertile blastoderms is in complete agreement with the incubation data."

Characteristics of infertile and fertile chicken eggs closely parallel those of pheasants. In comparing our results with those of Olsen, it appears that pheasant eggs show a greater tendency toward invasion of white material into the area pellucida.

Materials and Methods

In 1946 a limited fertility experiment was conducted with Mongolian ring-necked pheasants at a California state game farm. On May 21st eight hens were separated from cocks and placed in a common pen.

No record was kept of eggs collected on May 21st and 26th. During the remaining 30 days eggs were collected daily and date-marked with pencil to insure separate handling. There was a total egg production of 104 for this period.

The method employed was to set the eggs in an incubator for hatching. The eggs were candled daily and when it was determined that embryonic development had ceased in any of the eggs, the latter were broken into Petri dishes for examination of the germinal disc or embryo. A dissecting microscope and hand lens were available but seldom employed as they infrequently contributed to accuracy.

In 1947 search of certain areas in the Sacramento Valley resulted in the finding of 171 Chinese ring-necked pheasant nests. Only 38 clutches hatched. When it became obvious that eggs in certain nests could not hatch, the eggs were picked up and used for analysis of fertility. These included eggs that were occasionally left in a nest after predation, eggs left in abandoned nests, and eggs from dump nests, (nests in which more than one hen lays eggs, which are seldom hatched). Single eggs were classified as "dropped eggs." Many additional eggs were obtained from nests that had been exposed in mowed fields. A total of 2,522 eggs of wild pheasants were picked up and of these 1,228 were examined; yet no nest capable of hatching was disturbed. In addition 337 eggs from the State Game Farm at Yountville, discarded for purposes of incubation because of cracks or breaks in the shell incurred in laying or in handling, were checked for fertility. Eggs were broken into Petri dishes in the laboratory for examination.

Results of Fertility Tests

In the limited fertility experiment of 1946 it was found that the gross fertility was 76.0 percent up to and including the day of the last fertile egg which was laid on the twenty-seventh day, June 16. It was

TABLE 1

Egg Fertility Computations

	Total nests	Number eggs found	Unexamined or undetermined	Number fertile eggs	Number infertile eggs	Percent of fetility of examined eggs
I. Field Study Nests						
Dump nests	49	553	193	334	26	92.8
Destroyed[1]	77	672	556	112	4	96.6
Hatched[2]	38	354	27	349	5	98.6
Abandoned	7	77	17	60	0	100.0
Dropped eggs		18	5	8	5	61.5
II. Mowed Field Nests						
Alfalfa, 1st cutting	65	438	264	166	8	95.4
Alfalfa, 2d cutting	23	150	80	67	3	95.7
Vetch	29	230	149	81	0	100.0
III. Totals of Wild Eggs		2,522	1,291	1,177	51	95.9
IV. Yountville Game Farm						
Cracked eggs		337	6	306	25	92.4
Grand totals	288	2,859	1,297	1,483	76	95.1

[1] Eggs left after visit by predator, trampling by sheep, etc. Included some dump nests.

[2] Undeveloped eggs left after hatching have been placed in the infertile column. The percentage of fertility then could not be less than 98.6 percent.

found that the fertility dropped markedly the twenty-first day after sexual segregation (Figure 2a). Previous to the noticeable drop in fertility on the twenty-first day, the fertility averaged 89.7 percent. Owing to the small number of hens involved and the lateness of the laying season it was decided to repeat the experiment in subsequent years.

Comparative fertility of eggs collected in 1947 is shown in Table 1. Only 13 dropped eggs were examined of which eight were fertile (61.5 percent). Fertility of eggs found in dump nests (92.8 percent) was slightly lower than that for destroyed nests (96.6 percent) or for hatched nests (98.6 percent or higher). Sixty eggs from six abandoned nests were all fertile as were 81 eggs from nests found in mowed vetch fields.

Nests found in mowed alfalfa fields included eggs from both dump nests and "going nests" (being incubated). Fertility averaged 95.4 percent for the first cutting of alfalfa and 95.7 percent for the second cutting.

The pre-nesting sex ratio in the areas in which nests were found varied from 59 cocks to 100 hens to 27 cocks to 100 hens. No difference was noted in fertility of eggs from areas of different cock-hen ratios.

In both 1947 and 1948 no areas with a markedly unbalanced cock-hen ratio could be found; so the effect on fertility of a shortage of cocks

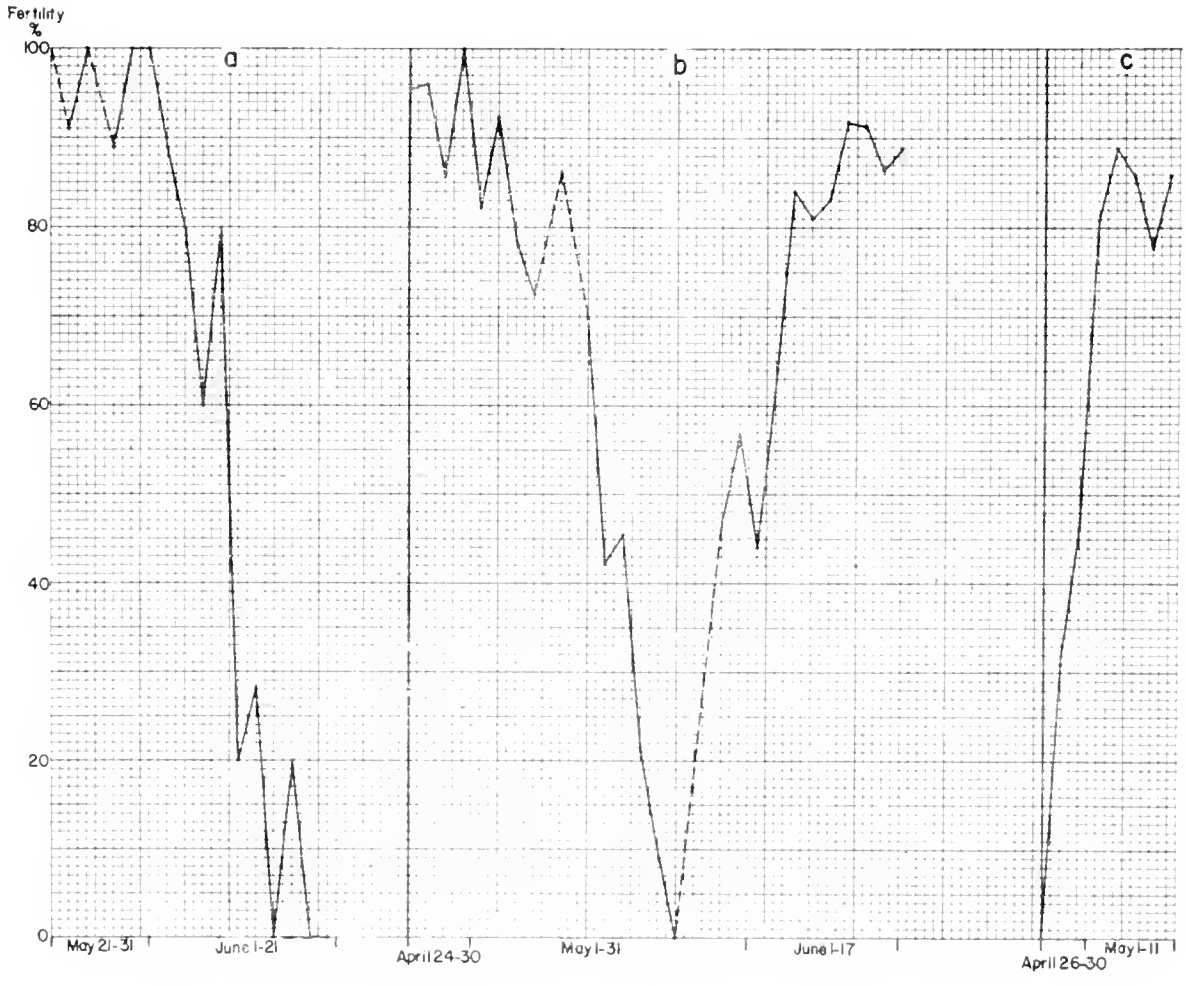

FIGURE 76. Fertile egg production of pheasant hens in a state game farm. Broken lines indicate days during which data were not secured. (a) Fertile egg production of eight pheasant hens segregated from cocks in 1946. (b) Fertile egg production of 24 pheasant hens segregated from cocks in 1947. A single cock was reintroduced with the hens the evening of May 24th. (c) The rise in fertility of eggs from 24 pheasant hens after introduction of a single cock on April 25, 1948.

could not be studied for wild birds. Twenty-four hens were separated from their cocks on April 24, 1947, at a State Game Farm. Eggs from this cage were thenceforth collected daily. The date of collection was marked on the shell of each egg and examination for fertility was made at the end of each week. After the twenty-first day, fertility dropped steeply (Figure 2b). The last fertile egg was laid on the twenty-ninth day after removal of the cocks.

One cock was introduced into this pen on the third day after the last fertile egg was laid. For four days thereafter, because of a misinterpretation of instructions, eggs were not picked up. On the fifth day fertility was already up to 46.1 percent (Figure 2b). By the twelfth day fertility was 84.0 percent, and by the eighteenth day it was 91.7 percent, or about average for the game farm. Thereafter, fertility fell off slightly, possibly because of the lateness of the season.

The following year a similar experiment was made. The last fertile egg was laid on April 20th, twenty-six days after the cocks were removed. A single cock was put in the cage with 24 hens on April 25th, and eggs were picked up daily thereafter. The eggs collected between the sixth and fifteenth days after the introduction of the cock averaged 84.0 percent fertile. The rise in fertility is shown in Figure 2c.

As a test of the ability of one cock to service a large number of hens, a single cock was put in a cage with 50 hens before breeding started. On April 22, 23, and 24, 1948, these hens laid 105 eggs. Examination of these showed 91 to be fertile (86.7 percent) and 14 infertile. This compared favorably with the average percentage of fertility (86.3 percent) for this game farm during the period of April 23d to May 8th of the previous year.

Again from May 18 to 22, 1948, 100 eggs were collected from this pen, of which 90 were examined by cutting a window one centimeter square in the shell of each egg. The shell membrane was removed with a pair of forceps. The germinal disc was then typed as fertile or infertile and the data written on the shell. The windows were sealed with cellulose tape and the eggs were incubated for 24 hours, when they were re-examined for development. In the 90 eggs examined development had proceeded according to the original fertility typing. Of these eggs 65 (72.2 percent) were fertile. It is pointed out that an infection of gapeworm in the parent birds seemed to have lowered egg production and also may have affected the fertility.

Summary

The germinal disc of an infertile egg is whiter than that of a fertile egg, the margin is irregular, and there are many clear lacunae (vacuoles) usually concentrated around the edge of the disc. The germinal disc of a fertile egg is not an intense white, the margin is clean cut, and, except in unusual cases, there are no vacuoles.

An examination of 1,177 eggs picked up from wild nests showed a percentage of fertility of 61.5 for dropped eggs, 92.8 for dump nests, 96.6 for destroyed nests, 98.6 or higher for hatched nests. Sixty eggs from six abandoned nests were all fertile as were 81 eggs from nests found in mowed fields. No difference was noted in fertility of eggs from areas with cock-hen ratios ranging from 59 cocks to 100 hens to 27 to 100 hens.

When 24 hens were separated from cocks, fertility dropped off steeply after the twenty-first day. The last fertile egg was laid on the twenty-ninth day after separation. Fertility of 50 hens with one cock was 86.7 percent in April and 72.2 percent in May.

Conclusion

Tests on the game farm have shown that a ratio of one cock to 24 hens or one cock to 50 hens results in normal fertility of eggs. Our experiments have shown that one servicing by the cock lasts for a period of about 21 days. Shick (loc. cit. p. 304) found that the average was 22 days. On an area (Sartain Ranch) that received perhaps the heaviest hunting pressure in California in 1946 the cock-hen ratio dropped to 3.4 cocks to 100 hens. An influx of cocks from other areas changed this ratio to 22 cocks to 100 hens before breeding season, but the evidence indicates that even though the post-hunting season ratio had remained unchanged, there would have been no problem of infertility of hens.

In no instance have sex ratios as low as two cocks to 100 hens been observed in the field, a ratio which the previous pages have shown result in an adequate percentage of egg fertility. Given a reasonably short season and adequate cover, hunters will not shoot down the cocks to the point below which fertility of hens is endangered. Legal hunting of cocks therefore, has little effect on the field fertility of pheasants in their observed Sacramento Valley habitat.

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NOTES

DO LOBSTERS SHRINK WHEN COOKED?

Some fish dealers claim that the spiny lobster (*Panulirus interruptus*) shrinks in length as a result of cooking and subsequent icing or refrigeration. Some dealers honestly believe this, but more frequently this claim is a convenient alibi for possessing "shorts" a little under the legal minimum size limit of 10½ inches. On several occasions during the last few years, fish and game wardens have measured a number of lobsters before and after cooking and have found no shrinkage in length but unfortunately these trials were not recorded for future reference.

In order to have a definite record, the following trial was made at a San Pedro fish market on March 15, 1948. Fifteen live lobsters were measured at 10 a.m. The small lobsters, or "bugs" as they are often called, were cooked about noon and left to cool that afternoon. They were iced the following morning and measured again about 1.30 p.m. on March 16th. The two measurements were made carefully in the same manner by the same warden using the same measuring stick. Measurements were read to the nearest sixteenth of an inch. Each lobster was marked with a serially numbered metal tag clamped on the tail.

The accompanying table presents the results in inches and sixteenths.

Alive		Cooked and iced		Change in length to $\frac{1}{16}$ of an inch
Inches	Sixteenths	Inches	Sixteenths	
10	12	10	12	----
10	8	10	10	+2
10	8	10	8	----
10	8	10	8	----
10	9	10	8	−1
10	8	10	8	----
10	12	10	12	----
10	8	10	10	+2
10	8	10	8	----
10	12	10	14	+2
11	13	11	12	−1
10	12	10	10	−2
12	12	12	10	2
10	8	10	8	----
12	14	12	14	----

The lobster is a rather awkward animal to measure accurately and small variation is to be expected in several measurements of the same lobster. Use of a scale graduated in units smaller than one-sixteenth of an inch therefore does not seem justified. It is apparent from the available figures that the natural error in measurement is greater than

possible shrinkage due to cooking. In fact the limited measurements available do not prove that any shrinkage or lengthening occurs. If there is any shrinkage it would require very careful measurement of a large number of animals before such a slight change in length could be demonstrated. For all practical purposes the shrinkage or lengthening, if any, is negligible and can be disregarded.

Pleading shrinkage as an excuse for possessing short lobsters is not a new idea. At San Diego nearly 30 years ago (March 27, 1919) fish and game wardens measured 73 lobsters before and after cooking but the measurements were recorded in quarter inches. In five instances on the first measurement a border line case was estimated in eighths of an inch. The second measurement, after cooking, was less carefully done and in only one case was an eighth inch recorded. The final result showed an average of one-sixteenth of an inch shorter on the second measurement, which seems to have been considered as evidence that shrinkage could be disregarded. This result can not be accepted as demonstrating shrinkage. The scale units used were too large and obviously the second measurement was more hastily taken so that the two measurements were not strictly comparable. The wardens of 30 years ago were not concerned with splitting hairs to a sixteenth of an inch. Maybe they were right. If there is any shrinkage, it is too small to notice on an ordinary measuring stick, so what difference does it make whether the lobster shrinks or not?—*W. L. Scofield, Bureau of Marine Fisheries, California Division of Fish and Game, March, 1948.*

DEEP DRAGGING BY EUREKA OTTER TRAWLERS

During the month of April, 1948, two otter trawl captains, Noel Franklin of the "*Andrew Jackson*" and Ralph Mason of the "*Memories*" dropped their nets out near the 200 fathom curve off of the Northern California coast. They obtained good catches of Dover sole, *Microstomus pacificus*, and sablefish, *Anoplopoma fimbria*. A scarcity of Dover sole in the depths where they were normally taken led to the exploration of the deeper water. As a result of these experiments, fishing operations are being conducted at depths varying between 185 and 215 fathoms. No change in gear was used other than a cable to depth ratio of 2 to 1 rather than the 3 to 1 ratio usually employed. By a cable to depth ratio is meant the amount of cable necessary to make the net fish properly at the desired depth. Cable lengths of 300 fathoms are commonly used to fish depths of 100 fathoms, but it was found that a cable length of 400 fathoms would allow the drag net to fish properly at 200 fathom depths.

By deep dragging the fishermen stated that they could obtain a full load in a day and a half, while four- or five-day trips had to be made when fishing in shallower water to obtain a similar load. Single hauls of 15,000 pounds were made by these large trawl vessels. As a result of the success of these two vessels, additional trawlers with winches large enough to carry the extra steel cable required, will probably be rigged for dragging in deeper water. The bottom area between 100 and 200 fathoms, newly invaded by these trawlers, will add approximately 1,500 square miles to the 6,000 already utilized by the California trawl fishery.

A sample of the deep water catch indicated that the Dover sole had spawned some months previous to being caught. The average weight of

the fish measured in the round, was two pounds and five ounces with range limits of from one to five pounds. The 100 fish sample varied in length between 14 and 23 inches with an average of 19 inches. Measurements were made from the tip of the snout to the end of the longest caudal ray.

Deep dragging allows the vessels to follow the Dover sole on their migrations to deeper water. The abundance of sablefish at these greater depths makes dragging there additionally lucrative. The opening of new area to the fishery will tend to relieve the pressure on old grounds where other species have been subjected to increasingly heavy fishing during the last 15 years.

The few Rex sole, *Glyptocephalus zachirus*, seen in the catch were mostly females heavy with eggs. Sablefish made up about 40 percent of the total catch, but the fishermen said they threw back many of the small sablefish weighing less than five pounds, as the market will not accept them. It is of interest to note that the small sablefish were not spared by the five-inch mesh nets in use on these vessels.—*Edwin K. Holmberg, Bureau of Marine Fisheries, California Division of Fish and Game, May, 1948.*

USE OF DUKW'S IN THE FISHERY FOR BASKING SHARKS, *CETORHINUS MAXIMUS*

An unusual and unique method of fishing for basking sharks is being employed by fishermen at Pismo Beach, California. This entails the use of surplus U. S. Army DUKW's in team with a small land plane of the Piper Cub type.

The DUKW is parked on the beach and the plane makes routine scouting trips over the water. When a group of basking sharks is sighted, the plane circles the spot and calls the DUKW by one-way radio. The DUKW with a crew of three travels up or down the beach until opposite the circling plane and then enters the surf. Most of the sharks are taken

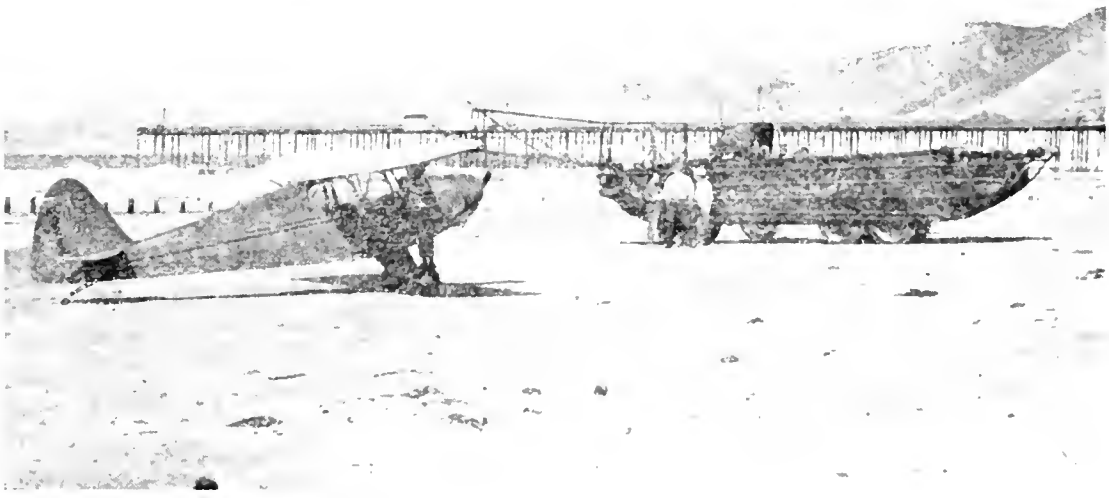

FIGURE 77. DUKW and plane on beach at Pismo. Photo by John F. Janssen, Jr.

between one-fourth mile and one mile off-shore and within four feet of the surface.

The plane remains in sight of any other sharks in a school while the one which has been harpooned is being killed by the crew of the DUKW. The dead shark is then tied to an anchored buoy and the DUKW goes to shore, races up or down the beach until opposite the remainder of the school of sharks and again enters the surf. The same procedure is repeated until the sharks have either sounded or moved out of the vicinity.

The sharks are left tied to anchored buoys (usually not over two days), until sold to a processing plant via long distance telephone. When a shark has been sold, the crew of the DUKW takes one end of a long

FIGURE 78. DUKW showing pulpit and spear ready for use. Truck is sometimes used for pulling the carcass to the beach. Photo by John F. Janssen, Jr.

line out through the surf and ties it to the tail of the shark. The DUKW then returns to shore, where the other end of the rope is hooked up to its winch and the shark is pulled ashore, up a sliding ramp, and into the bed of a truck, which hauls it to the processing plant.

During the calendar year, 1947, approximately one hundred basking sharks were taken at Pismo Beach by these DUKW's. In the first two months of 1948, some fifteen were landed. The best day in 1947 for a single DUKW was seven sharks.—*John E. Fitch, Bureau of Marine Fisheries, California Division of Fish and Game, June, 1948.*

RETIREMENT OF S. H. DADO

S. H. Dado, Assistant Chief, Bureau of Marine Fisheries, retired on June 30, 1948, after over 30 years' service with the Division of Fish and Game. Starting as a Special Agent in 1918, Mr. Dado was made Senior Supervising Deputy in 1927. His title was changed to Assistant Chief of the Bureau of Commercial Fisheries, as it was then known, in 1931.

Howard Dado, in his long association with N. B. Scofield who founded the Bureau, was instrumental in the growth of the organization which administers the extremely important marine fisheries of the State. Since his first appointment, the fishing industry has grown tenfold, and all this time Howard has maintained close touch with the members of the industry, compiling catch reports and giving guidance to the industry.

When Mr. Dado's retirement was announced, the Fish and Game Commission passed the following resolution:

> "WHEREAS, For the past thirty years Mr. S. H. Dado, Assistant Chief, Bureau of Marine Fisheries, has faithfully served the public, the State of California, and the Fish and Game Commission; and
>
> "WHEREAS, During this time Mr. Dado has given unsparingly of his talents toward the smooth functioning of his Bureau which has grown to keep pace with the expanding fisheries; now, therefore, be it
>
> "*Resolved* by the Fish and Game Commission of the State of California, in regular meeting assembled, that its regret be expressed to Mr. Dado at his retirement; and be it further
>
> "*Resolved*, That its thanks and appreciation be and hereby are expressed publicly to Mr. Dado for his contributions to progress in fisheries conservation."

These sentiments were reaffirmed by representatives of the fisheries.

The best wishes of all his associates go to Howard and Mrs. Dado, who will continue to make their home in San Mateo.—*Richard S. Croker, Chief, Bureau of Marine Fisheries, California Division of Fish and Game, July, 1948.*

RETIREMENT OF W. C. MALONE

W. C. Malone, having reached retirement age, was retired on June 30, 1948.

"Bill" Malone was appointed a part-time deputy with the State in 1916. At that time, he was County Fish and Game Warden for San Bernardino County. He was made a full-time State Deputy in 1930, and has served in that capacity until retirement. Except for a few temporary assignments, his entire career with the division has been in San Bernardino County.

Many changes have occurred in fish and game since Bill Malone first became a warden in San Bernardino County in 1916, and he has many interesting experiences to recount.

Bill and Mrs. Malone will make their home in San Bernardino. Our best wishes go to them for a long, and happy retirement.—*L. F. Chappell, Bureau of Patrol, California Division of Fish and Game, August, 1948.*

RETIREMENT OF H. C. JACKSON

It is with regret that we announce the retirement of Assistant Chief of Patrol H. C. Jackson, which occurred June 30, 1948, after 17 years of service with the bureau.

Assistant Chief Jackson entered state service as a fish and game warden in 1931, and was stationed in Santa Barbara County. In 1938 he was elevated, through promotional examination, to the position of Captain of Patrol. He served in this capacity in several of the Southern California districts until 1946, at which time he was promoted to Assistant Chief of Patrol.

The training school for wardens was started at this time, and Jackson, in addition to other duties, was assigned the task of initiating the school program, serving as its director. The accomplishments of the school under his management, were outstanding and met with unanimous approval. He was largely responsible for the compilation of information for the "California Warden's Manual," which is an exceptional publication on the subject.

Chief and Mrs. Jackson will make their home in Southern California, and intend to do considerable traveling. Our best wishes go to them for a happy and enjoyable retirement.—*L. F. Chappell, Bureau of Patrol, California Division of Fish and Game, August, 1948.*

REVIEWS

One Day at Teton Marsh

By Sally Carrighar; illustrated by George and Patritia Mattson. New York, Knopf, 1947. 239 pp., illus. $3.50.

As the title states, the story is set at Teton Marsh, Wyoming, and covers a period of a few days during the autumnal equinoctial storms. The marsh was created from a meadow by a beaver dam and the destruction of the dam during the storm effects the lives and welfare of the several animals described in the story.

The activities of each of the principal characters are covered in separate chapters but the interrelationship between them is clear.

The book can be read in installments without affecting its continuity and is heartily recommended for limited time reading or for an evening's pleasure.—*James F. Ashley, California Division of Fish and Game.*

The Ways of Fishes

By Leonard P. Schultz, Curator of Fishes, Smithsonian Institution, United States National Museum, with Edith M. Stern. Van Nostrand Co., Inc., 1948. 264 pp., 80 figs. $4.

The title of this volume is highly successful in that it provides the reader with a clear idea of the contents. Dr. Schultz himself has further defined them in his preface: "This book will make no attempt to give a comprehensive picture of the behavior of fishes. It will simply tell something about the habits of those fishes which seem to me most unusual and interesting."

There is here, then, no effort at an organized presentation of facts about evolution, anatomy or physiology. There is, instead, a series of notes or comments, many of which are drawn from Dr. Schultz's personal observations. He has traveled widely in North and South America, and in the far Pacific regions. He has traveled largely for the purpose of finding out about fish. And his writings show his tremendous energy, his enthusiasm, and his interest in all that has to do with his favorite form of animal life. Random selections from his chapter headings show the wide range of topics covered: "Migration," "Fishes dangerous to man," "Males that incubate," "Electricity and luminescence," "Nest builders in streams."

One may wish that a more complete and critical account had been given of the "homing" of salmon than the two pages allotted to this, one of the most talked of, investigated, and written about of all fish "ways"; one may question the amount of space (30 pages) devoted to the classification of fishes in the appendix, a check list, down to families, of all known fishes living and fossil—and wonder whether those so advanced in ichthyology as to benefit from this will be readers of the rest of the volume. But no one can help being interested in Dr. Schultz's personal encounters with stinging fish in the United States, in South America and in the South Pacific; in the exact and revealing observations he made, while stationed at Bikini waiting for the finale of "Operations Crossroads," on flying fishes, their motive power, methods of locomotion, speed of flight and distances covered; in his rectification of many of the misconceptions about sharks, coupled with his verification of the fact that certain species do attack and devour human beings; in his brief but none the less vivid summary of his own very thorough observations on the spawning act of the landlocked sockeye salmon, otherwise known as the "little redfish" or kokanee. And, for my money, as it will I expect be for many others', the most successful single chapter in the book is "Home Aquaria: Their A B C's": eight pages of do's and don't's, of advice about such essential factors as oxygen, plants, light, temperature, feeding and the

like, so simply and so compactly presented as to make it possible for the beginner to set up and keep a home aquarium without passing through the many pitfalls which often beset his path.—*Brian Curtis, California Division of Fish and Game.*

Animals Alive

By Austin H. Clark; illustrations by Frederick M. Bayer. D. Van Nostrand Co., 1948. 426 pp., illus., appendix, index. $4.

This is one of a new group of books in various fields of natural history designed for the entertainment and education of the general reader. The authors have been selected from the staff of the Smithsonian Institution. This alone should indicate the ample qualifications of Dr. Clark to write such a book.

The precise information contained is presented in an easy manner which will not bore the dilletante in zoology. At the same time no professional biologist can read this book without adding greatly to his store of knowledge. It is as if you got the professor to talking after the lecture was over and he told of the many sidelights of his subject. In other words, this is true science in its most readable form.

Any book of this sort must of necessity lack much continuity. However, the reader will be so intrigued by the continuous flow of interesting information that more than an outline is unnecessary.

The title might have been "An Introduction to Ecology" as the animals are considered in their environment rather than as zoo specimens. This book will be a valuable auxiliary to the regular college zoology text and will also be of use as collateral reading on the high school level.

The illustrations are scientifically accurate although they certainly yank the animals out of their environment. Also the relation of the drawings to the text is rather vague. The printing leaves nothing to be desired.—*J. A. Aplin, California Division of Fish and Game.*

Fire

By George R. Stewart. New York, Random House, 1948. 336 pp. $3.

This is another novel by the author of "Storm." The author is a professor of English at the University of California who has exhibited an ability to delve into a subject to its core for authentic data on which to base his story.

The chief character is a forest fire and the narrative carries the reader from the events leading up to the birth of the fire, through its eleven days of life and its final demise. It is very vividly told; a map on the inside covers and flyleaves enables one to follow the progress of the fire as it moves over one ridge and then another.

Not only does this story give the reader the interesting approach of the trials and tribulations of a forest fire and the relation to its fellow flora and fauna, but it also depicts man's conflict and efforts in combatting and finally overcoming it. Even a human love interest is brought in, along with humor, tragedy, failure and final victory. The reader is constantly right on the spot sweating along with the rest of the fire-fighting crews. The book is fascinating reading and an education for all outdoorsmen.—*Carlton M. Herman, Editor, California Fish and Game.*

The Great Forest

By Richard G. Lillard. New York, Alfred A. Knopf, 1947. 339 + xiv pp., illus. $5.

This is really a history book. It begins: "When explorers landed, America was trees." America is vastly different today. The changes that have occurred and the political, industrial, economic and social implications of depletion of our forest heritage is documented in a clear, readable and unbiased presentation.

This book is a history of the trees of the United States, the role they have played in the peaceful, though often rugged development of our country; their part in the wars we have waged; forest fires; land clearing for agricultural purposes; the lumbering industry and its development, exploitation, labor problems and its future; conservation and vital importance to our future history. The author, a native of California and currently a professor of English at the University of California at Los Angeles, well acquainted with forests by virtue of his extensive travels, has done a tremendous amount of research through literature and documents to make this work a valuable reference as well as interesting reading. He has presented an important part of the history of our country that is usually omitted from most textbooks to which the average American is exposed in the academic interlude of early life.

Appendices include a list of the biggest trees of the common North American species, a history of the "most famous log cabin" (birthplace of A. Lincoln), relative

value of forest crops, a list of present day uses of wood and uses of turpentine and rosin, specifications of the lumber used in the construction of a modern fishing boat of the North American fleet and illustrations of an overhead cableway skidder and the uses of lumber in construction. Sources of principal quotations are documented at the back of the book which also includes a very extensive bibliography and useable index.

Because of the role of the Great Forest in our past history, in our current housing shortage and high costs of lumber, and the vital importance of all our natural resources to our future well being, this book is a must not only for conservationists but for every American who wants to know what goes on.—*Carlton M. Herman, Editor, California Fish and Game.*

How to Live in the Woods

By Homer Halsted. Boston, Little Brown and Co., 1948. 249 pp., illus. $2.75.

This is the kind of book all sportsmen and campers like to read. It contains much factual information on tools and other equipment, an excellent chapter on first aid, a list of sources of information on where to go. To the novice planning to go traveling on foot, via dogsled, horseback, automobile or canoe, the book has all the information on what to take and what to do with it when you get there and how to be sure of getting back in one piece. It considers wearing apparel, tents, supplies, groceries, hunting and fishing equipment. It explains many ways of making a fire and how to prepare your food, including many interesting recipes. One full page is devoted to the art of dish-washing.

To the experienced camper such a book can be a lot of fun, particularly when read in camp. Where you agree with the author you feel an inward pride at your own knowledge; where you disagree with his advice, you have many interesting topics for discussion or argument. The suggested lists of groceries for trips of various lengths will undoubtedly come up for much discussion, for every camper soon develops his own ideas on this subject. The author presents methods of treatment of fish and game, but here again sportsmen soon develop their own theories. The author dresses his deer on its back and then hangs it head up. The reviewer has heard much controversy on this subject among hunters.

An amusing discussion that may strike a familiar chord to many a camp cook is the author's notes on preparing eggs: "scrambled eggs are usually a second thought with me. If a yolk is runny, or breaks when put into the pan, I whip it up with a fork, as it fries, and smugly announce that we're having 'em scrambled, for a change."

The jacket of the book states that the author has had wide experience in countless camping, fishing, hunting and prospecting expeditions as well as service with the army. If the jacket gets lost, the reader will still be aware of this.—*Carlton M. Herman, Editor, California Fish and Game.*

REPORTS

GAME CASES

April, May, June, 1948

Offense	Number arrests	Fines	Jail sentences (days)
Deer: Closed season, possession doe, spike buck, yearling	20	$2,930 00	99
Deer meat: Possession closed season	40	5,196 00	727
Doves: Possession closed season, 22 rifle	7	338 00	
Ducks: Closed season, purchase	8	512 00	
Frogs: Over limit, under size, closed season, shooting	15	380 00	
Geese: Possession closed season	2	85 00	
Nongame: Shooting	10	122 50	
Mudhens: Possession closed season	1	25 00	
Pigeons: Possession closed season	14	560 00	30
Pheasants: Hen, closed season, 22 rifle	20	810 00	
Quail: Possession closed season	2	60 00	
Rabbits: Possession closed season	11	315 00	
Shorebirds: Possession	1	25 00	
Hunting: No license, spotlighting, early shooting, in refuge, using traps, unplugged gun, shooting from power boat, public highway, allowing dogs to run deer, falsifying license application	55	1,975 00	
Totals	206	13,333 50	856

FISH CASES

April, May, June, 1948

Offense	Number arrests	Fines	Jail sentences (days)
Abalones: Over limit, under size, out of shell	200	$6,975 00	
Angling: No license, set lines, spear within 300′ of dam, closed season, night fishing, back dating license, transfer of license, falsifying license application, early fishing, using traps, restricted area, using explosives, game fish or bait	603	10,504 00	11
Bass: Under size, night fishing, closed season	26	518 00	
Catfish: Under size, over limit, closed season	9	165 00	
Crappie: Closed season	2	50 00	
Bluegill: Over limit	7	200 00	
Sunfish: Closed season, over limit	10	220 00	
Clams: Under size, over limit, out of shell, failure to show	150	3,225 00	67½
Crabs: Under size	5	125 00	
Cockles: Closed season, over limit	13	210 00	
Lobsters: Under size	4	175 00	
Pollution: Oil, sawdust, sewage	19	2,500 00	
Salmon: Snagging, closed season	2	50 00	
Trout: Closed season, over limit, netting, set lines, 22 rifle	47	1,665 00	
Seine nets: District 22, illegal use			
Gill nets:	6	350 00	
Records: Failure to submit, failure to issue receipt	4	425 00	
Commercial: Fish wastage, no processor's permit, failure to register boat, bringing filleted fish ashore, no party boat license, possession striped bass, no license, under size fish	54	4,195 00	
Chumming:	4	125 00	
Perch: Closed season	1	35 00	
Totals	1,166	$31,715 00	78½

SEIZURES OF FISH AND GAME

April, May, June, 1948

Fish:	
Abalones	1,464
Abalones, pounds	1,365
Bass	112
Bass, pounds	15
Catfish	277
Catfish, pounds	69
Clams	4,039
Crabs	45
Crabs, pounds	1,200
Crappie	30
Bluegills	216
Cockles	2,209
Lobster	31
Salmon, pounds	11
Sunfish	126
Trout	354
Trout, pounds	44
Suckers	68
Mackerel and sardines, pounds	507,770
Game:	
Deer	21
Deer meat, pounds	704
Doves	12
Ducks	21
Frogs	121
Geese	3
Mudhens	1
Nongame	12
Pigeons	31
Pheasants	15
Quail	2
Rabbits	16
Shorebirds	1
Squirrels	1

DIVISION OF FISH AND GAME
STATEMENT OF EXPENDITURES
For the Period July 1, 1947, to June 30, 1948 (Ninety-ninth Fiscal Year)

Function	Salaries and wages	Operating expenses	Equipment	Total
Administration:				
Conservation education and public information	$8,588 92	$36,318 65	$865 29	$45,772 86
Executive	10,487 35	6,979 79	21 12	17,488 26
Library	6,198 69	177 52	1,048 67	7,424 88
Office	35,143 33	56,188 37	638 54	91,970 24
Office—Fresno		468 90	661 83	1,130 73
Office—Terminal Island			147 38	147 38
Totals, Office	$60,418 29	$100,133 23	$3,382 83	$163,934 35
Redding Warehouse		82 24		82 24
Undistributed		6,727 80	48 58	6,776 38
Totals, Administration	$60,418 29	$106,943 27	$3,431 41	$170,792 97
Patrol and Law Enforcement:				
Headquarters	$18,563 43	$21,280 72	$1,187 01	$41,031 16
Airplane	2,478 40	1,896 85	151 14	4,526 39
Cannery inspection	12,800 26	1,207 32		14,007 58
Land Patrol:				
North Coast District	108,718 02	24,551 05	14,115 11	147,384 18
Northeast District	45,362 70	11,375 51	4,444 41	61,182 62
North Valley District	83,965 53	22,300 06	1,716 71	107,982 30
South Valley District	74,771 12	13,512 16	3,299 94	91,583 22
South District	118,964 22	29,766 40	13,684 81	162,415 43
Totals, Land Patrol	$431,781 59	$101,505 18	$37,260 98	$570,547 75
Marine Patrol:				
Headquarters	$93,749 70	$24,048 63	$20,618 70	$138,417 03
Bonita	1,334 30	1,443 43	1,910 12	4,687 85
Broadbill	4,384 30	2,784 13	5 63	7,174 06
Perch	5,336 06	4,780 14	249 26	10,365 46
Rainbow	3,348 40	3,006 98	41 07	6,396 45
Tuna	5,085 00	3,526 64	1,912 45	10,524 09
Tyee	2,492 24	1,461 02	55 56	4,008 82
Yellowtail	4,945 00	2,659 42	475 43	8,079 85
Small Boats		2,347 69	319 03	2,666 72
Skipjack	4,922 00	954 17		5,876 17
Grunion	3,280 00	62 34		3,342 34
Totals, Marine Patrol	$128,877 00	$47,074 59	$25,587 25	$201,538 84
Undistributed		$100,832 10	$2,565 44	$103,397 54
Totals, Patrol and Law Enforcement	$594,500 68	$273,796 76	$66,751 82	$935,049 26
Marine Fisheries:				
Central Valleys Investigation	$30,748 95	$11,868 32	$2,930 75	$45,548 02
Executive (Headquarters)	29,745 12	12,336 98	3,395 38	45,477 48
Library	2,805 00	1,533 34	142 25	4,480 59
Marine Fisheries Investigation	54,305 83	8,629 46	13,402 91	76,338 20
Statistics	47,565 35	10,543 85	2,315 12	60,424 32
Undistributed		7,050 36	198 22	7,248 58
Vessel—N. B. Scofield	19,569 78	60,268 71	2,211 28	82,049 77
Vessel—N. B. Scofield—abatement		—65,000 00		65,000 00
Totals, Marine Fisheries	$184,740 03	$47,231 02	$24,595 91	$256,566 96
Fish Conservation:				
Biological Survey	$58,685 66	$8,240 13	$4,305 10	$71,230 89
Fish Screens and Stream Improvement	11,915 89	3,895 60	299 46	16,110 95
Headquarters	24,708 10	10,056 84	385 10	35,150 04
Statistics		1,298 02		1,298 02
Undistributed		152,755 16	13,086 60	165,841 76
Hatcheries (See list, p. 230)	311,141 75	97,443 69	11,870 98	420,456 42
Totals, Fish Conservation	$406,451 40	$273,689 44	$29,947 24	$710,088 08

DIVISION OF FISH AND GAME

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1947, to June 30, 1948 (Ninety-ninth Fiscal Year)

Function	Salaries and wages	Operating expenses	Equipment	Total
Hatcheries:				
Alpine		$81 45		$81 45
Basin Creek	$6,029 84	1,066 46		7,096 30
Benbow Dam Experimental Station	2,429 00	260 13		2,689 13
Brookdale	8,313 68	1,155 15	$21 53	9,490 36
Burney	7,469 05	1,315 00	98 68	8,882 73
Cedar Creek		260 00		260 00
Central Valley	15,052 12	4,210 40	396 49	19,659 01
Crystal Lake	2,964 92	1,899 02	188 17	5,052 11
Fall Creek	5,545 00	814 06	13 80	6,372 86
Feather River	5,437 15	814 53		6,251 68
Fillmore	27,867 48	10,279 20	4,668 73	42,815 41
Hot Creek	24,219 01	22,142 14	576 63	46,937 78
Huntington Lake	1,080 00	401 36		1,481 36
Kaweah	5,419 13	1,145 47	579 11	7,143 71
Kern	6,096 76	1,778 08	246 18	8,121 02
Kings River	8,017 66	1,438 38	22 31	9,478 35
Lake Almanor	10,306 00	2,007 92	72 46	12,386 38
Little Walker Lake Egg Collecting Station	879 00	22 45		901 45
Madera	2,738 88	366 27	26 50	3,131 65
Miscellaneous Egg Collecting Station	4,034 40	603 66		4,638 06
Mt. Shasta	51,006 26	13,832 84	2,838 93	67,678 03
Mt. Tallac	11,609 12	1,644 96	118 35	13,372 43
Mt. Whitney	26,894 02	12,424 22	900 84	40,219 08
Moorehouse Springs	1,171 00	157 93		1,328 93
Mojave River	6,300 44	2,582 34	44 70	8,927 48
Prairie Creek	6,473 62	1,524 35		7,997 97
Sequoia	5,908 00	2,768 81	114 47	8,791 28
Tahoe	9,349 52	3,438 61	208 43	12,996 56
Whittier	10,222 00	3,293 24	292 61	13,807 85
Yosemite	7,063 25	1,456 67	117 33	8,637 25
Yreka Warehouse		34 72		34 72
Yuba River	4,292 26	248 48	91 36	4,632 10
Hatchery Supervision	26,953 18	1,975 39	233 37	29,161 94
Totals, Hatcheries	$311,141 75	$97,443 69	$11,870 98	$420,456 42
Game Conservation:				
Field Supervision	$20,747 42	$3,106 61	$599 70	$24,453 73
Big Game Investigation	4,357 00	651 53		5,008 53
Big Game Range Management	6,855 00	1,116 62	6 03	7,977 65
Big Game Trapping	7,093 29	2,761 30	3,679 71	13,534 30
Disease Investigation and Research	13,753 15	3,002 98	155 31	16,911 44
Food Habits—Investigation and Research		62 91		62 91
Fur Management	5,000 06	927 86	41 00	5,968 92
Game Statistics	2,480 00	304 86	653 44	3,438 30
Upland Game Investigation	3,181 00	662 05	71 70	3,914 75
Waterfowl Land Acq. and Dep.	3,520 00	582 81		4,102 81
Headquarters	19,245 83	8,936 57	611 97	28,794 37
Predatory Animal Control:				
East Central California	21,496 72	2,627 53		24,124 25
North Central California	13,982 08	3,822 50		17,804 58
Northern California	23,146 60	7,634 92	24 86	30,806 38
Southern California	20,840 40	2,615 59		23,455 99
West Central California	14,791 35	2,851 52		17 642 87
Undistributed		38,746 49	52,357 98	91,104 47
Game Farms (See list, p. 229)	103,933 04	43,645 24	820 22	148,398 50
Game Management (See list, p. 229)	76,591 22	25,043 51	4,909 65	106,544 38
Totals, Game Conservation	$361,014 16	$149,103 40	$63,931 57	$574,049 13

DIVISION OF FISH AND GAME

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1947, to June 30, 1948 (Ninety-ninth Fiscal Year)

Function	Salaries and wages	Operating expenses	Equipment	Total
Game Farms:				
Bakersfield	$2,533 00	$135 19		$2,668 19
Brawley	3,801 91	1,323 21	$7 69	5,132 81
Castaic	2,672 00	1,380 09	191 78	4,243 87
Chico	5,188 85	1,114 35		6,303 20
Fresno	9,584 72	4,347 91	115 88	14,048 51
Los Banos	18,542 74	7,034 02	94 51	25,671 27
Los Serranos	2,181 30	378 47		2,559 77
Marysville	3,415 34	2,356 96	30 14	5,802 44
Porterville	5,196 64	3,046 63	23 89	8,267 16
Redding	4,962 62	2,261 75		7,224 37
Sacramento	998 00	240 61		1,238 61
Stockton	583 22	22 65		605 87
Ukiah	2,672 00	931 07	43 59	3,646 66
Valley Center	4,913 18	1,501 30	108 36	6,522 84
Willows	36,687 52	17,571 03	204 38	54,462 93
Yountville	$103,933 04	$43,645 24	$820 22	$148,398 50
Totals, Game Farms				
Game Management:				
Central California	$4,173 40	$555 36		$4,728 76
Doyle Winter Range	2,589 54	541 44		3,130 98
Elk Refuge	1,776 59	925 16	$37 25	2,739 00
Grey Lodge Refuge	7,709 86	606 11	757 46	9,073 43
Honey Lake Waterfowl Development	6,680 66	1,557 38	46 15	8,284 19
Imperial Public Shooting Grounds	4,521 83	8,174 89	24 99	12,721 71
Imperial Refuge	2,988 00	619 13		3,607 13
Interstate Deer Herd	4,028 00	757 30	14 17	4,799 47
Kettleman Hills Quail Refuge	1,270 71	233 10		1,503 81
Los Banos Refuge	6,081 99	1,731 29	2,010 74	9,824 02
Madeline Plains Wildfowl Development	9,091 09	2,370 28	407 14	11,868 51
Northeast California	3,591 00	1,472 25	124 33	5,187 58
Quail Management, Desert Areas	3,095 99	1,345 22	16 70	4,457 91
Southern California	3,591 00	924 73	1,108 18	5,623 91
Southern Coast of California	3,893 68	1,337 23	8 62	5,239 53
Suisun Refuge	6,634 00	1,158 12	157 57	7,949 69
Tehama Winter Range	4,873 88	734 52	196 35	5,804 75
	$76,591 22	$25,043 51	$4,909 65	$106,544 38
Totals	$180,524 26	$68,688 75	$5,729 87	$254,942 88
Licenses:				
Salaries and Wages	$35,753 45			$35,753 45
Operating Expenses		$68,898 52		68,898 52
Equipment			1,103 03	1,103 03
Totals, Licenses	$37,753 45	$68,898 52	$1,103 03	$105,755 00
Reimbursement Maintenance Deduction				$ 14,315 19
Totals, Fish and Game Support 1947-48 F. Y.				$2,737,986 21
Contributions to State Employees' Retirement Fund				$ 22,147 81
Other Current Expenses:				
Game Management (in cooperation with the Federal Government as provided by the Pittman-Robertson Act)				$110,270 90
Reimbursement from Federal Government, pro rata share Pittman-Robertson Act				$ 20,010 61
Net total, Pittman-Robertson Act				$90,260 29
Special claim for Secretaries of State Board of Control				905 36
Totals, Other Current Expenses				$91,165 65

DIVISION OF FISH AND GAME

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1947, to June 30, 1948 (Ninety-ninth Fiscal Year)

Function	Salaries and wages	Operating expenses	Equipment	Total
Capital Outlay:				
Construction, Improvements, Repairs and Equipment				
Administration—				
Office Buildings: Redding and Alturas				$10,568 90
Patrol and Law Enforcement—				
Purchase of Boat				$10,402 87
Marine Fisheries—				
Terminal Island Laboratories				$4,500 00
Research Vessel				77,044 13
Totals, Marine Fisheries				$81,544 13
Bureau of Fish Conservation—				
Central Valley				$646 77
Fall Creek Hatchery				595 52
Fillmore Hatchery				3,994 97
Hot Creek Hatchery				467 54
Kaweah Hatchery				1,804 71
Kern River Hatchery				780 68
Madera Hatchery				919 82
Mojave Hatchery				5,798 54
Mt. Whitney Hatchery				8,802 17
Sequoia Hatchery				265 01
Tahoe				620 17
Yuba River Hatchery				4 49
Totals, Bureau of Fish Conservation				$24,700 39
Bureau of Game Conservation—				
Food Habits and Disease Laboratory				$256 13
Imperial Valley Public Shooting Grounds				1,750 16
Los Banos Refuge				150 19
Suisun Refuge				331 38
Tehama Winter Range				378 99
Valley Center Game Farm				4,500 00
Totals, Bureau of Game Conservation				$7,366 85
Totals, Conservation, Improvement, Repairs and Equipment				$134,583 14
Construction of Rearing Pens for Pheasants				10,269 69
Totals, Capital Outlay				$144,852 83
Grand Totals, Fish and Game Preservation Fund Expenditures for the Fiscal Year, 1947-48, for the period, July 1, 1947 to June 30, 1948				$2,996,152 50

DIVISION OF FISH AND GAME

STATEMENT OF REVENUES

For the Period July 1, 1947, to June 30, 1948 (Ninety-ninth Fiscal Year)

Revenue for Fish and Game Preservation Fund:	Detail	Total
1948 series—		
Angling:		
Citizen	$1,458,997 00	
Excess fee	210 10	
Nonresident 1 year	9,265 00	
Nonresident 10 day	1,163 50	
Alien	17,550 00	
Duplicate	493 50	
Fish tags	6,348 80	
Game tags	165 36	
Fish importer	70 00	
Fish party boat permits	617 00	
Market fisherman	73,440 00	
Fish breeder control	505 00	
Game breeder	2,565 00	
Kelp license	10 00	
Game management area licenses	350 00	
Game management area tags	3 60	
Hunting license	48 00	
Deer tags	12 00	
Deer meat agents locker permits	7,264 00	
Deer meat agents—Wardens	304 00	
Total 1948 series		$1,579,381 86
1947 series—		
Angling:		
Citizen	$843,276 00	
Alien	6,650 00	
Nonresident	22,299 00	
Duplicate	4,613 50	
Hunting—Archery—Citizen	2,332 00	
Archery—Nonresident	75 00	
Hunting—Citizen	915,509 00	
Hunting—Junior	43,983 00	
Hunting—Nonresident	48,080 00	
Hunting—Declared alien	2,450 00	
Hunting—Alien	2,950 00	
Hunting—Duplicate	3,276 50	
Hunting—Commercial club citizen	675 00	
Hunting—Commercial club operator—Citizen	225 00	
Trapping—Citizen	1,570 00	
Trapping—Alien	24 00	
Fish packer and shellfish dealer—Citizen	14,795 00	
Fish packer and shellfish dealer—Alien	580 00	
Archery—Deer tags	590 00	
Deer tags	299,604 00	
Fish tags	3,891 76	
Game tags	344 70	
Market fisherman	50,810 00	
Fish importer	40 00	
Fish party boat permits	155 00	
Fish breeders control	70 00	
Game breeder	250 00	
Kelp license	50 00	
Game management—Area licenses	120 00	
Game management—Area tags	178 68	
Deer meat agents—Locker permits	4,000 00	
Deer meat agents—Wardens	397 00	
Total 1947 series		$2,273,864 14
1946 series—		
Angling—Citizen	$4 00	
Angling—Alien	5 00	
Hunting—Citizen	254 00	
Hunting—Junior	22 00	
Hunting—Duplicate	11 00	
Trapping—Citizen	3 00	$296 00
		3 00
Total 1946 series		$299 00

DIVISION OF FISH AND GAME

STATEMENT OF REVENUES—Continued

For the Period July 1, 1947, to June 30, 1948 (Ninety-ninth Fiscal Year)

	Detail	Total
Other Revenue—		
Lease of kelp beds	$1,565 00	
Fish packers tax	192,061 36	
Kelp tax	2,098 05	
Salmon packers tax	77,895 66	
Sardine tax	40,294 43	
Public shooting grounds	1,830 00	
Miscellaneous revenue	27,534 99	
Court fines	123,739 25	
Interest on surplus money investment fund	15,430 41	
Total other revenue		$482,449 15
Grand total Fish and Game Preservation Fund		$4,335,994 15

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