CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

Volume 36 San Francisco, October, 1950 Number 4

ANNOUNCEMENT

A portion of the July 1950 issue of *California Fish and Game* was trimmed below standard size. Any subscriber maintaining permanent files who was inconvenienced by receiving a small copy may obtain a standard-size copy on an exchange basis as long as the supply lasts. Mail the trimmed copy to:

The Editor, California Fish and Game
State Fisheries Laboratory
Terminal Island Station
San Pedro, California

Be sure to indicate your correct return address.

CALIFORNIA FISH AND GAME

PHIL M. ROEDEL, Editor ..... Terminal Island

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

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

CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 36 ISSUED OCTOBER 20, 1950 No. 4

TABLE OF CONTENTS

THE CALIFORNIA MULE DEER IN CHAPARRAL FORESTS[1]

By Fred P. Cronemiller and Paul S. Bartholomew
U. S. Forest Service

INTRODUCTION

The California mule deer (*Odocoileus hemionus californicus*), according to Cowan (1936), ranges wholly within California from Orange County to Monterey County in the Coast Range and to El Dorado County in the Sierra Nevada. It intergrades over a considerable distance with the Columbian black-tailed deer (*Odocoileus hemionus columbianus*) in the north and with the southern mule deer (*Odocoileus hemionus fuliginatus*) in Orange County. It winters in the chaparral and intermingled oak-woodland at lower elevations. In the Sierra Nevada it summers in the conifer timber belt. In the Coast Ranges and in Southern California, because of the general absence of higher elevation types, it summers mostly in the chaparral belt.

The life history and food habits of mule deer in California have been covered by Dixon (1934) with particular attention to conditions in the Sierra Nevada.

Johnson (1939) recognized a difference in size between the animals of this race found in the Sierra Nevada as contrasted with those occupying the chaparral belt yearlong. In the latter area the animals breed earlier, and coordinate life processes—fawning, antler development and shedding, and pelage changes—occur at correspondingly early dates. During the period 1935-1941 forest officers, with the cooperation of the California Division of Fish and Game, measured and weighed a large number of deer in each national forest in California. Figure 139 shows the frequency distribution of weights of this species (hog dressed) on the Angeles and Sierra National Forests, which provide good samples of deer from the two different habitats.

In the chaparral belt which covers much of the deer territory of Southern California, the primary value of these lands is as watersheds. The maintenance of a regular flow of usable water, reduction of floods and siltation is vital to the dependent agriculture and to the intensive municipal and industrial development in the valleys.

In a number of areas highly developed agricultural lands adjoin the chaparral-covered mountains occupied by deer, with the result that some crop damage occurs. Of major importance, however, is the fact that hunting seasons as established are traditionally at the height of the fire season, which is most serious in these highly inflammable types. Because of the extreme fire hazard a considerable area of public land within the national forests is necessarily closed to public use. Large areas have been

[1] Submitted for publication April, 1950.

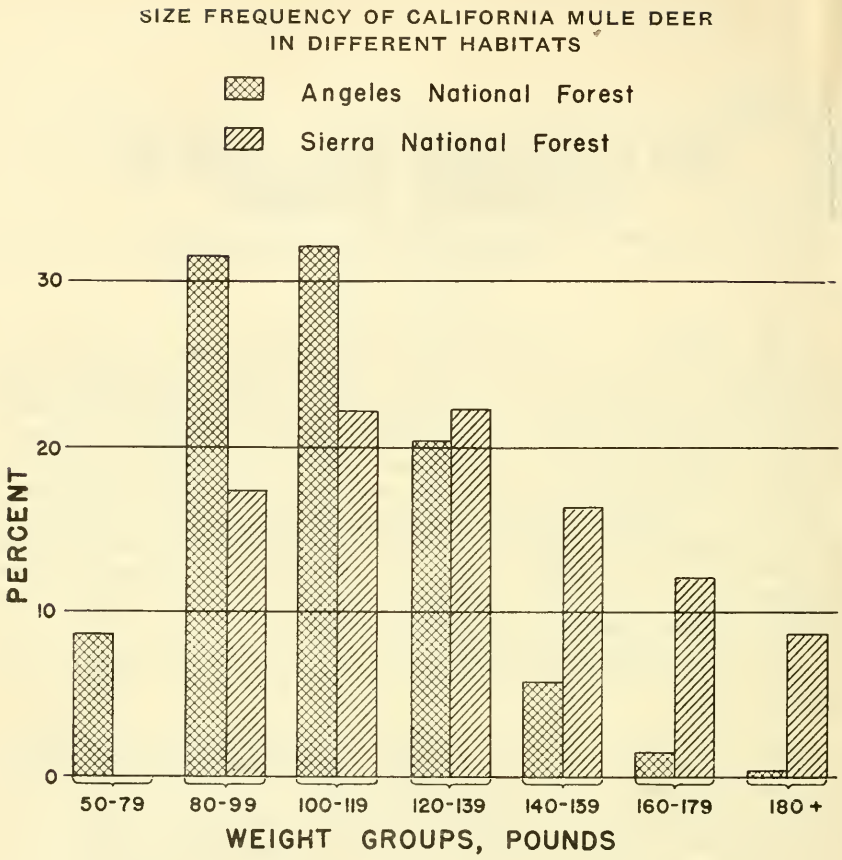

FIGURE 139

set aside as game refuges through legislative procedures. Much of the support for the legislation stemmed from a desire for the elimination of the risk of fire resulting from occupation of these areas by hunters. Finally, and for the same reason, much of the ranching area is closed to hunters.

Because of these problems, involving both land use and the inherent characteristics of the animals themselves, a study was inaugurated by the second named author, under the direction of the first to secure facts of value for managing the deer herds and for coordinating sport hunting with other forms of land use. The deer harvest was studied for all of the Angeles National Forest open to shooting. Life history of deer was studied in detail on the San Dimas Experimental Forest.

Because of the nature of the road system and the presence of fire crew stations, forest officers, fire wardens and game wardens at most control points, it was possible to contact most of the hunters, measure hunting effort and examine the kills. Splendid cooperation of the Los Angeles County fire wardens and state game wardens was received. The second named writer was employed continuously on the project from February, 1940, to June, 1942, spending the greater part of his time on

life history and allied studies within the study area. As a result, many individual deer became known and mothers and progeny recognized permitting conclusions not possible with casual observations.

DESCRIPTION OF THE FOREST AND OF THE STUDY AREA

The Angeles National Forest covers about 640,000 acres (1,000 sq. mi.) in the Sierra Madre Mountains and lies mostly within Los Angeles County, California. The topography is rugged, with elevations of 500 feet to over 10,000 feet. A small area on the northeastern side may be termed desert, while the bulk of the area is in the chaparral belt. A limited area of high mountains, mostly above 6,000 feet, is coniferous forest. Although most of the forest is covered with chaparral and woodland-chaparral, the vegetation ranges from desert cacti to timberline trees and shrubs.

The life history study area is a natural unit including all of the San Dimas Experimental Forest and some contiguous area. It is situ-

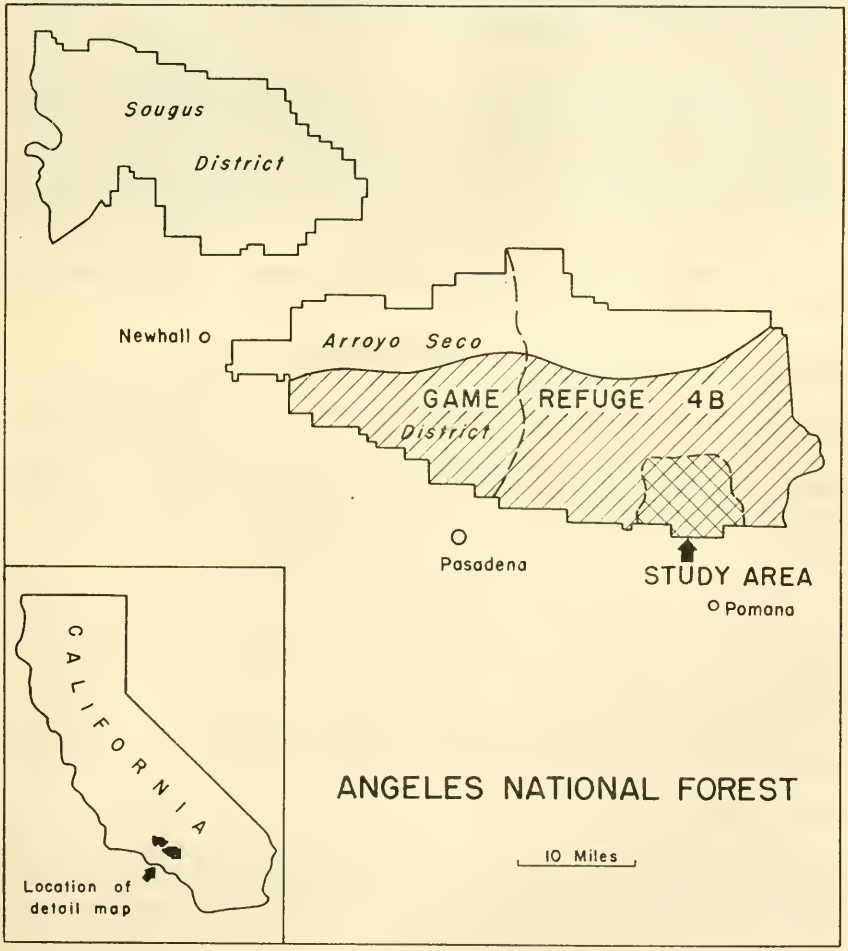

FIGURE 140

ated north of the towns of San Dimas and Claremont and comprises about 20,000 acres. Elevations vary from 700 feet to more than 5,600 feet. The area is drained by Big Dalton and San Dimas Canyons. These have deep-cut channels with frequent waterfalls, cascades, and box canyons. Vegetative types are principally chaparral[1] and woodland mixtures. Chamise, the most abundant shrub on south-facing slopes below 4,600 feet altitude, is usually associated with hairy ceanothus but sometimes also with bigberry manzanita or Eastwood manzanita. Oak chaparral on northerly slopes is dominated by California scrub oak, usually associated with hairy ceanothus. Slopes above 4,600 feet altitude, if facing to the south, are clothed mainly with chamise, chaparral whitethorn, dwarf interior live oak, and the two species of manzanita. At these higher altitudes, the commonest dominants on north facing slopes are canyon live oak and bigcone spruce. Open stands of sagebrush, composed principally of California sagebrush, white sage, and California buckwheat, occur commonly in the foothills and on the steep slopes higher in the mountains. Riparian and oak woodland, composed of many species but chiefly of white alder and coast live oak respectively, occur along stream channels.

The Experimental Forest is fairly typical of the chaparral forests in Southern California. It is within the Angeles National Forest and also within a long-established state game refuge, 4B.

The Angeles National Forest and the San Dimas Experimental Forest are accessible by a limited number of roads and foot trails. The Experimental Forest also has a series of contour trails at altitudes of 2,100, 3,100, 4,100, and 5,100 feet. The latter area, with the exception of the lower reaches of San Dimas Canyon, is closed to public travel year long.

THE ENVIRONMENT

Climate

The annual precipitation in the study area averaged about 32 inches during the period 1933 to 1942.

Only one to two inches of rain can be expected during the dry summer season May 1st to October 31st. Over 90 percent of the precipitation occurs during the remainder of the year. This is mostly in the form of rain, although some snow occurs quite frequently above 4,000 feet elevation.

The mean annual temperature on the Experimental Forest from 1933 to 1941 was 59 degrees F., with a monthly mean of 46 degrees in January and 75 degrees in July and August. During the same period the maximum temperature was 110 degrees; the minimum 14 degrees. A daily range of 30 degrees or more is of frequent occurrence.

The wind velocities are generally quite low. The lower elevations are subject to frequent fogs in the months of May and June.

Cover Types

The vegetative cover of the study area varies according to the topography, elevation, and soil. The predominant woody species are hard leaved and evergreen. Table 1 shows the percentage of the area occupied by each of the recognized cover types.

[1] See page 365 for scientific names.

FIGURE 141. Chaparral type in the San Dimas Experimental Forest showing characteristic shrub density and topography. Chamise-buckthorn mixtures with the latter predominating in the foreground. A service trail and contour trails at 3,100′, 4,100′ and 5,100′ elevation are shown

TABLE 1

Composition of Vegetation in San Dimas Experimental Forest

Type	Percentage	Remarks
Chamise	54.4	With some *Ceanothus crassifolius* in mixture throughout.
Chaparral	24.2	Mixed hard leaved shrubs. At lower altitudes the characteristic species are scrub oak, *Ceanothus oliganthus*, manzanita, quinine-bush, toyon, holly-leaf cherry, lemonadeberry, and coffee-berry. At higher elevations *Ceanothus divaricatus* and manzanita are prominent.
Oak-woodland	5.3	Canyon live oak. Only in San Dimas Canyon.
Riparian		Two subtypes, alder and California live oak.
Bigcone spruce	3.8	Occurs only in San Dimas Canyon.
Ponderosa pine	.2	Occurs only in San Dimas Canyon.
Grassland	.1	Occurs only in San Dimas Canyon.
Plantation	1.2	Occurs only in San Dimas Canyon.

All of the types are occupied by deer. The chamise, chaparral, and riparian types are the most attractive. The oak-woodland has little food due to the lack of carpet vegetation but is traversed by deer enroute to water. The extensive areas where chamise and *Ceanothus crassifolius* are dominant provide excellent cover where not too dense. Chamise areas with scrub oak are generally too dense for occupation by deer, except on the edges. The lower foothills of the valley edge are commonly clothed with a black sage-white sage type, affording ready passage to deer. The highest slopes are often covered with dense canyon live-oak woods with tangles of fallen limbs, largely avoided by deer, although a few bucks maintained trails to water through the tangles.

Fire

The protection of the area from fire has resulted in a reduction of the available food supply for deer. Areas long unburned become almost impenetrable, in addition to having relatively little palatable food within reach. Burns with sprouting species of chaparral are quickly invaded by deer for the abundant and palatable sprouts, although these are obtained at considerable risk in inadequate escape cover. The chamise types appear to lose their attractiveness to deer the third year following the fire. In mixed brush types the effect is more lasting.

FIGURE 142. Detail of deer habitat on main canyon slopes of the Arroyo Seco, Angeles National Forest, showing canyon live oak patch, right center, used for bedding and resting cover. Prominent trail leads down point to water. Minor trails lead up ridge and to the left into low shrub feeding areas

A very large part of the deer habitat in Southern California has been swept by fire at least once during the last century. Up to the advent of modern fire fighting much of the area was probably burned several times in a century. Chaparral vegetation developed as a "fire type." Extensive fires are known to have occurred about 1823 and in 1869. Scarcely a year has passed without one fire or more burning areas of 100 to 5,000 acres, and several fires of 10,000 to 75,000 acres have occurred since the fire fighting organization began to function in 1897. Recovery of the vegetation from a large fire that occurred in the study area in 1919 is complete,

with the exception of areas on poor or unstable soil which support only a sparse growth of chamise or sage. Early photographs indicate that these latter areas were in a similar condition prior to the 1919 fire. It is believed significant that species yielding the greatest volume of forage taken would be rated very low in desirability even on critical winter ranges in Northern California.

Food

Of the 530 species of higher plants known to occur in the study area, 117 were found to be used for food by deer. It is probable that the majority of the species are occasionally used during the growing season.

Leaves of scrub oak and toyon comprised 95 percent of the stomach contents of carcasses examined in the summer and fall, while grassy material, mixed with a wide variety of herbs, was more common at other periods. Of the browse species, mountain mahogany and holly-leaf cherry were favored foods being commonly overbrowsed but not abundant. Chamise was preferred only in the spring and adventitious growth was selected if available. Acorns of the California live oak were picked up as they dropped in the fall and were much preferred to the acorns of scrub oak and canyon live oak. However, a few of the latter were taken after the rainy season was under way.

Certain species of plants are especially picked out by deer. The shoots of lilies, soapplants, death camas, and rein-orchis are nipped off close to the ground. The flower stalks of yucca are often eaten as soon as they emerge from the basal crown of leaves. Almost all of the composites with milky juice, the species of *Phacelia*, and the annual lupines are well liked. Along the streams the leaves and stalks of *Boykinia rotudifolia* evening-primrose, monkeyflower, and hedge-nettle are quite acceptable. Seedlings of pigweed and *Amaranthus* on silt deposits in the reservoirs are eaten. Wild snapdragon is a food par excellence.

Other foods included flowers of wild buckwheat, leaves of poison oak and of the thorny *Ceanothus divaricatus*, the tender shoots of thistles, and mushrooms of the genus *Russula*.

Except for the most favored species, the foods taken are abundant. Only two small areas of a few acres each show signs of general overbrowsing. On the other hand, the most favored species are commonly overused. This is particularly true on the well populated areas on portions of the forest open to hunting.

Water

Surface water was available in the majority of the draws during winter. The upper sections of the draws gradually dry up as the seasons change from winter to spring. Numerous seeps are well distributed and some have yearlong flows. Stream pools generally fill with silt, into which the water sinks by the end of the summer. Bedrock at the lower end of a silted pool may force water to the surface. Flows over cascades are temporarily impounded in the pools at the base of the falls. Even the smallest draws have small depressions where water collects. Smaller surface flows sometimes evaporate entirely during the day in summer but there is usually a sufficient amount at night or in cloudy weather to satisfy the thirst of at least a few deer. The range of individual deer, especially those occupying a territory near the top of a divide, varied seasonally in relation to the availability of water. Very few deer

had to travel more than one-quarter mile to reach open water. A considerable number of deer, mainly does and fawns, ranged close to the reservoirs of canyon bottoms, where water was always available.

Associated Fauna

The most important species sharing the habitat with deer and bearing a direct relation to them are the mountain lion and coyote.

At least two mountain lions ranged through the study area. In the first year of the study (1940), their tracks were reported on two occasions. In the second year (1941), sight records of mountain lions were reported on six occasions in the lower canyons and on top of divides. A number of deer kills were ascribed to mountain lions.

Coyotes were fairly common in most parts of the study area. Their tracks were in evidence everywhere—on roads, trails, firebreaks, and canyon bottoms. The known trapping effort from 1937 to 1941, inclusive, averaged 4.6 man months per year and the total catch was 162. The traplines were confined to the roads and varied in location from one year to another. While the trapping effort appears to have removed most of the coyotes which traveled the roads, it had little effect on those individuals that ranged in the less accessible territory. Tracks appeared on the roads a few days after trapping was discontinued.

Bobcats and foxes are abundant in the study area. There was no evidence that the bobcat played an important role in deer management. Roaming dogs are known to have ranged along the roads nearer the valley and were reported to be chasing deer. There was no evidence that they killed any deer.

Other

The mineral requirement of deer is met in part by visitations to licks in lime accumulations. These usually occur in seep areas or on the sides of semipermanent waterfalls. A number of large licks were found in San Dimas Canyon. Some were grottoes extending 10 feet into the canyon wall with stalactites and stalagmites of pinkish color. Narrow shelves at different levels of a 100-foot-high bank were well packed with small cavities in the lime. The pockets were invariably found freshly tracked by deer which clambered along the steep bank to obtain the mineral laden drip.

THE DEER HERDS

Numbers

Because of the dense cover and the absence of concentrations of deer at any season of the year, censusing is extremely difficult.

The deer population was estimated on the basis of sight records obtained mainly by systematically traversing foot trails during the winter when the deer territory was restricted. For convenience, the area was divided into sectors and a record kept of the deer seen in each, individually and as family groups.

Peculiarities of antlers, color patterns of the tail, and distinguishing marks such as cuts in the ear, pale coat, and the extent of the dark pattern on the front of the head permitted reidentification of individuals. The best census record was used as a base, with the addition of records of recognizably different deer seen on other days. The deer seen in one sector were then compared with those seen in an adjacent sector. Records

which seemed to be possible overlaps were taken from the sector of least occurrence and credited solely to the sector having the larger number of observations of the deer in question.

The number of deer seen during the first year in the study area was 396 individuals. In the following year the total was 539. A population of 12 to 15 deer per square mile was indicated and agrees with the estimate for the forest as a whole.

The sector method of listing deer probably involves some duplication of records which cannot be eliminated by comparison of records in adjacent sectors; yet the total deer population is considerably higher than the sight records. In fact, in the dense manzanita thickets and canyon live oak woods in the higher country, evidence of tracks pointed to a deer population several times larger than was indicated by sight records.

It seemed that an increase in deer population occurred during the second year of the study. This was also indicated by the larger loss of deer struck by cars along the canyon roads. The heavier snows at higher elevations may have driven some extra-territorial deer into the census areas, however, and the census work was concentrated in the best deer territory during the second year. Therefore the population increase may only have been slight.

Size and Sex Classification in Field Counts

Except for the period February to May identification as to size and sex was readily accomplished in the areas where the deer were accustomed to the presence of humans. Deer inhabiting the more remote areas often slipped into cover before satisfactory identification could be made. Categories were set up for all deer noted (Table 2).

TABLE 2

Size and Sex of Deer in the San Dimas Study Area

	1940	1941
Does	119	196
Fawns	81	116
Yearling does	22	29
Spike bucks	19	36
Forked-horns	27	77
3-point bucks [1]	7	14
4-point bucks [1]	4	9
5-point bucks [1]	1	2
6-point bucks [1]		1
Adults, not otherwise classified	8	1
Bucks not classified, but not including spike bucks or small forked-horns with short tines	21	14
Unclassified	87	44
Totals	396	539

[1] Western count: number of tines per antler.

Size Classification in Kill

Since 1935, information on the harvest of legally killed bucks has been gathered on the Angeles National Forest, including weight hog dressed, point numbers, antler spread and beam diameter, and notations on location of the kill, body condition, and shedding of the pelage and velvet. The present paper analyses data recorded from 2,681 bucks taken from 1936 to 1941, inclusive, for which these data are complete.

Classification of the data was made on the basis of weight and antler beam diameter. Actual weights were secured of 52 percent of the bucks taken by hunters. Point number and antler spread were found to bear little correlation with body weight or antler beam diameter. Brow tines were absent in all yearling deer. There was a progressive increase in the percentage of bucks bearing brow tines as age and weight increased. The distribution of antler beam diameter and weight classes is shown in Table 3. While the correlation is significant, a number of deer fall outside when a classification is made on the basis of either weight or antler beam diameter. This appears to be due mostly to the fact that fawns born in

TABLE 3

Classification of 2,681 Angeles National Forest Bucks by Weight and Antler Beam Diameter

Beam diameter in 1/10 in.	Weight groups—pounds															Totals
	50-59	60-69	70-79	80-89	90-99	100-109	110-119	120-129	130-139	140-149	150-159	160-169	170-179	180-189	200+	
.2 and .3	1		1		1											3
.4 and .5		7	23	12	10	8	8	1	1	2	2					74
.6	2	17	36													
and				142	115	70	37	26	3	3	2	1				521
.7	1	15	51													
.8 and .9	1	7	54	172	222	216	109	85	32	11	3			1		913
1.0 and 1.1		1	17	50	100	140	175	139	71	34	9	10	1	1		748
1.2 and 1.3				2	9	31	35	76	46	42	14	10	2	2		269
1.4 and 1.5					4	9	7	23	34	20	8	7	2	1	2	117
1.6 and 1.7						1	1	3	4	4	1	2	2			18
1.8 and 1.9					2		1				2	1		1		7
2.0 plus							1	1	2	3	1	2	1			11
Totals	5	47	182	378	463	475	374	354	193	119	42	33	8	6	2	2681

the early part of the fawning period enjoy a distinct advantage, for at that time, feed is succulent, resulting in a plentiful supply of milk. When the fawn begins to graze it still has some succulent feed to start on. The latest born fawns are affected by a reduced milk supply, relatively earlier weaning, and poor feed when they begin to graze. It was estimated that this could result in a difference of 30 pounds or more between the earliest and latest born fawns. It was definitely observed that the late born fawns are much smaller and in poorer condition at the time of the change to winter pelage.

Under the two factors of weight and antler beam diameter the kill has been classified into four classes, two of which are subdivided. These are shown in Table 4.

A detailed description of the classes follows:

Class 1. Yearlings (as indicated by dentition; temporary premolars mostly present) to 90 pounds in weight (one exception) with an antler beam diameter of less than 0.7 inch. Point classes predominantly 1 x 2 and 2 x 2; a few in the 2 x 3 class. Antler spread from 4 to 17 inches.

Class 2. Mostly two-year-old deer (with permanent premolars but slightly worn) weighing at least 60 pounds (two exceptions) but less than 130 pounds and with an antler beam diameter of at least 0.4 inch but less than 1.2 inches. All point classes from 1 x 2 to 4 x 4 represented, with spreads of 4 to 25 inches. (One aberrant 1 x 1 buck weighed 120 pounds and had an antler spread of 3 inches.)

TABLE 4

Scheme of Classification of 2,681 Legally Killed Bucks in the Angeles National Forest

Weight in 10-pound groups on x axis
Antler beam diameter in tenth-inch units on y axis

	50 60 70 80 90	100 110 120	130 to 210
2 and 3	Class I Yearlings 100 deer	Class II Mainly 2-year-olds. 957 deer	Class IV Superior Weight Classes
4 and 5			Subclass A. Inferior as to antler beam diameter
6 and 7		Class III Mature Deer of Less Than Superior Rank	
8 and 9			187 deer
10 and 11		Subclass A. With normal antler development 1,027 deer	
12 and 13		Subclass B. With superior antler beam diameter 204 deer	Subclass B. With superior beam diameter 206 deer
14 and 15			
16 and 17			
18 and 19			
20 and over			

Class 3. Mature deer of less than 130 pounds in weight and with an antler beam diameter of at least 0.6 inch.

Subclass A. Antler development moderate; the beam diameter less than 1.2 inches (two exceptions in the 80-pound group). All point classes from 1 x 2 to 4 x 4 represented, with spreads ranging from 4 to 25 inches.

Subclass B. Antlers of superior size, of trophy value, with a beam diameter of 1.2 inches or more. Point classes from 1 x 2 to 4 x 4 (one odd, 3 x 5) with spreads from 8 to 25 inches.

Class 4. Superior deer of at least 130 pounds in weight.

Subclass A. Antlers less than 1.2 inches beam diameter, of inferior trophy value. Point classes from 1 x 2 to 4 x 4 and odd (1 x 3 and 2 x 4). Spread 6 to 19 inches.

Subclass B. Antlers of high trophy value, with a beam diameter of 1.2 or more inches. Point classes from 1 x 2 to 5 x 6 and odd (2 x 4 and 3 x 5). Spreads of 8 to 25 inches.

Antler Development

The first indication of antlers in buck fawns is a blunt bump at the side of the front of the head. On this bump—the pedicel—the antler

proper develops. The rate of growth of the antler in yearling deer is slow, and some deer attain spikes only two inches in length during a period of five or six months. The rate of growth does not exceed 1.5 inches per month in small fork-horns but in the largest bucks may exceed an average of 2.5 inches per month.

Shedding of the "velvet" antler covering occurs principally in August. The best evidence on this point is found in the records of the deer kill presented in Table 5 and Figure 143.

TABLE 5

Loss of Velvet in 2,934 Legally Killed Bucks in Angeles National Forest

(By five-day periods—last period with only two days)

Antler condition	August					September						October		
	1	15	20	25	30	4	9	14	19	24	29	4	9	14
In velvet	410	121	19	7	13	4	1	10	1	3	0	0	4	0
Hard	244	300	130	53	106	123	50	505	86	120	178	104	234	108

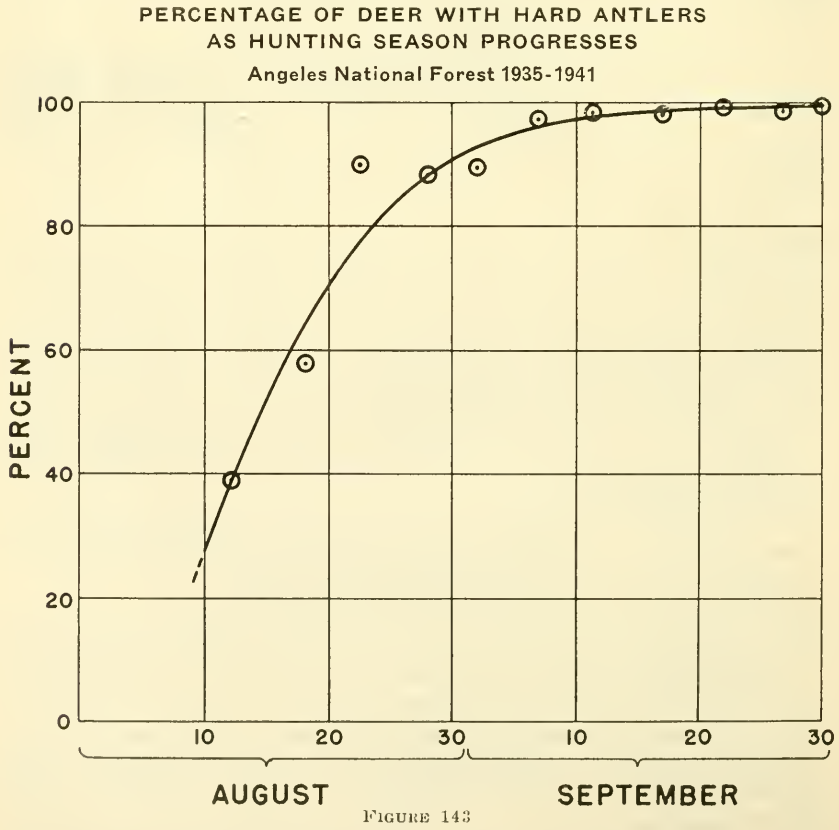

FIGURE 143

The open season in each of the six years for which data are available was one month. The opening date in 1936 was August 15th; in 1937

and 1938 the season opened on September 15th; and in 1939, 1940 and 1941 the opening date was August 10th.

Breeding

Bucks were seen with does by the middle of September. Rutting activity is general during the last week in September and the first three weeks of October. The earliest fawning date evident indicates that breeding occurs as early as the first week in September. Rutting activity is sporadic after late October, with the coming of cooler weather following the first fall rains. An occasional buck and doe were seen in company as late as December 15th. Breeding at that late date would explain an occasional record of small spotted fawns seen late in the fall after the majority of the fawns had attained winter pelage.

The census data in the study area for 1941 indicated a total of 117 bucks of forked-horn point class or better in comparison with 193 does of breeding age. These figures give a buck-doe ratio of 60:100 for this refuge area.

A few old bucks were observed during the height of the rut in deep canyons far from any known does. One of four spike bucks with long antlers having a beam diameter larger than usual was seen engaged in intense rutting activity.

The bulk of the fawn crop is dropped in May. However, the whole period of fawning seems to extend over a period of three months, as a few undersized fawns seen in late fall were thought to have been dropped about July 1st. One fawn found on April 5th appeared to be less than a week old.

The bicornuate type of uterus in deer leads one to expect twin births. The smaller does seen in late spring were generally accompanied by single fawns, while mature does seen during the same period usually had twins.

A low rate of survival is indicated. A comparison of the number of does and fawns seen in the study area, month by month, is shown in Table 6. A part of the indicated loss of fawns in March and April may result

TABLE 6

Numbers of Does and Fawns Sighted by Months

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Does	18	20	29	28	53	48	78	65	66	54	28	19
Fawns	3	10	26	26	39	44	56	47	51	48	12	9

from the dispersal of young males. Forty-four percent of the does with fawns had twins in July and August as compared with 6 percent in March and April.

Movements

Deer were generally active for a large part of the day during the winter when the days were short and the weather not too inclement. The members of a family group fed actively during the first two or three hours of daylight. Individual deer would bed down to ruminate, while other members of the group continued to feed. Feeding and ruminating continued until midday with some deer in evidence at all times. Generally all members of a group rested from midday until about an hour before dusk, when feeding became general.

Deer were not active at midday in the spring. Very few individuals were observed between the hours of 10 a.m. and 3 p.m. on sunny days, although deer were seen in numbers up to midday on cloudy days with cool temperatures. The tendency of the deer to feed during the cooler hours increased as the weather grew warmer.

As winter approached, the activity of the deer gradually spread over more hours of daylight. Deer were generally active on frosty mornings until the sun warmed the air.

No definite migrations occur within the study area since all of the territory is suitable for occupation at all seasons of the year.

Information on the movements of individual deer was obtained by trapping and releasing them after ear-tagging or belling. An adult doe was trapped near Dry Lake in the summer of 1941 and released after belling and ear-tagging. During the remainder of the summer this animal remained in a wooded cove of about 10 acres. She appeared to be the leader of a small group of does and fawns which followed her lead when she was flushed. The entire group of deer left the cove when it was blanketed with six inches of snow, the heaviest storm of the year, and moved a few hundred yards across a low saddle to a slope with southwest exposure where the snow quickly melted. The group returned to the wooded cove in about two weeks when it became free of snow. Following a second snowfall the same behavior was noted. The entire group of deer remained within a quarter of a mile of the cove during 10 months of observation.

Through the cooperation of the California Division of Fish and Game, a second doe, which had been trapped elsewhere, was released in the center of the study area after belling. This doe was seen once in the next two months, about a mile distant from the point of release. She was found several months later at the edge of the foothills more than five miles distant from the point of release. She remained in a restricted territory of less than 10 acres during the next six months.

The introduction of other deer did not furnish useful information on movements.

The limited data furnished by marked deer indicate that does in this area spend the greater part of their lives on a few acres, with seasonal movements just sufficient to escape adverse weather conditions. Within the experimental area the distance of movement from the preferred territory during the two years of study did not exceed a quarter of a mile. Elsewhere, higher elevations and more severe weather conditions force some deer to move greater distances.

There is less information on the movements of bucks, yet there are definite indications that their movements are quite restricted. Some individual bucks could be recognized, and these were found to remain in definite and restricted territories. They move more freely during the rut, but at other seasons of the year their movements do not greatly exceed those of other classes.

Most antlers are dropped in February, but the period of shedding extends over 10 to 12 weeks. The earliest record of loss of antlers was that of a spike buck seen on December 24th with one antler gone. A large buck observed on January 2d had lost both antlers.

Quantitative data on the progress of shedding are furnished by two censuses made in the best buck territory. Of 27 bucks seen on January

21st, six, or 22 percent, were bareheaded, three others (a spike buck, a forked-horn, and a three-pointer) had each lost one antler, while the remaining 18 bucks retained both antlers. On February 18th, in the same area, eight bucks out of ten were bareheaded; a three-pointer retained one antler, and a forked-horn retained both. The latest date of a buck observed retaining both antlers was March 5th.

Antlers may be lost accidentally at other times of the year. A buck with one antler missing was seen in the study area on October 15th.

The deer kill records provided a wealth of material on the dimensions of antlers. These records were confined to the legal kill of forked-horn bucks or larger, with the addition of a few spike bucks illegally taken.

Antler beam diameters varied from 0.3 inch to over 2.0 inches. The antler spread of 2,681 bucks taken by hunters ranged from 3 to 25 inches. The degree of spread had very little correlation with the beam diameter or body weight, the range of the spread being wide in deer of every class of weight and antler beam diameter. The diversity of the spread was due to two distinct types of antlers. The antlers of some deer arched only slightly, with the tips slightly separated. Other bucks carried antlers well arched, with the tips well separated.

The branching of antlers was diverse. In few cases were points symmetrical in length and angle of divergence from the beam. About 80 percent of the bucks had the same number of points on both antlers, about 19 percent had an extra point on one antler, while less than 1 percent had two extra points on one side.

Death Losses

Two mountain lions were known to be in the study area, and 162 coyotes were removed from it within a five-year period. However, relatively few deer carcasses were found which could definitely be ascribed to predators. The great majority had been cleaned by scavengers before being found. Evidence as to the cause of death therefore was often lacking. During the two years of field work, five kills were known to be from mountain lions, and probably three others. Three deer were known to be killed by coyotes, and probably three others.

Falls are the main cause of accidents. Deer were seen sliding back down roadcuts on many occasions when their momentum just failed to carry them to the top as they sought to escape. While deer generally keep on their feet as they slide, this is not always the case. A buck flushed from his bed in a canyon bottom attempted to escape by scaling the canyon wall. He paused after ascending 30 feet, then began sliding and tumbled to the stream bed, nearly catching one foot behind a protruding root. The carcass of a yearling was found with one leg bone which had healed after being broken.

Sixteen deer are known to have perished from falls. Six of these were old bucks which tumbled into canyons where the walls were nearly perpendicular. In one case the cause of the accident was clear. Tracks showed that the buck was attracted by succulent vegetation on a slippery bank and in attempting to reach it slipped and plunged into the canyon a hundred feet below.

Drowning is known to have accounted for the loss of two deer. A newly born fawn fell into a pond, and a yearling drowned as it tried to cross a narrow canyon during a freshet.

Two deer apparently died from fright. One was frightened from its bed by shouting and collapsed as it tried to escape. Another deer just outside the study area wandered onto cultivated land, where it ran about wildly, finally succumbing to fright and exhaustion.

Accessibility to a metropolitan area makes considerable poaching probable. Three deer carcasses were found bearing signs of having been illegally shot. Commercial killing of deer is known to have occurred in 1940. Several groups of poachers were suspected and one arrested. Poaching is restricted to the edge of the study area, and the extent of loss on this account can only be surmised.

No plants definitely known to be poisonous to deer were found in the study area. Three species of larkspur of unknown toxic quality were found, but in such quantity as to make it extremely doubtful if deer could obtain a lethal quantity. Poisonous mushrooms of the genus *Amanita* were found, but none had been disturbed by deer.

A number of deer were killed when struck by cars on the canyon roads, particularly on the high-speed road into San Antonio Canyon. The known loss on this road in 1940 was five, while in 1941 the loss jumped to 24. In addition, eight other deer were struck by cars and thought to be too badly injured to survive. The largest loss was at the time of the rut when the deer were less cautious.

Nine deer were taken under permit by ranchers, on account of crop damage, in 1940, and one in 1941. Previous to the study the number so taken was larger.

Practically all of the study area is within a game refuge. In the lower fringe open to shooting, the known hunter take was 14 in 1940 and 16 in 1941.

One buck was reported to have received a fatal wound while fighting with another buck. Five adult bucks from a group of nine which frequented the vicinity of a road camp at the edge of the study area were each blind in one eye supposedly the result of fighting during the rutting season.

The cause of death of 36 animals whose carcasses were cleaned by scavengers could not be ascertained.

The known loss of deer in the study area was 68 in 1940 and 75 in 1941, but considering all factors this can represent only a fraction of the actual loss.

There was no direct evidence of loss by disease during the study which started in 1940. However, late in 1938 there was an outbreak of disease in the western part of the refuge which resulted in the decimation of the herds in the Arroyo Seco district over the next three years. The disease was never definitely identified. It quickly spread over the west end of the San Gabriel Mountains. There was some loss in the Saugus district, but there it hardly reached epidemic proportions. The focus of the loss was within the refuge which gives rise to the suspicion that inviolate refugees may create conditions suitable for the development of disastrous epidemics. According to returned tags received by the California Division of Fish and Game, the deer kill was maintained during the period throughout the remainder of Los Angeles County and in adjoining counties indicating a nearly stable population elsewhere.

The Hunt

The record of hunter effort and success in the Angeles Forest is available from 1935. Data from the Arroyo Seco and Saugus districts (Table 7) illustrate the extremely heavy hunting effort in Southern California where the number of hunters on favored areas may exceed 100 per square mile on opening day. Table 7 shows that the buck kill in the Arroyo Seco districts held up well for three years until the deer population broke as the result of disease. The take for the four succeeding years was roughly one-half that of each preceding year. At the same time hunting effort fell off as the degree of success dwindled, but there was a lag and the ratio of effort to success grew steadily wider.

TABLE 7

Hunting Effort and Success in Arroyo Seco and Saugus Districts

Year	Arroyo Seco District adjoining refuge 4B			Saugus District remote from any refuge		
	Number deer killed	Number hunters	Success ratio	Number deer killed	Number hunters	Success ratio
1935	189	3,634	1:19	344	4,048	1:12
1936	152	4,974	1:33	427	7,945	1:19
1937	160	4,755	1:30	[1] 522	5,722	1:11
1938	79	3,763	1:48	436	6,144	1:14
1939	48	3,314	1:72	315	12,935	1:41
1940	22	2,570	1:107	181	9,796	1:54
1941	13	1,940	1:138	190	12,205	1:64

[1] The opening of the Sawmill Mountain Road, seven miles long, gave hunters access to some territory long closed.

In the Saugus district, the deer herd held up well from 1935 to 1938, with a notable increase in the take in 1937 when the Sawmill Mountain Road was opened to the public. In 1939 and 1940 there was some decrease in the deer population and the total take dropped but then stabilized. The ratio of effort to success widened not only because of the reduced take but also because of an increase in hunting effort, a part of which was a shift from the Arroyo Seco district where "luck" was poor.

The length of the hunting season loses its assumed importance when the kill by periods is studied. The percentage of the kill by five-day periods over the seven years is shown in Figure 144. The lack of the usual peak for the final period is attributed to the fact that other portions of the State opened for deer hunting the day following the close of this district.

With over 55 percent of the kill occurring during the first five days of the season, the small, well spaced additional kill during the following periods indicates that length of season here is of minor importance. However, spreading hunting effort over a long space of time makes for somewhat more skillful and safer hunting, and less crowding of public camps.

Refuges

A large refuge of 293,000 acres was established on the Angeles National Forest in 1929. As previously indicated its purpose in part was to reduce human use of the extremely valuable watersheds and thereby remove a threat of fire. As a refuge it was expected to provide a reservoir of bucks for breeding purposes or for an overflow of deer to stock the surrounding area.

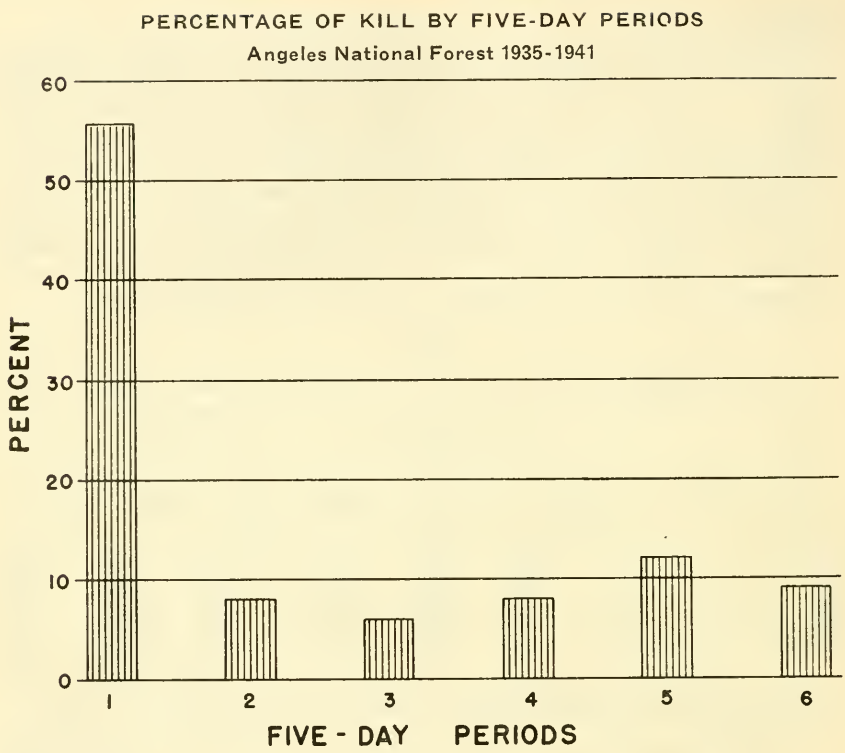

FIGURE 144

The units into which the kill is segregated in Table 7 are separate topographic areas, one in the San Gabriel Mountains adjacent to the refuge and the other on Sawmill-Liebre Mountain remote from refuge influence. The former area has the highest capacity for deer, having a higher average elevation, and is considerably better in food production per unit of area. The difference in kill per square mile is not as great as the difference in food production. There is no indication therefore that the refuge has improved hunting within the area it might influence. Instead it has reduced hunting opportunity and success to an extent equivalent to the area it occupies.

A comparison of the quality of bucks on the study area which has long been closed to shooting with those taken in an area adjacent to the refuge and with those taken in an area remote from the refuge is shown in Table 8. These include those censused in the study area in 1941 and those taken in the areas open to hunting in 1941 in the Arroyo Seco and Saugus districts. Under field conditions the classification of observed bucks into the categories given in Table 4 lacks the precision made possible by measurement of killed bucks. An approximation is made by combining Classes I, II, III-A as used in Table 4 to receive deer of small and medium size and by lumping Classes III-B, IV-A and B to include deer of superior size and antler development.

Only 22 percent of the deer taken either adjacent to or remote from a refuge were superior animals, having escaped the hunter long enough

TABLE 8

Quality of Bucks Taken in Open Territory and of Those Sighted in the Refuge in 1941

Area	Number of bucks	Percent in Classes I, II and IIIA	Percent in Classes IIIB, IVA and IVB
Saugus [1] (from kill record)	170	77.4	22.6
Arroyo Seco (from kill record)	14	78.5	21.5
Refuge 1B, Study area (sight record)	93	48.4	51.6

[1] North of the Santa Maria River, remote from refuge.

to reach full maturity. Within the refuge, over one-half of the bucks seen attained such size. It is not indicated that any appreciable number of deer moved out of the refuge into open territory nearby to improve the number or quality of deer taken.

Hunting has not reduced bucks sufficiently to affect breeding in the area open to shooting. During the seven-year period that detailed records of hunting effort and success were kept, the hunters' take declined markedly within the area that might have been influenced by the refuge but was maintained to a much greater degree elsewhere.

DISCUSSION

Limiting Factors

Weather rarely kills deer in the chaparral country. Storms that might do so are very infrequent and deer can escape to lower elevations. Such losses that might be attributed to storms would merely be the hurrying of the demise of an otherwise weakened animal.

There is no indication that predatory animals are a major factor in the deer population. The drain from this source can be but a very small percentage of the breeding potential. Deer numbers increased beyond the apparent habitat capacity with a near normal predator population and reduced sharply with no obvious change in predator pressure.

Some areas are without deer for a portion of the year because of lack of water. It is not known if this seasonal lack is a problem.

The legal hunting of bucks has not appeared to have prevented the effective breeding of does, and the breeding potential may be expected to operate normally.

It is concluded from the conditions observed that health is the limiting factor. This can also be deduced from the evidence that other limiting factors—weather, predation, and heavy hunting pressure—are ineffective.

The foods taken are adequate but of questionable nutritive quality, the bulk of them being thorny, hard-leaved material.

It is believed that holding the population to a lower average level is desirable, thereby increasing the level of nutrition, at least from the more desirable species, increasing resistance and reducing the opportunity for contact and spread of disease. In that manner it should be possible to harvest the maximum number of animals.

Possible Hunting Seasons

The extremely high value of the watershed lands in Southern California, the high fire hazard, and the serious results in floods, siltation,

and reduced production of usable water make necessary an almost total elimination of human use over a large area during the fire season.

This was a major factor in the creation of Refuge 1-B and others, by legislative action. It has also caused the U. S. Forest Service to close additional areas to public use and has resulted in restrictions in regard to travel and use of other areas by county ordinance. For similar reasons particularly that of fire hazard, hunters are excluded from a major portion of the privately owned ranges in Southern California.

Only by placing the hunting season outside of the fire season (June 1st-November 30th) can there be a greatly increased opportunity for deer hunters to enjoy their sport.

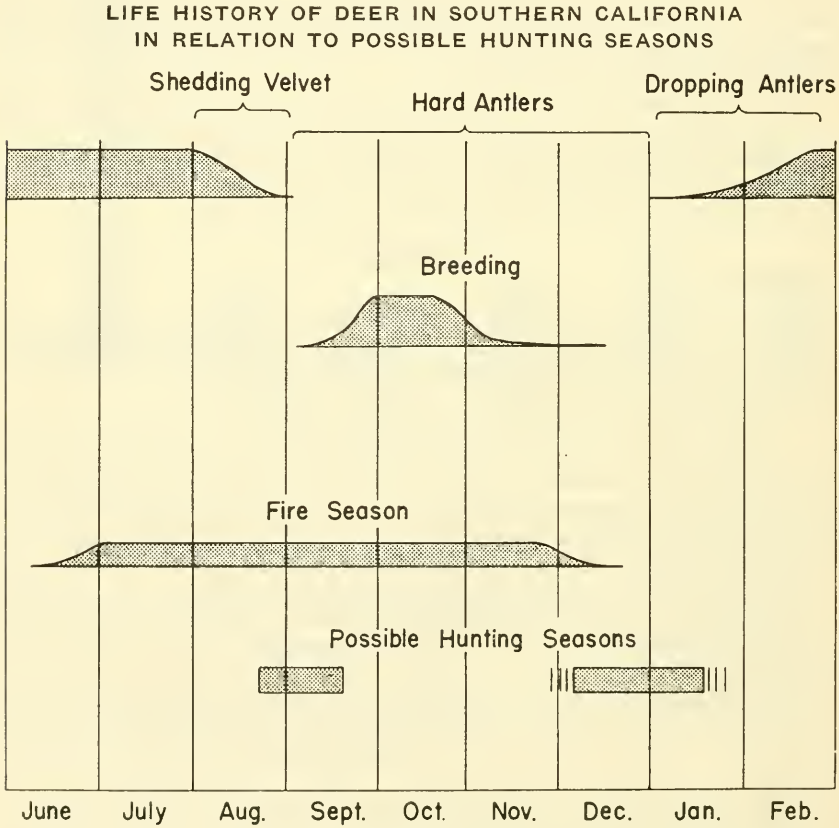

FIGURE 145

Such a season was opened in Southern California December 11, 1943. Deer averaged eight pounds lighter than in previous years, due probably to exertion during the rut and to a seasonal decline in forage quality. A small sampling of hunter reaction by forest officers indicated that about 30 percent of the successful hunters favored the winter season, 30 percent were rather violently opposed to it and the remainder indicated no particular preference.

As indicated in Figure 145, there are at least two possible seasons: August 20th-September 20th, extending from the time most horns are rubbed of velvet and are good trophies, to the beginning of the rut, after which the sporting qualities of hunting are lower and Californians have an unfounded aversion to deer meat. During this period only a limited area is open to public use. Temperatures are high, hunting is confined mostly to early morning hours and much meat spoils before it can be gotten into refrigeration. The other period is between the end of the rut and before antlers drop. During this period bucks are lower in quality, having little fat, but are of good flavor (Cook and others, 1949). There is no loss because of the weather. At this time the fire season is over, a much larger area of both public and private land is open, some rain has fallen and weather is normally excellent for hunting. However the reverse was true in 1941 when the December season was tried. In many states the hunt is either during or after the rut.

Bag Limit

Recently the limit was reduced from two bucks to one per hunter. A one-buck limit has to a limited extent the effect of encouraging hunters to try for the larger deer instead of killing the first deer seen. A one-buck limit would have improved slightly the success ratio shown in Table 7. Obviously, the success ratio does not entitle any hunter more than one deer. On the other hand, bucks are not being overshot and the number that would be taken as a second buck under a two-buck limit would be of little moment. The use of such a management tool should be based on conditions over a wider area.

The occurrence of epidemic disease indicated a population above habitat capacity and would direct management to holding numbers at a lower level. The take on these herds has not been adequate either from the standpoint of efficiency of harvest or for the maintenance of a healthy productive herd. The removal of specified numbers of does is strongly indicated in order to secure a maximum harvest and keep the size of the herd down to a safe, healthy level.

Habitat Management

The opportunities to manipulate cover in the interest of deer are few. In some areas in Southern California, the development of additional water supplies might be helpful. Firebreaks and roadsides provide "edges" and are commonly used by deer. This indicates that breaking up the brushfields that contain good forage species by tractor ways would improve the habitat. Because of the high watershed values the manipulation of the heavy brush cover is strictly limited.

CONCLUSIONS

1. A three-year study was made of a herd of California mule deer and its chaparral habitat within a game refuge on the Angeles National Forest, California. The five-year record of hunting effort and deer kill was studied for the portion of the forest opened to deer hunting.

2. Census and classification of animals was made by sight records over a two-year period. The breeding season was established, the periods of antler development, rubbing and shedding were recorded. The buck kill for the forest was classified as to size and antler development.

3. The California mule deer is markedly smaller in the chaparral forests of Southern California than the same race in the higher, more humid forests of the Sierra Nevada.

4. Forage, though abundant, is low in quality. The most desirable species are not common. They are often overbrowsed.

5. Neither predation, hunting under the existing buck law, nor weather appears to be an important factor in controlling the size of the deer herd. It is deduced that health is the prime factor. This was borne out by the occurrence of an epidemic that resulted in heavy losses in deer on the forest.

6. A very heavy hunting pressure was noted with a normal hunting success of less than one successful hunter in 15.

7. When hunter success was compared in areas adjoining and remote from a large refuge, it was concluded that the refuge (under the existing buck law) contributed nothing to the immediately surrounding area open to shooting either in number of animals taken or in their trophy qualities. Instead, the opportunity for successful hunting was apparently reduced by the proportion the refuge deer numbers were to the total population. In addition, the lack of mobility of females in this area would indicate that the refuge is not a management tool under any form of harvesting. Instead management must be applied in the areas open to shooting.

8. Placing the hunt after the rut would get it outside of the fire season and permit the opening of considerable additional areas of national forest and privately owned ranch land to hunting. Bucks are less desirable at that time, having lost much of their fat, yet at present much meat is lost by spoilage since the hunting season is in the hottest period of the summer.

9. Possibilities for habitat management are limited. Manipulation of the chaparral cover by fire or by other means will increase food production for deer. However, the high watershed values in Southern California preclude extensive use of such practices.

APPENDIX

Common and Scientific Names of Plants Used in Text

Alder	*Alnus rhombifolia*
Big cone spruce	*Pseudotsuga macrocarpa*
Buckthorn	*Ceanothus crassifolius* and *C. oliganthus*
Buckwheat	*Eriogonum fasciculatum* var. *foliolosum*
California sagebrush	*Artemesia californica*
Canyon live oak	*Quercus chrysolepis*
Chamise	*Adenostoma fasciculatum*
Chaparral whitethorn	*Ceanothus leucodermis*
Coast live oak	*Quercus agrifolia*
Death camas	*Zygadenus fremontii*
Dwarf interior live oak	*Quercus wizlizenii* var. *frutescens*
Evening primrose	*Oenothera* spp.
Hairy ceanothus	*Ceanothus oliganthus*
Holly leaf cherry	*Prunus ilicifolia*
Manzanita	*Arctostaphylos* spp.
Mountain mahogany	*Cerococarpus betuloides*
Pigweed	*Chenopodium album*
Poison oak	*Rhus diversiloba*
Ponderosa pine	*Pinus ponderosa*
Quinine bush	*Garrya veachii*
Rein-orchis	*Habeneria leucostachys*
Scrub oak	*Quercus dumosa*
Soap plant	*Chlorogalum pomeridianum*
Sugar bush	*Rhus ovata*
Toyon	*Photina arbutifolia*
White sage	*Salvia alpina*
Yucca	*Yucca whipplei*

REFERENCES

Cook, Bessie B., Lois E. Witham, Marion Olmstead and Agnes Fay Morgan
1949. The influence of seasonal and other factors on the acceptability and food value of the meat of two subspecies of California deer and of antelope. Hilgardia, vol. 19, p. 265-284.

Cowan, Ian McTaggart
1936. Distribution and variation in deer (genus *Odocoileus*) of the Pacific coastal region of North America. Calif. Fish and Game, vol. 22, p. 155-246.

Dixon, Joseph S.
1934. A study of the life history and food habits of mule deer in California. Calif. Fish and Game, vol. 20, p. 181-282; 315-354.

Johnson, F. W.
1939. Deer kill records—a guide to management of deer hunting. Calif. Fish and Game, vol. 25, p. 96-165.

A PRELIMINARY REPORT ON THE FISHERY AND ON THE BIOLOGY OF THE SQUID, *LOLIGO OPALESCENS* [1]

By W. Gordon Fields
Hopkins Marine Station of Stanford University, Pacific Grove

INTRODUCTION

The fishery for the squid, *Loligo opalescens* Berry, is comparatively old in California, dating at least to the establishment in 1863 of a Chinese fishing village near the present site of the Hopkins Marine Station on the southern shore of Monterey Bay. For many years this industry remained of minor importance, but since 1942 it has become one of the major fisheries of the Monterey Bay area. In 1946 squid landed at Monterey

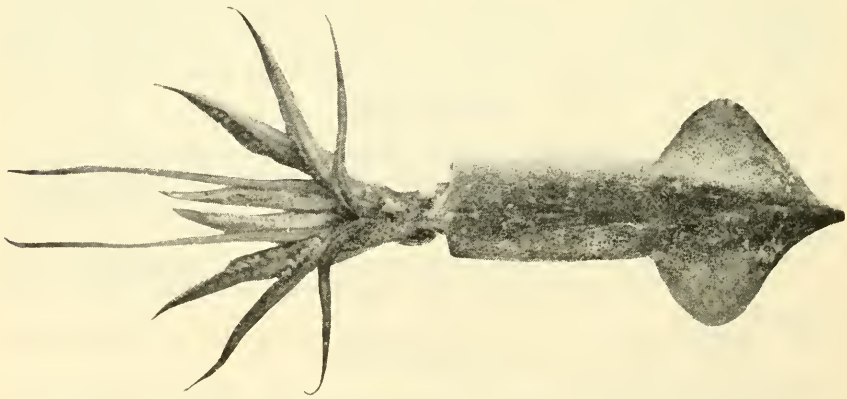

Figure 146. A 12-inch squid, *Loligo opalescens*. Photograph by J. B. Phillips

exceeded even the sardine catch of the same region in value, and brought the fishermen $1,214,091. Elsewhere there has been little development of this fishery, although *Loligo opalescens* is found from Puget Sound to Lower California, with the result that 99 percent of the squid caught along the California coast during the past 14 years has been taken within a very few miles of Monterey.

The present study of the fishery and of the biology of the animal upon which it is based was undertaken to increase our previously fragmentary knowledge of this commercially valuable mollusk. This preliminary report summarizes observations on a few phases of the investigation; further work is being done on all parts of the problem.

[1] Submitted for publication March, 1950.

I wish to express my appreciation for advice and for assistance given me to Dr. Tage Skogsberg and Dr. Rolf L. Bolin of the Hopkins Marine Station, to Mr. Julius B. Phillips of the California Division of Fish and Game, to my colleagues at the Hopkins Marine Station, and to the men in the fishing industry. My thanks go also to the Bureau of Marine Fisheries of the California Division of Fish and Game, which has cooperated in every way in addition to providing a fellowship to assist continuation of this program.

HISTORY

Any understanding of the squid fishery requires the consideration of several factors. Methods and intensity of fishing, means of preservation of the catch, domestic demand and availability of foreign markets—not meagerness of squid population—seem to have been the most important factors regulating the amount taken in the past, although there appear to be natural fluctuations in abundance as well.

The original fishing method, described by Collins (1892), was to row a skiff with a blazing torch at the bow about the bay at night until a school of squid had been attracted to it, whereupon two accompanying skiffs would set a small purse seine, about 180 feet long and 18 feet deep, around the school. Considerable numbers were taken in this primitive and laborious manner, sun dried, and exported chiefly to China.

The same author reported that the total weight of cured fisheries products shipped from Monterey during 1888 was 280,000 pounds. This included "quantities" of small fish and abalone, but, as the monthly variations presented by Collins conform closely to the present pattern

FIGURE 147. Squid being unloaded from large skiffs into the hopper of a cannery suction pump. Boats in the background are still on the squid fishing grounds. Photograph by J. B. Phillips, Monterey, May 1946

of squid catches, we may assume that much of this was squid—possibly about 100 tons.

According to Wilcox (1907) the same fishing methods persisted with little change through 1904. The squid catch in that year was about 125 tons. In 1905 the lampara net, capable of taking from 5 to 20 tons in a single haul, was introduced by the Italian fishermen. Using this vastly superior equipment they took complete control of the squid fishing, although the Chinese and Japanese continued to dry and market the catch. The lampara net has remained standard equipment on the smaller boats to the present time, but in recent years many larger boats have been using modern purse seines. When squid are scarce fishing is still done at night because schools are easier to find and identify in darkness; during seasons when squid are congregated over exactly known spawning areas the fishing activities shift to early daylight hours.

Scofield (1924) stated that the annual catch varied greatly, but usually was from 100 to 150 tons a year. He ascribed the fluctuations to changes in abundance, although he stated that catch alone is a poor criterion of size of population. As no records were kept prior to 1916, the catch in some years may have greatly exceeded the reported average. For example, Heath (1917) stated "Five thousand odd tons were taken in a single season," but he gave neither date nor source of information.

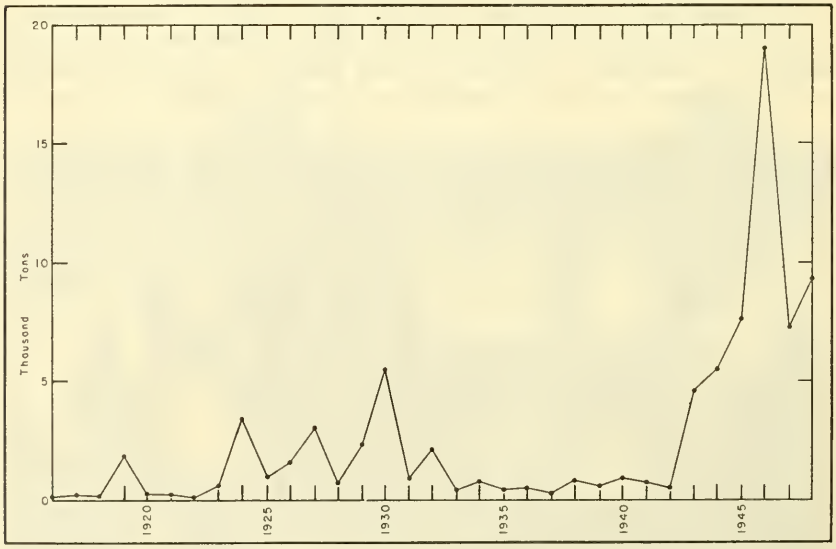

FIGURE 148. California squid landings, 1916-1948

From records of the Bureau of Marine Fisheries, data have been drawn for Figure 148 which shows the annual squid landings in California from 1916 to 1948, inclusive. The catch in 1916 was about 140 tons; until 1932 it fluctuated above this amount, the peak being 5,500 tons in 1930. The average annual catch for the 10-year period of 1923-32 was 2,100 tons. Most of this product was dried for shipment to China. Phillips (1937) ascribed the varying catch during this period to the instability of China's silver exchange and to competition from Japan's

squid fishery. Owing to financial conditions the Oriental market was closed in 1933. Since then no squid has been dried except for 70 tons in 1946. Apparently this venture was not successful, because it has not been repeated.

Fortunately new methods of preserving the catch had been developed, and new markets had become available. Records show that 196 cases of squid were canned in 1920, and that some squid has been canned every year since then except in 1927 and 1932. During the 20-year period 1923-1942 the annual pack was, on the average, 12,500 cases, and exceeded 20,000 cases in seven of those years. Each case contained 48 cans; the nine-ounce size was commonly packed, although one-pound, half-pound and seven-ounce cans were used to a limited extent. A small part of the canned product was sold in the United States and the remainder was exported chiefly to Greece.

Classic (1929) reported that the freezing of squid for the domestic market began about 1926. Freezing and canning maintained the fishery at somewhat more than 400 tons annually from 1933 to 1942. Lately the demand for the frozen product has increased so that it alone takes up this amount each year.

Classic (1949) states that before 1935 the usual price for squid to be dried for export was $8 to $15 per ton; $25 a ton was received for catches destined to be sold, fresh or frozen, in the domestic market. Lately approximately $60 per ton has been paid by the canneries, and $80 by the dealers in fresh and frozen squid. During the past 10 years the average prices received by the fishermen for squid for all purposes were:

1935	$59 per ton	1944	$55 per ton
1939	42 per ton	1945	55 per ton
1940	33 per ton	1946	63 per ton
1941	37.50 per ton	1947	54 per ton
1942	66 per ton	1948	54 per ton
1943	58 per ton		

Under lend-lease, and later for the United Nations Relief and Rehabilitation Administration, large quantities of canned squid were purchased for export to Mediterranean countries and to the Philippine Islands. With a profitable market for the whole catch assured, many large purse seine boats and additional canneries entered the squid industry. The catch rose to 19,000 tons in 1946. In that year 643,843 cases of squid were canned; the average annual pack for the five years 1943-1947 was 263,871 cases. Since 1942 the one-pound can has been used almost exclusively, so each case represents 48 pounds. The annual catch continued at about 10,000 tons through 1948 while the Philippine market was being exploited.

Changes in other phases of the fishing industry affect the squid fishery. During the period 1934-1945 the seasonal sardine catch at Monterey varied between 100,000 and 250,000 tons. The addition of larger and more efficient boats to the fishing fleet greatly increased its fishing capacity; the number of canneries and reduction plants in the Monterey district rose from 18 in 1941 to 41 in 1947. In 1946 the sardine catch fell to 36,000 tons, in 1947 to 18,000 tons.

Thus we find in the Monterey Bay region a large investment in canneries and in fishing boats and equipment, and also a considerable population which depends upon the fishing industry for its livelihood. With

men and equipment idle half the year and no assurance of adequate returns during the formerly lucrative sardine season, there is a tremendous economic pressure to develop other oceanic crops. Of these, the squid is potentially one of the most valuable because it appears in huge numbers and because it may be captured and preserved by present methods and with existing equipment.

The economic pressure caused by the waning sardine catch, combined with the assurance of a profitable market brought many larger boats into the squid fishery in 1946. If the domestic market were to react more favorably to squid, or if economic conditions should permit export to proven foreign markets, a greater portion of the capacity of the sardine fishing industry might be turned against the squid.

In such a case, protective measures might be needed in order to maintain the species adequately and yet allow the highest possible annual catch. To attain these objectives, any regulations adopted would need to be based upon full understanding of the biology of the squid. The present investigation was undertaken to obtain some of this essential information. Findings to date in certain phases of this investigation are given in the following pages, but work continues upon all parts of the problem.

COMPOSITION OF THE SPAWNING POPULATION

The squid fishery is based upon spawning individuals or upon schools approaching the spawning area. Most of the catch is from schools consisting entirely of squid, and is taken over the spawning grounds off the southern shore of Monterey Bay between Pacific Grove and Seaside. In almost every animal obtained there the stomach was empty. Many samples were caught outside of this area, but were minority populations in schools of fish. These were feeding instead of spawning and the digestive tracts contained food. Almost all of the very small squid were taken in these samples.

Because very few small squid were caught in the southern part of Monterey Bay, and these only occasionally, and because no immature squid except those newly hatched were ever found there, it is concluded that this is strictly a spawning area into which the squid migrate in schools for spawning, then leave.

Material

A series of 31 samples of squid was collected between September 1946 and July 1947. The length, weight and mantle thickness of each animal were measured, the reproductive systems were dissected and each part was weighed. A second series, of four large random samples, was taken in September and December 1948, and February and May 1949, and similar measurements were made. It was believed that these data would be adequate to show any changes in the condition of the reproductive systems if there were a distinct season during which no spawning took place. Weight and mantle length were recorded for the specimens in ten other random samples taken during the year from June 1948 to May 1949. These and the four samples previously described included more than 1,300 animals. From these animals length frequencies were determined and weight-length relationships, derived from earlier samples, were confirmed. Thirty-six additional samples, some random, some selected, were taken between June 1948 and May 1949; from these supplementary data were obtained.

Standard Length

The mantle length was taken as the basic measurement for comparative purposes because this dimension is stable regardless of the cause of death or subsequent treatment. The skeletal pen prevents any change in the mantle length. Measurements were made from the tip of the rostrum above the head to the posterior end of the mantle. This is the dimension meant when the term length is used.

Length Frequencies

Male

In 14 large random samples measured between June 1948 and May 1949 there were 598 male squid. Their frequency in each 5-millimeter range of mantle length is shown, as a percentage of the total number of individuals, in Figure 149. The mantle length of the smallest was 99 mm; that of the largest was 189 mm. A large proportion, 68.6 percent, was found within a narrow range of 30 mm between 146 and 175 mm inclusive. Only 5 percent were of greater size, while 26 percent were smaller. The largest number of specimens within any 5 mm range was found between 161 to 165 mm, inclusive. The smaller specimens increased quite regularly in frequency with increasing size to the group of greatest frequency.

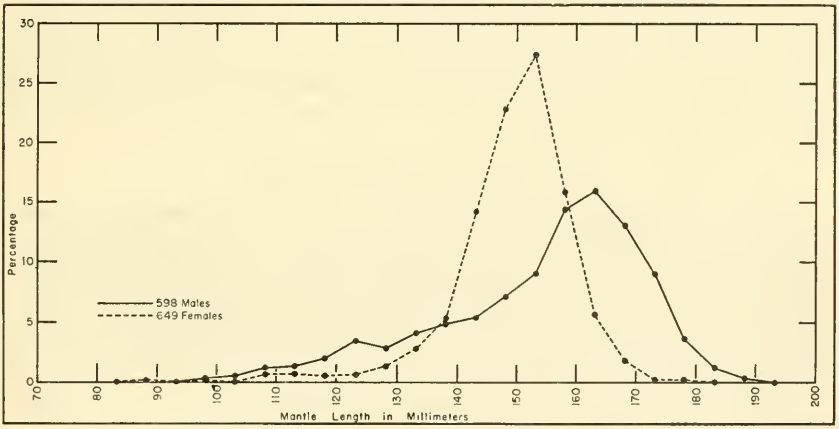

FIGURE 149. The frequency of males and of females in each 5 mm. range of mantle length, shown as a percentage of the total number of individuals of the respective sex

Female

In 14 large random samples taken between June 1948 and May 1949 there were 725 female squid. Weight-length data are available for only 649 of these, however, because only 75 of the 151 females of the May 10 sample were measured. In Figure 149 their frequency in each 5 millimeter range of mantle length is shown as a percentage of the total number of females. The mantle length of the largest measured was 176 mm; of the smallest 89 mm. Ninety-one percent of the specimens were between 136 and 165 mm long. Only 2 percent were larger, while 7 percent were smaller. The largest number of specimens within any 5 mm range was found between 151 to 155 mm, inclusive.

Comparison of Male and Female Populations

In these samples most of the individuals of each sex fell within a comparatively narrow size range of approximately 30 mm. Very few were larger. In spawning schools there are four times as many small males as small females. Within the limits of the normal spawning sizes the males of any sample are more widely distributed in size while the females form a much more compact group. The average mantle length of the male squid exceeds that of the female by about 10 mm.

Comparison With Other Years

These length frequencies are not typical of all years, because in April, May and June of 1949, squid, usually abundant in those months, were very scarce and the proportion of smaller animals in the population was higher than normal. The latter trend was apparent from January onward and affected more than half of the samples included. Therefore the lengths shown must be considered lower than the average for other years.

In an earlier series, collected from September 1946 to July 1947, 29 samples from spawning schools included 73 male and 111 female squid. These were selected for sex and therefore were not random samples. The average lengths for males and for females exceeded those reported above by approximately 10 mm in each sex. In other respects the two series are comparable: the average male length exceeded that of the female by 10 mm; 71 percent of the males and 88 percent of the females fell in compact groups each with a range less than 30 mm; the proportion of individuals below these groups, and the continuous range of sizes were both greater for the male than for the female animals in this series. Thus the same general pattern is demonstrated; further sampling will show the range of its annual variations.

Size at Which Maturity Occurs

Squid were considered to be sexually mature if spermatophores were present in the spermatophoric sac of the male or if mature ova were found in the oviduct of the female. All animals collected from schools composed exclusively of squid were mature. Although not present in large numbers, mature animals of either sex smaller than 110 mm may be found with the schools during much of the year. Small males are more frequently precocious in their association with spawning schools than are small females. In a group of samples made up of individuals less than 130 mm in length there were 317 males and only 45 females.

Mature male squid ranging down to 72 mm in length have been observed; the smallest mature female examined was 81 mm long. However, male and female squid may remain immature to a length of 110 mm and 120 mm, respectively. Such animals have been found in feeding aggregations with schools of sardines caught elsewhere in Monterey Bay while much smaller mature individuals were being caught over the spawning areas in schools of squid. Thus males may become mature when as small as 72 mm, or may remain immature until more than 110 mm in length; comparable sizes for the female are 81 mm and 120 mm, respectively.

Condition of Animals in Spawning Schools

Condition Before Spawning

The squid in spawning schools are in excellent condition when they enter the spawning area. Each animal is fat and heavy, its skin is glossy

and unmarked. The mantle is large in circumference, and thick and firm. In most cases the stomach is empty.

In female squid the ovary and the egg-filled oviduct are very large and completely fill the posterior third of the mantle cavity. The gland of the oviduct and the nidamental gland are large, firm and white. The accessory nidamental glands are orange-red in color, and may be seen clearly through the translucent mantle. In mature specimens 80 to 110 mm long the whole reproductive system, including ova, may make up more than 25 percent of each animal's weight; in animals of average spawning size this system may account for 30 percent to 50 percent of the total weight.

In male animals the testis is of medium size, the spermatophoric organ is large and firm, and the spermatophoric sac, filled with neatly-stored spermatophores, extends almost to the posterior end of the mantle cavity. Once an animal becomes mature, spermatophores are present in this sac during all seasons and throughout the animal's life. In mature males 80 mm to 110 mm long the reproductive system may weigh 10-12 percent as much as the whole squid; when the animal reaches average spawning size this system makes up only 4½-7 percent of the total weight.

Changes Due to Spawning

Spawning brings about profound changes in the squid. In the female, weight loss may be more than 50 percent of the animal's original weight. The spent female squid is small in diameter and the mantle is thin and limp. Few eggs in the ovary are approaching maturity; few or no mature eggs remain in the membranous oviduct. The gland of the oviduct and the nidamental glands are small and flaccid; the accessory nidamental glands are faintly pink. The oviduct, and an area on the mantle adjacent to it, bristle with spent spermatophores. Frequently, spent females (and occasionally males) are found to be extensively mutilated.

The male squid show similar changes during spawning, but the proportion of weight lost is smaller than in the female. The testis and spermatophoric sac become small and the spermatophores are reduced in number, but the chief weight loss is from reserves in the mantle tissues. The arms become scarred and the edge of the mantle may become ragged from encounters with other animals.

The changes which occur during spawning make the squid less acceptable to the industry, and when the proportion of spent animals in the catch becomes too great, as it does occasionally in June and September, the packing of frozen squid ceases until fresh schools appear.

WEIGHT-LENGTH RELATIONSHIP

Weight-length relationships were determined from scatter diagrams representing 495 male and 536 female squid. Groups of 5-millimeter range of mantle length were set up, and the average weight in each group was found for each sex. These data, and weight-length curves based upon them, are shown in Figure 150. The weight differences are small between male and female animals which are less than 120 mm in length; in larger specimens the average weight of the male is greater than that of the female of comparable length. This difference increases regularly with increasing mantle length.

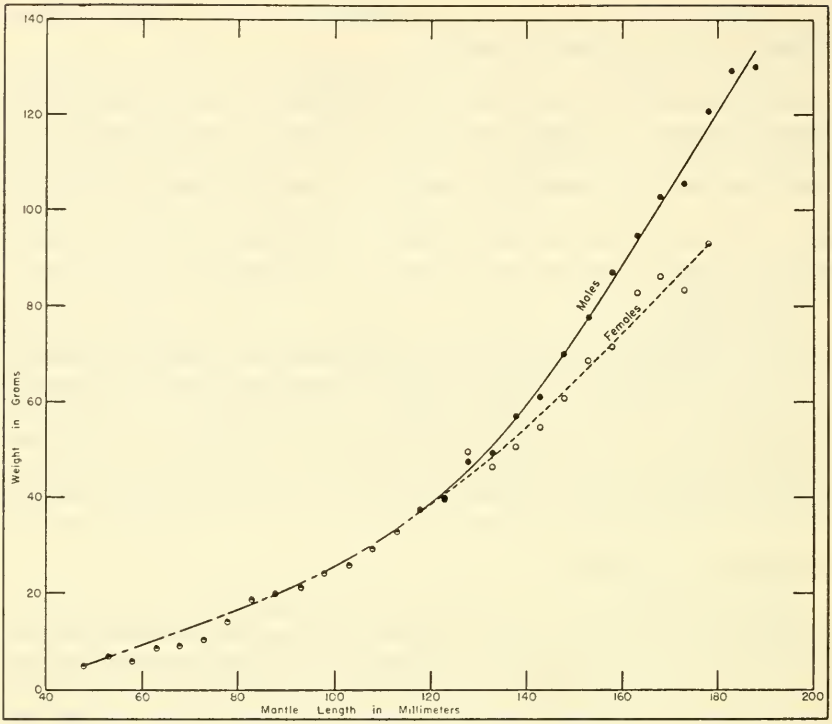

FIGURE 150. Weight-length relationship

In general, the weights of the male squid are closer to their group averages than the weights of the female are to theirs. The numbers of specimens which deviate from their group average weight by more than 10 percent, 20 percent, etc., of that weight are shown below as a percentage of the total number of individuals of that sex:

Percentage of specimens which deviate from their group average weight by:

	More than 10 percent	*More than 20 percent*	*More than 30 percent*	*More than 40 percent*	*More than 50 percent*
Males	53%	18%	4%	0.8%	0.2%
Females	62%	33%	13%	3%	0.4%

Among female squid the greatest degree of deviation from average weight was found in animals 135 mm to 165 mm long, that is, within the average spawning range. Among male squid the greatest deviation was not found within the common spawning range but among the precocious small animals 95 mm to 140 mm long.

SPAWNING SEASON

Information which might aid in defining the spawning season of *Loligo opalescens* has been collected from many sources.

Condition of Reproductive Systems

It was believed initially that all segments of the squid population living in Monterey Bay and vicinity ranged through the southern por-

tion of the bay for feeding, as well as for spawning. It was thought, as a consequence, that the squid caught there would be representative of all ages and conditions of the population. Accordingly, samples were collected and the animals were examined in the hope that consistent trends in proportions or in the condition of organs or sex products would outline periods of spawning and of its cessation, and, possibly, show the relative numbers of animals participating at different times of the year.

No trends indicative of a spawning season were observed, nor was any evidence obtained that physical condition precludes spawning at any time of the year. Large reserves of spermatophores and mature ova are found throughout the year and, except in freshly exhausted specimens, the accessory organs are maintained in potential spawning condition at all times. The schools captured by fishermen are not representative of the general population. Instead, they consist exclusively of mature animals which have migrated from their usual environment to the southern part of Monterey Bay, where spawning occurs. The erratic differences in condition observed were not seasonal, but depended upon whether the school was taken before, during, or after spawning.

Times of Occurrence of Egg Masses

Egg masses in the water are tangible evidence that spawning has occurred; and the degree of development of the embryos permits accurate estimation of the time at which they were laid. Varying quantities of egg masses may be found in the vicinity of Monterey during any month in which squid are caught over the spawning areas. Squid have spawned on every occasion when they have been brought alive to the Hopkins Marine Station aquarium.

Fishing Records of Previous Seasons

The average monthly catches during the three six-year periods, 1931-1936, 1937-1942, and 1943-1948, are compared in Figure 151. Where a general pattern is repeated through so many years, catch becomes acceptable as a criterion of size of that portion of the whole population which spawns in this area. The records for 1943 to 1948 are most valid, because throughout those years there was constant demand and very intensive fishing over the small area into which the schools migrate to spawn. These figures should reflect quite accurately the fluctuations in the numbers of squid temporarily inhabiting the spawning grounds, and show also the variations in the intensity of spawning. The major spawning season in this area, then, includes those months in which good catches are made consistently; the months commonly barren are those which intervene between seasons.

Figure 151 shows the average monthly catch as a percentage of the average annual catch for each six-year period. Owing to the grouping of the data the general pattern is apparent. In January, February and March the catch is low; normally each of these months produces less than 5 percent of the annual yield. In April the squid appear in larger numbers and in this and the three ensuing months the great bulk of the year's catch is taken (for example, 77 percent in 1943-48). The peak is in May, but the average catch of this month exceeds that of June only slightly. In August, September, October and December few squid are caught; in November they are found in somewhat greater numbers. All

FIGURE 151. Average monthly catch as a percentage of the average annual catch for each six-year period

three of the six-year groups conform closely to this pattern, but within each the annual variations are considerable.

The season of most intense spawning is, therefore, in April, May, June and July; a minor peak often occurs in November. In some years spawning animals are taken in every month; in others none may be found for periods of a month or more.

A complete summary covering various phases in the biology of the squid, still being studied, will be published at a later date.

REFERENCES

Classic, Ralph F.
1929. Monterey squid fishery. Calif. Fish and Game, vol. 15, p. 317-320.
1949. Squid. Calif. Div. Fish and Game, Fish Bull. 74, p. 172-174.

Collins, J. W.
1892. Report on the fisheries of the Pacific Coast of the United States. U. S. Fish. Com., Rept. for 1888, p. 3-269.

Heath, Harold
1917. Devilfish and squid. Calif. Fish and Game, vol. 3, p. 103-108.

Phillips, Julius B.
1937. Squid. Calif. Div. Fish and Game, Fish Bull. 49, p. 113-117.

Scofield, W. L.
1924. Squid at Monterey. Calif. Fish and Game, vol. 10, p. 176-182.

Wilcox, W. A.
1907. The commercial fisheries of the Pacific Coast states in 1904. U. S. Bur. Fish., Doc. 612, 74 p.

WINTER INJURY TO YOUNG FUR SEALS ON THE NORTHWEST COAST[1]

By Victor B. Scheffer
U. S. Fish and Wildlife Service
Seattle, Washington

In January and February, 1950, the bodies of young fur seals (*Callorhinus ursinus*) washed ashore in great numbers along the seacoast of Washington and Oregon. Twenty-nine of them bore metal tags which biologist Karl W. Kenyon had attached to seal pups on the Pribilof Islands, Alaska, in late summer of 1949. Since Mr. Kenyon had tagged 20,000 seals out of an estimated 500,000 born, one can deduce that the total number of yearling seals, tagged as well as untagged, which washed ashore in the winter of 1950 was over 700. From identical series of taggings in 1947 and 1948 we recovered, respectively, three and two stranded carcasses. Apparently then, the mortality in the winter of 1950 was unusually high.

The tagged seals were recovered in various stages of preservation, but mostly fresh, between December 31, 1949, and April 2, 1950. Fourteen of the bodies were recovered between mid-January and mid-February. Of all the bodies, 10 were from Washington and 19 from Oregon. The southernmost was from Elk River, between Cape Blanco and Port Orford, Oregon; the northernmost from Copalis, Washington. Most of the bodies were picked up by beachcombers. A resident of Seaview, Washington, had 30 skins in his possession when he was visited by a federal agent.

The metal tag used on fur seals in 1949 was applied to the left hind flipper, was numbered individually, and carried the statement "Notify F & W Service, Washington, D. C." As a consequence, most of the recoveries were reported first to our Washington office.

In March, Mr. Kenyon and I examined the bodies of nine male and nine female seals brought to our laboratory. These were "yearlings," that is six to eight months old, and were greatly emaciated. One weighed only 11½ pounds, the average weight of the newborn pup (Figure 152). All of the stomachs were empty, or contained dark-colored mucus.

From each of the beachcombers we received a postcard or letter describing the circumstances of the find. Three of the men thought that oil on the water was an important cause of mortality. "There was much oil or tar in the surf water at the time we found the seal. Got it all over our boots. . . ." "This seal had some heavy oil on it which I believe caused its death." "Some were covered with heavy crude-oil; some were not." We do not believe that oil, sporadically observed on inshore waters and beaches of the Pacific Coast, was a serious factor. One man reported that "this seal evidently was shot as a hole was on each side just back of the head, one hole much larger than other, no doubt that it was shot."

[1] Submitted for publication April, 1950.

Commercial fishermen or bounty hunters after hair seals may have killed this individual through oversight.

After examining the weather records for January and February we concluded that severe and prolonged storms were responsible for the unusual mortality. From the U. S. Weather Bureau (Climatological Data, Washington, v. 54, no. 1, p. 2) we quote: "January 1950 was outstandingly the coldest, snowiest month in the 60 years of state climatic record. . . . The month was marked by a severe cold storm on the 13th followed by successive snows and steady cold in the latter half. . . . The monthly average temperature, 15.5° [F.], was 15.8° below normal." North Head, on the ocean at the mouth of the Columbia River, had the highest monthly mean for the state, 33.6°. The severe weather of January carried over into the first week of February.

FIGURE 152. Emaciated body of an Alaska fur seal recovered from the Washington coast in February 1950; weight 11½ pounds

The young fur seals were probably weaned in November and December on the Pribilof Islands, whence they moved into the North Pacific Ocean. Here, during their first winter at sea, learning to feed for themselves, they encountered heavy seas and below-freezing temperatures. We believe that many of them were unable to maintain their body heat and eventually succumbed. How many carcasses were lost at sea it is difficult to estimate. The extent of the loss may be calculable in the summer of 1952 when the survivors of the class of 1949 will have attained the age of three years and will appear on the commercial killing fields of the Pribilof Islands.

NETTING BAIT AND CANNERY FISH WITH THE AID OF LIGHTS[1]

By Parke H. Young
Bureau of Marine Fisheries
California Division of Fish and Game

The demand for live bait by the Los Angeles Harbor sportfishing fleet has been great enough to occupy six to ten bait boats during the spring, summer and fall months. During part of 1948, fishing for anchovy, sardine, queenfish and kingfish was carried on by bait fishermen much as it had been for many years. Bait was customarily taken just at dawn. At this time the schools of fish made known their presence by one or more indications, but mostly by small splashes on the surface of the water. The experienced bait fisherman is quick to detect these schools and to lay out his net. Shortly after daybreak, the sportfishing boats began to make their appearance, coming alongside of the waiting bait boat where the necessary amount of bait was taken from the net and transferred to the sport vessel.

Sportfishing during 1948 was not considered good locally, and, for the latter half of the season, sport boat operators began to travel farther and farther, making necessary a much earlier departure hour in order to give a full day of fishing. Hauling bait at dawn no longer sufficed, nor did holding bait in floating live cars serve to satisfy the demands of the early hour customers. As bait men were obliged to fill their bait orders without fail, many methods, hastily devised, were tried but found inadequate. However, it was discovered that under lights from moored ships or wherever lights were to be found, bait could often be taken in quantity. Following this idea, floating kerosene or gasoline lanterns were tried at various locations in the outer harbor, and their ability to attract bait aided materially in producing sufficient quantities for the sportfishing fleet. Lights are not as effective, however, when operated in competition with the moon.

For the remainder of 1948, nearly all of the harbor bait fishermen used floating lanterns to aid them. The procedure to determine whether or not the required amount of fish had collected under the lanterns varied between boats. Most of the boats were by this time equipped with fathometers, and by passing as near to the lanterns as space would allow, the fishermen were able to gain an idea as to the extent and density of the school. Boats without fathometers had to depend on vision alone. The net was payed out in the usual manner, completely encircling the lantern and the unsuspecting school of baitfish.

Shortly after the beginning of the sportfishing season in 1949, it again became apparent that lights would be necessary if ample bait was to be provided. Some bait boats appeared on the fishing grounds equipped with small gasoline engines, which were used to generate electrical power

[1] Submitted for publication March, 1950.

for 500-, 750-, or 1,000-watt incandescent light bulbs. Skillful use of this powerful source of light resulted in large catches being made more easily and more often. In typical use, either a 500-watt or a 750-watt bulb, reflector, and portable gasoline engine generator were mounted in a skiff and anchored on a chosen spot somewhere within the outer breakwater. As in the case when gasoline lanterns were used, some estimate of the extent of the school was made by the fishermen. If satisfactory, the net was payed out, and the skiff, with its light extinguished, rowed out of the circle leaving the fish to their fate.

In Australia, a fishing method that is practically identical to the light fishery of Southern California has been developed, also for capturing sardines. Australian fishermen are using 1,000-candlepower electric lamps which compare closely with 1,000-watt lamps.

At the beginning and during the greater part of the sardine season, starting in October of 1949, the bait fishermen sold great quantities of sardines for canning purposes. These relatively few boats were rapidly joined by approximately 30 additional vessels that also operated within the confines of Los Angeles Harbor. The new boats that entered the fishery used, for the most part, time-proven fishing methods. Nearly all of the operators soon discovered that, in order to compete with the bait fishermen, they had to install an artificial light system on their craft. At the close of the sardine season, it would have been difficult to find a single boat that had not adopted night fishing with lights as the most profitable method of operation within Los Angeles Harbor.

Daily tonnages of sardines delivered by individual harbor vessels were small, usually ranging from one or two tons up to 15 tons. During the frequent and extended inactivity of the purse seine fleet, caused by disputes over price, the small boats composing the harbor fleet were able to furnish enough sardines to keep part of the canners operating.

A CHECK LIST OF THE FRESH-WATER AND ANADROMOUS FISHES OF CALIFORNIA[1]

By Leo Shapovalov and William A. Dill
Bureau of Fish Conservation
California Division of Fish and Game

INTRODUCTION

Purpose

Scientific workers and laymen alike have long felt the need for a comprehensive and accurate handbook of the fresh-water and anadromous fishes of California. Much material on the subject has been written since 1854, when Dr. W. P. Gibbons published the first scientific description of a California fresh-water fish. At first glance it might seem that the accumulated body of information would make the compilation of such a handbook an easy task. Unfortunately, this is not the case. As data have accumulated, the realization of the complexity of the systematic status and interrelationships of the fishes has grown. It is now clear that even the compilation and integration of the published data will be a long-term, laborious, and painstaking task.

The authors have prepared the present article in the belief that a generally acceptable list of the known fishes constitutes an essential first step in the compilation of the above handbook.

A second purpose is to fill the immediate need of the California Division of Fish and Game for official common names for the fishes found in the fresh waters of the State. With respect to the common marine fishes of California, such a need was met first by Walford (1931) and more recently and in revised form by Roedel (1948). Evermann and Clark (1931) did publish a list of California fresh-water fishes, but it was not as inclusive as the present one, contained many errors, and the common names did not receive the sanction of the Division of Fish and Game.

The selection of common names for California fresh-water fishes is complicated by two somewhat paradoxical factors: the multiplicity of names which have already been applied to certain species; and—in the case of certain other forms—by the dearth of common names. Thus, members of the genus *Cyprinodon* have been called by such varied names as "desert minnow," "desert killifish," "pursy minnow," "pygmy fish," and "pupfish." Conversely, there are a large number of native cyprinids which are so similar and undistinctive in appearance that the layman has never recognized their specific differences nor called them by any name other than the rather general "chub" or "shiner."

This list attempts to reconcile such difficulties by assigning one "official common name" to each species and subspecies. In the future these names will be used in all publications of the California Division

[1] Submitted for publication June 1950.

of Fish and Game. The general principles underlying our choice of names are outlined in a later section.

Scope

The main list covers both native and successfully established exotic species.

We have attempted to include all native forms whose occurrence has been reported in the literature or verified through the examination of collections. The existence of some of these as valid species or subspecies (*Salmo gairdneri rosei*, for example) has been questioned by some workers. Our criterion for inclusion of such forms is very simple: we have tried to include all forms whose taxonomic identity has not yet been disproved in *published* literature. Possibly certain other records of occurrence (such as those for *S. clarkii pleuriticus*) are based on misidentification. Possibly some of the native species are no longer a part of our fauna. The inclusion of *Plagopterus*, for example, rests upon a single collection made in 1890. However, it is practically impossible to prove or disprove such suppositions. Hence, in the case of the native species it has been thought best to err on the side of inclusiveness rather than on the side of exclusion.

On the other hand, our main list, p. 385, includes only those exotic or introduced species of which breeding populations are known to have survived. Introduced forms which failed to become established or are of uncertain status have been placed in a supplementary list, p. 388.

Fishes recorded only from outside California have not been included even if the stream in question also flows into or out of this State, e.g., the Klamath and Truckee Rivers. However, in the case of the Colorado River, which is a boundary stream, fishes recorded from the Arizona side of the stream, and even from the mouth of its tributary, the Gila River, have been included.

Most of the fishes in the check list are strictly fluvial or anadromous. For the sake of completeness we have also listed those marine and brackish water species which are known to penetrate into fresh water. However, strictly marine species which recently have been introduced into the Salton Sea, an inland body of water with salinity approaching that of ocean water, have been omitted.

Hybrids have also been omitted. Both interspecific and intergeneric hybrids of a number of the species listed have been recorded from the natural waters of California.

Choice of Names

In order that this list will not simply be another array of arbitrary selections, the authors have—insofar as it has been possible—adhered to a set of basic rules or criteria for the selection of common names, as follows:

(1) Names should agree with those in actual common use; or—when there is no common or vernacular use—with those in published literature. Strictly "book names" should be avoided.

(2) Names should agree with those on other authoritative lists, especially those of the American Fisheries Society (1948), the Outdoor Writers Association of America (1948), and Roedel (1948).

(3) Names should indicate relationship and not confuse it.

(4) Names should be descriptive.

(5) Preference should be given to names which are short, distinctive, interesting, catchy, romantic, or euphonious.

Each of these qualifications has exceptions which make it useless by itself. Therefore, each principle listed above should be read as though it were prefaced by the words, "Other considerations being equal. . . ." For example, the name "Sacramento Perch" does not meet either Rule 3 or 4 above, since this species (*Archoplites interruptus*) is not a true perch. However, since it is so commonly used (Rule 1) and since it agrees fully with the name used in the two primary references cited in Rule 2, it would be foolish to select another name.

Aside from such considerations, an attempt has been made to promote the twin ideals of stability for individual names and the designation of relationships through the selection of common names according to a definite plan. Such aims have long been recognized by ornithologists and are well exemplified by the names listed in "The Distribution of the Birds of California," by Grinnell and Miller (1944). Thus, wherever possible the same basic common name has been given to all members of a single genus, with prefixes added to that common name for each full species of that genus. In the case of subspecies, additional prefixes have been added to the specific name. For example, all members of the genus *Siphateles* have been termed Chub; members of the *Siphateles bicolor* group have been termed Tui Chub; each subspecies of this group is further designated by an additional term such as Sacramento for *S. b. formosus*, the Sacramento Tui Chub.

It should be noted that this method will permit the retention of at least part of the common name even if the species or subspecies undergoes a revision which will change the scientific name.

The authors are inclined to share Alden H. Miller's (*op. cit.*) opinion that only full species deserve common names. Nevertheless, we have listed common names for each subspecies, with full recognition that a number of them may not endure. One reason prompting this decision is that certain subspecies have been distinguished as entities almost from the beginning, and it would seem unfortunate to obscure (through omission) such names as "Kokanee" or "Piute."

It should also be noted that a number of systematists have disagreed with certain of our groupings; e.g., that for the native trouts, in which assignment to specific or subspecific status is, in some instances, original with the authors. However, a firm nomenclature has never been developed for some of these plastic groups. And—as we have stated before—even after some decided changes in scientific nomenclature, most of our common names can still be retained with enough recognizable parts to promote stability.

ACKNOWLEDGMENTS

Manuscript copies of this list have been thoroughly discussed with the members of the biological staff of the Bureau of Fish Conservation. In addition, semifinal drafts have been read by Carl L. Hubbs, W. I. Follett, Robert R. Miller, George S. Myers, L. P. Schultz, W. M. Chapman, and R. S. Croker. We are most appreciative of the criticisms of these men and many of their suggestions have been incorporated into the final list. However, a number of differences of opinion have not been reconciled, so it should not be considered that they are in full agreement with our presentation.

CHECK LIST

Native Species and Established Exotic Species

This list consists of 101 full species, which may be subdivided as follows: 64 native fresh-water and anadromous species, 11 native species which occasionally penetrate into fresh water, and 26 introduced species.

Species which have been introduced into California waters are denoted by an asterisk (*), and marine fishes which occur only occasionally in fresh water by an "O."

Family Petromyzontidae. The Lamprey Family.

1. *Entosphenus tridentatus* (Gairdner). Pacific Lamprey.
2. *Lampetra fluviatilis* (Linné). River Lamprey.
3. *Lampetra planeri* (Bloch). Brook Lamprey.

Family Acipenseridae. The Sturgeon Family.

4. *Acipenser transmontanus* Richardson. White Sturgeon.
5. *Acipenser medirostris* Ayres. Green Sturgeon.

Family Elopidae. The Ten-pounder Family.

6. *Elops affinis* Regan. Ten-pounder. O

Family Clupeidae. The Herring Family.

7. *Clupea pallasii* Cuvier and Valenciennes. Pacific Herring. O
8. *Alosa sapidissima* (Wilson). American Shad.*

Family Osmeridae. The Smelt Family.

9. *Thaleichthys pacificus* (Richardson). Eulachon.
10. *Spirinchus thaleichthys* (Ayres). Sacramento Smelt. O
11. *Hypomesus pretiosus* (Girard). Surf Smelt. O
12. *Hypomesus olidus* (Pallas). Fresh-water Smelt. O

Family Salmonidae. The Salmon and Trout Family.

13. *Oncorhynchus gorbuscha* (Walbaum). Pink Salmon.
14. *Oncorhynchus keta* (Walbaum). Chum Salmon.
15. *Oncorhynchus kisutch* (Walbaum). Silver Salmon.
16. *Oncorhynchus tshawytscha* (Walbaum). King Salmon.
17. *Oncorhynchus nerka* (Walbaum). Red Salmon.
    - 17a. *Oncorhynchus nerka nerka* (Walbaum). Red Salmon (anadromous form).
    - 17b. *Oncorhynchus nerka kennerlyi* (Suckley). Kokanee Red Salmon (fresh-water form).*
18. *Salmo trutta* Linné. Brown Trout.*
19. *Salmo clarkii* Richardson. Cutthroat Trout.
    - 19a. *Salmo clarkii clarkii* Richardson. Coast Cutthroat Trout.
    - 19b. *Salmo clarkii henshawi* Gill and Jordan. Lahontan Cutthroat Trout.
    - 19c. *Salmo clarkii seleniris* Snyder. Piute Cutthroat Trout.
    - 19d. *Salmo clarkii pleuriticus* Cope. Colorado River Cutthroat Trout.
20. *Salmo gairdnerii* Richardson. Rainbow Trout.
    - 20a. *Salmo gairdnerii gairdnerii* Richardson. Steelhead Rainbow Trout.
    - 20b. *Salmo gairdnerii stonei* Jordan. Shasta Rainbow Trout.
    - 20c. *Salmo gairdnerii gilberti* Jordan. Kern River Rainbow Trout.
    - 20d. *Salmo gairdnerii rosei* Jordan and McGregor. Lake Culver Rainbow Trout.
    - 20e. *Salmo gairdnerii evermanni* Jordan and Grinnell. San Gorgonio Rainbow Trout.
    - 20f. *Salmo gairdnerii aquilarum* Snyder. Eagle Lake Rainbow Trout.
    - 20g. *Salmo gairdnerii regalis* Snyder. Royal Silver Rainbow Trout.
21. *Salmo agua-bonita* Jordan. Golden Trout.
    - 21a. *Salmo agua-bonita agua-bonita* Jordan. South Fork of Kern Golden Trout.
    - 21b. *Salmo agua-bonita whitei* Evermann. Little Kern Golden Trout.
22. *Salvelinus fontinalis* (Mitchill). Eastern Brook Trout.*
23. *Salvelinus malma* (Walbaum). Dolly Varden Trout.
24. *Cristivomer namaycush* (Walbaum). Lake Trout.*
    - 24a. *Cristivomer namaycush namaycush* (Walbaum). Common Lake Trout.*
25. *Coregonus williamsoni* Girard. Mountain Whitefish.

Family Catostomidae. The Sucker and Buffalofish Family.

26. *Megastomatobus cyprinella* (Valenciennes). Bigmouth Buffalo.*
27. *Pantosteus santa-anae* Snyder. Santa Ana Mountain-sucker.
28. *Pantosteus lahontan* Rutter. Lahontan Mountain-sucker.

29. *Catostomus occidentalis* Ayres. Western Sucker.
    29a. *Catostomus occidentalis occidentalis* Ayres. Sacramento Western Sucker.
    29b. *Catostomus occidentalis lacus-anserinus* Fowler. Goose Lake Western Sucker.
30. *Catostomus rnniotiltus* Snyder. Monterey Sucker.
31. *Catostomus microps* Rutter. Sacramento Small-scaled Sucker.
32. *Catostomus tahoensis* Gill and Jordan. Tahoe Sucker.
33. *Catostomus arenarius* Snyder. Sand-bar Sucker.
34. *Catostomus latipinnis* Baird and Girard. Flannelmouth Sucker.
35. *Catostomus rimiculus* Gilbert and Snyder. Klamath Small-scaled Sucker.
36. *Catostomus snyderi* Gilbert. Klamath Large-scaled Sucker.
37. *Catostomus humboldtianus* Snyder. Humboldt Sucker.
38. *Xyrauchen texanus* (Abbott). Razorback Sucker.

Family Cyprinidae. The Carp or Minnow Family.

39. *Cyprinus carpio* Linné. Carp.*
40. *Carassius auratus* (Linné). Goldfish.*
41. *Tinca tinca* (Linné). Tench.*
42. *Notemigonus crysoleucas* (Mitchill). Golden Shiner.*
    42a. *Notemigonus crysoleucas auratus* Rafinesque. Western Golden Shiner.*
43. *Orthodon microlepidotus* (Ayres). Greaser Blackfish.
44. *Mylopharodon conocephalus* (Baird and Girard). Hardhead.
45. *Lavinia exilicauda* Baird and Girard. Hitch.
    45a. *Lavinia exilicauda exilicauda* Baird and Girard. Sacramento Hitch.
    45b. *Lavinia exilicauda harengus* Girard. Monterey Hitch.
46. *Ptychocheilus grandis* (Ayres). Sacramento Squawfish.
47. *Ptychocheilus lucius* Girard. Colorado River Squawfish.
48. *Gila robusta* Baird and Girard. Bonytail Chub.
    48a. *Gila robusta elegans* Baird and Girard. Colorado River Bonytail Chub.
49. *Gila oreuttii* (Eigenmann and Eigenmann). Southern California Chub.
50. *Gila coerulea* (Girard). Klamath Chub.
51. *Gila crassicauda* (Baird and Girard). Thicktail Chub.
52. *Pogonichthys macrolepidotus* (Ayres). Splittail.
53. *Richardsonius egregius* (Girard). Lahontan Red-sided Shiner.
54. *Hesperoleucus symmetricus* (Baird and Girard). Western Roach.
    54a. *Hesperoleucus symmetricus symmetricus* (Baird and Girard). Sacramento Western Roach.
    54b. *Hesperoleucus symmetricus subditus* Snyder. Monterey Western Roach.
55. *Hesperoleucus navarroensis* Snyder. Navarro Roach.
56. *Hesperoleucus parvipinnis* Snyder. Short-finned Roach.
57. *Hesperoleucus venustus* Snyder. Venus Roach.
58. *Hesperoleucus mitrulus* Snyder. Northern Roach.
59. *Siphateles bicolor* (Girard). Tui Chub.
    59a. *Siphateles bicolor bicolor* (Girard). Klamath Tui Chub.
    59b. *Siphateles bicolor obesus* (Girard). Coarse-rakered Tui Chub.
    59c. *Siphateles bicolor pectinifer* (Snyder). Fine-rakered Tui Chub.
    59d. *Siphateles bicolor formosus* (Girard). Sacramento Tui Chub.
60. *Siphateles mohavensis* Snyder. Mohave Chub.
61. *Rhinichthys osculus* (Girard). Speckled Dace.
    61a. *Rhinichthys osculus robustus* (Rutter). Lahontan Speckled Dace.
    61b. *Rhinichthys osculus carringtonii* (Cope). Pacific Speckled Dace.
    61c. *Rhinichthys osculus klamathensis* (Evermann and Meek). Klamath Speckled Dace.
    61d. *Rhinichthys osculus nevadensis* Gilbert. Nevada Speckled Dace.
62. *Plagopterus argentissimus* Cope. Woundfin.

Family Ameiuridae. The Catfish Family.

63. *Ictalurus lacustris* (Walbaum). Channel Catfish.*
    63a. *Ictalurus lacustris punctatus* (Rafinesque). Southern Channel Catfish.*
64. *Ictalurus catus* (Linné). White Catfish.*
65. *Ameiurus nebulosus* (Le Sueur). Brown Bullhead.*
    65a. *Ameiurus nebulosus nebulosus* (Le Sueur). Northern Brown Bullhead.*
66. *Ameiurus melas* (Rafinesque). Black Bullhead.*
    66a. *Ameiurus melas melas* (Rafinesque). Northern Black Bullhead.*
67. *Ameiurus natalis* (Le Sueur). Yellow Bullhead.*
    67a. *Ameiurus natalis natalis* (Le Sueur). Northern Yellow Bullhead.*

Family Cyprinodontidae. The Killifish Family.
68. *Fundulus parvipinnis* Girard. California Killifish.
68a. *Fundulus parvipinnis parvipinnis* Girard. Southern California Killifish.
69. *Cyprinodon macularius* Baird and Girard. Desert Pupfish.
70. *Cyprinodon nevadensis* Eigenmann and Eigenmann. Nevada Pupfish.
70a. *Cyprinodon nevadensis nevadensis* Eigenmann and Eigenmann. Saratoga Nevada Pupfish.
70b. *Cyprinodon nevadensis amargosae* Miller. Amargosa Nevada Pupfish.
70c. *Cyprinodon nevadensis calidae* Miller. Tecopa Nevada Pupfish.
70d. *Cyprinodon nevadensis shoshone* Miller. Shoshone Nevada Pupfish.
71. *Cyprinodon salinus* Miller. Salt Creek Pupfish.
72. *Cyprinodon radiosus* Miller. Owens Valley Pupfish.

Family Poeciliidae. The Top-minnow Family.
73. *Gambusia affinis* (Baird and Girard). Mosquitofish.*
73a. *Gambusia affinis affinis* (Baird and Girard). Western Mosquitofish.*

Family Pleuronectidae. The Right-handed Flounder Family.
74. *Platichthys stellatus* (Pallas). Starry Flounder. O

Family Serranidae. The Sea Bass Family.
75. *Roccus saxatilis* (Walbaum). Striped Bass.*

Family Percidae. The Perch Family.
76. *Perca flavescens* (Mitchill). Yellow Perch.*

Family Centrarchidae. The Sunfish Family.
77. *Micropterus dolomieu* Lacépède. Smallmouth Black Bass.*
77a. *Micropterus dolomieu dolomieu* Lacépède. Northern Smallmouth Black Bass.*
78. *Micropterus punctulatus* (Rafinesque). Spotted Black Bass.*
78a. *Micropterus punctulatus punctulatus* (Rafinesque). Northern Spotted Black Bass.*
79. *Micropterus salmoides* (Lacépède). Largemouth Black Bass.*
80. *Chaenobryttus coronarius* (Bartram). Warmouth.*
81. *Lepomis cyanellus* Rafinesque. Green Sunfish.*
82. *Lepomis gibbosus* (Linné). Pumpkinseed.*
83. *Lepomis macrochirus* Rafinesque. Bluegill.*
83a. *Lepomis macrochirus macrochirus* Rafinesque. Common Bluegill.*
84. *Archoplites interruptus* (Girard). Sacramento Perch.
85. *Pomoxis annularis* Rafinesque. White Crappie.*
86. *Pomoxis nigro-maculatus* (Le Sueur). Black Crappie.*

Family Mugilidae. The Mullet Family.
87. *Mugil cephalus* Linné. Striped Mullet. O

Family Embiotocidae. The Viviparous Perch Family.
88. *Cymatogaster aggregata* Gibbons. Shiner Perch. O
89. *Hysterocarpus traskii* Gibbons. Fresh-water Viviparous Perch.

Family Cottidae. The Sculpin Family.
90. *Cottus gulosus* (Girard). Riffle Sculpin.
91. *Cottus asperrimus* Rutter. Rough Sculpin.
92. *Cottus macrops* Rutter. Bigeye Sculpin.
93. *Cottus asper* Richardson. Prickly Sculpin.
94. *Cottus bairdii* Girard. Baird Sculpin.
94a. *Cottus bairdii beldingii* Eigenmann and Eigenmann. Mountain Baird Sculpin.
94b. *Cottus bairdii shasta* Jordan and Starks. Shasta Baird Sculpin.
95. *Cottus klamathensis* Gilbert. Klamath Sculpin.
96. *Cottus aleuticus* Gilbert. Aleutian Sculpin.
97. *Leptocottus armatus* Girard. Staghorn Sculpin. O

Family Gasterosteidae. The Stickleback Family.
98. *Gasterosteus aculeatus* Linné. Three-spined Stickleback.

Family Gobiidae. The Goby Family.
99. *Eucyclogobius newberryi* (Girard). Tidewater Goby.
100. *Gillichthys mirabilis* Cooper. Longjaw Mudsucker. O
101. *Clevelandia ios* (Jordan and Gilbert). Arrow Goby. O

SUPPLEMENTARY LIST

Exotic Species—Unsuccessfully Introduced or of Uncertain Occurrence

The exotic fishes listed below fall into several groups:

(1) Fishes known to have been introduced but which have not survived; e.g., No. 16.
(2) Fishes reported—possibly erroneously—to have been introduced, but which have not survived; e.g., No. 8.
(3) Fishes introduced so recently that their survival is uncertain (e.g., No. 4a), or which are not known to have established breeding populations (e.g., No. 22).
(4) Fishes which have been reported from this State but whose identification is questioned by the authors; e.g., No. 13.
(5) Fishes which have not been recorded from the State for many years; e.g., No. 15a.

As will be seen by our annotations, we know of no demonstrable evidence that any of them are successfully established in the fresh waters of California today.

The general sources for the history and lack of success of most of these introductions are fairly well known. Therefore, there is little point in listing all the references concerning the status of these fishes. We have alluded to specific literature only when our opinion differs from that of the authors cited, or when such inclusion serves to clarify the exact status of the species.

Family Chanidae. The Milkfish Family.

1. *Chanos chanos* (Forskål). Milkfish.*

Milkfish from the Hawaiian Islands were planted in a stream in Solano County in 1877. There are no records of their survival there. The species is an ocean fish which occasionally enters fresh water.

Family Salmonidae. The Salmon and Trout Family.

2. *Salmo salar* Linné. Atlantic Salmon.*
2a. *Salmo salar salar* Linné. Atlantic Salmon (anadromous form).*
2b. *Salmo salar sebago* Girard. Landlocked Atlantic Salmon (fresh-water form).*

Both subspecies have been planted several times. The old records of their survival may be dubious; there are no authentic recent records.

3. *Salmo clarkii* Richardson. Cutthroat Trout.
3a. *Salmo clarkii lewisi* (Girard). Yellowstone Cutthroat Trout.*

Several shipments of Cutthroat Trout eggs have been brought in from other states, and plants made in California waters. It is probable that most of these were *S. c. lewisi*.

4. *Salmo gairdnerii* Richardson. Rainbow Trout.
4a. *Salmo gairdnerii kamloops* (Jordan). Kamloops Rainbow Trout.*

The only plant of Kamloops in California waters was made in June 1950, when 1,000 yearlings were released in tributaries of Shasta Lake, Shasta County. See Wales (1950).

5. *Coregonus clupeaformis* (Mitchill). Lake Whitefish.*
5a. *Coregonus clupeaformis clupeaformis* (Mitchill). Great Lakes Whitefish.*

All plants were made during the last century. Even the few old reports of recapture (*circa* 1880) are considered highly dubious.

Family Thymallidae. The Grayling Family.

6. *Thymallus signifer* (Richardson). Arctic Grayling.*
6a. *Thymallus signifer tricolor* Cope. American Arctic Grayling.*

Several repeated attempts have been made to introduce this form, and it apparently met with a brief success in Yosemite National Park following plants made during the 1929-1933 period. The last authentic report of its survival there (in Grayling Lake) appears to have been in 1934. Its present occurrence is highly doubtful.

Family Esocidae. The Pike Family.

7. *Esox masquinongy* Mitchill. Muskellunge.*

7a. *Esox masquinongy ohioensis* Kirtland. Chautauqua Muskellunge.*

Introduced into Lake Merced, San Francisco County, in 1893. None survived.

8. *Esox lucius* Linné. Pike.*

9. *Esox vermiculatus* Le Sueur. Grass Pickerel.*

E. lucius was supposedly introduced in 1891, but one of the fish resulting from this shipment was identified in 1896 as *E. vermiculatus*. Possibly both species were included. There are no records of capture of either species after 1896.

Family Characidae. The Characid Family.

10. *Astyanax fasciatus* (Cuvier). Banded Tetra.*

10a. *Astyanax fasciatus mexicanus* (Filippi). Texas Banded Tetra.*

According to Evans and Douglas (1950) this species as well as *Agosia chrysogaster, Pimephales promelas confertus* and *Fundulus zebrinus* have been sold as live bait along the Arizona-California boundary in recent years. Since they have been used in the Colorado River it is possible that some have escaped into this water. None has actually been observed in the river itself.

Family Cyprinidae. The Carp or Minnow Family.

11. *Agosia chrysogaster* Girard. Longfin Dace.*

See No. 10a.

12. *Pimephales promelas* Rafinesque. Fathead Minnow.*

12a. *Pimephales promelas confertus* (Girard). Southwestern Fathead Minnow.*

See No. 10a.

Family Ameiuridae. The Catfish Family.

13. *Ictalurus furcatus* (Cuvier and Valenciennes). Blue Catfish.*

14. *Ameiurus platycephalus* Girard. Flat Bullhead.*

On the basis of a survey made in 1925, Coleman (1930) records "The Great Blue, or Forked-Tail Cat—*Ictalurus furcatus,* Cuv. and Vincen.," and "The Brown-spotted Cat—Ameirus (*sic.*) *platycephalus,* Girard," from Clear Lake, Lake County. Neither has been recorded from the lake since that time, despite extensive collecting. Hence Coleman's paper is the sole evidence for the existence of these species in California. We believe that he confused *Ictalurus catus* (which *is* found in Clear Lake and which is often called "forked-tail catfish" or "blue cat") with his *"furcatus."* We suspect that his record of *A. platycephalus* is based upon his erroneous interpretation of fishermen's reports.

15. *Ameiurus melas* (Rafinesque). Black Bullhead.*

15a. *Ameiurus melas catulus* (Girard). Southern Black Bullhead.*

A collection from the Colorado River at the mouth of the Gila River in 1904 included this subspecies, according to Robert R. Miller. We know of no later records from California.

Family Anguillidae. The Fresh-water Eel Family.

16. *Anguilla bostoniensis* (Le Sueur). American Eel.*

Introduced in 1874, 1879, and 1882. There are no authentic records of survival.

Family Cyprinodontidae. The Killifish Family.

17. *Oryzias latipes* (Temminck and Schlegel). Medaka.*

The statement by Snyder (1935), "It has been found in San Francisquito Creek," and Coates (1942, p. 185), ". . . this fish has been turned loose in . . . parts of California, where it is reported to be thriving," are the sole bases for its admission to this list. In a conversation with Snyder on March 21, 1943, he told us (W. A. D.) that some of his students had collected this form in San Francisquito Creek, Santa Clara County. He did not recall the date or other circumstances.

18. *Fundulus zebrinus* (Jordan and Gilbert). Southern Plains Killifish.*

See No. 10a.

Family Percidae. The Perch Family.

19. *Stizostedion vitreum* (Mitchill). Walleye.*

19a. *Stizostedion vitreum vitreum* (Mitchill). Yellow Walleye.*

Introduced in 1874. No records of continued survival.

Family Centrarchidae. The Sunfish Family.[1]

20. *Enneacanthus gloriosus* (Holbrook). Blue-spotted Sunfish.*

This species is listed in the accession list for Steinhart Aquarium as having been collected in March 1931, in the vicinity of Willows, California. The identification was made by Alvin Seale, but the specimens were not saved. We believe this to be a misidentification.

21. *Ambloplites rupestris* (Rafinesque). Rock Bass.*

21a. *Ambloplites rupestris rupestris* (Rafinesque). Northern Rock Bass.*

It is recorded in literature as having been introduced in 1874 and again in 1891, and another record of a plant of "Rock bass" in 1917 was furnished W. A. D. by E. H. Glidden. Brief statements by Neale (1931, p. 12) and Anon. (1934) as to its limited success in California, and its occasional listing in State fish rescue records up to 1939, are the only bases for belief that this fish ever endured. The terminology used in these rescue records (published in the Biennial Reports of the California Division of Fish and Game) has often been inexact. We have been unable to find a single verifiable record of the occurrence of the Rock bass in California.

Family Gobiidae. The Goby Family.

22. *Gillichthys detrusus* Gilbert and Scofield. Gulf Mudsucker.*

Evans and Douglas (1950) give several recent records of this form from the Salton Sea and state that it has been sold at Winterhaven, California, and Topock, Arizona, for use as bait. As yet there is no conclusive evidence that it has established itself in California waters.

---

[1] "*Lepomis euryorus* McKay." Seale (1930) lists "Sunfish. *Eupomotis euryoris*" in an article entitled, "List of twenty fresh water fishes found in California that may be used in small aquariums or garden pools." The Steinhart Aquarium accession list for 1931 records "*Apomotis euryorus*" as collected near Willows, California. The identification was made by Alvin Seale; the specimens were not saved. Hubbs and Hubbs (1932) have proved that the nominal species "*Lepomis euryorus*" is a hybrid between *Lepomis cyanellus* and *Lepomis gibbosus*. Both of these species are known to be present in California but *L. gibbosus* has not yet been recorded from near Willows, nor do we have any records of its presence in the State as early as 1930 or 1931.

REFERENCES

American Fisheries Society
1948. A list of common and scientific names of the better known fishes of the United States and Canada. American Fisheries Society, Special Publication no. 1. 45 pp.

Anon.
1934. The rock bass *(Ambloplites rupestris)*. The Aquarium Journal, vol. 7, no. 10, p. 192.

Coates, Christopher W.
1942. Tropical fishes for a private aquarium. The World Publishing Co., Cleveland and New York. xi + 226 pp.

Coleman, George A.
1930. A biological survey of Clear Lake, Lake County. California Fish and Game, vol. 16, no. 3, pp. 221-227.

Evans, Willis A. and Philip A. Douglas
1950. Notes on fishes recently introduced into Southern California. California Fish and Game, vol. 36, no. 4, pp. 435-436.

Evermann, Barton Warren and Howard Walton Clark
1931. A distributional list of the species of freshwater fishes known to occur in California. California Division of Fish and Game, Fish Bulletin 35. 67 pp.

Grinnell, Joseph and Alden H. Miller
1944. The distribution of the birds of California. Cooper Ornithological Club. Pacific Coast Avifauna, no. 27. Berkeley, California. 608 pp.

Hubbs, Carl L. and Laura C. Hubbs
1932. Experimental verification of natural hybridization between distinct genera of sunfishes. Papers of the Michigan Academy of Science, Arts and Letters, vol. XV, 1931, pp. 427-437.

Neale, George
1931. The spiny-rayed game fishes of the California inland waters. California Fish and Game, vol. 17, no. 1, pp. 1-17.

Outdoor Writers Association of America
1948. Standard check list of common names for principal American sport fishes. 24 pp.

Roedel, Phil M.
1948. Common marine fishes of California. California Division of Fish and Game, Fish Bulletin 68. 150 pp.

Seale, Alvin
1930. List of twenty fresh water fishes found in California that may be used in small aquariums or garden pools. The Aquarium Journal, vol. 3, no. 7, pp. 38-39.

Snyder, J. O.
1935. California fresh water fish. The Aquarium Journal, vol. 8, no. 9, p. 146.

Wales, J. H.
1950. Introduction of Kamloops Rainbow Trout into California. California Fish and Game, vol. 36, no. 4, p. 437.

Walford, Lionel A.
1931. Handbook of common commercial and game fishes of California. California Division of Fish and Game, Fish Bulletin 28. 181 pp.

PERFORATED PLATE FISH SCREENS[1]

By J. H. Wales, E. W. Murphey, and John Handley
Bureau of Fish Conservation
California Division of Fish and Game

INTRODUCTION

The screening of irrigation ditches and mining and power conduits to prevent the loss of fish has been a serious problem since the time water was first diverted from the rivers and streams of California. With the ever increasing use of water in this State the screening of these diversions for the protection of fish has become a major concern of conservationists. In 1945, the Bureau of Fish Conservation of the California Division of Fish and Game was given charge of fish screen installation and maintenance except in the Central Valley area. The improvement of existing fish screen designs was one of the primary objectives of the new Fish Screen and Stream Improvement Detail. In 1947 a new type of screen, consisting basically of a perforated metal plate, was designed by E. W. Murphey, and it is with this recent design that this paper deals.

It is evident that a screen in a diversion ditch will quickly plug up with debris and prevent water from passing through. Consequently, a self-cleaning device must be provided. Before the development of the perforated plate screen, there were two types of self-cleaning screens in common use in California: a stationary or "parallel bar" screen, and a revolving or "rotary" screen. The first type, a frame of closely spaced parallel bars resting at an angle in the ditch, is equipped with cleaner bars attached to endless chains. These are drawn up the face of the screen, over the top, down the back side, and then under the bottom of the screen through a rubber seal. The rotary screen is simply a drum covered with wire mesh. Debris which collects on it is carried up and over the top as it revolves. Rubber seals are provided at the bottom of the drum and at each end to make it fish-tight. Both types of screens are almost identical in their mechanical drive parts, which consist of a paddle wheel to furnish driving power, and chains and sprockets, or shaft and bevel gears, to transmit the power which rotates the round screen or operates the cleaners on the bar type.

Serious mechanical defects have been apparent in both screens. The openings in the parallel bar screens are too large to exclude small fish, and neither the bottom seal nor the cleaning method is satisfactory. The newer California rotary screens are a distinct improvement in that much smaller openings ($\frac{1}{8}''$ x $\frac{1}{8}''$ mesh), which stop most fish, can be used. However, the rubber seals are difficult to keep fish-tight. They cannot be examined without lifting the entire screen, and because the screens are very heavy the seals have not ordinarily been checked more than once a year. Considerable power is required to turn the heavy rotary screens,

[1] Submitted for publication June 1950.

and their gears or chains lose power through friction. Variation in water flow also disturbs the efficiency of the rotary screen; the flow must remain almost constant if the screen is to be kept clean and still not overflow. In both rotary and bar screens part of the mechanical drive operates under water, where the gears and bearings are quickly worn out by sand and fouled by rust.

Summing it up, we can say that an adequate screen requires:

(1) Smaller openings than those used in the bar type.
(2) Elimination of side and bottom rubber seals.
(3) A minimum of water power to move the cleaning device.
(4) The ability to operate at variable flows.
(5) Bearings and working parts above water level.

The new perforated plate screen not only meets these requirements far better than the older types, but is also cheaper and easier to build and maintain.

DESCRIPTION OF THE NEW PERFORATED PLATE SCREEN

The Automatic Cleaning Device

Basically the new fish screen consists of a perforated metal plate, with circular openings of $\frac{5}{32}$ inch diameter, which is placed in the ditch at an angle of approximately 32 degrees. Directly behind it, as shown in Figure 153, there is an improved paddle wheel which provides the power to operate a wiper bar which travels up and down over the surface of the plate.

The wiper bar is the most revolutionary feature of this new screen. There are many possible designs and materials of which it can be constructed. One successful bar used on a direct drive model is illustrated in Figure 153. It is a length of $\frac{3}{16}''$ bar steel $3\frac{1}{2}''$ wide and bent longitudinally so that its beveled edges will cut underneath the debris on both the up stroke and the down stroke. A soft rubber wiper is not as desirable as a thin, hard edge of wood, metal, or some synthetic material. The two edges of the wiper blade should be fairly sharp, so that they will cut under the debris—not crush and roll over it. Also, the bearing surfaces of the wiper blade should be hard, to minimize friction and wear.

Because of this radically different type of cleaner it is possible to seal the bottom edge as well as the sides of the plate so that no fish are able to get under or around these edges. In developing the wiping bar, Murphey found that a scraper pushed down across the face of the plate carried all the debris ahead of it until it reached the unperforated (selvage) margin along the lower edge of the plate. There is no current of water through this unperforated edge and the flowing water strikes it and sweeps up and over the cleaner bar, carrying the debris with it. The material is thus automatically swept onto the upper edge of the cleaner bar, and when the bar is pulled back up again it takes the debris up with it. It is a very simple matter to arrange the cleaner and the plate so that the debris can either be dropped over the edge of the plate into the water below the screen or deposited on the perforated plate just short of the edge. Where this latter method is used small fish have a chance to flip back into the water. If a by-pass flow is provided the small fish usually can escape by that route and will not lie on the plate.

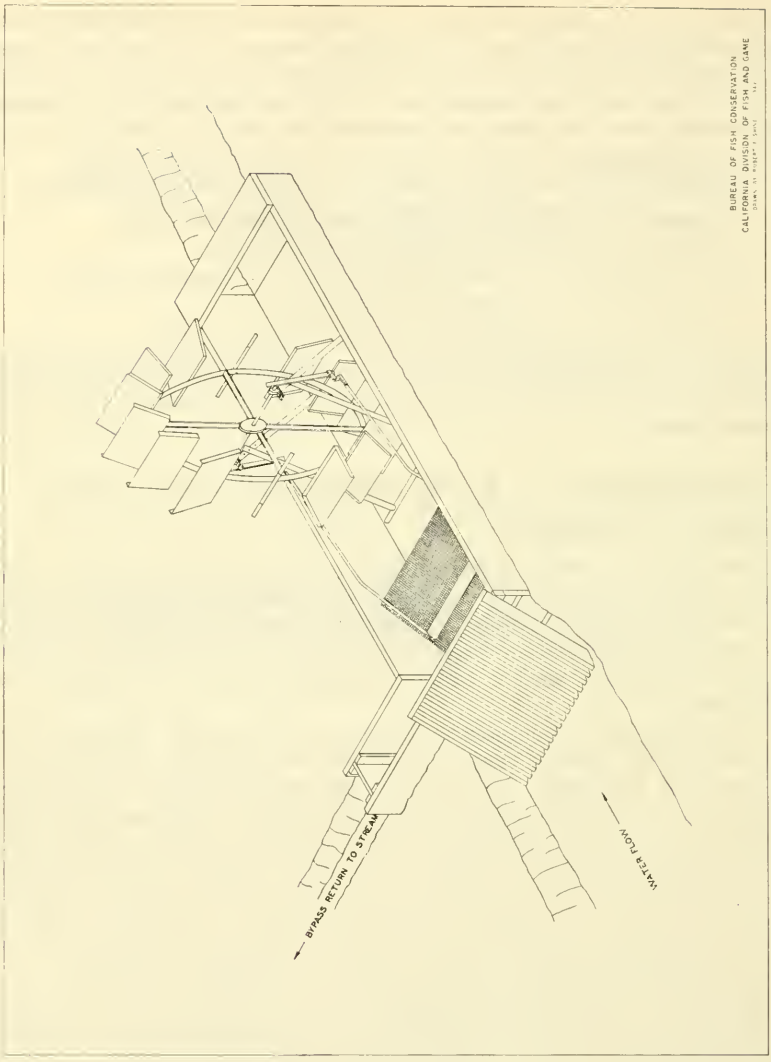

FIGURE 153. View of perforated plate fish screen with direct drive cleaner assembly

Several different types of driving mechanisms have been developed for this wiping arm. The first one devised by Murphey, shown in Figures 153 and 154, has a direct drive. It is the most practical type for small irrigation ditches with a moderately swift flow of water. The "direct drive" has no gears to slow it down or to increase its power. The paddle wheel is made quite large, and this tends to serve the same purpose. Some variation in the length and power of the stroke of the cleaner can be achieved by changing the location of the pivot point between cleaner arm and crank arm. The "direct drive" screen is inexpensive and simple to build. A perforated plate 40 inches x 6 feet appears to be the optimum size for use with this type of cleaner. The estimated cost for construction and installation of a 3′ x 4′ screen of the direct drive type is $243.

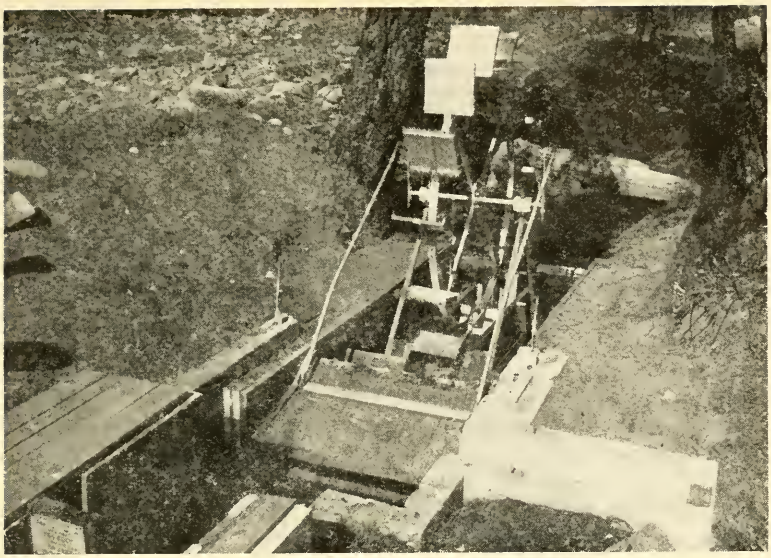

FIGURE 154. Direct drive model, perforated plate fish screen. Dimensions of plate 3 feet by 4 feet. Flow capacity of this screen from 1 to 4.5 c. f. s. Installed on Indian Creek, a tributary of the Trinity River, Trinity County, California. This screen has been installed in a part of the foundation chamber formerly occupied by a rotary screen

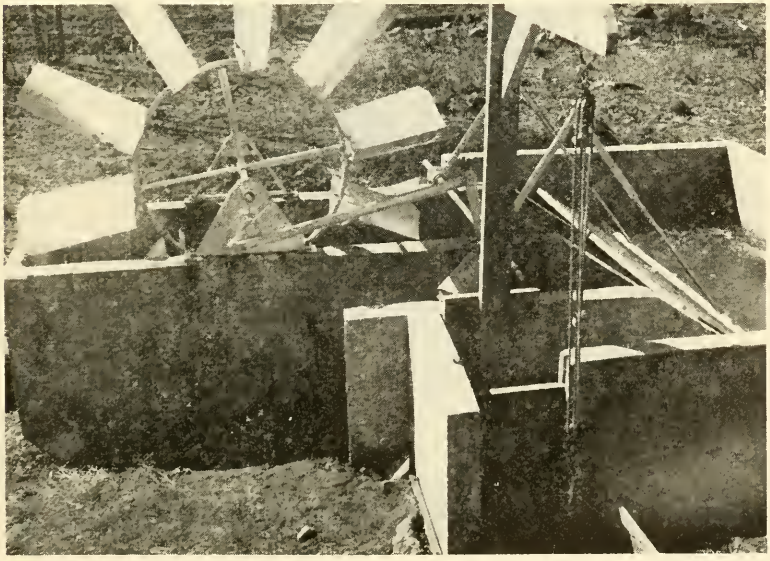

FIGURE 155. Geared model, perforated plate fish screen. Dimensions of plate 4 feet by 8 feet. Flow capacity of this screen from 2 to 9 c. f. s. Installed on Fall Creek, a tributary of the Klamath River, Siskiyou County, California. Trap at outlet of by-pass chamber permits count of fish stopped by screen

A second type of driving mechanism, which utilizes a reducing gear to increase its power and dependability in slowly flowing water has also been developed. In this type, shown in Figures 155 and 156, a small paddle wheel can be used even with a large perforated plate. If a paddle wheel with large blades is provided, a single wheel will generate enough power to turn a long jack shaft driving two or more cleaner bars. The estimated cost of construction and installation of a 3′ x 4′ screen with geared drive is $343.

For large irrigation ditches the size of the perforated plate required to pass large volumes of water may be too great to permit use of the cleaner assemblies just described. A further development, using a hydraulic drive of the sort illustrated in Figure 157, has proved quite satisfactory in a 45-c.f.s. diversion in the Klamath River drainage. There

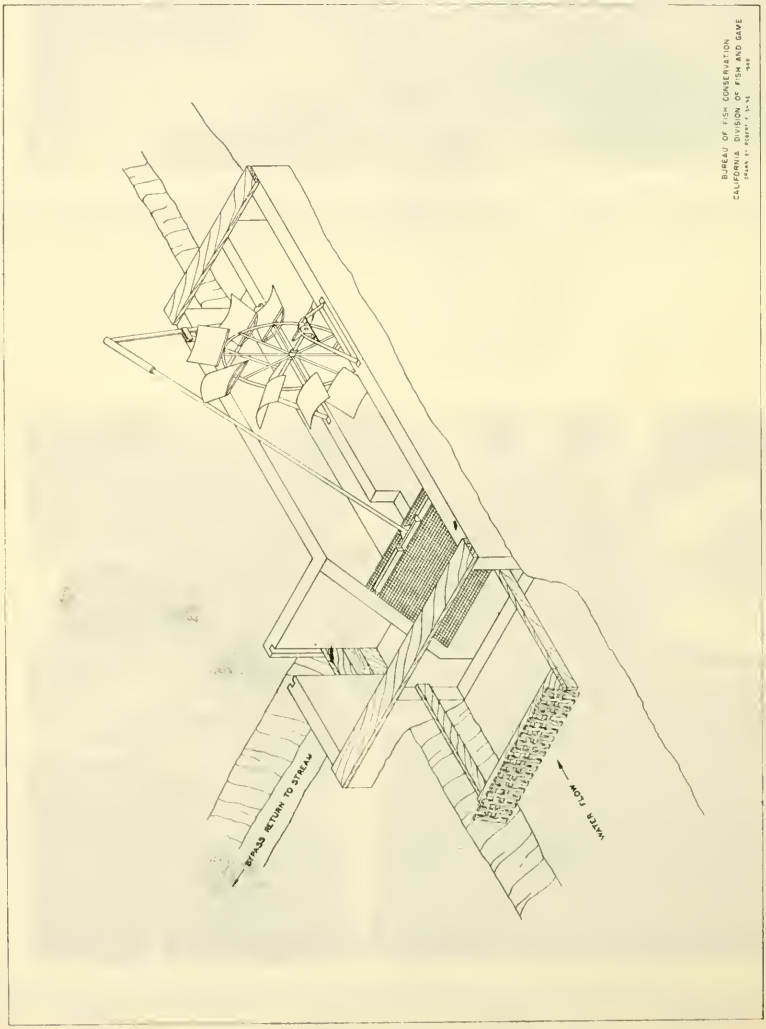

FIGURE 156. View of perforated plate fish screen with gear driven cleaner assembly

are three plates, each 5½ feet wide and 12 feet long. The derrick arms are lifted by an oil pump and double action hydraulic cylinder. When the cleaner bars have been lifted to the top edge of the plate and the debris deposited, a valve is reversed in the cylinder and oil is forced in the opposite direction and the cleaners are pushed back to the bottom of the plate. The valve is then reversed again and the pump forces the oil back into the cylinder and raises the piston and the connected derrick arms. The pump which operates this hydraulic drive is powered by a ¼-h.p. motor at a cost of about 7 cents a day.

A paddle wheel is ordinarily used to drive the cleaning mechanism, although electric motors can often be substituted to advantage, particularly on large diversions of the type just mentioned.

In small irrigation ditches the paddle wheel blades are set with very little clearance. This permits the use of a large part of the available water power, but also increases the chances of stopping the wheel by having small bits of debris wedge between blades and foundation sides. In order to obviate this difficulty a wooden grill should be placed above

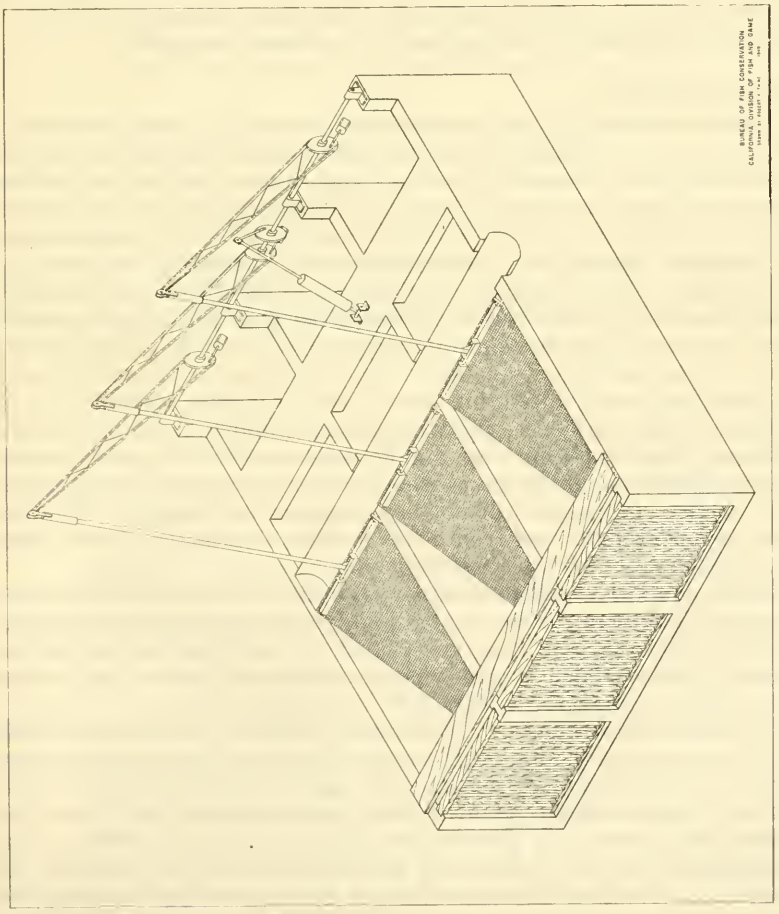

FIGURE 157. View of perforated plate fish screen operated by hydraulic cylinder. Drive assembly is much simplified in the drawing. Motor and pump are not shown

the screen, as shown in Figure 156. Either a stationary grill with bars extending from water surface to ditch bed or the floating grill, shown in Figure 156, will stop the larger pieces of debris. This is highly desirable in locations where there are many tree branches. Such branches can interfere with the cleaner and cleaner arms and should be stopped by a rack or grill. The floating grill shown in Figure 156 is not a complete barrier; therefore it cannot block the entire ditch and back up the water. However, it does stop the floating objects and it will rise and fall as the water level varies.

Even with a debris rack above the screen there are many sticks that get onto the screen and are carried over by the wiper. These sticks can become wedged under the paddle blades and stop the wheel. In order to prevent this the direct drive screen can be equipped with a plate to divert the debris to one side or the other of the paddle wheel. In the gear-driven screen the paddle wheel is set at one side and shielded to exclude the debris.

The paddle blades illustrated in Figure 156 are curved to catch the water and develop more power. The gears are a standard make of machined cast iron with a ratio of $3\frac{1}{2}$ to 1. The remainder of the drive assembly is quite simple and need not be described in detail.

The Perforated Plate

Plate with holes $\frac{5}{32}$ inch in diameter centered $\frac{3}{16}$ inch is now being used in California. However, these specifications should not be accepted as the final choice, since the tests of various combinations of hole size and spacing have not been exhaustive. Obviously, the holes should be as large as possible and yet too small for the smallest fish to pass through. Also, the holes should be as close together as is consistent with strength.

The gauge of thickness of metal plate used for the screen is a matter of some concern. Debris will not become stuck in the holes as readily when the plate is thin, but light gauge plate will not be as flat nor will it wear as long as the heavy gauge material. The use of 12- and 14-gauge steel plate has been favored, but this is not invariable. Possibly if some metal other than steel were used the gauge would have to be changed. Aluminum plate has been tried and found too soft. It is quite possible that something else can be found which will prove more resistant to rust and algae than steel and still not be unreasonably expensive. The perforated plates are obtained from firms making a specialty of such materials regularly used for many other purposes.

Anyone familiar with previous types of fish screens will immediately see the good points in the perforated plate, but the ever-present question of water capacity arises. How large must the plate be for a given flow of water? This problem is somewhat involved and some of the factors which must be considered will now be discussed.

The area of openings in a perforated plate can be computed quite easily. For example, the plates which are being used at present are about 46 percent open. However, this does not mean that 46 percent as much water can pass as would get by without any screen at all. Water does not flow freely through a circular hole and the volume is reduced. Also, a small head of water developed on the upstream side of the screen will increase the velocity of the water flowing through the perforations. For these reasons the calculations of volume which will pass a plate of certain

dimensions become involved. However, the area of the plate screen should be at least twice the cross-sectional area of the conduit and three times the area is not out of reason. Ordinarily the water in the ditch can be backed up slightly without overflowing the ditch bank, but in some cases the ditch banks are so low that backing up cannot be permitted. Also, it must be remembered that debris and rust will reduce the open area in the plate somewhat and allowance for this must be made in the calculations.

The next consideration is of greatest importance. Tests made by Wales (unpublished) indicate that the swimming speed of fingerling trout is in proportion to their length and that a fish one inch long can swim about one foot per second, a fish two inches long can swim about two feet per second, etc. For trout a foot long or less the length of the fish in inches is roughly the same as the swimming speed in feet per second. A great many trout and salmon entering irrigation ditches in California are about *one and one-half inches in length,* so attempts to reduce the velocity of the water flowing through the screen to *one and one-half feet per second* or less have been made. Commonly the velocity of the ditch flow is greater than this and in order to slow it down it is necessary to widen the screen. A young trout or salmon about one and one-half inches in length may be carried down the ditch by water which is too swift for it to swim against but on reaching the screen it comes into water which has been slowed down. Here it can swim about and eventually find its way to the by-pass. If the perforated plate had been smaller the velocity of the water passing through it would have been greater, possibly so great that the small fish would have been drawn onto the plate and held there, unable to escape.

It will be noted in Figures 158 and 159 that a heavy horizontal line has been drawn across the graphs at the velocity point of 1.5 feet per second. For example, from Figure 159 it can be seen that a single panel will pass 4.5 c.f.s. at a velocity of 1.5 feet per second.

The By-pass

With mechanical difficulties minimized, there is still the problem of getting the small fish back into the stream after the screen has stopped them from going down the irrigation ditch. This problem is overcome if a small by-pass flow of water back to the stream is provided immediately above the screen.

The by-pass channel is cut through the ditch bank to the stream from which the water was first diverted. Figures 153 and 156 show a special chamber built in the side of the screen form just upstream from the perforated plate. Small fish upon reaching the perforated plate work across it into this by-pass chamber, where they tend to rest and take shelter. The by-pass gate is provided with check slots into which check boards can be dropped, thus raising the water in the chamber to the desired level. In the top check board of the gate either a hole or a notch may be cut in the upper edge. The size of this opening will vary with the total flow in the irrigation ditch or with the demands of the water owner. For the small and medium size screens it has been found that the by-pass flow can be quite small. In screens using a 3′ x 4′ plate and passing a flow of 1 to 4 c.f.s. a 2″ x 4″ opening in the top check board will pass enough water to attract and allow the passage of the fish and still

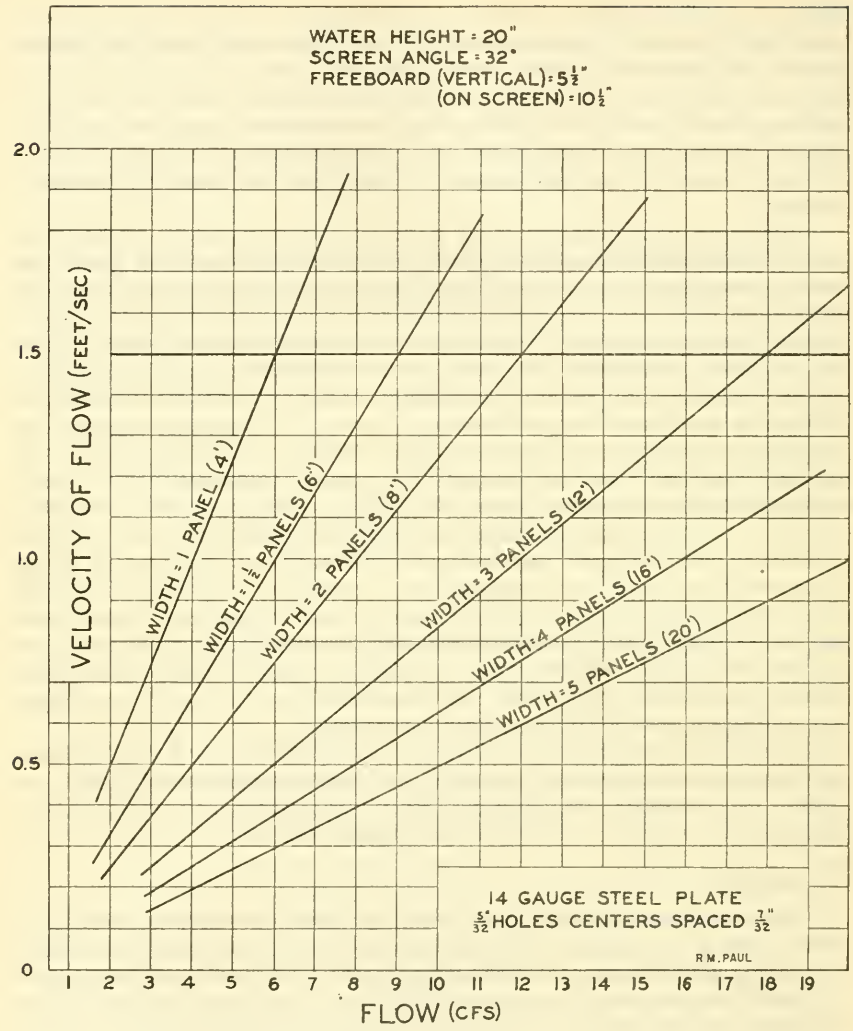

FIGURE 158. Capacity-velocity chart for perforated plates 4 feet high but of different widths. In reading these curves take, for example, the panel 4 feet wide and note that with a water velocity of 1.5 ft. per sec. the volume of water which it will pass is about 6 c. f. s.

not take enough by-pass water to interfere with most irrigation needs. It has not been found necessary to have a submerged opening in the by-pass gate to attract the fish. However, such an opening will function in spite of variations in the water level, whereas a notch in the top edge of the by-pass gate would become useless if the water level dropped appreciably.

Small by-pass holes have one serious disadvantage in that they can become clogged by a twig, a few leaves, or a pine cone. Larger openings will become clogged much less frequently. In order to avoid obstruction of the by-pass hole a grill can be dropped into slots at the entrance

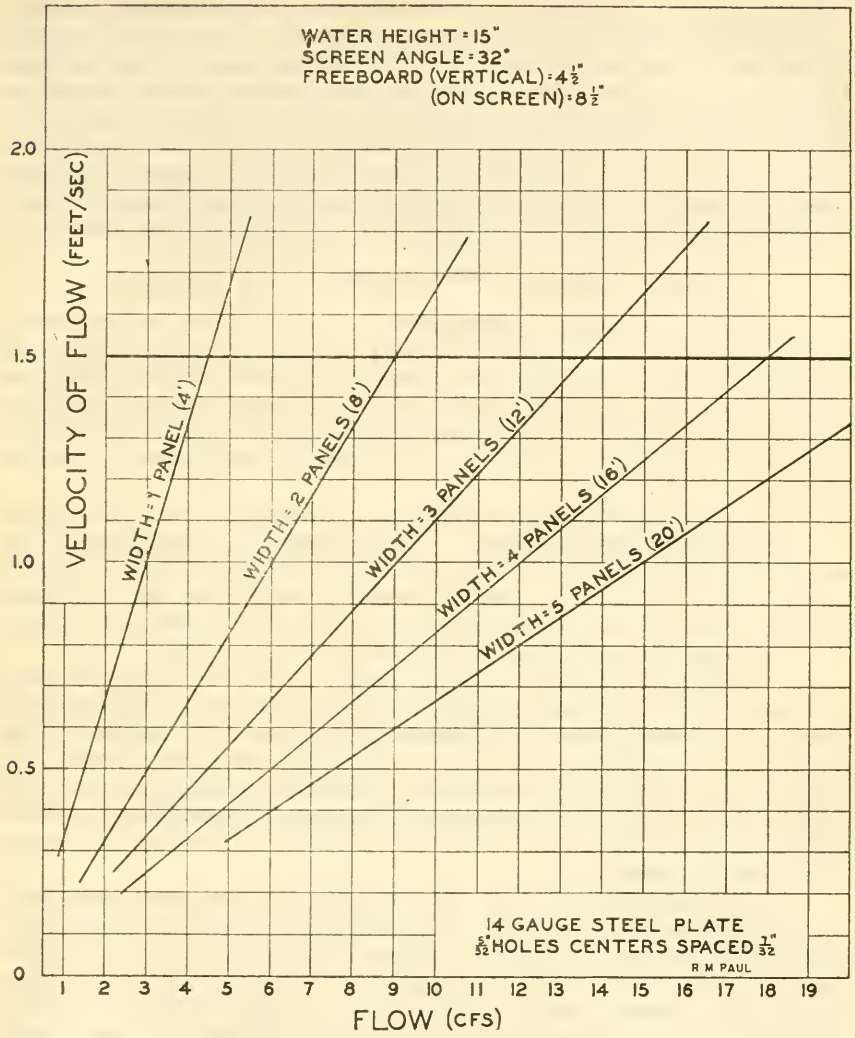

FIGURE 159. Capacity-velocity chart for perforated plates 3 feet high but of different widths. In reading these curves take, for example, the panel 4 feet wide and note that with a water velocity of 1.5 ft. per sec. the volume of water which it will pass is about 4.5 c. f. s.

to the by-pass chamber. This grill will catch a great deal of debris before it becomes so clogged that fish cannot get by. Even though the serviceman may visit the screen once a week it is always possible that the by-pass opening will become clogged a few minutes after he has left and no fish will be able to escape for days.

TESTING THE NEW SCREEN

Tests were made in 1949 to determine the effectiveness of a newly installed perforated plate screen with a direct drive cleaner. This screen was located in a small Trinity County ditch with an average flow of

about 2 c.f.s. A trap was placed in the by-pass and in addition a trough was arranged to catch any fish which might be carried over the plate by the wiper bar. In five tests of 24 hours each a total of 555 fish was trapped in the by-pass and only one fish was carried over by the wiper bar. It can be seen that in three months possibly 10,212 fish were saved by this one small screen. Tests similar to this are being conducted each season in other ditches scattered through Trinity and Siskiyou Counties. Some of these tests indicate a much greater saving of small salmonids, and a special report on these experiments will be made at a later date.

POSSIBLE USES OF PERFORATED PLATE SCREENS

In California the perforated plate screens will be used primarily in irrigation ditches. Some will be used in hydroelectric conduits and possibly some will find places in other commercial conduits. They are now also being used in fish hatcheries to keep debris out of ponds and troughs, and to prevent the movement of fish from pond to pond. These screens are also highly suitable for experimental installations of various types.

There would seem to be no limit to the amount of water which could be screened by perforated plate. A small direct drive model which can operate on a minimum of $\frac{1}{2}$ c.f.s. has been constructed, but, of course, much smaller plate screens can be made if needed. From this minimum the plate screens can be increased by setting small plates side by side or by increasing the depth as well as the width of the plate.

It is believed advisable to clean screen plates over four feet deep by some system other than the paddle wheel assemblies described herein. One such cleaner system is illustrated in Figure 157. Ordinarily the depth of a fish screen will be limited to about 15 feet. This limitation is imposed by factors other than screen mechanics. After the depth limit has been reached there is, theoretically, no limit to the width of a screen, and so we may assume that there is no limit to the amount of water which can be passed.

The perforated plate screen, like the rotary, can be made impassable for most young fish simply by using sufficiently small perforations or screen mesh which is fine enough. However, the plate screen, unlike the rotary, is fish tight at sides and bottom. For young trout and salmon the $\frac{5}{32}''$ hole is small enough to effect 100 percent exclusion. Therefore, if precautions are taken to avoid drawing the fish over with the cleaner bar, 100 percent stoppage of these fish can be expected.

The cost of the perforated plate screen is far less than that of any other self-cleaning fish screen. Some idea of the costs of small models can be obtained from the figures given earlier in this paper. Naturally, the cost of a fish screen would be of limited importance if its other features were inferior to the earlier types of screens, but since the perforated plate screen is superior in all important respects to other mechanical screens, the smaller cost is an added inducement for its use.

It has been found that this fish screen is valuable in obtaining an estimate of the number and species of fish descending any ditch. Traps can be placed in the by-pass flow and, in addition, a trough may be placed beneath the upper edge of the screen plate to catch everything which the wiper bar carries over. It has been found that some species, such as young lampreys, will lie on the plate and allow themselves to be carried

over. Similarly, dead or dying fish will be deposited in this debris trough. By using this debris trough and a by-pass trap all the downditch migrants can be captured for enumeration or study. This system has been adapted to the enumeration of king salmon fingerling migrants.

Despite our satisfaction with the perforated plate screen, we do not intend to be blinded to the possibility of discovering other even more satisfactory means of screening water diversions.

Working plans of both the "direct drive" and the geared model screens can be obtained from the Bureau of Fish Conservation, California Division of Fish and Game, Ferry Building, San Francisco 11, California.

UPLAND GAME COOPERATIVE HUNTING AREAS[1]

By Harold T. Harper, George Metcalfe, and John F. Davis
Bureau of Game Conservation
California Division of Fish and Game

INTRODUCTION

Each year California's unattached hunters are finding fewer areas on which to hunt. Most of the State's pheasant population is found in the rice growing region of the Sacramento Valley, which is extensive in size and provides excellent pheasant hunting. Trespass and damage to crops, livestock, fences, and other property by a minority of unsportsmanlike hunters have created an unfriendly situation between sportsmen and landowners. Consequently, available hunting areas have decreased rapidly in the past few years. Opening these areas to controlled pheasant hunting has been one of the most urgent problems confronting the California Division of Fish and Game.

An experimental pheasant study area, the Sartain Ranch, initiated by division game biologists, was instrumental in the development of regulated hunting on private lands in California. Hunting on this ranch was successfully controlled in 1947 and 1948 by the division in cooperation with the landowner. The experience gained in these two years led to the development of a cooperative hunting plan in 1949. In this year Senate Bill No. 677 [2] establishing cooperative hunting areas, was passed by the State Legislature. Rules and regulations for the management and control of these areas were then drawn up by division employees.

In order to minimize the problem of supervision and control, and at the same time to accommodate a large number of hunters, it was required that on any prospective area there be at least 5,000 acres in a continuous tract open to public hunting. A provision was made to allow the landowner to collect a daily fee not to exceed two dollars per hunter if he so desired, with the stipulation that 25 percent of the total collected was to be used for wild life maintenance and habitat improvement. Three types of zones were provided for in 1949: closed zones (for protection of crops, buildings, and livestock) on which no hunting was permitted; restricted zones, on which permission to hunt was granted solely by landowners; and open zones, which were open to public hunting by permit. Restricted zones were limited in size to 20 percent of the total area, while open zones had to be either a 5,000-acre tract or 50 percent of the entire cooperative hunting area, whichever was larger. The maximum number

[1] Submitted for publication June, 1950. Federal Aid in Wildlife Restoration Act, California Project 22-R. The authors wish to express their appreciation for important contributions made by Project 22-R Assistants Dale Shaffer, Chester Hart and Fred Jones. Also, the efforts made by the Bureau of Patrol and Bureau of Game Conservation members to make the cooperative hunting areas a success is gratefully acknowledged.

[2] Senate Bill No. 677 and rules and regulations governing cooperative hunting areas are presented in Appendix A, Items 1 and 2, respectively.

of hunters allowed at any one time was one per five acres of open land, with the stipulation that this could be decreased as conditions warranted.

In preparation for the 1949 pheasant hunting season six cooperative hunting areas were established by the division. Five of these did not charge for hunting privileges, while one did. Included in this one area was a 1,680-acre tract that was open to hunting under the pheasant planting policy and on which no fee was charged.

Each area was posted by the Division of Fish and Game at no expense to the landowner. Posting was done about one week prior to the season and signs were removed immediately after the season. Each type of zone was posted at least every one-fifth mile, the signs designating the type of zone by both wording and color. Table 1 shows the acreage of each type of zone on each cooperative hunting area with the number of hunters allowed on the area at any one time. Figures 160 and 161 show the signs used on the cooperative hunting areas in 1949.

TABLE 1

Size of Each Zone in Cooperative Hunting Areas and Maximum Number of Hunters Permitted on Open Zones

Area	Open zone	Hunters allowed at any one time per day	Restricted zone	Closed zone	Total acres
Staten Island	7,500	600	0	1,700 1,000 open on last day	9,200
Williams	5,000	500	1,300	500	6,800
Sutter Basin	8,900	900	450	2,950 850 open on fourth day	12,300
Natomas	8,800	1,600	1,400	400	10,600
Grimes	15,800	1,600	3,080	320	19,200
Sartain	12,450	2,300	1,500	50	14,000
Totals	58,450	7,500	7,730	5,920 1,850 opened during season	72,100

FIGURE 160. Signs used on cooperative hunting areas

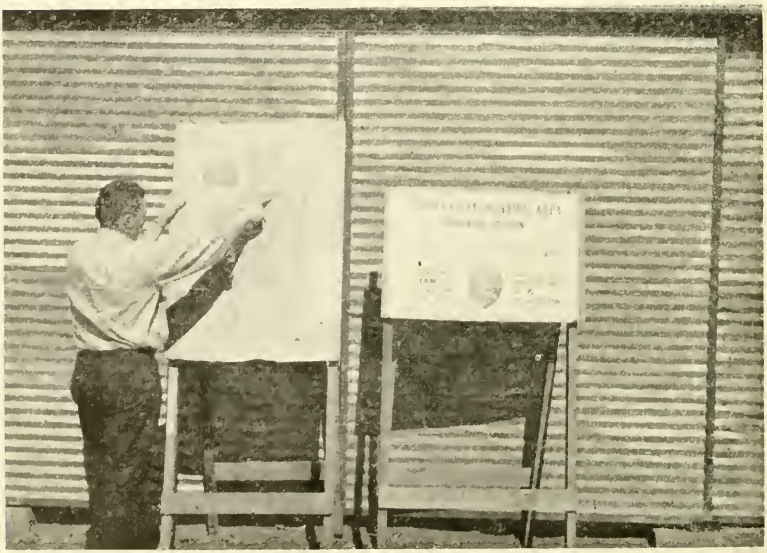

FIGURE 161. Map and checking station sign for Sartain area

Checking and permit stations were set up on easily accessible roads in conspicuous locations. These were operated by division employees where the landowner permitted hunting without charge; however, if a charge was made the landowner was responsible for collecting the fees, but division personnel checked the hunters off the area. Before hunting, each hunter was required to obtain a permit and an arm band, colored to correspond to the signs on the zone for which issued. After the day's hunt, permits and arm bands were returned to the checking stations. To obtain desired information it was required that the questionnaire part of each permit be filled out.

CHECKING METHODS

Permit stations were operated the full 10 days of the season. Each hunter was issued a permit and an arm band with the number of the area on it. Permits and arm bands issued for one particular area were not valid on other areas. Each hunter was given a sheet of instructions and a map showing the boundaries of the area he was on and location of the various zones. Figures 162, 163, and 164 show the type of arm band and permit used.

Hunters were briefed on types of signs enclosing designated zones and were instructed to hunt only in areas posted with signs corresponding to the color of their arm bands.

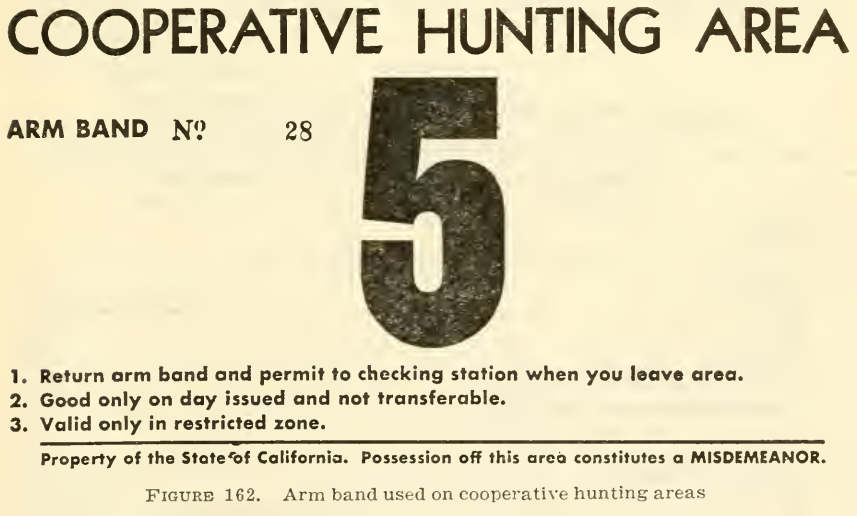

FIGURE 162. Arm band used on cooperative hunting areas

Area No.....

Arm band No.....

Permit Nº 38198

Fee $..... Date.....
Month Day Year

I hereby agree to abide by the Cooperative Hunting Area rules and regulations.

Name.....

Address.....
Street No. City

COOPERATIVE HUNTING AREA PERMIT

Area No..... Arm Band No.....

Permit Nº 38198

I hereby agree to abide by the Cooperative Hunting Area rules and regulations as shown on the reverse side of this permit.

.....
Name of Permittee

the bearer, is hereby granted permission to hunt upon.....
Ranch

.....
or Property

For this day only.....
Month Day Year

.....
Signature of Grantor

RETURN FILLED OUT PERMIT BEFORE LEAVING AREA

KILL RECORD

	PHEASANTS	QUAIL		OTHER (fill in)
		Cock	Hen	
No. Bagged				
No. Crippled and Lost				
Band Nos. (look for leg and wing bands)				

Number of hours hunted on this area.....

Did you use a dog? Yes.....No.....
(check one)

Remarks and Suggestions.....

Use of this area shall be at the sole risk of the permittee, and neither the Division of Fish and Game nor the landowner shall be liable in damages to any permittee.

FIGURE 163. Cooperative hunting area permit form

COOPERATIVE HUNTING AREA
RULES AND REGULATIONS FOR HUNTERS

1. All hunters must obtain valid permits before hunting on the area and return filled out permits before leaving the area or at the end of the day's hunt. Possession of a firearm while on the area without a valid permit shall be considered prima facie evidence of hunting.
2. Permits are valid only for day and area issued.
3. Hunters on cooperative hunting areas must wear an appropriate arm band. Arm bands must be returned to checking station before leaving the area or at the end of the day's hunt.
4. The provisions of the Fish and Game Code apply on these areas. Any person who has had a permit revoked may not obtain a permit to hunt an open cooperative hunting area during the current upland game season.
5. On open areas the Division of Fish and Game reserves the right to refuse to issue a permit to anyone, and to revoke any permit and eject the holder forthwith from the area for unsportsmanlike conduct, or for any reason when it appears that the safety and welfare of the area or that of other permittees is endangered. Decision of the authorized employee of the Division of Fish and Game in this respect shall be final.
6. The Division of Fish and Game will enforce the trespass provisions of the Penal Code and the provisions of the Fish and Game Code within such areas during the upland game season.
7. Use of the area shall be at the sole risk of the permittee, and neither the Division of Fish and Game nor the landowner shall be liable in damages to any permittee.

FIGURE 164. Reverse side, cooperative hunting area permit form

Checking stations opened at 5 a.m. on the first three days and at 7 a.m. on the remaining days of the season. After receiving permits, hunters were directed to designated parking areas posted with "Park Here" signs.

TABLE 2

Numbers of Checking Stations and Personnel on Cooperative Hunting Areas for 1949 Hunting Season

	Day of season									
	1	2	3	4	5	6	7	8	9	10
Permit and checking stations										
Staten Island	2	2	2	2	2	2	2	2	2	2
Williams	3	3	3	2	2	2	2	2	2	2
Sutter Basin	4	4	4	2	2	2	2	2	2	2
Natomas	4	4	4	4	4	4	4	4	4	4
Grimes	5	5	5	4	4	4	4	4	4	4
Sartain	4	4	4	4	3	3	3	3	3	3
Totals	22	22	22	18	17	17	17	17	17	17
Checkers [1]										
Staten Island	8	8	8	4	4	4	7	4	8	8
Williams	8	8	7	5	5	5	5	5	5	5
Sutter Basin	8	8	8	8	6	6	6	8	6	6
Natomas	10	10	10	6	6	6	6	6	6	6
Grimes	21	21	21	11	11	11	11	11	10	10
Sartain	12	12	12	8	8	8	8	8	9	9
Totals	67	67	66	42	40	40	43	42	44	44
Wardens										
Staten Island	4	4	4	4	4	4	4	2	4	4
Williams	4	4	4	2	2	2	2	2	------	------
Sutter Basin	2	2	3	3	4	3	3	6	2	2
Natomas	6	6	6	6	6	6	2	6	6	1
Grimes	4	4	10	4	4	4	4	4	4	4
Sartain	4	4	4	3	3	3	1	3	4	4
Totals	24	24	31	22	23	22	16	23	20	15

[1] On four areas 19 sportsmen assisted in writing permits and directing traffic. These worked mainly during the first three days of the season.

Table 2 shows the number of stations and personnel used on each of the six cooperative hunting areas. Local sportsmen assisted division employees on four areas the first three days of the season, and many landowners assisted with the issuing of permits. This cooperation was gratefully received and was much needed by the division.

Division wardens were present on all areas to enforce trespass rules and game laws. Violations were few and consisted mainly of trespass on restricted zones. This was probably due to inability of hunters to recognize the signs bounding such zones.

DESCRIPTION OF AREAS

The cooperative hunting areas were selected on the basis of capacity to support a maximum number of hunters, heavy pheasant populations, availability to hunters, and willingness of landowners to open their land to controlled hunting. Five areas were located in the Sacramento Valley and one in the Delta region (Figure 165). Table 3 gives the crops and crop acreages for each area. Rice and barley were the principal crops

TABLE 3

Approximate Acreages of Crops on Cooperative Hunting Areas, 1949

	Staten Island	Williams	Sutter Basin	Natomas	Grimes	Sartain
Alfalfa		80				
Asparagus	1,400					
Barley stubble	500		1,050			160
Celery	200					
Fallow rice		300			695	
Field corn	6,100					
Irrigated pasture		380	1,880	285		
Orchard					160	20
Pasture						70
Plowed	450	2,340	7,230	4,535	11,815	9,020
Rice stubble		3,500	2,140	5,780	6,490	4,620
Sorghum		200				
Sugar beets	300					110
Sunflowers					40	
Tomatoes	250					

grown in 1949 on all areas except Staten Island, where truck crops were important.

All areas were traversed by roads and were easily found by hunters from descriptions and directions given in leading newspapers. On Staten Island only one road passed through the area, which simplified the checking problem.

Control of the hunting rights on four of the cooperative areas was divided among several landowners. In these cases one was selected as spokesman for the group. On two areas, Sartain and Staten Island, control of the hunting rights was under one person.

Game farm cocks were released prior to and during the season on all cooperative hunting areas except the Sartain, where birds were liberated only on the pheasant planting policy area.

HUNTING SEASON RESULTS

The following information was obtained from the filled out permits for each day for each area: number of cocks bagged, number crippled

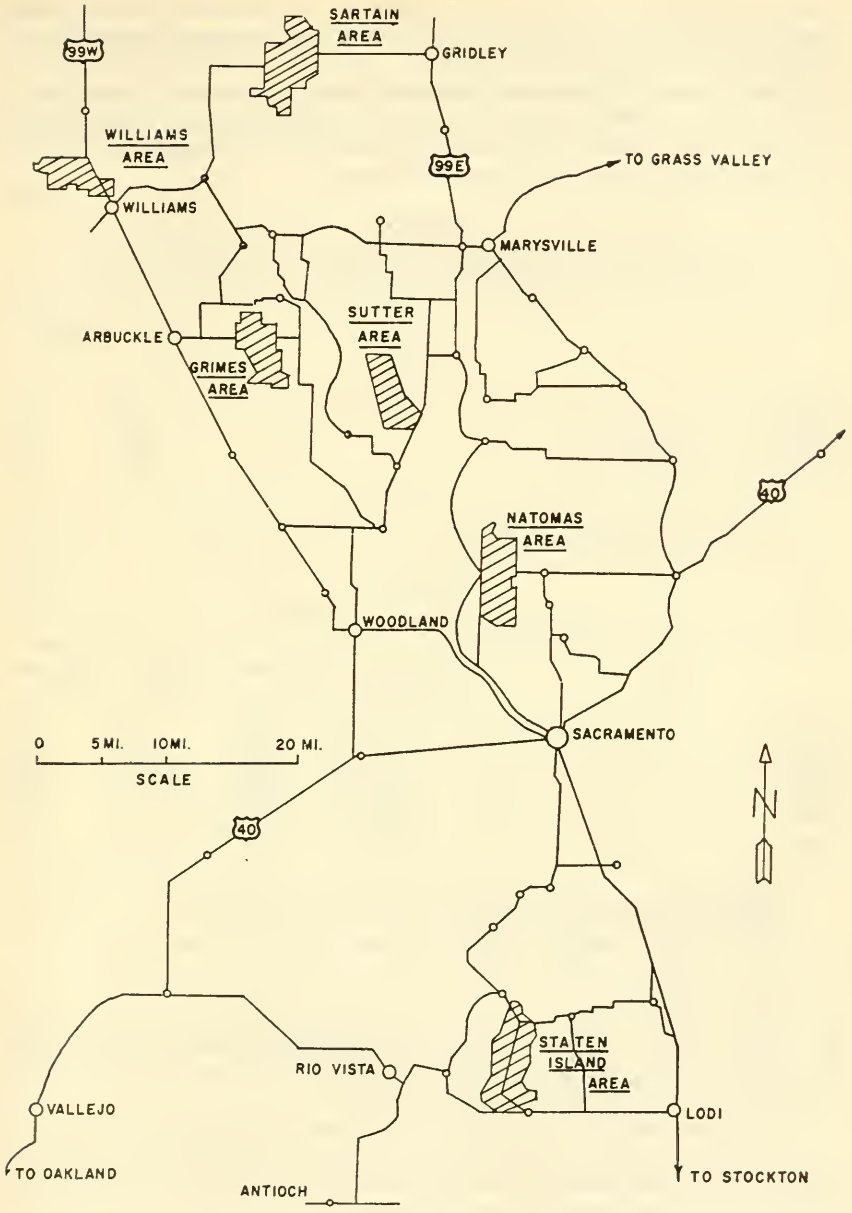

FIGURE 165. Location of cooperative hunting areas

and lost, band numbers, number of hours hunted, whether or not a dog was used, and remarks and suggestions. The permits issued on the pheasant planting policy area on Sartain's did not contain space for these questions. However, hunter questionnaire cards were filled out for 2,848 hunters who hunted on the part of the ranch which included that area. The data obtained from these questionnaire cards were felt to be

more representative of the entire Sartain Cooperative Hunting Area than the data from the permit returns, and were therefore used in compiling most of the report for that area.

The cooperative hunting plan was readily accepted by hunters, as shown by the 41,166 man-days hunted on the six areas. Table 4 gives the number of permits issued on each area and the percentage of volunteer returns upon which this report is based.

TABLE 4

Number of Permits Issued and Returned on Each Cooperative Hunting Area, 1949

Area	Permits issued	Percent returned
Staten Island	5,717	97.9
Williams	3,906	95.5
Sutter Basin	6,726	97.6
Natomas	10,922	94.9
Grimes	9,377	97.8
Sartain	†4,518	*82.1

† Total pheasant planting policy and cooperative area permits issued, less duplications.
* Percent return of cooperative area permits only.

TABLE 5

Hunter Days and Birds Killed

Area	Checked hunter days	Total hunter days	Checked kill [3]	Calculated kill [4]
Staten Island	5,597	5,717	1,523	1,556
Williams	3,731	3,906	1,140	1,193
Sutter Basin	6,564	6,726	2,274	2,330
Natomas	10,362	10,922	2,013	2,122
Grimes	9,171	9,377	3,441	3,518
Sartain	[1] 2,848	[2] 4,518	[1] 1,723	2,733
Totals	38,273	41,166	12,114	13,452

[1] Study area figures.
[2] Total pheasant planting policy and cooperative area permits issued, less duplications.
[3] Includes game farm birds taken on or off areas.
[4] Calculated by figuring nonreturning permittees had the same success as those returning permits.

Kill and Hunter Days

Total checked kill and hunter days tabulated for the 10-day season for all cooperative hunting areas are presented in Table 5. Figures for the Sartain area include hunter days and kill from the 1,680 acres operated under the pheasant planting policy.

All areas except the Sartain had the maximum allowable number of hunters on opening day. The two dollar fee on the Sartain Ranch turned a few hunters away, and also the other five areas were closer to the large cities and attracted more hunters.

Birds Killed per 1,000 Acres

Table 6 compares the combined kill of game farm and wild birds per 1,000 acres with the kill of wild birds alone. Game farm birds released on the areas but reported as killed elsewhere are included, as the returns of these were not separated from those killed on the areas. However, the returns from off the areas were less than 5 percent.

Daily Percent of Kill

Table 7 shows the daily percent of the checked kill for all areas. Table 8 shows the seasonal kill of wild and game farm birds.

More than two-thirds of the total checked kill was taken during the first three days on all areas except Staten Island, where 56 percent was taken.

TABLE 6

Kill per 1,000 Acres

Area	Calculated kill per 1,000 acres (Game farm and wild)	Calculated wild kill per 1,000 acres
Staten Island	183	97
Williams	189	94
Sutter Basin	228	171
Natomas	208	152
Grimes	186	145
Sartain	199	151
Over-all average	198	141

TABLE 7

Daily Percents of Total Seasonal Kill

	Staten Island	Williams	Sutter Basin	Natomas	Grimes	Sartain	Totals and averages	
							Daily	Cumulative
Total known bag	1,523	1,140	2,274	2,013	3,441	1,723	12,114	----------
Day of season:								
1	40.6	38.6	46.6	36.7	51.0	48.5	44.9	44.9
2	10.3	13.9	19.8	20.5	19.9	13.6	17.3	62.2
3	4.8	8.6	12.4	10.9	12.6	10.6	10.7	72.9
4	6.5	3.5	4.4	2.4	2.7	2.7	3.5	76.4
5	6.2	9.0	2.9	7.6	2.1	6.8	5.0	81.4
6	6.9	13.6	1.6	5.9	4.7	4.2	5.4	86.8
7	4.6	4.8	6.6	6.3	2.6	2.4	4.4	91.2
8	2.0	2.4	2.5	3.5	2.0	1.9	2.4	93.6
9	5.8	3.2	2.5	3.8	1.4	2.0	2.8	96.4
10	12.3	2.4	.7	2.4	1.0	7.3	3.6	100.0

TABLE 8

Comparison of Daily Percents of Seasonal Kill of Wild and Game Farm Birds

	Type of bird	Total known bag	Day of season										
			1	2	3	4	5	6	7	8	9	10	Unknown
Staten Island	Wild	795	44.6	14.2	7.4	4.0	2.6	3.7	2.8	1.6	2.9	16.2	
	Game farm	728	35.8	5.8	1.9	9.2	10.2	10.4	6.5	2.5	8.9	7.8	0.8
Williams	Wild	540	45.1	19.2	13.4	4.0	2.9	4.9	1.9	1.7	4.0	2.9	
	Game farm	600	30.0	7.8	3.5	3.8	14.3	21.2	7.3	3.0	2.2	1.7	6.2
Sutter Basin	Wild	1,689	47.8	22.6	14.5	5.1	3.2	1.8	2.1	0.8	1.5	0.6	
	Game farm	585	37.2	9.2	4.4	1.5	1.4	1.3	19.2	7.5	5.2	1.0	12.1
Natomas	Wild	1,440	39.8	23.9	12.5	2.5	5.2	3.8	3.7	3.1	3.4	2.1	
	Game farm	573	26.9	11.0	6.3	2.1	13.6	11.0	12.6	4.4	4.5	3.1	4.5
Grimes	Wild	2,670	50.4	21.1	13.7	2.8	2.1	2.3	2.3	2.2	1.5	1.1	
	Game farm	771	49.0	14.1	7.5	2.0	2.1	12.5	3.6	1.0	0.5	0.3	7.4
Sartain	Wild	1,318	48.3	15.7	12.5	2.9	1.9	3.2	1.7	2.4	2.4	9.0	
	Game farm	405	48.6	6.4	4.7	2.0	22.7	7.4	4.7	0.5	1.0	1.7	0.3
Totals and averages	Wild	8,452	46.9	20.3	12.9	3.4	3.0	2.9	2.4	2.0	2.3	3.9	
	Game farm	3,662	37.9	9.3	4.8	3.5	9.6	10.9	8.9	3.1	3.9	2.7	5.4

TABLE 9

Percent of Kill Made Up of Game Farm Birds

	Sartain	Grimes	Natomas	Sutter Basin	Williams	Staten Island	Average
Day of season:							
1	23.5	21.6	20.9	20.6	40.9	42.2	25.5
2	11.6	15.9	15.3	12.0	29.7	27.4	16.3
3	10.4	13.4	16.4	9.2	21.4	19.3	13.4
4	17.4	16.1	25.0	9.1	42.5	67.7	30.1
5	78.6	21.6	50.6	12.3	83.5	77.7	58.1
6	41.7	59.6	52.9	13.5	81.9	71.7	61.0
7	45.2	30.8	57.1	75.8	80.0	68.0	55.5
8	6.1	11.6	35.7	75.9	64.3	58.1	55.3
9	11.4	8.5	34.2	54.4	36.1	73.9	29.7
10	5.6	6.1	36.7	35.3	37.0	30.5	21.6
Season totals	23.5	22.4	28.5	25.7	52.6	47.8	30.2

TABLE 10

Summary of Releases and Kill of Game Farm Birds on All Cooperative Hunting Areas, 1949

Date released	Cocks released	Total returns		Returns by day of season										
		Number	Percent	1	2	3	4	5	6	7	8	9	10	Uuknown
January	100	1	1.0	1										
March	185	7	3.8	3		1	1							
May	25	3	12.0	1		1	1				1	1		
June	150	15	10.0	9	2	2			1				1	
July	567	61	10.7	31	6	6	4	1	3	2		2	2	4
August	407	98	24.0	29	8	6	2	2	2	2		3	42	2
September	100	46	46.0	32	7		1		2	2		1	1	
October	140	64	45.7	39	5	6	1	2	2	2		2	1	4
November 3-10	2,282	1,028	45.0	534	160	78	32	18	27	25	15	20	9	110
November 13-16	1,987	1,141	57.4	708	155	74	37	47	31	13	5	7	4	60
Subtotals	5,943	2,464	41.5	1,387	343	174	79	70	68	46	21	36	60	180
November 20	200	125	62.5				46	18	4	4	45	5	3	
November 21	399	286	71.7				3	159	61	35	7	4	8	9
November 22	844	500	59.3					106	245	85	32	14	14	4
November 23	411	287	69.8						19	154	55	42	10	7
Subtotals	1,854	1,198	64.6				49	283	329	278	139	65	35	20
Grand totals	7,797	3,662	47.0	1,387	343	174	128	353	397	324	160	101	95	200

Kill of Game Farm Birds

Game farm birds made up approximately 30 percent of the total checked kill on all areas (Table 9). On the Staten Island and Williams areas about half of the kill consisted of game farm birds, while on other areas they made up between 20 and 30 percent of the bag.

Table 10 presents a summary of releases and kill of game farm birds for all areas, and Table 11 gives similar data for each area. An over-all return of 47 percent was received from 7,797 birds stocked on the areas. Returns were greatest from birds released during the season, averaging 65 percent. Releases made before the season yielded an average return of 42 percent, with very low returns generally resulting from liberations made prior to September. Figure 166 gives band returns by date of release. A few releases of game farm birds gave returns considerably

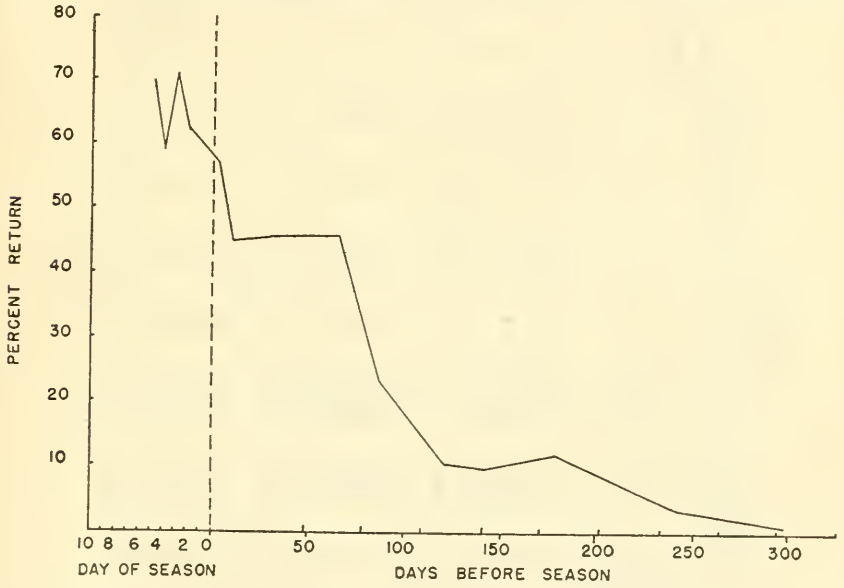

FIGURE 166. Band returns by date of release from all liberations of game farm birds on cooperative hunting areas, 1949

below average. On the Grimes area, a release of 555 birds on November 14th yielded a return of only 33 percent, which was slightly greater than half the average return from birds released near this date. Liberations totaling 325 birds made on November 7 and 10 on the Williams area gave a return of approximately 30 percent, which is about two-thirds of the average from other releases made then. The cause of these low returns is not known, but is probably that the birds were either killed by predators or died from unknown reasons before the season or perhaps many of them found refuge from hunters in closed zones.

Game farm birds released during the season were quickly harvested, as shown in Table 12. The effectiveness of these releases in increasing the bag or hunter success was limited to the first two or three days following the release.

TABLE 11

Releases and Kill of Game Farm Birds by Area

Date released	Cocks released		Total returns		Returns by day of season										
	Number	Age (months)	Number	Percent	1	2	3	4	5	6	7	8	9	10	Unknown
No. 1 Staten Island:															
Aug. 29	158	3	57	36.0	1	4	1			2	2		3	42	2
Nov. 15	207	4	168	81.1	128	20	9	2	5	2		1			1
Nov. 16	100	4.5	75	75.0				17	30	14	6	3	4	1	
Nov. 16	275	5	164	59.6	132	19	4	2	3	1					3
Nov. 20	200	4.5	125	62.5				46	18	4	4		47	6	
Nov. 22	216	4.5	139	64.3					17	53	36	14	11	8	
Totals	1,156	3–5	728	62.9	261	43	14	67	73	76	48	18	65	57	6
No. 2 Williams:															
July 25	417	3	31	7.4	13	4	3	3	1	1	1		1	1	3
Nov. 3	200	4	108	54.0	68	13	5	4	1	6	2	2		1	6
Nov. 4	225	4	109	48.4	47	17	8	7	2	2	4	3	4	2	13
Nov. 7	156	4	45	28.8	29	6	1	2			2		3		2
Nov. 10	169	4	52	30.7	23	7	4	1	1	5	3				8
Nov. 22	436	4	241	55.2					81	110	28	11	2	6	3
Nov. 23	29	4	14	48.2						3	4	2	3		2
Totals	1,632	3–4	600	36.7	180	47	21	17	86	127	44	18	13	10	37
No. 3 Sutter Basin:															
Nov. 4	160	4	68	42.5	27	13	7	3	3		2	2			11
Nov. 5	160	4	97	60.6	56	12	5	1	1		2		3		17
Nov. 7	160	4	92	57.5	60	16	3	1	1		1			2	8
Nov. 8	160	4	78	48.7	37	8	7	4	1		1		1		19
Nov. 9	110	4	65	59.0	38	5	4		2	1			1		14
Nov. 23	259	4	185	71.4						4	107	42	26	4	2
Totals	1,009	4	585	57.9	218	54	26	9	8	5	113	44	31	6	71

TABLE 11—Continued

Releases and Kill of Game Farm Birds by Area

Date released	Cocks released		Total returns		Returns by day of season										
	Number	Age (months)	Number	Percent	1	2	3	4	5	6	7	8	9	10	Unknown
No. 4 Natomas:															
Jan. 23	100	6	1	1.0	1										
Mar. 20	185	10	7	3.7	3		1	1				1	1		
May 23	25	12	3	12.0	1		1	1							
Oct. 23	40	3	8	20.0						1	1		1	1	4
Nov. 3	360	6	135	37.5	71	27	13	2	3	4	5	3	3	2	2
Nov. 4	422	6	179	42.4	78	36	21	7	3	9	3	5	5	4	8
Nov. 21	206	4	152	73.7				1	72	37	20	5	3	5	9
Nov. 23	123	4	88	71.5						12	43	11	13	6	3
Totals	1,461	3–12	573	39.2	154	63	36	12	78	63	72	25	26	18	26
No. 5 Grimes:															
Nov. 13	751	4	467	62.1	294	80	43	6	4	3	2	1	3		31
Nov. 14	555	4	184	33.1	84	29	15	9	4	11	5			2	25
Nov. 22	192	4	120	62.5					8	82	21	7	1		1
Totals	1,498	4	771	51.4	378	109	58	15	16	96	28	8	4	2	57
No. 6 Sartain:															
June 11	50	6 wks	5	10.0	2		1			1				1	
June 24	100	6 & 8 wks	10	10.0	7	2	1								
July 15	150	6, 8, 9 wks	30	20.0	18	2	3	1		2	1		1	1	1
Aug. 16	249	6–12 wks	41	16.5	28	4	5	2	2						
Sept. 13	100	3	46	46.0	32	7		1		2	2		1	1	
Oct. 14	100	3.5	56	56.0	39	5	6	1	2	1	1		1		
Nov. 16	99	4.5	83	83.8	70	7	3	1	1					1	
Nov. 21	193	5	134	69.4				2	87	24	15	2	1	3	
Totals	1,041	1.5–5	405	38.9	196	27	19	8	92	30	19	2	4	7	1

Hunting Pressure

Approximately 63 percent of the hunter days were expended during the first three days of the season (Figure 167). Hunting pressure was low on the following week days and increased slightly on the final weekend. Table 13 gives the daily percent of hunter days for each area.

The daily percentage of gun hours (Table 14) is parallel to the daily percentage of hunters but shows that, in general, hunters were in the field slightly longer during the early part of the season.

Daily and seasonal hunter days per 1,000 acres for each area are given in Table 15. Hunter days per unit area were considerably greater

TABLE 12

Rate of Kill of Game Farm Birds Released In-season, by Percents of Total Return

	Days after release					Later or unknown
	0	1	2	3	4	
Daily	10.7	50.4	18.1	9.4	2.9	8.5
Cumulative	10.7	61.1	79.2	88.6	91.5	100.0

TABLE 13

Daily Percent of Hunters

Day	Staten Island	Williams	Sutter Basin	Natomas	Grimes	Sartain
1	16.8	24.2	22.2	23.5	25.4	33.0
2	17.2	24.2	23.2	22.3	25.5	25.8
3	15.5	15.0	16.8	14.6	18.9	15.1
4	5.0	3.7	4.1	3.2	2.8	2.9
5	5.5	4.5	4.5	5.8	3.4	3.9
6	5.0	5.2	3.1	5.5	3.3	3.5
7	9.1	5.9	6.8	9.4	5.4	2.9
8	6.1	4.6	4.6	3.8	3.8	3.6
9	10.8	7.4	9.1	6.8	7.3	4.3
10	9.0	5.3	5.6	5.1	4.2	5.0

TABLE 14

Daily Percent of Gun Hours

Day	Staten Island	Williams	Sutter Basin	Natomas	Grimes	Sartain [1]
1	19.1	27.2	21.5	26.7	27.0	35.3
2	16.9	24.5	24.0	22.7	25.9	23.4
3	14.0	13.9	17.5	14.1	17.2	17.2
4	4.8	3.5	4.1	3.3	3.0	2.7
5	5.8	4.7	4.6	5.8	3.0	3.8
6	4.9	4.7	2.7	5.1	2.9	3.3
7	7.9	5.0	5.9	7.7	4.9	2.8
8	6.1	4.6	4.3	3.7	3.5	2.6
9	10.3	7.1	9.8	6.0	7.3	3.8
10	10.2	4.8	5.6	4.9	5.3	5.1

[1] Study area figures.

TABLE 15

Hunter Days per 1,000 Acres

Day	Staten Island	Williams	Sutter Basin	Natomas	Grimes	Sartain [1]
1	113	150	146	249	126	123
2	116	150	153	236	126	100
3	104	93	111	155	94	73
4	33	23	27	34	14	14
5	37	28	29	61	17	17
6	33	32	20	58	16	16
7	61	37	45	99	27	16
8	42	28	30	40	19	13
9	73	46	60	72	36	18
10	61	33	37	54	21	22
Totals	673	620	658	1,058	496	412

[1] Study area figures.

TABLE 16

Gun Hours per 1,000 Acres

Day	Staten Island	Williams	Sutter Basin	Natomas	Grimes	Sartain [1]
1	443	563	543	823	552	593
2	392	507	606	700	530	404
3	325	288	442	435	352	298
4	111	72	103	102	61	48
5	136	97	116	179	61	67
6	114	97	68	157	59	58
7	183	103	149	237	100	51
8	142	95	109	114	72	47
9	239	147	247	185	149	68
10	237	99	141	151	109	88
Totals	2,322	2,068	2,524	3,083	2,045	1,723

[1] Study area figures.

TABLE 17

Average Hours Hunted Daily per Hunter on Each Cooperative Hunting Area

Area	Average hours hunted
Staten Island	3.4
Williams	3.3
Sutter Basin	3.8
Natomas	2.9
Grimes	4.1
Sartain	4.2
Over-all average	3.6

on the Natomas than on any other, doubtless due to the close proximity to Sacramento. Sartain supported the least hunting per unit area because of the location and charge for hunting.

Gun hours per 1,000 acres is given by days for each area in Table 16. Heaviest pressure occurred on the first day on all areas except Sutter Basin, where pressure was greatest on the second day.

Table 17 gives the average hours per hunter day for each area. The higher number of hours on the Sartain area is probably due to the fee charged which created an incentive to hunt longer. The lower average on Natomas was again due to the close proximity to Sacramento, which made it convenient for hunters with limited time to hunt. A total of 147,587 hours was expended in 41,166 hunter days on all six areas.

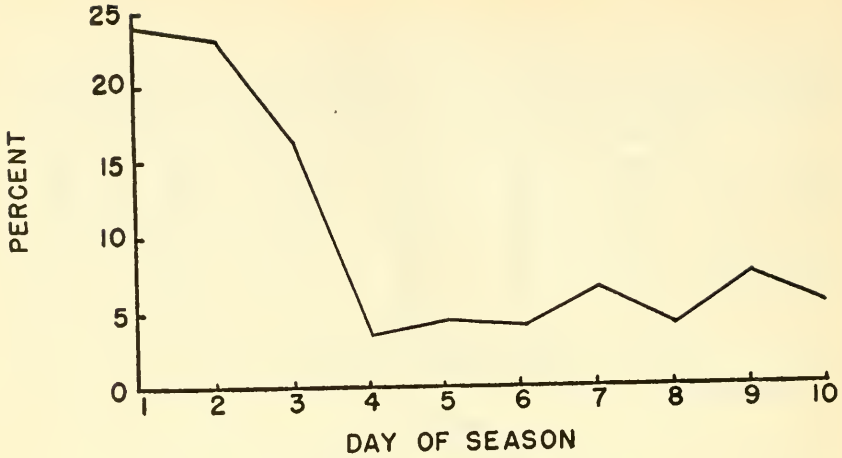

FIGURE 167. Daily percent of hunters (all areas)

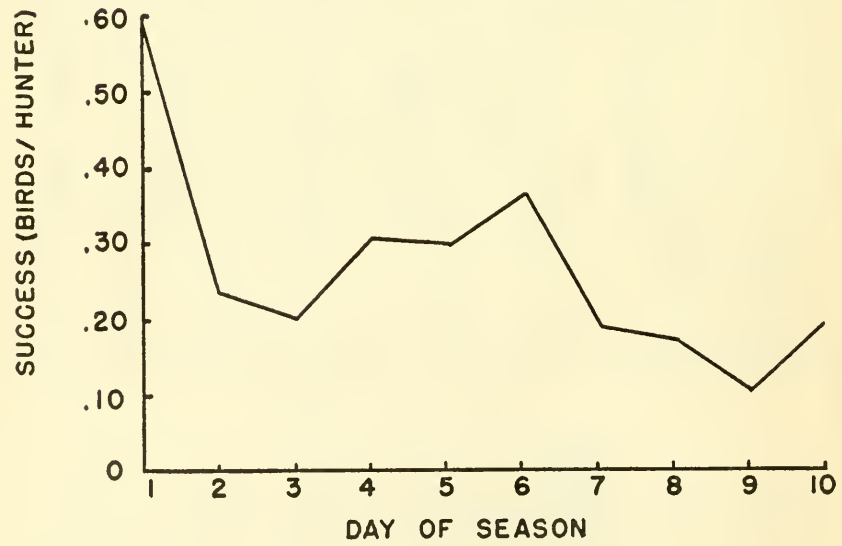

FIGURE 168. Hunter success (birds per hunter, all areas)

Hunter Success

Hunter success by day for all areas combined is given in Figure 168, and similar data for each area are given in Table 18. The Sartain area maintained a higher success for each day of the season than any other area. This was due mainly to less hunting pressure than on the other areas. Hunting success increased on all areas during the week days following releases of game farm cocks. However success dropped rapidly

TABLE 18

Hunter Success by Day
(Birds per Man)

Day	Staten Island	Williams	Sutter Basin	Natomas	Grimes	Sartain[1]
1	.66	.48	.73	.30	.75	.96
2	.16	.17	.30	.17	.29	.32
3	.08	.17	.25	.14	.24	.36
4	.35	.28	.37	.14	.35	.49
5	.31	.60	.22	.25	.23	.98
6	.38	.78	.18	.21	.54	.63
7	.13	.24	.33	.13	.18	.38
8	.09	.16	.19	.17	.19	.36
9	.14	.13	.09	.10	.07	.27
10	.37	.13	.04	.09	.08	.84
Seasonal average	.26	.31	.34	.19	.38	.60

[1] Study area figures.

TABLE 19

Hunter Days Getting Bag on All Areas

	Two birds	One bird	No birds
Hunter days	2,597 24%	6,349	28,640 76%

TABLE 20

Use and Effect of Dogs on Kill

Area	Percent hunter days	Percent total bag	Percent total crippling loss
Staten Island			
With dog	28	40	26
Without dog	61	55	73
Not specified	11	5	1
Williams			
With dog	43	55	46
Without dog	43	33	46
Not specified	14	12	8
Sutter Basin			
With dog	42	54	51
Without dog	35	32	41
Not specified	23	14	8
Natomas			
With dog	57	72	65
Without dog	40	25	35
Not specified	3	3	—
Grimes			
With dog	48	59	52
Without dog	44	36	47
Not specified	8	5	1
Sartain			
With dog	37	52	55
Without dog	28	30	36
Not specified	35	18	9
Totals			
With dog	48	57	49
Without dog	41	35	46
Not specified	11	8	5

TABLE 21

Effect of Dogs on Success and Crippling Loss

Area	Percent hunters with two birds	Percent hunters with one bird	Percent hunters with no birds	Percent [1] crippling loss
Staten Island				
With dog	10	20	70	10
Without dog	5	14	81	20
Not specified	3	6	91	9
Williams				
With dog	9	21	70	10
Without dog	5	13	82	17
Not specified	8	10	82	9
Sutter Basin				
With dog	11	22	67	13
Without dog	7	19	74	10
Not specified	4	10	86	5
Natomas				
With dog	4	16	80	10
Without dog	1	9	90	15
Not specified	3	10	87	2
Grimes				
With dog	11	24	65	9
Without dog	7	18	75	13
Not specified	5	10	85	7
Sartain				
With dog	19	32	49	21
Without dog	13	27	60	23
Not specified	9	8	83	10
Totals				
With dog	9	21	70	10
Without dog	5	15	80	15
Not specified	5	9	86	7

[1] Given as percent of the bag made by each group.

again after the game farm birds were taken. Twenty-four percent of the hunter days accounted for all birds taken on the areas, i.e., one bird was taken for every four hunter days.

Use of Dogs

Hunter success was uniformly higher when dogs were used, also crippling loss was somewhat lessened. Table 20 gives the total percentage of kill and crippling loss by hunters with and without dogs. Hunters using dogs were considerably more successful in bagging two birds than those without dogs. Table 21 shows the percentage of successful hunters with one and two birds with and without dogs for each area. Crippling loss varied from 9 to 21 percent of the total kill for hunters using dogs and from 10 to 23 percent for those without dogs.

Home Counties of Hunters

The percentage of hunters by region of residence is given in separate tables for each cooperative hunting area. The Natomas area was the only one where local hunters predominated, as the city of Sacramento was in the local area. On all other areas San Francisco Bay region hunters made up the largest percent. San Joaquin Valley and Los Angeles area hunters together made up less than 10 percent of the total hunters on all cooperative hunting areas. Tables 22 through 27 give the breakdown of residence of hunters on the six areas.

TABLE 22

Residence of Hunters by Region on Staten Island Cooperative Hunting Area No. 1

Region of residence	Percent		
	Opening three days	Weekdays	Final weekend
Local	34.5	40.1	30.3
San Francisco Bay region	51.6	46.5	58.8
Southern California	1.5	1.1	.7
San Joaquin Valley	1.3	2.2	.5
Upper Sacramento Valley	.4	.5	.1
Others	3.1	1.7	1.2
Unknown	7.6	7.9	8.4

Local: San Joaquin, Sacramento, Yolo, eastern half Solano and Contra Costa Counties.
S. F. Bay Region: Marin, Alameda, San Francisco, San Mateo, Santa Clara, Sonoma, Napa, western half of Solano and Contra Costa Counties.
Southern California: Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
Upper Sacramento Valley: Sutter, Yuba, Colusa, Glenn, Placer, El Dorado, Amador, Plumas, Butte, Nevada Counties.
San Joaquin Valley: Stanislaus, Merced, Madera, Fresno, Kings, Kern, Tulare, Mariposa, Tuolumne Counties.
Others: All other counties.
Unknown: Residence not stated on permit.

TABLE 23

Residence of Hunters by Region on Williams Cooperative Hunting Area No. 2

Region of residence	Percent		
	Opening three days	Weekdays	Final weekend
Local	9.8	20.8	12.1
San Francisco Bay region	64.1	44.3	63.0
Southern California	6.2	9.6	1.1
San Joaquin Valley	1.9	5.7	1.2
Other Sacramento Valley and mountain counties	3.2	3.8	3.1
Others	9.0	7.1	8.1
Unknown	5.8	8.7	11.4

Local: Glenn, Colusa, Lake, Butte, Yolo, Sutter, Yuba Counties.
S. F. Bay Region: Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Sonoma, Napa Counties.
Southern California: Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
San Joaquin Valley: Stanislaus, Merced, Madera, Fresno, Kings, Kern, Tulare, Mariposa, Tuolumne, San Joaquin Counties.
Other Sacramento Valley and Mountain Counties: Sacramento, Placer, El Dorado, Amador, Plumas, Nevada, Tehama Counties.
Others: All other counties.
Unknown: Residence not stated on permits.

TABLE 24

Residence of Hunters by Region on Sutter Basin Cooperative Hunting Area No. 3

Region of residence	Percent		
	Opening three days	Weekdays	Final weekend
Local	18.8	31.1	23.1
San Francisco Bay region	57.9	45.7	61.7
Southern California	2.6	3.7	1.2
San Joaquin Valley	2.6	1.7	.7
Upper Sacramento Valley and mountain counties	6.0	4.9	3.0
Others	3.0	2.4	1.4
Unknown	9.1	10.5	8.9

Local: Sutter, Sacramento, Yolo, Placer, Nevada, Yuba, Butte, Colusa Counties.
S. F. Bay Region: Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Sonoma, Napa Counties.
Southern California: Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
San Joaquin Valley: San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Kern, Tulare, Mariposa, Tuolumne Counties.
Upper Sacramento Valley and Mountain Counties: Tehama, Glenn, Placer, El Dorado, Amador, Plumas Counties.
Others: All other counties.
Unknown: Residence not stated.

TABLE 25

Residence of Hunters by Regions on Grimes Cooperative Hunting Area No. 5

Region of residence	Percent		
	Opening three days	Weekdays	Final weekend
Local	7.6	17.8	8.8
San Francisco Bay region	65.4	54.7	68.8
Southern California	3.2	2.3	1.1
San Joaquin Valley	2.8	1.6	1.3
Other Sacramento Valley and mountain counties	8.3	11.8	8.3
Others	4.7	3.9	3.0
Unknown	8.0	7.9	8.7

Local: Glenn, Colusa, Lake, Yolo, Sutter, Yuba, Butte Counties.
S. F. Bay Region: Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Sonoma, Napa Counties.
Southern California: Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
San Joaquin Valley: San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Kern, Tulare, Mariposa, Tuolumne Counties.
Other Sacramento Valley and Mountain Counties: Sacramento, Placer, El Dorado, Amador, Nevada, Tehama Counties.
Others: All other counties.
Unknown: Residence not stated on permit.

TABLE 26

Residence of Hunters by Region on Natomas Cooperative Hunting Area No. 4

Region of residence	Percent		
	Opening three days	Weekdays	Final weekend
Local	66.8	67.3	69.7
San Francisco Bay region	9.4	4.8	9.0
Southern California	2.9	2.2	1.1
San Joaquin Valley	1.7	1.3	1.0
Other Sacramento Valley and mountain counties	3.2	3.6	4.3
Others	2.1	1.5	.7
Unknown	13.9	19.3	14.2

Local: Sacramento, Yolo, Yuba, Colusa, Placer Counties.
S. F. Bay Region: Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Sonoma, Napa Counties.
Southern California: Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
San Joaquin Valley: San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Kern, Tulare, Mariposa, Tuolumne Counties.
Other Sacramento Valley and Mountain Counties: Tehama, Glenn, Butte, El Dorado, Amador, Plumas, Nevada, Counties.
Others: All other counties.
Unknown: Residence not stated on permit.

TABLE 27

Residence of Hunters by Region on Sartain Cooperative Hunting Area No. 6

Region of residence	Percent		
	Opening three days	Weekdays	Final weekend
Local	21.6	26.2	34.0
San Francisco Bay region	47.4	39.2	47.6
Southern California	11.2	13.8	1.1
San Joaquin Valley	6.0	4.7	3.7
Other Sacramento Valley Counties	6.2	4.7	7.0
Other	7.6	11.4	6.6

Local: Plumas, Butte, Colusa, Glenn, Sutter, Yuba, Nevada Counties.
S. F. Bay Region: Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Sonoma, Napa Counties.
Southern California: Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
San Joaquin Valley: San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Kern, Tulare, Mariposa, Tuolumne Counties.
Other Sacramento Valley Counties: Placer, El Dorado, Amador, Sacramento Counties.
Other: All other counties and out of state.

REACTIONS OF HUNTERS TO COOPERATIVE HUNTING AREAS

Comments of hunters on cooperative areas were recorded on returned permit forms. Favorable reactions to this type of controlled shooting far exceeded unfavorable remarks. As could be expected hunters bagging one or more birds were better satisfied than those who were unsuccessful. On the Sartain area criticism was directed toward the fee for hunting privileges; however, most of this was from unsuccessful hunters.

A vast number of hunters expressed their wishes toward increasing the number of cooperative hunting areas where they could hunt without fear of being rejected. Table 28 shows the percentage of favorable and unfavorable comments by successful and unsuccessful hunters for each area.

TABLE 28

Reaction of Hunters to Cooperative Hunting Areas

Area	Number	Successful		Unsuccessful		Total	
		Percent		Percent		Percent	
		Favorable	Unfavorable	Favorable	Unfavorable	Favorable	Unfavorable
Staten Island	1	95.9	4.1	93.5	6.5	94.2	5.8
Williams	2	98.8	1.2	95.0	5.0	96.2	3.8
Sutter Basin	3	98.9	1.1	95.8	4.2	97.4	2.6
Natomas	4	98.8	1.2	94.2	5.8	95.7	4.3
Grimes	5	95.3	4.7	87.7	12.3	92.5	7.5
Sartain [1]	6	85.2	14.8	61.3	38.7	76.4	23.6
Totals		96.2	3.8	93.4	6.6	94.5	5.5

[1] Fee of $2 per day per hunter.

REACTION OF LANDOWNERS COOPERATING

Questionnaires were sent to each cooperating landowner or agent two days before the close of the season requesting their comments. Of 24 questionnaires returned, 18 expressed their wishes to continue with the cooperative plan under the present system or with minor improvements. Six did not state their desires, but when contacted personally all were highly favorable toward this method of controlled hunting.

Three landowners or lessees were in favor of charging a small fee for hunting. One such landowner purchased the shooting rights in 1949 on land which he leased for farming to prevent commercial hunting club operators from obtaining the hunting rights.

Hunter damage to cooperating landowner's property was negligible during the season. Only three reported any damage and this was mainly restricted to fence breakage. The remainder reported no destruction to livestock, crops, fences, gates or miscellaneous property. Many stated they had damage in past years and that controlled hunting on their land in 1949 was the primary reason for no destruction of property.

Of the total number of questionnaires returned, nine landowners reported more hunters than in previous years, but only five stated they had too many hunters at any one time. Two landowners reported they had fewer hunters than in past years. The remainder said they had about the same number.

Constructive suggestions were received from landowners in regards to type of signs used for each zone, number and placement of signs, method of posting, and methods of issuing permits.

SUMMARY AND CONCLUSIONS

1. To open land closed to pheasant hunting, Senate Bill No. 677, establishing cooperative hunting areas, was passed by the State Legislature in 1949.

2. Six cooperative areas were operated by the California Division of Fish and Game during the 1949 hunting season.

3. A total of 72,100 acres was under controlled hunting with a maximum of 7,500 hunters permitted at any one time.

4. A total of 41,166 man-days of hunting was expended on the areas and a checked kill of 12,114 birds was taken.

5. An over-all average of 198 cocks per 1,000 acres was taken on all the areas with a wild kill of 141 birds per 1,000 acres.

6. More than two-thirds of the total kill was made during the first three days on all areas except Staten Island where 56 percent was taken.

7. Game farm birds were released on all areas.

8. Game farm birds made up about half of the kill on the Staten Island and Williams areas. On the other four areas approximately 30 percent of the kill was from game farm birds.

9. Returns from 7,797 stocked birds amounted to 47 percent. Birds released in-season gave a 65 percent return while those liberated prior to the season yielded a return of 42 percent. In-season released birds were mostly harvested by the second and third day after release. This indicates that game farm releases in-season should be made the day before hunting pressure is expected to be high.

10. Approximately 63 percent of the hunter days was expended during the first three days of the season. Pressure lowered during the week days and increased slightly on the final week end. Hunter days per unit area were considerably greater on the Natomas than on any other, doubtless due to the close proximity of Sacramento; Sartain supported the least hunting per unit area because of location and charge for hunting.

The Sartain area supported the highest average number of hours hunted per day, probably due to the fee charged which created an incentive to hunt longer. Natomas had, by far, the lowest average which was again due to the close proximity of Sacramento, which made it convenient for hunters with limited time to hunt. A total of 147,587 hours was expended in 41,166 hunter days on all six areas. Gun hours per 1,000 acres were greatest on all areas the first day except the Sutter Basin where pressure was greatest on the second day.

11. The Sartain area maintained a higher hunter success for each day of the season than any other area due to having the lowest hunting pressure. Game farm birds released in-season increased success on all areas during the week days. One bird was taken for each four hunter days on all areas.

12. Hunter success was uniformly higher when dogs were used, also crippling loss was somewhat lessened. Hunters using dogs were considerably more successful in bagging two birds than those without dogs.

13. The largest percentage of hunters on all areas except the Natomas were from the San Francisco Bay region. Local hunters were most numerous on the Natomas.

14. Reactions to this hunting plan were recorded and favorable reactions to this type of controlled shooting far exceeded unfavorable remarks. On the one area which charged, some criticism was directed toward the fee for hunting. However, most of this was from unsuccessful hunters. Most hunters expressed wishes for more cooperative hunting areas.

15. The most impressive point of the plan was that the 24 cooperating landowners, when contacted by printed questionnaires or in person, were all in favor of this method of controlled hunting. Hunter damage to cooperating landowners' property was negligible during the entire season.

16. This cooperative hunting area plan will do much to alleviate the largest problem confronting the California Division of Fish and Game in pheasant management—that of opening land to hunter access where wild ring-necked pheasants are plentiful.

APPENDIX A

ITEM NO. 1

Senate Bill No. 677

SECTION 1. Section 1159 is added to the Fish and Game Code, to read:

1159. To provide added protection for landowners and lessees from depredations of trespassers and to provide greater access for the public to hunt on privately owned or controlled lands, the commission may contract with the owners or lessees of lands where upland game birds exist for the establishment of cooperative hunting areas upon such terms as the respective parties may agree subject to the following conditions.

Each cooperative hunting area shall be at least five thousand acres in size and may consist of the adjoining lands of one or more owners. The boundaries of such areas shall be posted by the Fish and Game Commission with a sign stating that legal hunting will be allowed in the area if written permission is obtained from the owner or lessee or his duly authorized agent. The Fish and Game Commission shall enforce the trespass provisions of the Penal Code and the provisions of this code within such areas.

The commission may establish rules and regulations for the management and control of such areas during the regular open seasons on upland game birds; provided, that such rules and regulations shall not conflict with or modify the provisions of this code or its orders of the commission made pursuant to Sections 14 to 19.6 thereof. The owners or owner or lessees or lessee of a cooperative hunting area may collect a daily fee not to exceed two dollars ($2) per day per area from each permit hunter.

As used in this section, the words "upland game birds" mean the order of Gallinae as enumerated in Section 1174 of this code.

APPENDIX A

ITEM NO. 2

Rules and Regulations for the Management and Control of Cooperative Hunting Areas

(Adopted by the Fish and Game Commission in meeting July 22, 1949, pursuant to Section 1159 (Ch. 529, Stats. 1949) Fish and Game Code.)

1. The word "landowner" as used herein refers to the owner or lessee of lands used by agreement with the Fish and Game Commission for a cooperative hunting area, or the duly authorized agent of such owner or lessee or their successors in interest.
2. With the consent of the Fish and Game Commission, the landowner may be allowed to designate "closed zones" or "restricted zones" within any, or that portion of any, cooperative hunting area established on his property. The balance of the property covered by the agreement shall be known as the "open zone," available for public hunting under the conditions hereinafter stipulated.
3. If a fee is to be charged for hunting privileges on a cooperative hunting area, the amount thereof must be designated in the agreement between the Fish and Game Commission and the landowner or landowners concerned. Any such fees shall be collected by the landowner but may not exceed $2 per day per hunter. At least 25 percent of the income derived from such fees shall be devoted to habitat maintenance and improvement, subject to evaluation and approval by the Division of Fish and Game.
4. *Closed zones* shall not be open to hunting at any time by any person, including landowners, lessees or their duly authorized agents.
5. *Restricted zones* shall not exceed 20 percent of the total of cooperative hunting area. The boundary thereof shall be shown on the map of the area and approved by the Fish and Game Commission when the project is accepted. The boundaries of such restricted areas shall be posted accordingly, and hunting therein shall be at the pleasure of the landowner. All hunters shall obtain permits and arm bands before hunting on restricted zones.
6. *Open zones:*
   (a) At least 5,000 acres, or a minimum of 50 percent of the entire cooperative hunting area, whichever is greater, shall be included in open zones.
   (b) All hunters shall obtain permits and arm bands, at a designated checking station, before hunting in open zones, and shall return permits and arm bands, with all required information, before leaving the area or at the end of the day's hunt.
   (c) Permits to hunt in an open zone shall be issued under the direction of the Division of Fish and Game, on a first-come, first-served basis.
   (d) Permits shall be valid only for the day and area issued.
   (e) The total number of hunters shall not exceed one hunter per five acres of open zone at any one time.
   (f) The representative of the Division of Fish and Game may, at his discretion, further restrict the number of hunters in any way in order to protect game or property.

(g) The representative of the Division of Fish and Game may refuse to issue a permit to anyone.

(h) Prior to the acceptance or issuance of a permit, all permittees shall consent in writing to the terms and conditions of these rules and regulations and to the terms and conditions set forth on the permits.

(i) The Division of Fish and Game, upon request of the landowner, shall furnish an employee to issue permits to hunt in open zones where no fees are charged. (The landowners shall be responsible for the issuance of permits where fees are to be charged.)

7. The authorized representative of the Division of Fish and Game may forthwith seize and revoke the permit of any person authorized to hunt on any cooperative hunting area, and eject him or her forthwith from the area, for any one or all of the following reasons:

(a) Any act, or threatened act, on the part of a permittee which appears to said representative to be a violation of any of the provisions of the Fish and Game Code, the regulations of the commission made pursuant thereto, or of these regulations.

(b) Any act, or threatened act, on the part of the permittee which appears to said representative to endanger the person or property of others.

The decision of the authorized representative of the Division of Fish and Game in such respects shall be final and binding upon permittees.

8. The provisions of the Fish and Game Code, and the regulations of the commission made pursuant thereto, shall apply to the entire cooperative hunting area, irrespective of zone. Any person whose permit has been revoked shall not be entitled to another permit to hunt on any cooperative hunting area during the current upland game bird season.

9. All permits shall state on their face that the use of the area is at the sole risk of the holder thereof, and that neither the State of California nor any agency thereof, nor the landowner, shall be liable in damages or otherwise to the permittee on account of any reason whatsoever. Said permittee shall hold the State of California and its agencies and the landowner free and harmless for all claim and demand whatsoever which may arise out of or incidental to his use of the cooperative hunting area.

10. If the lands used for a cooperative hunting area are owned or controlled by several persons they shall appoint one person to act as their agent for the entire area.

11. Lands designated and set aside for "closed zones" and "restricted zones" shall be patrolled by the employees of the Division of Fish and Game in the same manner as other portions of the cooperative hunting area during the open season for the upland game birds for which the area is primarily established.

The Fish and Game Commission further finds that the adoption of this regulation is necessary for the preservation of the public peace and general welfare. 14 C. A. C. Sec. 273. Authority, Ch. 529, Stats. 1949. Passed unanimously.

SWIMMING SPEED OF THE WESTERN SUCKER, *CATOSTOMUS OCCIDENTALIS* AYRES[1]

By J. H. Wales
Bureau of Fish Conservation
California Division of Fish and Game

On April 13, 1950, the writer had an unusually good opportunity to observe the maximum swimming speed of the Western Sucker (*Catostomus occidentalis* Ayres). Such observations are rare and a report on this seems worthwhile.

Salt Creek is a tributary of the Sacramento River arm of Shasta Lake in Shasta County, California. Near the point where it enters the reservoir the stream flows through a large concrete culvert under U. S. Highway 99 and it was here that the observations were made.

Shasta Lake was filling with water and on April 13th its level extended up to the lower lip of the culvert in such a way that the suckers could swim directly from the reservoir up into the stream flow.

VELOCITY OF THE WATER

The concrete culvert is approximately half-round with a floor 12 feet wide and 187 feet long. The floor slopes from both sides toward the middle with a longitudinal slope of 1.2 percent. On the date of observation the flow in the stream was computed to be 36 c.f.s. and at the lower end of the culvert the depth of the water varied from zero at the sides of the floor to 7.5 inches in the middle. At the upper end of the culvert the depth at sides and middle was about 2 inches and 9.5 inches, respectively. The floor of the culvert was quite smooth, so there was a correspondingly smooth flow of water. The velocities were computed with a Price current meter and found to be:

Lower end of culvert	8.6 ft. per second
Upper end of culvert	7.2 ft. per second

SWIMMING ABILITY OF THE FISH

About 10 adult suckers were trying to ascend the culvert to spawn in the stream above. Their lengths were estimated to be 12 to 14 inches but none could be caught for actual measurement. They would dart out of the deep water where stream and reservoir met and swim up the culvert until exhausted and forced to drop back. Several fish would try the ascent at once, then drop back, wait a moment, and try again (possibly different groups of fish were involved). These fish were able to swim from 15 to 25 feet up the swift water in the section where the velocity was approximately 8.6 ft. per second.

[1] Submitted for publication May, 1950.

APPLICATION OF DATA

From time to time fish managers have become interested in the possibility of excluding rough fish from trout streams by the use of barriers. A difference in the swimming speed of the two groups of fishes might make certain types of barriers effective.

Since the writer has not made observations on the swimming speed of adult trout it will be necessary to quote pertinent data from a paper by Denil (1938).

"Trout 35 cm. [13¾ in.] expended effort of 390 grams corresponding to a velocity in reasonably horizontal water of approximately 3.5 m. per second [11.4 ft. per sec.].

"These limits for a trout, in sudden efforts, would be 1.4 times its weight; for a salmon, 1.2 times its weight. These coefficients should be reduced by ½ when the effort is for 50 to 60 seconds."

Denil (*op. cit.*) states, also, that cyprinids [species?] are able to develop a force of 0.5 times their weight for about 50 to 60 seconds and assumes that for sudden short exertions they could develop a force equal to their body weight. Obviously, this is slightly less than for Atlantic salmon (*Salmo salar*) and considerably less than for trout (presumably *Salmo trutta*).

It should be pointed out that the suckers observed in lower Salt Creek advanced up the stream about 2 feet per second while overcoming the flow velocity of 8.6 feet per second. Thus, for very short exertions they attained a swimming speed of about 10 feet per second. Obviously, a stream flow of 10.6 feet per second would make it impossible for these adult suckers to do more than hold their place in the current for perhaps 5 seconds. This is a figure comparable to the 11.4 feet per second recorded for 13¾-inch trout by Denil. It is not surprising that trout should be able to swim faster than suckers, but it is surprising that the difference is no greater.

In the practical application of these data we see that as the stream flow becomes slower than the maxima of 10.6 feet per second for the 12-inch sucker and 11.4 for the 13¾-inch trout, the fish are able to gain headway in the water. For example, if the velocity of the stream were 5.6 feet per second the sucker could advance 5 feet per second and a distance of 25 feet in 5 seconds. The writer does not know how long either the trout or suckers can sustain high swimming velocities, but it seems obvious that water velocity alone would be a poor basis on which to separate trout and rough fish.

REFERENCE

Denil, G.

1938. La mécanique du poisson de rivière: qualités nautiques du poisson; ses méthodes locomotrices; ses capacités; ses limites; résistances du fluide; effet de la vitesse de la pente; résistance de seuil. Bruxelles, 395 p., 118 figs. (Reprinted from Annales des travaux publics de Belgique, vol. 37, 1936; vol. 38, 1937; vol. 39, 1938.)

NOTES ON FISHES RECENTLY INTRODUCED INTO SOUTHERN CALIFORNIA[1]

By Willis A. Evans and Philip A. Douglas
Bureau of Fish Conservation
California Division of Fish and Game

During the past two years several species of exotic fishes have been brought into California as bait fishes and may now be established in natural waters of the State. For purposes of record, these species are listed below.

Agosia chrysogaster Girard. Longfin Dace.

This species is a member of the family Cyprinidae. Specimens were obtained on April 2, 1948 by Warden Leo Rossier at Shorty's Bait Shop, Topock, Arizona. Fishing concession operators along the Colorado River in the Parker area are also handling it for live bait use.

Reliability of information cannot be vouched for, but reported sources of fish shipments containing this species were the following:

(1) Upper Bill Williams River, Arizona;
(2) A creek tributary to the Virgin River, Utah (an obvious error);
(3) Hassayampa River, just below Wickenburg, Arizona.

Dr. Carl L. Hubbs, who identified one of the fish obtained on April 2, 1948, believes that they may have been obtained from the Bill Williams River or possibly from the Gila River in Arizona, where this species is abundant. Regarding this, Dr. Hubbs states, "It is certain that the species was not introduced, at least not directly, from Utah, since the species is one of the lower Colorado River system and surely does not occur as far upstream as Utah."

Many of the specimens were heavily parasitized by a large tapeworm.

Pimephales promelas confertus (Girard). Southwestern Fathead Minnow.

On March 23, 1950, specimens of this cyprinid, together with those of the two species listed below, were examined at Bob Williams' Bait Shop, Yuma, Arizona, by Carl L. Hubbs and Robert R. Miller. These three bait fishes were being imported from Truth or Consequences (formerly Hot Springs), New Mexico, where they were being reared in bait tanks adjacent to the Rio Grande below Elephant Butte Dam. They have been used as bait along the lower Colorado River and it is not improbable that individuals have escaped alive into the stream. However, no specimens have as yet been taken directly from the Colorado River or other California waters.

Dr. Hubbs considers the Fathead Minnow to be the most valuable forage fish of the three, and believes that the tetra may be rather dangerous because of its carnivorous nature.

[1] Submitted for publication June, 1950.

Astyanax fasciatus mexicanus (Filippi). Texas Banded Tetra.

The Texas Banded Tetra is the only representative of the family Characinidae found in the United States. Its possible presence in the natural waters of California has been described above.

Fundulus zebrinus Jordan and Gilbert. Southern Plains Killifish.

This species is a member of the family Cyprinodontidae. Notes on its possible presence in the natural waters of California have been given above.

Gillichthys detrusus Gilbert and Scofield. Gulf Mudsucker.

The Gulf Mudsucker, a member of the family Gobiidae, is a close relative of the Long-jawed Mudsucker, *G. mirabilis,* which for many years has been a popular bait fish in Southern California, especially in the San Diego region. Several records are now at hand of its sale by live bait dealers in the lower Colorado River area of Arizona and California and there is some evidence that the species has become established in the Salton Sea.

(1) On May 17, 1949 one of the writers (P.A.D.) obtained a dried specimen of *Gillichthys detrusus* (identification by Carl L. Hubbs) from C. Roy Hunter, resort owner at Desert Beach, at the northeast end of the Salton Sea. It had been picked up along the beach and reportedly was alive at the time.

(2) On June 13, 1949 six specimens were obtained from Brownie's Bait Shop, Winterhaven, California, and one from Shorty's Landing, Topock, Arizona. These specimens were also identified by Dr. Hubbs.

(3) On July 23, 1949 Kirby H. Walker obtained dried specimens from islands inhabited by pelicans in the southwest end of the Salton Sea. Identification was made by Dr. Hubbs.

No specific information regarding introductions of this species into the Salton Sea is available, but several possibilities have been suggested.

(a) The possibility of natural introduction through the irrigation system from the lower Colorado River received early consideration by Hubbs and others but may now be discounted, since recent collecting in the Salton Sea and from Laguna Dam to tidewater failed to secure specimens, other than a series from near the head of tidewater, below the mouth of Hardy River.

(b) An introduction may have resulted from escaped or dumped bait. Brownie's Bait Shop reports selling mudsuckers to several persons for bait use in the Salton Sea.

(c) It may have escaped from rearing ponds reportedly operated on the shore of the Salton Sea.

(d) A pelican flyway exists between the Salton Sea and the tidal flats in the Gulf of California, where the species is native, a distance of about 100 miles. It is possible, but not probable, that pelicans have carried live specimens into the Salton Sea from this source.

NOTES

INTRODUCTION OF KAMLOOPS RAINBOW TROUT INTO CALIFORNIA

The first known introduction of Kamloops rainbow trout, *Salmo gairdnerii kamloops* (Jordan), into California waters was made on June 17, 1950. At that time 1,000 fish were liberated in certain tributaries to Shasta Lake, Shasta County, California.

This introduction of Kamloops was made by the sportsmen of the City of Redding with the aid of the U. S. Fish and Wildlife Service and the California Division of Fish and Game. The sportsmen believed that this subspecies of rainbow would grow faster and be a better game fish than the native rainbows. This sportsmen's group imported 2,500 eggs from Idaho and these were hatched and reared for them by the Coleman Hatchery of the Fish and Wildlife Service. At the time of liberation these fish were 11 months old and averaged 12 per pound.

Following is a list of the waters planted:

	Number of fish
Squaw Creek	100
McCloud River	300
Sacramento River	200
Sugarloaf Creek	50
Middle Salt Creek	50
Big Backbone Creek	100
Shasta Lake at Bridge Bay	100
Shasta Lake at dam	100
Total	1,000

The fish were scattered in these streams directly above the confluence of each with Shasta Lake, in the hope that they will drop down into the lake soon after they have become acclimated.

It is realized that plants of fish as small as these may not establish spawning runs, even with reasonably good survival. However, since it is not known which tributaries will be best suited to their needs, it seemed wise to scatter them throughout six of the better streams.

All of these Kamloops trout were marked by removal of the left ventral and adipose fins, so that they may be distinguished from native rainbows. If any of these fish are caught and if their growth is sufficiently greater than that of the native trout, possibly larger plants at a later date will be justified.

The Redding sportsmen have given considerable publicity to this introduction and it is hoped and expected that all fishermen in Shasta Lake will watch for and report any rainbow trout with left ventral and adipose fins missing. The absence of these fins will be the only conclusive proof that a fish is a Kamloops trout. Marked fish should be brought to the Redding office or local representatives of the Division of Fish and Game for official examination and recording.—*J. H. Wales, Bureau of Fish Conservation, California Division of Fish and Game, June 1950.*

SOME LAHONTAN FISHES IN THE SACRAMENTO RIVER DRAINAGE, CALIFORNIA

An instance of the introduction en masse of four species indigenous to the Lahontan Basin into the Sacramento River drainage was noted on August 20 and 21, 1949, when Miller Lake, Placer County, and Richardson Lake, El Dorado County, were chemically treated by the California Division of Fish and Game to eradicate rough fish populations prior to restocking with rainbow and eastern brook trout.

The species obtained were three cyprinids, *Siphateles bicolor obesus, Richardsonius egregius,* and *Rhinichthys osculus robustus,* and a sucker, *Catostomus tahoensis.* Although all of the fish in the two lakes are assumed to have been killed, substantial populations of the above species occur in a small pond at the head of Miller Creek and in Miller Creek itself. This stream drains into the Rubicon River. Barrier dams were constructed at the outlets of the treated lakes to prevent re-entry of the unwanted species.

It has been assumed that the four Lahontan species were introduced by bait fishermen. This is probably true, as the overpopulation of rough fish, particularly the *Siphateles,* appears to have been a fairly recent thing.

The population of Richardson Lake was made up primarily of *S. b. obesus,* although substantial numbers of each of the other species were found. The population of Miller Lake consisted primarily of *C. tahoensis* and a few very large brown trout, although here, too, the other species were present.

Miller Lake at present drains into Miller Creek, but it appears entirely possible that this is a recent thing and that it once drained into Lake Tahoe via McKinney Creek. The grade separation between Miller Lake and McKinney Creek is slight and the character of the terrain is somewhat suggestive of an old landslide. The possibility of such an occurrence is further indicated by Rutter's (Bull. U. S. Bur. Fish., XXVII, 1907 (1908), pp. 103-152) report of *Catostomus tahoensis* from Miller Creek in Miller Pass. The pass where Miller Lake lies has been called Miller Pass, and as Rutter does not definitely locate his stream as to county, this pass may be the one he reported. If this is so, it seems likely that *C. tahoensis* and possibly two of the other species were not introduced by bait fishermen but occurred here naturally as the result of a landslide forcing Miller Lake into the Sacramento drainage. *S. b. obesus* was almost certainly introduced by bait fishermen, as it appeared only recently and immediately became a nuisance. *R. egregius* and *R. o. robustus* may or may not have occurred in the drainage naturally, since they are not as prominent a nuisance as is the *Siphateles* and therefore would not necessarily have been noticed, although it seems probable Rutter would have collected them if they had been present in 1907.—*J. B. Kimsey, Bureau of Fish Conservation, California Division of Fish and Game, May 1950.*

PACIFIC COD OFF NORTHERN CALIFORNIA

On October 21, 1949, the California Fish and Game research vessel, "N. B. Scofield," caught a Pacific cod, also known as Alaska codfish, *Gadus macrocephalus,* while engaged in experimental drag-net operations in the Eureka region. This specimen, 21¾ inches, total length, 5½ pounds gross weight, was taken in 43 fathoms of water about 12 miles northerly of the entrance to Humboldt Bay and seven miles off shore.

FIGURE 169. Pacific cod, *Gadus macrocephalus.* Photograph by J. B. Phillips

In a note in *California Fish and Game,* July, 1946, the author reported two other specimens caught in the Eureka region. These were taken by boats trawling between Trinidad Head and Humboldt Bay. Although the occurrence of the Pacific cod as far south as Eureka is uncommon, it is not rare. In one of the above cases, six specimens were reported as taken in a drag net but only the largest one was brought in for identification. Other drag boat operators tell of getting occasional specimens of the Pacific cod in their trawls during a season, but these are not always brought ashore. *J. B. Phillips, Bureau of Marine Fisheries, California Division of Fish and Game, May, 1950.*

REVIEWS

THE NATURE OF NATURAL HISTORY

By Marston Bates. Charles Scribner's Sons, New York, 1950, 309 p. $3.50.

Marston Bates set out to write this book with the avowed purpose of explaining the attitude and the method of modern science to the nonscientist. He attains his goal. His medium is natural history, his field, as an example of a science and as a framework on which to build his story. To Dr. Bates, natural history does not mean, as he puts it, the "oh my!" school of nature lovers. It means the study of plants and animals as individuals and as groups of individuals. The book carries the reader through the whys and the wherefores of natural science from an exposition on how living things are classified, and why a system is needed, to a final summing-up of what Dr. Bates feels science to mean in terms of objective and of purpose. Along the way there are sections on the geological history of life, its development and spread, on concepts of evolution, adaptation, and environment, on relationships for good or bad between organisms, on the organization of individuals into communities and populations. There is a fascinating chapter on the natural history of naturalists. The book is indexed and includes a good list of references.

A refreshing sense of humor prevails throughout the book. No more is presumed of the reader than intelligence and an interest, no matter how latent, in the subject, though at least a vague memory of high school biology would be helpful. The language is clear. There are technical terms, for these cannot be avoided in a book of this sort, but they are introduced with reason and are with few exceptions defined with care.

The reader will get a good groundwork in natural history and a picture of many of the theories and hypotheses upon which this science is or has been based. He will gain an appreciation of the workings of the "scientific mind," of how the scientist goes about his job and what he hopes for. This is a book to be read with profit and enjoyment by scientist and nonscientist alike.—*Phil M. Roedel, California Division of Fish and Game.*

THE FISHERMAN'S ENCYCLOPEDIA

Ira N. Gabrielson, editor; Francesca La Monte, associate editor; Stackpole and Heck, Inc., Harrisburg, Pa., 1950, xxix + 698 p., profusely illustrated, 17 color plates. $12.50.

This is a tremendous volume, both in content and size. With the whole of North America and the adjacent oceans as its field, it is a huge undertaking. No less than 64 persons, in addition to the editors, are listed as contributors, and the result is truly encyclopedic. Every topic likely to be of interest to the sportsman is covered in some degree, usually a large one. Probably the section titles best illustrate the scope: Game Fishes; Fishing Equipment and Fishing Methods; Craft for Fishing; Fishery Management Methods; Where to Fish; When and How to Fish; and Miscellaneous Topics. This latter potpourri includes essays on such

diverse topics as sportsmanship, fly tying, cookery, camping and canoeing, the Fish and Wildlife Service, the International Game Fish Association—to name a few. There is a glossary and an index.

The editors have struck an excellent balance. In general no one area, no one point of view, no particular technique is seen in faulty perspective. Naturally, in a compendium such as this, any reader is sure to find something to which he takes exception. This reviewer, no doubt because he works with marine fishes for a state agency, would have liked to find more of marine research—the section on fishery management is devoted to fresh water work—and something of the programs being carried on by the states. But this does not alter the basic fact that here is a fine collection of fishing data and fishing lore, assembled with care and presented in a manner which cannot fail to please.

What about details? There are, to be sure, errors of commission and of omission, and there are some inconsistencies. An occasional typographical error comes to light and at least two pictures are printed upside down. To save potential seekers or doubters a perhaps lengthy search, these are of the sawfish on page 12 and one of the two pictures of the starry flounder on page 68. Both the starry flounder and the halfmoon are illustrated twice. The over-all impression more than offsets these imperfections, which, by and large, are not serious and do not impair the general usefulness of the volume. The photographs are as a group far above average and the color plates unusually good. The general physical makeup and typography leave little to be desired.

Here, then, is a well-written book which more than lives up to its title. It is too bad that it is necessary to set so high a price on books of quality, for this is one which every sportsman will want to own. I am sure that all who purchase it will find themselves more than repaid in pleasure and information.—*Phil M. Roedel, California Division of Fish and Game.*

THE SEA AND ITS MYSTERIES

By John S. Colman; The British Book Centre, New York, 1950, 285 p., 36 figs., 1 fold-in map, 17 plates, 1 in color. $3.

"The Sea and its Mysteries" is more properly, if prosaically, "An Introduction to the Science of the Sea," and that is how its subtitle reads. This does not imply any lack of mysteries, for it is to solve them that the relatively young science of the sea exists. Many things about the sea are understood, and many questions relating to these things are answered in this book. Many other things are not understood or are only partly and perhaps incorrectly understood. These are the mysteries, and they form their part of the story.

Essentially, the book tells of oceanography and marine biology and of what these sciences involve. Not everything can be presented in one book of this size, as the author is very well aware, and doubtless no two people in the field would agree on just what topics should be emphasized. However, Mr. Colman has chosen his material with care and has not missed any essentials. He speaks distinctly so that no one need fear a text comprehensible only to another student of the sea. He has written

for the nonprofessional and done a good job—which by no means implies that the professional will not find the book useful.

The book starts with discussions of the physical makeup of the sea: its shape, constituents, currents and tides. This leads to a survey of life in the sea, both plant and animal, large and small, and the relationship of these living things to their environment and to each other. A separate chapter considers coral reefs, particularly the Great Barrier Reef of Australia which the author knows intimately. Another deals with the intertidal zone. The history of oceanography and fisheries research and something of their tools and techniques occupy all too short a space just before the final chapter, which tells of what the amateur naturalist might hope to see while passenger aboard a small cargo liner.

As is to be anticipated in a British book, most of the examples relate to the Atlantic in general and England in particular. Readers unacquainted with either will not find this a drawback, and those whose experience is in the Pacific should find their interest enhanced by the change of scene.

This book is recommended to anyone who wishes a general background in the science of the sea. The selected bibliography provides ample reference for those wanting to delve deeper into the subject.—*Phil M. Roedel, California Division of Fish and Game.*

THE AMERICAN WILD TURKEY

By Henry E. Davis; Small-Arms Technical Publishing Co., Georgetown, S. C., 1949, viii + 319 p., 21 figs. $5.

Mr. Davis, who is a lawyer, has based this book on experiences gained in his lifetime of hunting wild turkeys. He has divided space about equally between hunting methods and various aspects of life history and management. Anecdotes are heavily relied upon. Many of the plates are artistically excellent, though their value to the text is limited by the lack of numeration.

The author makes it clear that such first-hand information as he presents concerning behavior, life history, and population dynamics were acquired secondarily in the course of hunting turkeys. For such data he relies almost exclusively on Mosby and Handley's "The Wild Turkey in Virginia."

Several suggestions for turkey management are offered, including restocking with pure wild stock, predator control, revised open seasons, more stringent law enforcement and maintenance of required habitat. In this discussion the findings of research workers are in general concurred with, though particulars are somewhat adjusted to the personal views of the author.

A wealth of expert information on techniques and on various types of firearms, callers, etc., used in hunting turkeys is given in an easily read style. These sections should prove to be of interest to all sportsmen—whether turkey hunters or not. The scientific reader, however, will do well to look elsewhere for his information.—*Fred L. Jones, California Division of Fish and Game.*

TAKING LARGER TROUT

By Lawrence R. Koller; Little, Brown and Company, Boston, 1950; xvi + 273 p. $5.

This is not a book for the beginning angler. Koller points out that most such books treat the taking of trout in a general way only, i.e., how to catch trout, regardless of their size. He concentrates exclusively on the taking ". . . of trout that normally do not find their way into the casual fly caster's creel except by chance." By his own definition these "larger trout" appear to be those exceeding 12 inches in length—the "lunkers" whose size is reckoned in pounds rather than in inches.

Dry fly methods, the use of bait, and spinning are all discussed, but the greatest emphasis is laid on the use of wet flies, bucktails and streamers. Little attention is given to downstream casting methods. Instead, the across-stream cast and retrieve, the natural drift, and the upstream sunken fly are considered to be the most productive methods, and these are thoroughly described.

There is a good discussion of lures. The author's most unique contribution in this field is his detailed description of five different designs of a single wet fly pattern to meet changing conditions in water level, season, and type of stream.

Lake or pond fishing is not treated; this is a book on stream fishing alone. The accounts are drawn from the fabled streams of the Eastern states, but the western angler will recognize the applicability of the methods to our own waters.

Koller points out that with new developments in tackle, and the increase in number of fishermen, "Increasing emphasis must be placed on taking fewer fish for the creel so that each angler may have his chance . . ." He believes that today's angler should be content to take a few fish of worthy size, and his well written chapters should enable his readers to realize this aim. Forty line drawings and photographs, including two color plates of artifical flies, plus a colored frontispiece add to the attractiveness of the volume.—*William A. Dill, California Division of Fish and Game.*

FISHING IS FUN

By Arthur H. Carhart; The Macmillan Company, New York, 1950; 122 p. $1.95

The title of this book is aptly chosen because a large part of this fun is found in knowing the why's and wherefore's. Carhart stresses this basic understanding of fish, tackle and water throughout his account.

The book is designed primarily for the beginning angler and the occasional fisherman. It treats fresh water fishing from carp to trout, from cane pole to fly rod and from muddy slough to mountain stream—but always with the basic precept that fishing is fun.

One of the fascinations in fishing is the fitting together of skill in handling tackle with lore of fish and water. The author does an admirable job of covering these basic fundamentals in a thorough fashion. Any beginner who reads and studies this book will have a sound background in the art of angling and if coupled with understanding and practice can not help becoming a better fisherman. The expert is not

likely to find anything new in Carhart's explanations but he will find the book well worth reading—for the very same reason it behooves a practicing biologist to review occasionally an elementary textbook on biology—because the fundamentals, although all-important, are apt to be taken for granted while the reasons for them are lost.

The last chapter, "Your Future Fishing," discusses conservation in terms that everyone can understand and appreciate. For example, the author shows the futility and expense of raising fish in hatcheries as a cure-all for man's mismanagement of soil and water. As he puts it, "If the spawning conditions are right, natural production, at no cost, will surpass anything possible in the way of hatcheries."

Carhart's definition of sportsmanship in angling is worthy of the attention of every fisherman. "True sportsmanship is found in the way the fisherman goes about catching fish. He looks on it as a contest and the number of fish caught is not so important as skill in catching a few. A man casting a dry fly with highest skill can be just as poor a sport as anyone who baits a hook with a worm and drops it into a likely pool where catfish lurk. Any fishing should be a top-rate sport, and anyone who goes fishing may be a sportsman regardless of his tackle or the fish he catches. If he has the right attitude, plays the game fair, he is a good sportsman."—*Scott M. Soule, California Division of Fish and Game.*

THE SHELL COLLECTOR'S HANDBOOK

By A. Hyatt Verrill; G. P. Putnam's Sons, New York, 1950, xv + 228 p., 16 plates, 89 figs. $4.

Did you know that the paper nautilus is an octopus and that during the spawning season the female forms a shell to hold her eggs until the young are hatched, after which she sheds the shell? That a soft golden cloth, perhaps the most expensive of all textiles, is made from the thread-like byssus of a pen shell? That india ink and cuttlefish bone both come from the same species of squid? That one type of shell from China was so rare that counterfeits were made by the Chinese from rice paste and sold to collectors?

These facts and many other interesting notes on the natural history of mollusks are to be found in the pages of this book. In addition there are chapters containing advice on how to collect, clean, prepare and care for shells, and how to classify and identify them, as well as much other valuable information. Its beauty would have been enhanced by color plates of some of the exotic species, but the black and white photographs supplemented by nearly a hundred line drawings do a noble job of illustrating the text. The title is misleading as it is far more than just a guide book or manual. The book is definitely not a key and should not be purchased to identify shells from any particular geographical locality. It is a volume worth having on your shelves as a general reference, and it would be difficult to improve upon it for interesting reading.—*John E. Fitch, California Division of Fish and Game.*

THE EASTERN BROOK TROUT

By Bob Elliot; W. W. Norton & Co., Inc., New York, 1950; 242 p. $5.

With admirable singlemindedness, the author, Bob Elliot, has restricted himself to a discussion of but one fish—*Salvelinus fontinalis.* As an expert fisherman and a competent writer, he is able to communicate his enthusiasm and to share his enviable experiences in catching giant brookies in the few remaining wilderness areas of the east. In fact, one might suspect this volume to be a deliberate piece of high class advertising for New England in general and the State of Maine in particular. The apparent provincialism is justifiable, however, for Maine is one of the very last strongholds for truly large brook trout.

The history, identification and coloration of the brook trout are reviewed briefly in the first chapter. Other chapters are devoted to a discussion of the role of hatcheries, the future of the species and a few choice recipes for the fish gourmet. It is quite obvious, however, that this book is primarily intended for the fisherman, especially the trout angler with purist inclinations and an inherent love for the "square-tail." Appropriately, therefore, the remainder of the chapters make up a detailed guide for the brook trout angler. Here are presented methods of fishing, proper tackle and a short history of both. There are authentic lists of huge brook trout over six pounds, giving location, date caught, name of angler, size of fish and type of tackle used. Also listed are most of the better brook trout waters of United States and Canada. Some western states are included, but the California reader will be chagrined to find his state omitted. Even so, he will soon find himself back fishing again with the author, learning of new waters and perhaps new techniques. There is a bewildering list of favorite flies chosen by various experts. The author intimates, however, that the lack of agreement among them merely indicates that one should have confidence in the fly he is using, and should know how to use it properly, whether it is a Royal Coachman or a Parmachenee Belle.

Although this book has primarily a "popular" appeal, the fishery biologist and the fish culturist will find that the information which it contains regarding fish conservation is accurate. It is especially pleasing to see expressed in public the idea of fishing for sport rather than for meat or for the satisfaction of one's ego. Like many of us, Mr. Elliot feels that with the ever-increasing pressure upon our fisheries, this approach is mandatory.

With excellent format, sound references and 17 fine photographs by the author, this volume is quite worthy of a place upon the serious fisherman's book shelf.—*Herbert E. Pintler, California Division of Fish and Game.*

THE WAY TO GAME ABUNDANCE, AN EXPLANATION OF GAME CYCLES

By Wallace Byron Grange; Charles Scribner's Sons, New York, 1949; 365 p. $6.

The basic ecological principles governing game populations are presented as completely as possible in a style easily digested by the non-technical reader. Discussions of the various factors, such as the nature of behavior patterns, food dependencies, breeding potentials, and theories of predation and disease, are tied to a central theme which stresses species adaptation to particular plant succession stages. Upon this dependency is based Grange's theory of the causes and mechanics of game cycles.

In brief he has determined that set-backs in vegetational forms to subclimax stages are followed by peaks of abundance of game species finding optimum food and cover in those stages. In a short span of years, as the vegetation advances, the quality of the habitat decreases and the high density population experiences a "crash." The simultaneous occurrences of these highs and lows within a species over the entire continent is attributed to cyclic weather phenomena, which initiate the original vegetational set-back. The particular cyclic weather factor stated as being responsible is drought, which in turn favors extensive and frequent fires—the actual denuding agent, according to the author.

Grange goes on to discuss management techniques for game in general and for several species of farm game in particular. The use of fire is particularly stressed.

The chief example that is used to illustrate the working of the climatic-plant succession theory of game cycles is the snowshoe rabbit. The case here, as given, appears to be clear-cut. However, the evidence for similar causatives of "cycles" in some of the other species, particularly white-tailed deer and bobwhite quail, and those of the arctic, is not so clear.

The book has stimulated a good deal of thought above and beyond its bounds. The principles proposed may be contested from numerous points and at various levels, but the originality of thought and the contribution made toward the understanding of game cycles stands as a work of importance and of definite value.—*Fred L. Jones, California Division of Fish and Game.*

BOBWHITES ON THE RISE

By Verne E. Davison; Charles Scribner's Sons, New York, 1949; 150 p. $3.75.

This readable book summarizes much of the research and management work in respect to bobwhite quail. The section dealing with traditions to forget is unquestionably the most appealing to game and land managers and sportsmen alike. There is no doubt but that the discussions of traditions will be used as points of debate for years to come. The author could have driven his points home better if he had quoted the results of the work of the researchers at greater length, rather than depending so heavily on his bibliography. The book in itself does not serve as an all-inclusive guide to the game manager but it does tell where the information may be procured relating to bobwhite quail habitat management.

The final chapter on farmer-sportsman relationship recognizes the state ownership of game species but it also stresses the custodianship of the game by the landowner. Too little credit has been given to the person who raises game for the hunters and, as a palliative, the author proposes that hunting licenses be null and void until permission to hunt is secured from the landowner. Although the book is written particularly about bobwhite quail, portions are applicable to several game species.—*Henry A. Hjersman, California Division of Fish and Game.*

NORTH AMERICAN FRESH WATER SPORT FISH

By Lou S. Caine; A. S. Barnes and Company, New York, 1949; xii + 212 p. $5.

This book fulfills a definite need in the library of both angler and fisheries biologists for an up-to-date handbook covering all of our fresh-water sport fish, i.e., those which are ". . . fished for with hook and line and caught for sport or pleasure, regardless of . . . [their] . . . edible or game qualities."

It begins with a chapter on "Fish Facts": elementary notes on such subjects as color vision in fishes, fish anatomy, and ecology. This is followed by chapters covering each of twelve families: the sunfishes, the salmons and trouts, graylings, pikes, perches, basses, bowfins, drums, catfishes, minnows, suckers, and whitefishes. There is a section on tackle and a final chapter on angling methods. A bibliography comprised primarily of angling titles, but including some standard references, and an index completes the book. There are a few color plates and photographs; the frontispiece is from a painting of a brook trout by William J. Schaldach.

While the sections on tackle and fishing methods are of interest, the real value of the book lies in its descriptions of the fishes. These follow a standard form for each species: black and white drawing; common and scientific names; colloquial names; coloration; characteristics (for identification); range; habitat; size (including the world's record); natural foods; artificial lures; fishing methods; biological facts. Dr. Karl F. Lagler of the University of Michigan is responsible for these biological notes covering spawning habits, growth, etc. The descriptions are not always complete enough to enable the reader to distinguish between some of the closely related species, e.g., the Pacific salmons. However, it will facilitate the recognition of most of the species caught by anglers.

The scientific names are up-to-date. The official common names are those which were recently selected by the Outdoor Writers of America and should promote a stability in vernacular nomenclature.—*William A. Dill, California Division of Fish and Game.*

REPORTS

FISH CASES

April, May, June, 1950

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalone: Undersize; overlimit; no license; out of shell; closed season; diving gear in closed district; failure to show license; using another person's license; taking abalone in marine life preserve	188	$4,987 50	
Angling: No license; late angling; failure to show angling license on demand; possession of gaff; using artificial light; night fishing; using a license not issued to him; transferring license; using set lines; illegal spearing; angling with more than one line; fishing within 150 feet of lower side of a dam; angling in waters closed to fishing; closed season; taking fish other than by angling, i. e., by use of firearms; more than 2 attractor blades; possession of fishing equipment in fish refuge; false statement in obtaining citizen fishing license; making a false statement on angling license	449	6,002 00	12½
Barracuda: Selling fish from sport boat	1	10 00	
Black bass: Out of season; possession undersize; angling with too many poles	8	145 00	
Rock bass: Possession overlimit; no license; using another's license	1	45 00	
Striped bass: Angling, no license; overlimit; 2 lines; angling with more than 1 line; undersize	99	2,000 00	5+5 susp.
Carp: Night fishing; no license	2	35 00	
Catfish: Possession undersize; overlimit; no license; night fishing; taking catfish other than by angling; possession for sale untagged catfish; taking undersize channel catfish in District 22; angling with more than one line	36	905 00	50
Big neck clams: Overlimit; no license	14	305 00	
Cockle clams: Overlimit; no angling license; taking in closed season; undersize	27	570 00	
Gaper clams: No license; possession overlimit	5	45 00	
Pismo clams: Undersize; overlimit; no license; failure to return undersize to water; possession undersize in closed area; taking in state clam preserve; possession clam forks in clam preserve; possession clams out of shell	104	2,512 00	120
Razor clams: Overlimit	1	25 00	
Commercial: No license; no registration; dragging in less than 25 fathoms; no boat plates; failure to make fish purchase records; no party boat permit or records; false statement; no alien license; gill nets on boat in District 19A	51	1,512 50	
Crabs: Undersize; possession of over 500 lbs. on drag boat	6	375 00	
Crappie: Possession in closed season; taking in closed season; night fishing; failure to show license; no license	10	305 00	
Frogs: Closed season; possession spears within 300 feet of prohibited stream; undersize	14	430 00	
Halibut: Failure to show angling license	1	fine susp.	
Lobsters: Possession in closed season; possession of lobsters taken illegally; fishing in closed area; taking in closed season; undersize	11	395 00	
Mussels: No angling license	3	25 00	
Pollution: Use of bluestone; permitting petroleum product to enter state waters; by petroleum oil	7	625 00	
Rockfish: No angling license	1	10 00	
Salmon: Undersize; fishing within 250 feet of fishway; mutilation of fish; no license	8	520 00	
Sea urchins: Taking from Pt. Lobos State Park	2	20 00	
Shad: No license	2	20 00	
Sturgeon: Possession of sturgeon taken in gill net	2	50 00	
Sunfish: Possession in closed season; overlimit; out of season; no license; using another's license; predating license; fishing without license	30	640 00	27½
Trout: Fishing in closed waters; angling with more than 1 rod; overlimit; closed season; no license; fishing in closed stream; taking steelhead with spear; fishing within 150 feet of lower side of dam; night fishing; taking trout from waters of District 103.6; set line; 2 poles; using more than 2 attractor blades; fishing within 300 feet of inlet of lake; failure to tag domestic fish sold; possession steelhead taken with gaff	134	3,607 00	
Tuna: Possession of undersize tuna and offering for sale	1	60 00	
Yellowfin croaker: Possession of overlimit	1	25 00	
Totals	1,218	$26,206 00	215

GAME CASES

April, May, June, 1950

Offense	Number arrests	Fines imposed	Jail sentences (days)
Deer: Doe; possession parts of spike buck; using .22 rifle; out of season; possession of skin of female deer; transporting illegal deer into California; using spotlight; killing forked horn in District 1¾; failure to fill out tags; killing doe; taking deer in violation of fish and game regulations; possession of fawn; closed season; possession of light and gun in deer area	24	$2,050 00	180
Deer meat: Possession in closed season; illegal possession; possession of unstamped deer meat; possession of illegally taken game, i. e., deer meat; possession more than 15 days after legal season	20	2,231 00	90
Doves: Closed season; possession in closed season; taking out of season and by using air pistol	4	295 00	----------
Ducks: Bringing illegal ducks into California; making false statement on hunting license; closed season; using live decoys; possession of wooden duck in closed area; shooting with .22 rifle in game refuge; overlimit	11	597 50	----------
Geese: Hunting in closed season; on closed area; overlimit; possession of cackling goose and firearm on refuge	2	125 00	----------
Hunting: Taking game animals by use of artificial light and gun; possession of gun in refuge; using unplugged shotgun; shooting protected nongame birds; hunting in closed area; shooting from power boat; late shooting; no license	24	655 00	----------
Migratory waterfowl: Late shooting	1	20 00	----------
Nongame birds: Taking nongame birds; meadowlark; shooting seagulls	4	95 00	----------
Pheasants: Hen pheasants; possession of untagged pheasant; closed season; hunting on cooperative pheasant area; no permit; shooting out of season; hunting with .22 rifle	14	637 50	75
Quail: Possession in closed season; taking in game refuge; taking out of season	7	155 00	10
Rabbits: Taking cottontail rabbits in closed season; no license; night hunting; possession of cottontails in closed season; hunting rabbits without license; taking cottontails without license	73	3,092 00	----------
Shore birds: Taking protected shore birds	1	25 00	----------
Squirrels: Possession of tree squirrel	1	25 00	----------
Totals	186	$10,003 00	355

SEIZURES OF FISH AND GAME

April, May, June, 1950

Fish:	
Abalone	2,106
Barracuda, pounds	207
Black bass	9
Rock bass	17
Striped bass	176
Carp	7
Catfish	202
Big neck clams	273
Cockle clams	4,575
Gaper clams	47
Pismo clams	1,320
Razor clams	38
Crabs	22
Crappie	70
Frogs	31
Lobsters	246
Octopus	1
Salmon	25
Sea urchins	3
Sturgeon	1
Bluegill sunfish	400
Trout	875
Tuna, pounds	3,345
Yellowfin croaker	24
Game:	
Deer	4½
Doves	16
Ducks	42
Geese	4
Nongame birds	4
Pheasant	10
Quail	14
Rabbits	82
Shore birds	2
Squirrels	1

INDEX TO VOLUME 36

O

29004 6-50 7500