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AN EVALUATION OF FIVE TAG TYPES USED IN A STRIPED BASS MORTALITY RATE AND MIGRATION STUDY[1]

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INTRODUCTION

Tagging is one of the more important techniques used to study fish populations and the primary technique selected for a 1958-1961 study of the mortality rates and migrations of striped bass, *Roccus saxatilis,* inhabiting the Sacramento-San Joaquin River system and the San Francisco Bay area in California.

Four qualities that tags must possess if valid results are to be obtained from their use are:

a) They must not affect mortality.
b) They must not affect the fish's vulnerability to fishing gear.
c) They must not be shed.
d) They must be easily recognizable and contain sufficient instructions so the person catching the fish will see and know what to do with the tags.

Using these criteria five kinds of tags are evaluated in this paper.

Many tag types have been used in fish population studies, but none has been universally acceptable (Rounsefell and Everhart, 1953). In most previous striped bass studies, Petersen disk tags have been used (Clark, 1934; Pearson, 1938; Merriman, 1941; Morgan and Gerlach, 1950; Calhoun, 1952; Vladykov and Wallace, 1952; Calhoun, 1953). Generally the tags were shed quite rapidly, making them unsatisfactory for mortality rate studies. The shedding was caused partly by attachment at unsatisfactory locations on the fish (Calhoun, Fry and Hughes, 1951; Calhoun, 1953). However, relatively few of even the best-designed Petersen disk tags used by Calhoun were returned after the first year, indicating they were probably being shed (Chadwick, 1962).

The only other tag type used on striped bass before the present study was an internal one (Merriman, 1941; Raney, 1952). Although it offered promise, the difficulty of recovering this type of tag from the California sportfishery was believed insurmountable.

The promising results with disk-dangler tags (modified Atkins tags) on striped bass (Calhoun, 1953), on white catfish, *Ictalurus catus,* (Pelgen and McCammon, 1955), and on largemouth bass, *Micropterus salmoides,* (Kimsey, 1956, 1957) suggested that they might be the best

[1] Submitted for publication August 1962. This study was performed as part of Dingell-Johnson Project California F-9-R, "A Study of Sturgeon and Striped Bass", supported by Federal Aid to Fish Restoration funds.

tags available for striped bass. Consequently, they were selected as the standard tag for this study.

Other studies suggested that "spaghetti" tags (Wilson, 1953; Collyer, 1954; Kimsey, 1956) or Einer Lea hydrostatic tags (Kimsey, 1956; McCammon, 1956) might prove suitable, so they were tested. Work subsequent to the start of this study indicated that dart tags (Yamashita and Waldron, 1958) and streamer tags (David, 1959) might be suitable, so they were also included.

Most of my information about these tags was obtained by tagging groups of striped bass from the main population in the Sacramento-San Joaquin River system. Most of the bass were caught with gill nets in the Sacramento and San Joaquin rivers near Antioch during the spring spawning migration (Chadwick, 1960).

Since recoveries were from a sportfishery scattered over a wide area, biologists were able to examine few tagged bass. To obtain additional information about the condition of tagged fish, a postal card questionnaire (Figure 1) was sent to each angler returning a tag during 1959 and 1960. The questions asked were subjective, so the replies were of value only for comparative purposes.

Tag No. ______________

Condition of flesh around tag
(Check one)

_____no sign of a sore.

_____slight sore, not serious.

_____bad sore.

Was there a large amount of moss or other material attached to the tag:
Yes_____ No_____

If yes, please describe it.

Any further comments?

FIGURE 1. Postal card questionnaire sent to anglers returning tags.

The reliability of different kinds of tags was also tested by tagging landlocked striped bass in San Luis Wasteway, an irrigation canal near Los Banos, California. These were tagged in a wasteway pond that was about 200 feet wide, 200 yards long, and a maximum of 10 feet deep (Figure 2). Many of the bass tagged there could be recovered periodically by seining. Most were double-tagged and this was essential, since wounds from shed tags frequently healed so perfectly no external evidence of tagging could be seen.

Limited information was also obtained by observing a few tagged bass in a 1,000-gallon aquarium.

Since conditions in San Luis Wasteway and the aequarium were vastly different from the natural environment, the results were not comparable to those in the Sacramento-San Joaquin River, but they did provide useful information.

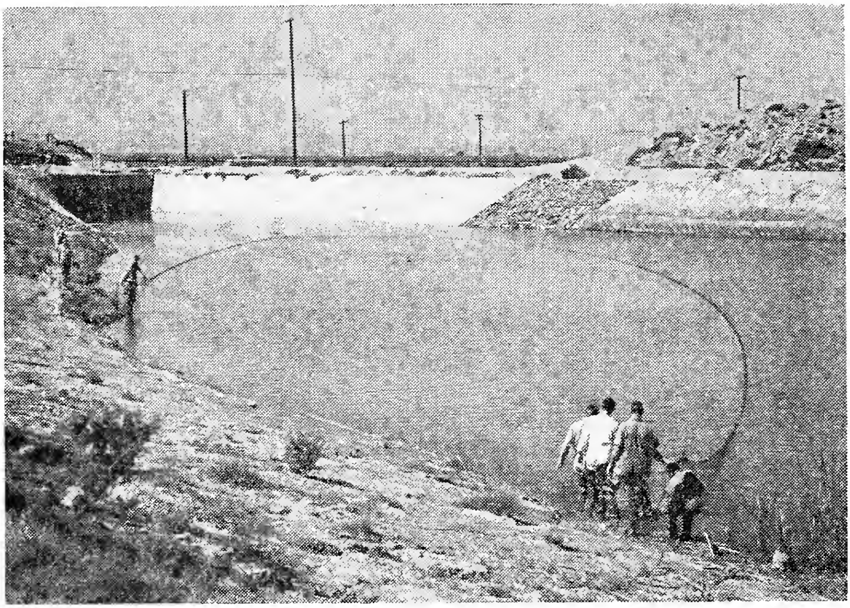

FIGURE 2. Seining at San Luis Wasteway to recapture tagged striped bass for examination. *Photograph by George Nokes, March 1961.*

DISK-DANGLER TAGS

Description and Application

The disk-dangler tag, originally described by Calhoun (1953), consists of a plastic disk (Figure 3A) attached with a double wire. All of our disks were made of cellulose nitrate 0.04 inches thick and 0.5 inches in diameter and consisted of three layers—a middle opaque white layer with the printing, laminated between two clear layers.

Three types of wire were tested: pure tantalum 0.020 and 0.025 inches in diameter and Type 302 soft stainless steel 0.020 inches in diameter.

The tags were placed about halfway between the lateral line and the base of the first dorsal fin under the longest spines. They were applied to unanesthetized bass in a canvas tagging cradle by pushing two 17-gauge, 3½-inch hypodermic needles through the fish, threading the two tag wires back through the needles as they were pulled out, twisting the two ends of the wire together, and cutting off the excess with a pair of pliers (Figure 4). The posterior wire was placed perpendicular to the midline of the body. The anterior wire was inserted at an angle, so it came out at the same point as the posterior wire on the tag side, and ½ to 1 inch away from the posterior wire on the other side. This arrangement is believed to improve stabilization of the wires in the flesh (Kimsey, 1956).

Tagging Studies

About 16,000 striped bass were marked with disk-dangler tags between 1958 and 1961, most in the lower portions of the Sacramento and San Joaquin rivers near Antioch, but some farther upstream at Verona

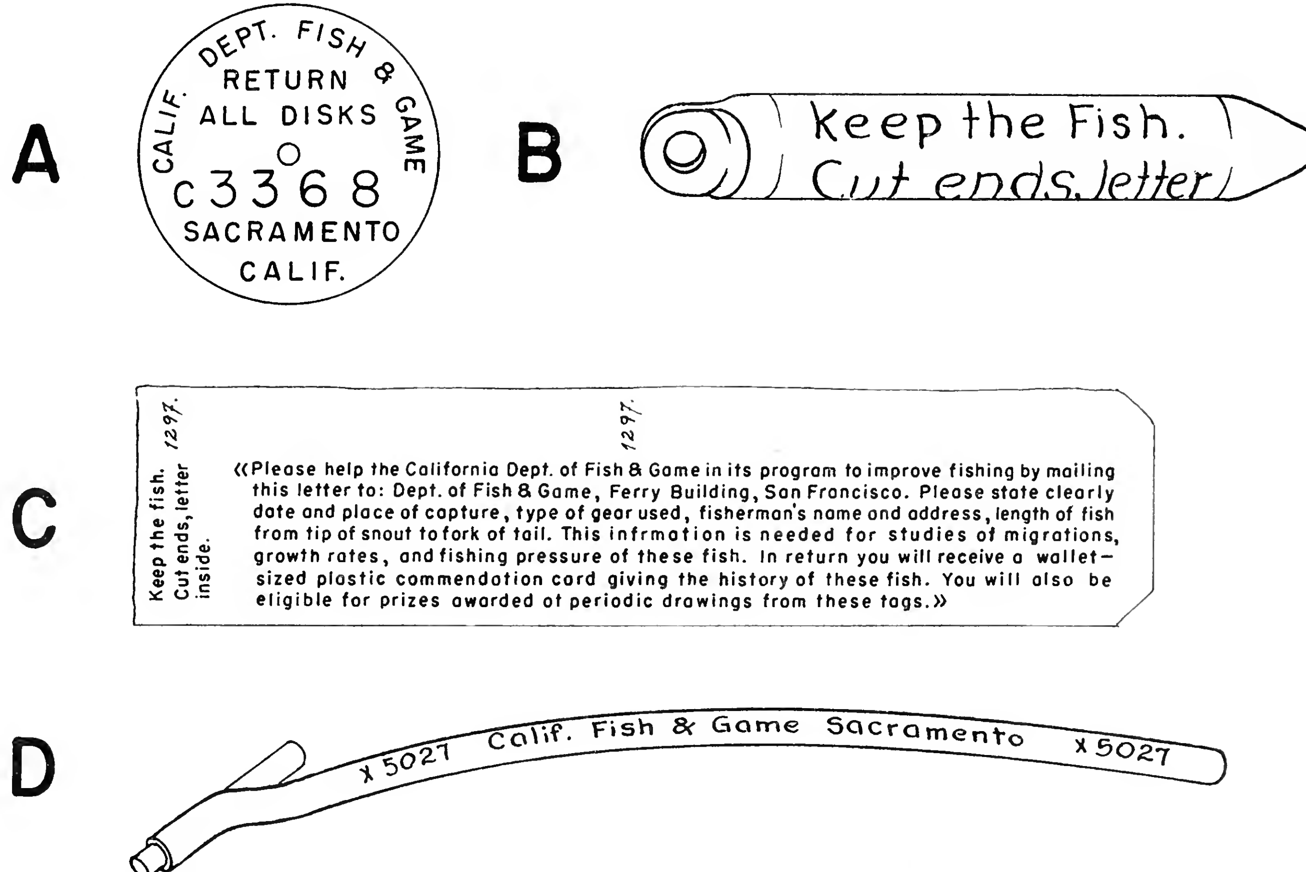

FIGURE 3. Diagrams of tags used: **A,** plastic disk used for disk-dangler and streamer tags; **B,** capsule of hydrostatic tag; **C,** message inside capsule of hydrostatic tag; **D** dart tag used at San Luis Wasteway.

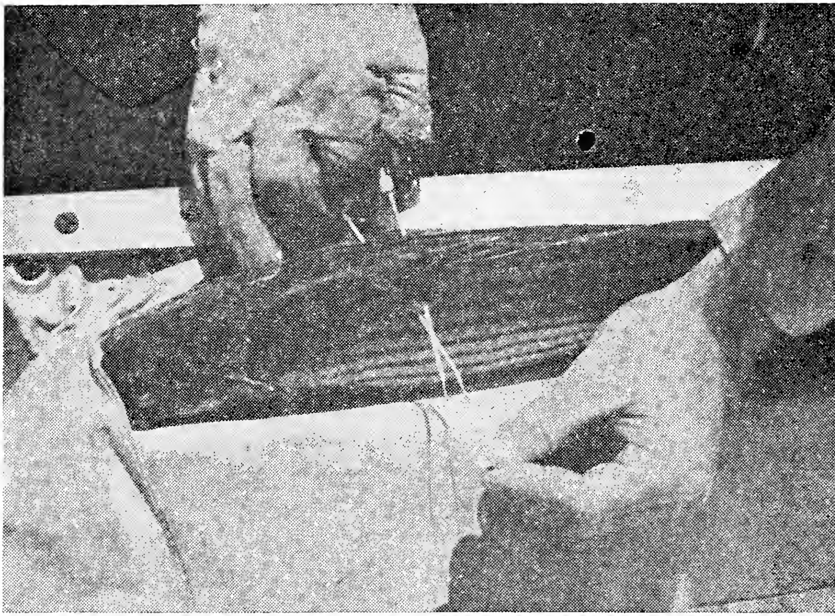

FIGURE 4. Tagging operation with bass in cradle and needles inserted through back. Wire on tag is being threaded back through needles. *Photograph by William Dillinger, May 1961.*

on the Sacramento River and at Prisoner's Point on the San Joaquin River. Others were tagged farther downstream in San Pablo Bay.

During the spring of 1958, comparative tests were made with 0.025-inch and 0.020-inch tantalum wire and 0.020-inch stainless steel wire. The comparative tests with 0.020-inch tantalum and 0.020-inch stainless steel wire were repeated during the springs of 1959 and 1960. The wire types being tested were used on alternate tags when being applied in a 1:1 ratio, or in the appropriate order when another ratio was used.

In addition to the regular field studies, 126 striped bass were tagged with disk-danglers at San Luis Wasteway during the late winters of 1958, 1959, and 1960. Both 0.020-inch tantalum and 0.020-inch stainless steel wires were used. Most fish were also marked with a second tag to measure shedding.

Ten bass tagged with disk-danglers in March 1961 were held for observation in a 1,000-gallon aquarium.

Evaluation of Results

Comparison of Three Kinds of Wire

The returns from field experiments with the three types of wire are summarized in Tables 1 and 2. A chi-square test indicates there is no significant difference between the returns of tantalum 0.020 and tantalum 0.025 wire ($\chi^2 = 0.37$, d.f. $= 1$, $P \cong 0.58$). For the 1958 tags, the stainless steel wire returns were significantly greater than the returns of tantalum 0.020 wire tags ($\chi^2 = 5.15$, d.f. $= 1$, $P = 0.02$). However, the opposite was true for the 1960 tags when the returns of tantalum 0.020 wire were substantially greater than those of stainless steel wire

($\chi^2 = 3.43$, d.f. = 1, P = 0.07). Returns from the 1959 tags were approximately equal for the two wires, so the differences were probably due to chance variations, indicating the overall effects of shedding, mortality, and vulnerability changes were equal in these tests.

TABLE 1

Returns from Striped Bass Tagged During the Spring of 1958 Near Antioch with Disk-Dangler Tags Attached with Tantalum Wire 0.020 and 0.025 Inches in Diameter

	0.020 Tantalum		*0.025 Tantalum*	
	Number	*Percent*	*Number*	*Percent*
Tagged	549		560	--
First-year returns	128	23	119	21
Second-year returns	36	7	34	6
Third-year returns	11	2	16	3
Total returns	175	32	169	30

TABLE 2

Returns from Striped Bass Tagged Near Antioch with Disk-Dangler Tags Having Tantalum and Stainless Steel Wire 0.02 Inches in Diameter

	1958 Tags				*1959 Tags*				*1960 Tags*			
	Tantalum		*Stainless*		*Tantalum*		*Stainless*		*Tantalum*		*Stainless*	
	No.	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*	*No.*	*Pct.*
Tagged	1,212		1,802		1,734		1,545		1,809		1,809	
First-year returns	231	19	392	22	260	15	238	15	278	15	239	13
Second-year returns	51	4	93	5	150	9	140	9	--	--	--	--
Third-year returns	30	2	47	3	--	--	--	--	--	--	--	--
Total returns	312	26	532	30	410	24	378	24	278	15	239	13

TABLE 3

Degree of Irritation Caused by Disk-Dangler Tags with Three Types of Wire, as Indicated by Postal Card Questionnaires

	Tantalum wire 0.020″ diameter	*Tantalum wire 0.025″ diameter*	*Type 302 soft stainless steel wire 0.020″ diameter*
Percentage having no sore	53.6	44.3	57.2
Percentage having slight sore	39.7	41.8	33.4
Percentage having bad sore	6.7	13.9	9.5
Total tags	1,219	79	887

The postal card questionnaires also indicated there was little difference in the irritation caused by stainless steel 0.020 and tantalum 0.020 wires (Table 3). Greater irritation was indicated for the tantalum 0.025 wire, but the number of replies was too small to permit valid conclusions.

Comparisons of the degree of irritation with the elapsed time between tagging and recapture for stainless steel and tantalum 0.020-inch wire indicate a static relationship (Table 4). While this does not necessarily indicate a static degree of irritation on an individual fish, it does indicate considerable continuing irritation with both wire kinds, and no overall trend of worsening or improvement in the degree of irritation.

The six 0.020 stainless steel wire and four 0.020 tantalum wire disk-dangler tags on the aquarium bass gave similar results. Within 10 months all 10 wires adhered firmly to the flesh, and in all but one of each the skin had grown completely over the wire knot.

TABLE 4

Degree of Irritation Caused by Disk-Dangler Tags with 0.020-Inch Tantalum Wire and Type 302 Soft Stainless Steel Wire and the Elapsed Time Between Tagging and Recapture, as Indicated by Postal Card Questionnaires *

Elapsed time (days)	*Tantalum wire*			*Stainless steel wire*		
	Slight sore (percent)	*Bad sore (percent)*	*Total tags*	*Slight sore (percent)*	*Bad sore (percent)*	*Total tags*
0- 89	33.3	6.4	141	27.7	9.9	141
90-179	44.9	10.8	185	34.9	9.0	189
180-269	46.2	7.6	158	33.8	12.0	133
270-369	39.8	8.9	123	38.1	12.2	147
370-459	26.4	2.3	87	29.4	8.2	85
460-549	30.0	7.8	90	37.8	4.9	103
550-639	46.3	7.3	41	26.5	8.8	34
640-999	32.4	5.9	34	30.9	7.3	55

* To avoid bias, only tags put on during spring months were used. No stainless steel wires were used during the fall.

However, there was evidence, primarily from San Luis Wasteway, that the wires are not equal in all respects. The only stainless steel wire tags used there were put on in March 1960. Of 14 bass observed a year later, none had shed its tag. On 10 of the 14, the skin had grown over the knot and healed completely, and the wires were firmly anchored in the flesh of 9 of the 14.

Somewhat different results were obtained there with 0.020 tantalum wire tags, which were put on in January 1958 and February and March 1959. Tags on 4 of the 41 bass recovered within a year had been shed, and the wire on a fifth broke at the disk when the fish struggled in a dip-net. Twenty-three of these were recovered again at the end of the second year; one more tag had been shed and the wire broke on two others as they struggled in the dip-net.

The skin had healed over the knot on only 10 of the 37 tantalum wire tags examined at the end of the first year, but this appears quite variable, since in one group, 8 out of 14 had healed over, while in the other group only 2 out of 23 had healed. At the end of the second year, the skin had healed over the knot in 14 of the 21 fish observed. On 17 of 18 fish, tantalum wire had adhered firmly to the flesh by the end of the first year.

These results indicate tantalum wire tags have a greater tendency to shed than do stainless steel wire tags, probably because of the lower tensile strength of tantalum wire. Tantalum wires adhere to the flesh more rapidly but the skin grows over the knot more slowly. These factors may be related, since if tags are not firmly secured the wire tends to pull into the flesh until it becomes anchored on pterygiophores and neural spines. Hence, the knot is no longer in a position to irritate and prevent healing.

Bass tagged in the Delta and examined after recapture showed a similar tendency for the skin to grow over the wound on the knot side more rapidly with stainless steel wires than with tantalum—13 out of 16 of the former and 17 of 29 of the latter being healed.

Shedding Rate

In addition to the tantalum wire tags shed at San Luis Wasteway, both stainless steel and tantalum wire disk-danglers were shed by striped bass tagged in the Delta. An angler caught a bass with the tantalum wire broken and the disk gone; one tantalum wire broke and the tag pulled out when a bass was caught in a gill net two years after tagging; one stainless steel wire was recovered with a section corroded away and the disk gone; three stainless steel wire tags were pulled off in gill nets 6 months to 2 years after tagging; an angler was reported to have caught a bass with the wire present but no disk; and a bass was seen with a tag scar but no tag. These observations are, of course, inadequate for estimating the rate of shedding.

The returns of disk-danglers from Delta tagging in 1958 declined sharply after the first year (Table 5). However, the low initial return and the more gradual rate of decline for 1959 and 1960 returns and evidence of non-returns of angler-caught tagged fish, suggest this difference was due to a higher angling mortality in 1958, rather than a greater shedding rate.

TABLE 5

Yearly Returns of Striped Bass Tagged with Disk-Dangler Tags in the Delta Near Antioch During 1958, 1959, and 1960

	No. tagged	*First-year returns*	*Second-year returns*	*Third-year returns*	*Fourth-year returns*
1958	4,228	952	218	107	33*
1959	3,279	498	290	96*	
1960	3,618	517	227*		

* Partial returns including only those received to 1/12/62.

However, tag returns suggested that tagged fish survival declined with time. For example, during 1959 survival indicated by the 1959 tag group was 0.58 while survival indicated by the 1958 tag group was only 0.44. In 1960, survival indicated by the 1960, 1959, and 1958 tag groups was 0.44, 0.33, and 0.31. Possible explanations for this are: (1) the rate of shedding increases with time, and (2) older fish suffer a higher natural mortality or lower angling mortality. The first- and second-year returns of the 1958 and 1959 tags (Table 6) indicate that older (larger) fish did have a higher total mortality in 1958, but not in 1959. The total mortality differences in 1958 were largely due to the angling mortality differences described above, so an increasing shedding rate is the most logical explanation.

TABLE 6

First Year Survival Indicated by Tag Returns from Various Length Groups of Striped Bass

Fork length in inches	*Year tagged* 1958	1959
15-18	0.29	0.57
19-20	0.28	0.60
21-22	0.26	0.51
23-24	0.17	0.74
25-27	0.20	0.52
28+	0.14	0.50

* Includes only non-reward disk-dangler tags from bass tagged near Antioch.

Effects on Mortality and Growth

There is no direct evidence of substantial mortality caused by tagging, but disk-dangler tags do lower the growth rate. In calculating striped bass growth rates, only measurements made by biologists were used. Expected growth was calculated using average annual increments determined by a recent growth study (Robinson, 1960) and assuming that growth occurred linearly from May through October. This is obviously an imperfect procedure, especially since all measurements were to the nearest inch and the sexes of most fish were unknown. However, the preponderance of negative deviations from mean growth (Table 7) is substantial evidence that these tags slow a fish's growth.

TABLE 7

Growth of Striped Bass Tagged with Disk-Dangler Tags

Deviation from average growth in inches	*Number of fish*
more than +1.4	2
+1.0 to 1.4	3
+0.5 to 0.9	3
+0.4 to —0.4	15
—0.5 to —0.9	14
—1.0 to —1.4	8
—1.5 to —1.9	5
—2.0 to —2.4	3
more than —2.4	5

Scales taken from three bass at the time of tagging were compared with scales taken from the same fish two years later. These indicated the growth rate declined after tagging, but there apparently was no traumatic upset at the time of tagging (Figure 5).

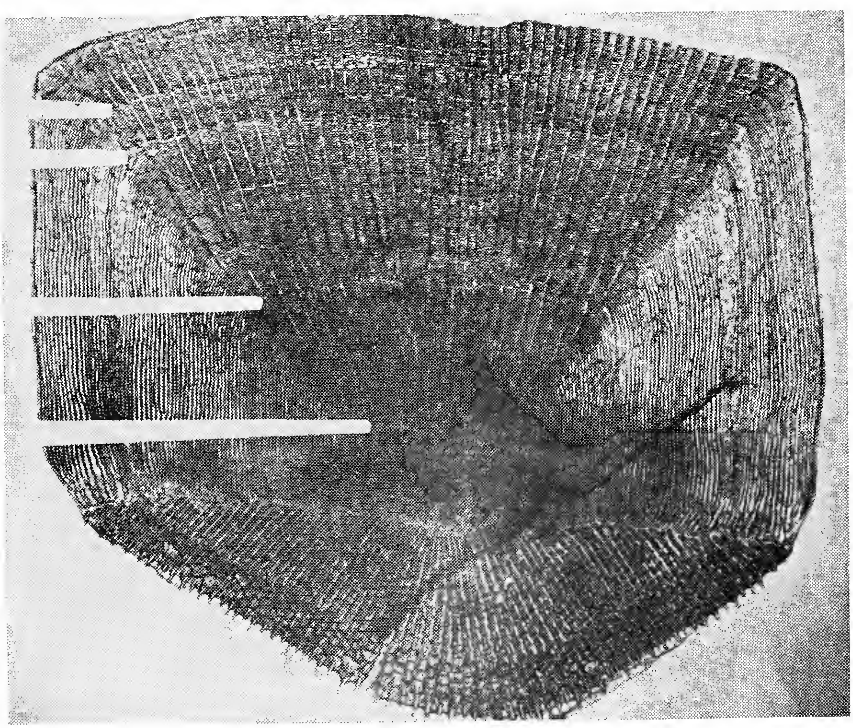

FIGURE 5. Scale from a striped bass which was 19 inches long when tagged June 10, 1959, and 24 inches long when recaptured April 17, 1961. Annuli marked by white lines. Third annulus was forming at time fish was tagged and the fifth was forming on the margin when recaptured. *Photographed by William Schafer, April 1962.*

A comparison of the growth of two tagged bass with untagged bass from the 1956 year-class (in the spring of 1961) indicated the two tagged fish grew unusually slowly the first year after tagging, but that growth was normal during the second year (Table 8). No generalizations can be made, however, because of the small sample size.

TABLE 8

Fourth- and Fifth-Year Scale Growth of Two Tagged and Several Untagged Striped Bass from the 1956 Year-Class

	*Scale Increment **			
Growth year	*Tagged bass #1*	*Tagged bass #2*	*Mean of 14 untagged ♀ ♀*	*Mean of 12 untagged ♂ ♂*
4	9	10	21	20
5	12	12	16	12

* Measured along anterior radius and expressed as a percentage of the radius.

Degree of Irritation Caused by Tags

The decrease in growth is probably associated with the irritation caused by the tag. The degree of irritation was quite variable: some fish healed completely, while others possessed irritated areas several inches long behind the tags. At San Luis Wasteway and in the Delta the irritation was frequently chronic and static. The tagged bass in the aquarium never rubbed their tags or gave any indication of irritation, despite the fact that some developed disk-sized sores, sensitive to the touch, under the tags.

The causes of tag irritation are not completely known. The obvious primary cause in many instances was the disk and wires rubbing against the fish. The most common result of irritation was an excoriated circular patch under the disk. The position of the tag when it stabilized in the flesh contributed to the degree of irritation. In some fish, the

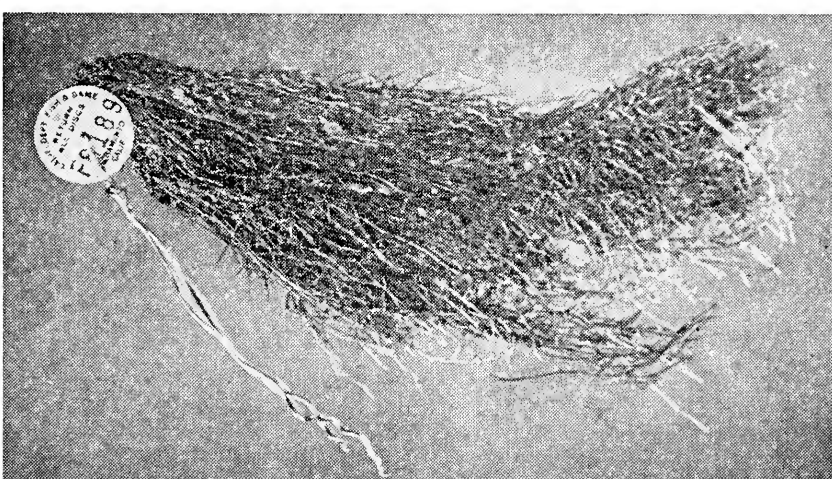

FIGURE 6. Disk-dangler with hydroid growth attached. Striped bass was at large only two months—being tagged May 17, 1960, and recaptured by an angler July 19, 1960. *Photographed by William Schafer, February 1962.*

tag stabilized at the spot it was applied, but in many, it pulled through the fish until the loop of wire became anchored on neural spines and pterygiophores. When this occurred the tag extended from the side of the fish on a wire stalk 0.5 to 1.5 inches long. This sometimes kept the tag away from the side of the fish and reduced irritation, but in other cases the tag would strike the side or dorsal fin and cause irritation at that site.

Personal observations and postal card questionnaires showed that marine organisms grew on many tags put on in the Delta and caused additional irritation. Barnacles often grew on tags, but hydroids were far more common and important. These frequently grew several inches long (Figure 6) and were probably responsible for most cases of severe irritation. The questionnaire results clearly showed the relationship between the occurrence of growths and the incidence of sores (Table 9).

TABLE 9

Comparison of Degree of Irritation Caused by Disk-Dangler and Hydrostatic Tags With and Without Organisms Growing on Tags

	Disk-dangler tags		Hydrostatic tags	
	Growths present (N = 522) Percent	*Growths absent (N = 1663) Percent*	*Growths present (N = 29) Percent*	*Growth absent (N = 63) Percent*
No sore	37	60	45	75
Slight sore	45	35	28	24
Bad sore	18	5	28	2

Internal Effects of Tags

One San Luis Wasteway bass which had shed a disk-dangler had a pocket of necrotic tissue about 2 inches long where the wire had been. The pocket was lined with connective tissue, and bacteria were numerous in the necrotic tissue. A Delta bass which had shed its tag had similar necrotic tissue but no bacterial infection. The pocket had no external opening in either fish.

Four Delta bass captured a year after tagging, with the tags on, were examined microscopically. All had necrotic tissue in some places along the wires, but no bacterial infection, even in pockets exposed to the outside. The tissue along one stainless steel and one tantalum wire was sectioned and stained. In both cases, the muscle fibres around the wire had been replaced by connective tissue. The connective tissue around the stainless steel wire was more heavily vascularized and some degeneration and inflammatory cells were present, but this evidence is insufficient to indicate differences between the two types of wire.

Effect of Tags on Vulnerability to Angling

Disk-dangler tag returns during the first four months after tagging near Antioch in the springs of 1959, 1960, and 1961 indicated bass are caught at a reduced rate immediately after tagging. This was determined by comparing the ratios of tag returns during each of four months following tagging from bass tagged during the year in question to tag returns during the same months from bass tagged the previous year (Table 10). The number of returns for each 10-day period indi-

TABLE 10

Ratios of Disk-Dangler Tag Returns During Four Months Following Tagging of Striped Bass in Given Years to Tag Returns During the Same Months from Bass Tagged in the Previous Year *

	Ratios for Monthly Periods			
Year	*Month 1*	*Month 2*	*Month 3*	*Month 4*
1959	1.0	1.5	1.5	2.0
1960	0.8	1.7	1.7	1.5
1961	0.4	0.8	0.3	1.0

* Includes only non-reward disk-dangler tags from bass tagged near Antioch.

cates this effect gradually declines during the first month (Table 11). The low returns could have been caused by differences in availability resulting from migration pattern differences of the tag groups in each pair, or to lowering of vulnerability to angling because of handling and tagging. The first-month returns for four other groups of disk-dangler-tagged bass tagged in different locations and/or seasons were similar (Table 11), so differential availability due to migration patterns cannot be the primary factor. Similar patterns for angling- and trap-net-caught bass indicate these capture methods have no differential effects on vulnerability. Not enough first-month returns were received from any other tag type to permit comparing tags. Therefore, it can only be concluded that the lessened vulnerability is due either to the tag's presence or to a general effect of handling common to several types of tagging operations.

TABLE 11

Tag Returns During First Thirty Days After Tagging for Various Groups of Striped Bass Tagged with Disk-Danglers

Tag Group			*Number of returns*		
Date	*Place*	*Method of capture*	*Elapsed days* (0-10)	*Elapsed days* (11-20)	*Elapsed days* (21-30)
Spring 1958	Antioch	gill net	7	7	11
Spring 1959	Antioch	gill net	5	9	16
Spring 1960	Antioch	gill net	4	7	11
Spring 1961	Antioch	gill net	3	6	8
Subtotal			19	29	46
Spring 1958	Fremont Weir	trap net	2	5	6
Fall 1958	San Pablo Bay	angling	14	23	27
Spring 1959	Prisoner's Point	gill net	1	2	6
Fall 1958	Antioch	gill net	0	3	7

HYDROSTATIC TAGS

Description and Application

The hydrostatic tags used in this experiment were identical to the disk-danglers except that a plastic capsule designed by Einar Lea of Norway, was used in place of the plastic disk. The capsule is bullet-shaped and hollow with a message printed on paper enclosed (Figure 3B). The capsules had a specific gravity almost equal to water, and this along with their shape would minimize resistance as the fish swam.

Type 302 soft stainless steel wire, 0.020 inch in diameter, was used for these tags. They were applied in the same manner as disk-danglers.

Four hundred and fifty-nine hydrostatic tags were attached to striped bass in the Delta during May 1959, alternately with 493 disk-danglers.[2]

Evaluation of Results

Tag returns from hydrostatic and disk-dangler tags have been similar during the 2½ years since tagging (Table 12). The promise of a prize drawing in the message in the hydrostatic tags could have biased their returns. However, this could not mask continual and substantial shedding, since that would have caused their returns to fall gradually behind those of disk-dangler tags. Since this was not the case, either the shedding rates were similar, or the hydrostatic tags suffered initial shedding which was balanced by lower nonreporting. Considering the similarity of attachment, equal shedding is more likely.

TABLE 12

Comparison of the Returns of Hydrostatic Tags and Disk-Dangler Tags Applied to Striped Bass in the Delta During May 1959

	Returns of Hydrostatic Tags		*Returns of Disk-Dangler Tags*	
Elapsed time after tagging	*Number*	*Percentage of number tagged*	*Number*	*Percentage of number tagged*
First year	75	16	76	15
Second year	43	9	45	9
Third year *	16	3	10	2
Total	134	29	131	27

* Tags received only during first seven months of third year.

The degree of irritation and incidence of aquatic growths was approximately the same for both disk-dangler and hydrostatic tags (Table 9). However, hydrostatic tags without growths did show less irritation than similar disk-danglers. A chi-square test indicates this difference is not significant at the 95 percent level ($\chi^2 = 5.6$, d. f. $= 2$, $P = 0.06$). However, the difference is substantial and a larger sample of hydrostatic tags might have shown it to be significant. Thus, tag shape may be important, with the hydrostatic capsule having less resistance and thus causing less irritation.

DART TAGS

Description and Application

Dart tags were first used successfully on skipjack *(Katsuwonus pelamis)* in Hawaii (Yamashita and Waldron, 1958). We tried two modifications: one was identical to the skipjack tag except that $\frac{1}{16}$-inch nylon rod was substituted for the barb (Figure 3D), and size 13 yellow Resinite tubing (Borden Company, Chemical Division) was used without an outside covering; the second was a commercially manufactured tag (Catalog Number FT#1, Floy Tag and Manufacturing Company,

[2] In this and tests described subsequently, numbers of each tag type were not equal even though they were usually applied alternately, since tags were paired in numbered series of 100 and tags in a series were often missing.

Seattle, Washington) (Figure 7). In this tag, the head and barb consisted of a piece of moulded nylon with a shaft that slid into the tubing. The tubing and head were glued together. Size 13 yellow Resinite tubing was also used for this tag.

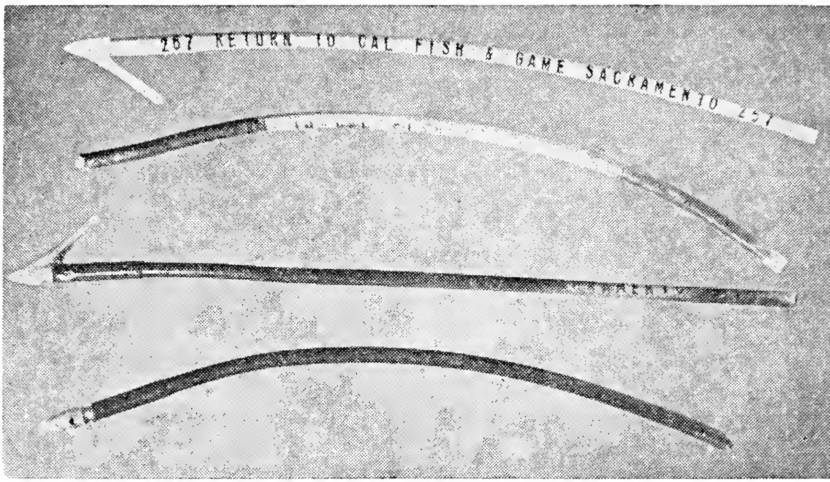

FIGURE 7. Dart tags from Floy Tag Company showing deterioration in writing and darkening of Resinite plastic. The top tag is new and the others are from striped bass that were at large 685 days, 743 days, and 687 days. Barbs were probably broken off tags by anglers when removing tags from fish. *Photographed by William Schafer, February 1962.*

Dart tags were applied with a needle identical to that described by Yamashita and Waldron (1958). At San Luis Wasteway, they were placed under the posterior part of the first dorsal fin, while in the Delta they were placed under the anterior part of the first dorsal (the same location as disk-danglers). All tags were affixed midway between the lateral line and the base of the fin and angled back at approximately 45° to the fish's midline. Great care was taken to hook the barb on a neural spine. Dissections of tagged bass showed this could be done unfailingly by feeling the needle slip past the spines and pulling back on the tag to make sure that it was hooked.

Tagging Studies

Sixty-four bass at San Luis Wasteway were double tagged during February and March 1959 with the first-described dart tag and disk-danglers.

In the Delta during May 1959, 466 striped bass were tagged with the Floy Company dart tags and 498 with disk-dangler tags.

Evaluation of Results

At San Luis Wasteway, 22 of 30 bass examined about a year later had shed their dart tags. Those still in place were in fair condition, with most causing only mild irritation where the tubing entered the fish.

TABLE 13

Comparison of Returns of Dart Tags and Disk-Dangler Tags Applied to Striped Bass in the Delta During May, 1959

Elapsed time after tagging	*Returns of Dart Tags*		*Returns of Disk-Dangler Tags*	
	Number	*Percent*	*Number*	*Percent*
First year				
First quarter	19	4.1	22	4.4
Second quarter	8	1.7	25	5.0
Third quarter	2	0.4	13	2.6
Fourth quarter	0		14	2.8
Total	29	6.2	74	14.9
Second year				
First quarter	7	1.5	18	3.6
Second quarter	2	0.4	16	3.2
Third quarter	1	0.2	6	1.2
Fourth quarter	2	0.4	6	1.2
Total	12	2.6	46	9.2
Third year				
First quarter	1	0.2	10	2.0
Second quarter	0		7	1.4
Grand total	42	9.0	137	27.5

Delta returns also indicated a high rate of shedding (Table 13). Shedding apparently increased sharply after the first three months, and by the second year about three-quarters of the dart tags had been lost.

There was no opportunity to observe bass marked with these tags in the Delta, but those tags returned showed rapid deterioration, i.e., the vinyl ink printing wore off and the plastic turned dark brown. Tags returned after two years were virtually illegible through a combination of these factors (Figure 10).

STREAMER TAGS

Description and Application

Streamer tags similar to those used on striped bass in North Carolina (Davis, 1959) were tested. They were made of the cellulose nitrate disks used for the disk-danglers and Number 208 Nylon net twine. They were assembled by threading the twine through the tag, tying a crossed running knot to hold the tag in place, tying the two ends of the twine together with a square knot, and fusing the ends together with a flame. They were made so the loop of twine was approximately 9 inches long.

These tags were affixed under the second dorsal fin midway between the lateral line and the fin base. This was done by sewing the loop of twine through the flesh with a carpet needle, passing the disk through the loop, and tying a double overhand knot as near the tag as possible. The point at which the twine passed through the fish was moved anteriorly or posteriorly, depending on the fish's size, so the disk would trail above the caudal peduncle and not hit the dorsal or caudal fins.

Tagging Studies

In March 1960, streamer tags were put on 2 striped bass in the aquarium and 49 in San Luis Wasteway. All of the latter were also tagged with disk-danglers.

In our main field experiment in the Delta, 299 streamer tags were attached alternately with 300 disk-danglers in May 1960.

Evaluation of Results

The results of these experiments have varied. The tag on one of the aquarium bass migrated dorsally and posteriorly and was shed in seven months. The tag on the second aquarium bass showed little migration, but the Nylon twine broke at the overhand knot after 16 months and the tag was shed a little over 3 months later.

At San Luis Wasteway there also was appreciable shedding. Four bass recovered five months after tagging had their tags still attached; however, those on 5 of 26 bass recovered at the end of the first year had been shed. On three of these, broken twine was still present but the disk was missing. On the other two, scar tissue indicated the tags had migrated out behind the dorsal fin. In one case, the tag had traveled about three inches. Many of the remaining tags were displaced a fraction of an inch and one had moved about 2 inches.

The returns of disk-dangler and streamer tags from the Delta were not significantly different over the first two years (Table 14). However, the returns of streamer tags did fall behind after the first nine months. While the difference between returns after nine months is not significant at the 95 percent level ($\chi^2 = 3.6$, d.f. $= 1$, $P = 0.06$), it is substantial and many have resulted from streamer tags being shed.

TABLE 14

Comparison of the Returns of Streamer Tags and Disk-Dangler Tags Applied to Striped Bass in the Delta During May 1960

Elapsed time after tagging	*Returns of Streamer Tags*		*Returns of Disk-Dangler Tags*	
	Number	*Percent*	*Number*	*Percent*
First year				
First quarter	10	3.3	11	3.7
Second quarter	20	6.7	18	6.0
Third quarter	12	4.0	7	2.3
Fourth quarter	5	1.7	7	2.3
Total	47	15.7	43	14.3
Second year				
First quarter	6	2.0	11	3.7
Second quarter	2	0.7	7	2.3
Third quarter	4	1.3	4	1.3
Fourth quarter	2	0.7	3	1.0
Total	14	4.7	25	8.3
Grand Total	61	20.4	68	22.7

"SPAGHETTI" TAGS

Description and Application

"Spaghetti" tags were first used on tunas (Wilson, 1953), and have since been used on a variety of fishes, including striped bass (Davis, 1959).

The tags used in our experiment were made of size 15 white Temflex 105 tubing (Irvington Division, Minnesota Mining and Manufacturing Company) with the legend printed on the tubing in vinyl ink (California Ink Company formula 104N5A4). No transparent covering tube was used over the Temflex tubing.

The tags were applied with a needle made of stainless steel tubing with a solid point. One end of the tag was slipped into the open end of the needle and the tag sewed through the fish. In some cases, the two ends were tied with a figure eight knot, while in others they were clamped together with a Number 1 monel strap tag (National Band and Tag Co.).

Tagging Studies

Our only tests with these tags were at San Luis Wasteway where in August 1957, we attached them under the second dorsal fin of 5 bass and between the dorsal fins of 10 others. In all cases, the ends of the tags were tied together.

In January 1958, we marked 10 bass with spaghetti tags placed under the second dorsal fin and 6 with tags between the dorsal fins. Four of those placed between the dorsals were fastened with monel straps and the remainder were tied.

Evaluation of Results

Of these 31 bass, 12 were recovered at the end of one year. Subsequent recoveries declined and only two of the 1957 fish and three of the 1958 fish were recovered during the final check in March 1961. While these observations are limited, some interesting things were learned.

The only tag shed was broken at the knot at the end of two years and lost during the third year. Three other tags broke but were not shed. One of these, broken at the knot at the end of the first year, was still attached six months later. Another, broken at the monel strap two years after tagging, was still in place at the end of three years. The third broken tag was on a bass not recovered until three years after tagging when all that remained was a piece of tubing 2 inches long, half imbedded in the fish's side.

A connective-tissue sheath typically formed around the tubing and in some cases a doughnut-shaped proliferation of connective tissue formed on the fish's side around the tag. Usually an appreciable amount of irritation occurred where the tags entered the flesh, and considerable necrosis developed around the connective tissue sheath. In several instances, there was so much necrosis the tag could be pulled out of the fish bringing a core of tissue with it. The irritation developed within the first six months and appeared to remain quite static after that.

"Spaghetti" tags rapidly became covered with heavy algal growth, and after 12 to 18 months the inscription on portions of the tags covered with algae was becoming illegible. This fading apparently resulted from the algae since the writing lasted considerably longer on portions of the tag in the flesh, and the algal covering was dense enough to prevent sunlight from affecting the tag. Most of the writing on the two August 1957 tags recovered in March 1961 was completely illegible, and the two January 1958 tags recovered then were difficult to read.

The Temflex plastic tubing became less flexible and darkened with time. Although it never became brittle, it definitely lost some of its flexibility and was not as desirable as the Resinite tubing in this respect. The tubing inside the flesh started darkening within a few days after the tags were attached. On those recovered after two years, most of the tubing outside the flesh had darkened also. The darkening of the tags in itself did not make them illegible.

DISCUSSION AND CONCLUSIONS

None of the tags used in these experiments fulfilled all of the requirements of a satisfactory tag.

Substantial returns of disk-dangler tags have been received through the fourth year after tagging. However, mortality estimates based on their returns would be biased by several factors, including a low initial rate of shedding, some subsequent increase in shedding rate, and a decrease in angling vulnerability immediately after tagging. The irritation and slower growth rate caused by tagging could easily affect the mortality of tagged bass and bias mortality estimates.

Hydrostatic tags gave overall results similar to those from disk-dangler tags, and they may be superior, since there is some evidence they cause less irritation. However, our experiment was too limited to compare the two thoroughly.

Dart tags were obviously unsatisfactory because of their high rate of shedding.

"Spaghetti" tags were judged unsatisfactory because of the tissue reaction to the Temflex tubing. However, their shedding rate was low, so a different type of plastic might make this tag satisfactory.

Streamer tags were satisfactory over a nine-month period, but evidence of lower returns after that, and shedding demonstrated in other experiments, indicate they are not as satisfactory as disk-dangler or hydrostatic tags.

A further disadvantage of dart and "spaghetti" tags was the deterioration of the tag's inscription. Most became illegible within two years, making them unsatisfactory for a long-term experiment.

While all of these tags are large enough to permit printing substantial directions, the lengthier message in hydrostatic tags is an advantage. As a result of their printed instructions, anglers usually include more complete recapture information when they return them. Many anglers catching tagged bass were not aware of the purposes of the program or what to do with the tags, thus a well-prepared message in a hydrostatic tag should make a tagging program more successful.

ACKNOWLEDGMENTS

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SUMMARY

Disk-dangler, hydrostatic, dart, streamer, and spaghetti tags were used in experiments to determine their suitability for striped bass.

Disk-danglers with pure tantalum wire 0.020 inch in diameter, tantalum wire 0.025 inch in diameter, and Type 302 soft stainless steel wire 0.020 inch in diameter gave about equally reliable results.

Some disk-dangler tags were shed and the rate of shedding probably increased with time. These tags also retarded the fish's growth, probably because of the irritation they caused. The degree of irritation was variable, depending a great deal upon the presence of aquatic growths, particularly hydroids.

Hydrostatic tags gave results similar to disk-danglers insofar as shedding rate and susceptibility to aquatic growths were concerned. Their shape might be superior to disk-dangler tags, since they caused less irritation.

Dart tags were shed more rapidly than the others. They had additional drawbacks in that the vinyl ink wore off rapidly, and the Resinite plastic used for them turned brown with age.

Substantial shedding of streamer tags occurred in two preliminary trials, but two-year returns were not significantly different from those of disk-dangler tags. However, streamer tag returns were lower after the first nine months, very likely because of greater shedding.

Spaghetti tags were unsatisfactory because they frequently caused considerable irritation, and fading ink plus discoloration made the legend difficult to read after about a year.

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COMMERCIAL FRESHWATER FISHERIES OF CALIFORNIA[1]

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INTRODUCTION

Seven species of freshwater fishes are taken commercially in California (Table 1). They may descend at times into brackish waters of bays and estuaries, but all are essentially freshwater fishes.

Five species—hardhead, hitch, Sacramento blackfish, splittail and western sucker—are native to California. Sacramento blackfish are sometimes called "hardhead" and lumped with "true" hardhead in catch statistics published by the California Department of Fish and Game. Carp, hardhead, hitch, Sacramento blackfish and splittail are minnows, family Cyprinidae, while bigmouth buffalo and western sucker are suckers, family Catostomidae. Two of the seven species, bigmouth buffalo and carp, were introduced into California.

Carp first were introduced into our waters from Holstein, Germany in 1812 when five individuals were placed in private ponds in Sonoma Valley (Poppe, 1880). Their forefathers were introduced into Europe in 1227 from Asia. In 1872 carp were popular and were recommended as valuable food fishes that would thrive in all warmer ponds, lakes and streams of California. At that time, carp sold so rapidly that no ponds were overstocked. Ten years after their introduction into California, they were so plentiful that the market price declined to 1.5 cents per pound (Hallock, 1949). In the early 1900's, carloads of carp were shipped east; however, at present they are transported to California from nearby states to help meet consumer demand.

TABLE 1

Common and Scientific Names of Commercial Freshwater Rough Fish in California

Common name	*Scientific name*
Blackfish, Sacramento	*Orthodon microlepidotus* (Ayres)
Buffalo, bigmouth *	*Ictiobus cyprinella* (Valenciennes)
Carp*	*Cyprinus carpio* (Linnaeus)
Hardhead	*Mylopharodon conocephalus* (Baird and Girard)
Hitch	*Lavinia exilicauda* (Baird and Girard)
Splittail	*Pogonicthys macrolepidotus* (Ayres)
Sucker, western	*Catostomus occidentalis* (Ayres)

* Introduced into California waters.

How and when bigmouth buffalo were introduced into California is not certain. They may have come from any of several sources, since commercial seiners travel widely throughout nearby states to obtain them for fresh fish markets of larger cities. Los Angeles fish markets commonly receive shipments of buffalo from Arizona and Utah. Al-

[1] Submitted for publication October 1962.

though known facts are lacking, some commercial operator may have brought them here to provide a local market supply. If this is true, they probably were introduced from the Roosevelt Dam Impoundment in Arizona, where several local commercial seiners have operated. About 1942, the first bigmouth buffalo were noted in the aqueduct system in upper and lower San Fernando Reservoir. At present they are reportedly found in 11 reservoirs of the Los Angeles Aqueduct system (Evans, 1950).

PRESENT AREAS FISHED

In 1960, California lakes and reservoirs yielded 91 percent of all commercial rough-fish landings with rivers and irrigation canals supplying the remainder.

The only producer in northern California is Clear Lake in Lake County which contributed 279,835 of the 494,706 pounds landed statewide in 1960.

In central California, fishermen trap small amounts of carp in the Sacramento River and adjoining sloughs near Rio Vista in Solano and Sacramento Counties. Small quantities of splittail are also taken in the river near Sacramento with hook and line. Thirty-four percent of the 1960 rough-fish catch came from reservoirs, irrigation canals and rivers in the San Joaquin Valley. Waters within this area include the San Joaquin River in Stanislaus, San Joaquin and Merced Counties; Modesto and Turlock Reservoirs in Stanislaus County; and Yosemite Lake, Bear Creek and Mud Slough in Merced County.

In southern California, small poundages of carp, bigmouth buffalo and western sucker are netted in Bouquet, Chatsworth, Fairmont and San Fernando Reservoirs in Los Angeles County; and Haiwee Reservoir in Inyo County.

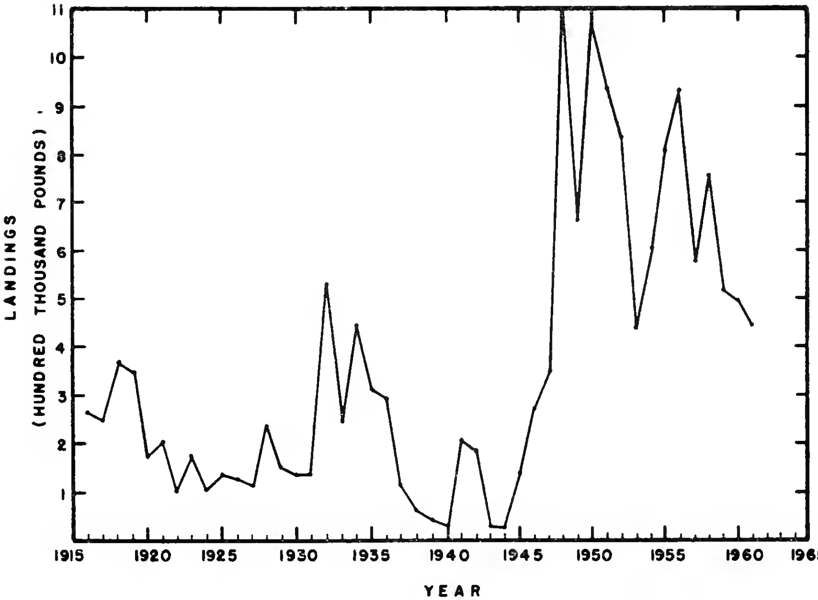

FIGURE 1. Annual rough-fish landings in California 1916-61.

ANNUAL LANDINGS

Rough-fish landings declined markedly following World War I and remained fairly constant from 1922 through 1931 with the Sacramento-San Joaquin Delta furnishing the bulk of the catch (Figure 1). Increased landings between 1932 and 1936 mainly were due to heavier fishing at Clear Lake. Landings at Clear Lake gradually declined and in 1937, the Sacramento-San Joaquin Delta again was principal producer.

The sudden rise in 1941 and 1942 was due to increased fishing in the Los Angeles area where 211,766 pounds of carp were netted.

Following 1944, landings rose rapidly to a peak of over one million pounds in 1948 when fishing resumed at Clear Lake and began at Lake Almanor in Plumas County. During the six years, 1950 through 1955, Lake Almanor yielded the bulk of the catch when Smith-Ferrari Fishmeal Company obtained a permit to seine carp and reduce them to fish meal for animal food supplements. When Lake Almanor operations ceased in 1955, Clear Lake resumed leadership and has been the main producer to the present time.

Rough-fish landings in 1960 amounted to nearly one-half million pounds worth about $55,000 to the fishermen. Carp, although first in poundage during 1960, was second in value to Sacramento blackfish from Clear Lake which yielded 29 percent by poundage, but 59 percent of the total value (Table 2). Hardhead, hitch and splittail have brought the same price as blackfish but contributed only small poundages to the fishery.

TABLE 2

Landings and Value of Freshwater Commercial Fish in California, 1960 *

	Pounds by area					
Species	*Lakes*	*Rivers*	*Total pounds*	*Total value*	*Percent by pounds*	*Percent by value*
Carp	274,352	44,247	318,599	$15,193	64	28
Blackfish, Sacramento	145,010	----	145,010	32,699	29	59
Splittail	----	675	675	236	1	<1
Miscellaneous †	30,422	----	30,422	6,860	6	13
Total	449,784	44,922	494,706	$54,988	100	100

* Values for 1961 not compiled; similar data for previous years not available.
† Includes hardhead, hitch and suckers.

FISHING METHODS

Shore seines, traps, and hook and line are used to take rough fish in California waters.

Shore Seines

Shore or beach seines catch the largest portion of rough fish in inland waters. In 1961 they took 394,988 pounds (90 percent of the catch).

Fishermen operate under a special permit issued by the Department of Fish and Game to seine rough fish considered harmful to sport species. Three such permits were issued in 1961. Permittees must possess a valid commercial fishing license and register their boats with the Department. These fishermen provide the Department with an advance schedule of fishing operations. Their activities are subject to close supervision by Fish and Game Wardens to insure that all incidentally caught sport fish are returned to the water unharmed. At times, the Department may transfer the sport fish to more desirable waters.

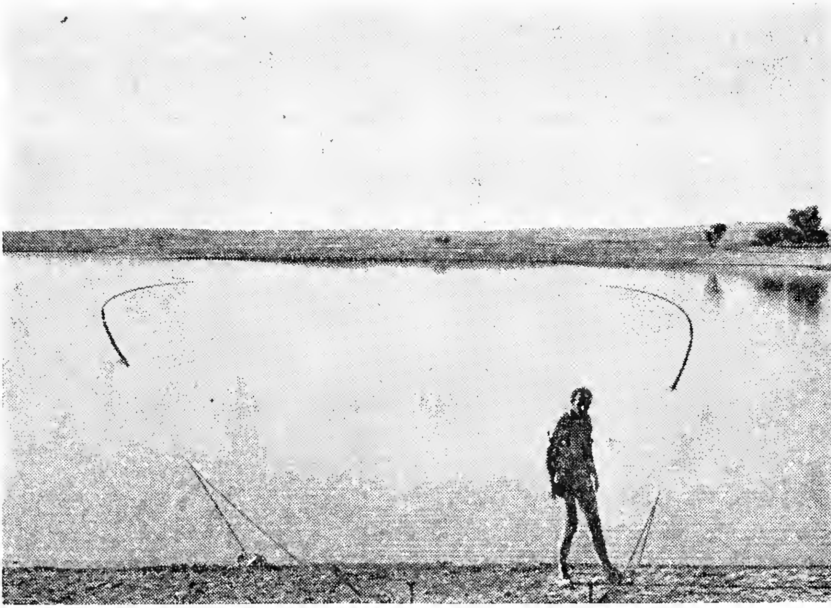

FIGURE 2. The net moving closer to shore. *Photographed by the author, September 1961.*

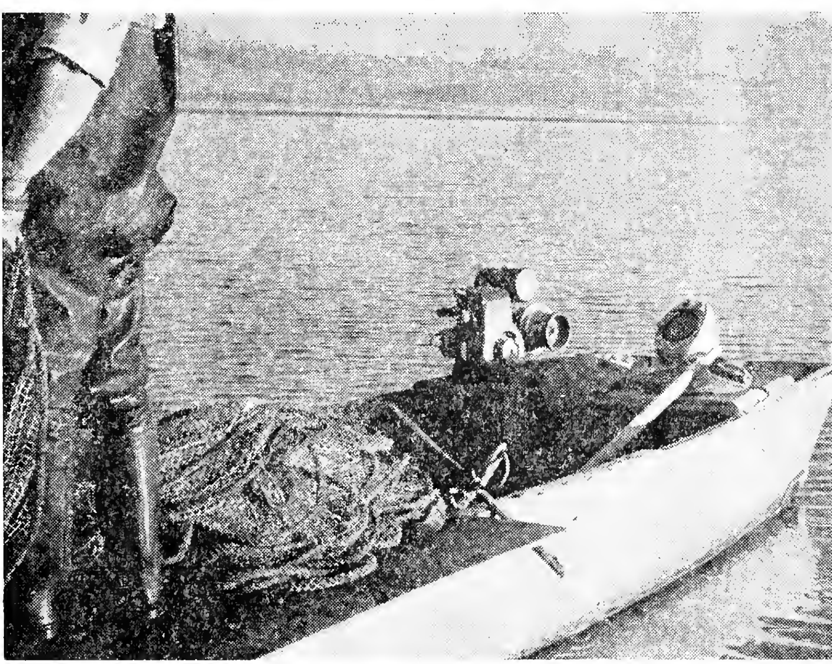

FIGURE 3. A power winch used for pulling net. *Photographed by the author, December 1961.*

Equipment used by these fishermen includes shore seines, live-holding pens and tanks, homemade flat-bottom skiffs and outboard motors (Davis, 1962). Flatbed trucks haul boats, nets and other gear to the fishing area.

To make a set, a 300- to 1200-foot shore seine is piled into a skiff and payed out in a large semicircle offshore (Figure 2). The net is towed into shallow water by two motor boats (one on each end); by a combination of one motor boat and man on shore; or by a makeshift winch

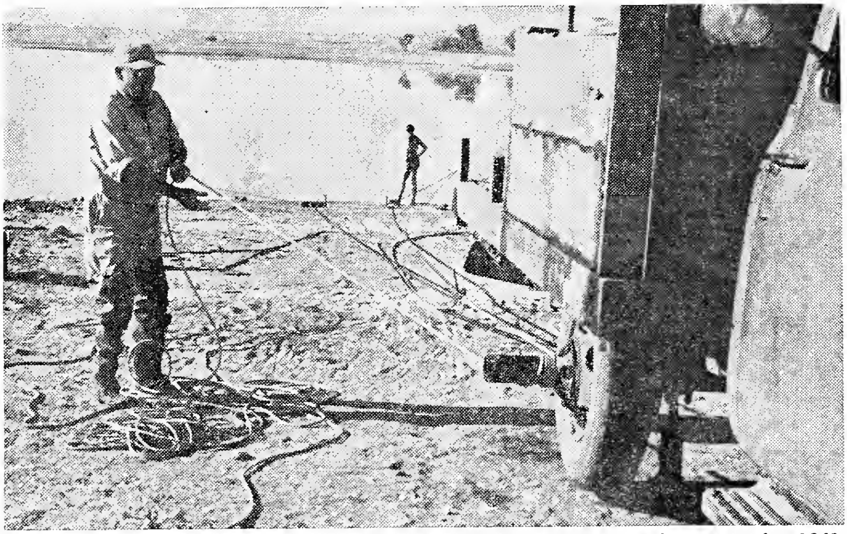

FIGURE 4. A makeshift winch used for pulling net. *Photograph by the author, September 1961.*

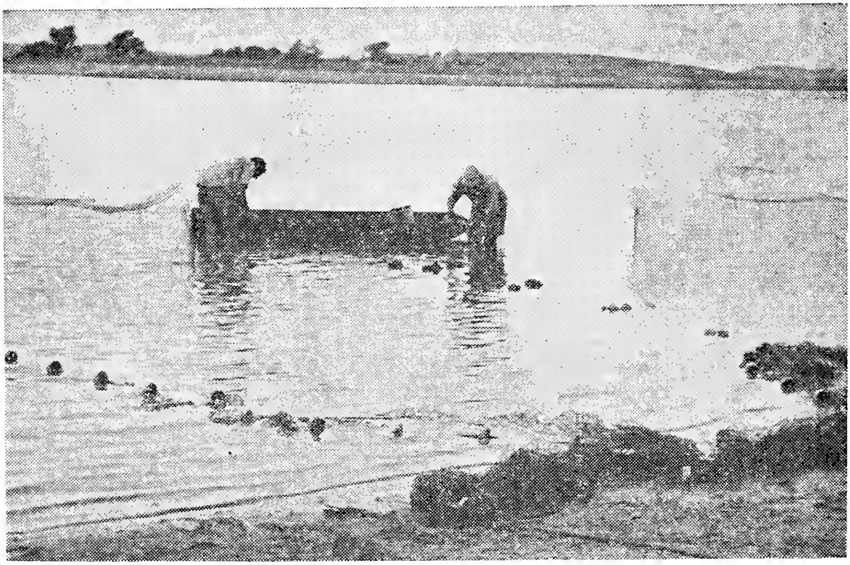

FIGURE 5. Live-holding pens and skiff used for sorting fish. *Photograph by the author, September 1961.*

bolted to the rear wheel of a truck. The wings are pulled ashore either by hand, by a power winch mounted on one of the boats (Figure 3) or by a makeshift winch on the truck axle (Figure 4). The last portion of the net is hauled in by hand, forcing the catch into the bag or pocket of the net.

A skiff and live-holding pens are used for sorting fish (Figure 5). Sacramento blackfish, hardhead, hitch, splittail and small silver-colored carp weighing less than three pounds are placed in wire live-holding pens before transporting them to market alive. Large carp, bigmouth buffalo and suckers are held in the boat and later iced in boxes (Figure 6).

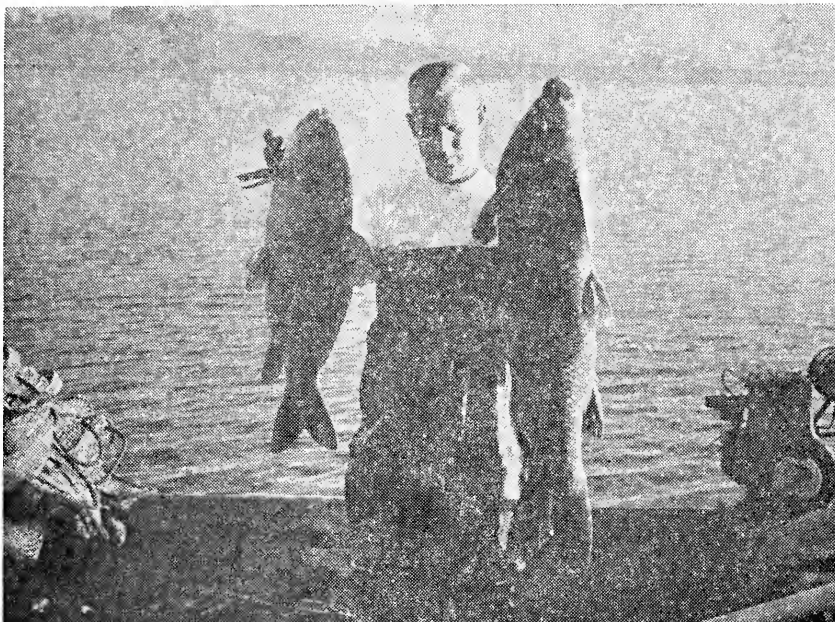

FIGURE 6. Bigmouth buffalo (left) and carp (right) taken with shore seine. ***Photograph by the author, December 1961.***

Generally, 800 to 1,000 pounds of live blackfish from Clear Lake are taken to market at one time; but as many as 2,000 pounds, depending on demand, may be trucked. A metal hatchery-type tank truck with a spray aerator is used to transport these fish.

San Joaquin Valley fish are hauled to market in a watertight wooden box built on the forward portion of a truck bed. Up to 1,000 pounds of live fish are transported at one time. Water is aerated by a circulating pump and a mechanical agitator suspended in a bucket (Figure 7).

Traps

Traps, the second most important gear for rough fish, took 42,801 pounds of carp in 1961 or 10 percent of all commercial rough fish.

Traps may be used throughout the year to take carp in any district with the provision that all fish other than carp are returned at once to the water.

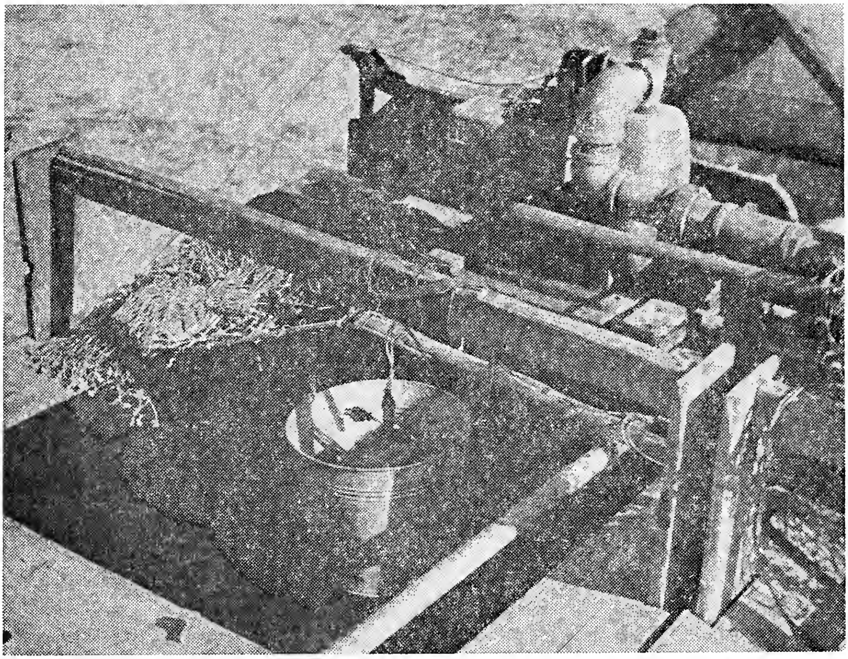

FIGURE 7. Looking down into live-holding tank on the truck. A mechanical agitator in the bucket and a water-circulating pump aerate the water. *Photograph by the author, September 1961.*

Fishermen currently trap carp in the Sacramento River and sloughs near Rio Vista. In other years, they have fished throughout the Delta.

Carp traps measure about 5 feet in diameter at the larger hoop (bottom) and 3 feet in diameter at the smaller hoop (top) and cost about $12 each to construct (Figure 8). Each is baited with 5 to 6 pounds of rolled barley (wet weight) tied in a fine-mesh bag within the funnel of the trap. Carp feeding on the barley crowd into the mouth of the funnel and are forced into the trap by other fish.

The trap's unique construction usually prevents fish other than carp from entering. The opening in the top allows carp which are down feeders (they feed head down and tail up) to enter from the top. Many species feed with their body parallel to the stream or lake bottom and would enter a trap only through a side opening.

One trap in a new area will yield an average catch of 150 to 200 pounds of carp in a two-night set. Each trap is marked with a wood float and is left from overnight up to 5 days but generally is lifted every 2 days. The fish are held in live pens in the lower Sacramento River. Twice a week, a wholesale fish dealer from Richmond takes 700 to 1,000 pounds of fresh carp to markets in Oakland and Richmond.

Hook and Line

In 1961, hook and line fishermen took 765 pounds of carp and splittail or less than 1 percent of all commercial rough fish. These were taken in the Sacramento River near Sacramento and sold to wholesale fish dealers in the area.

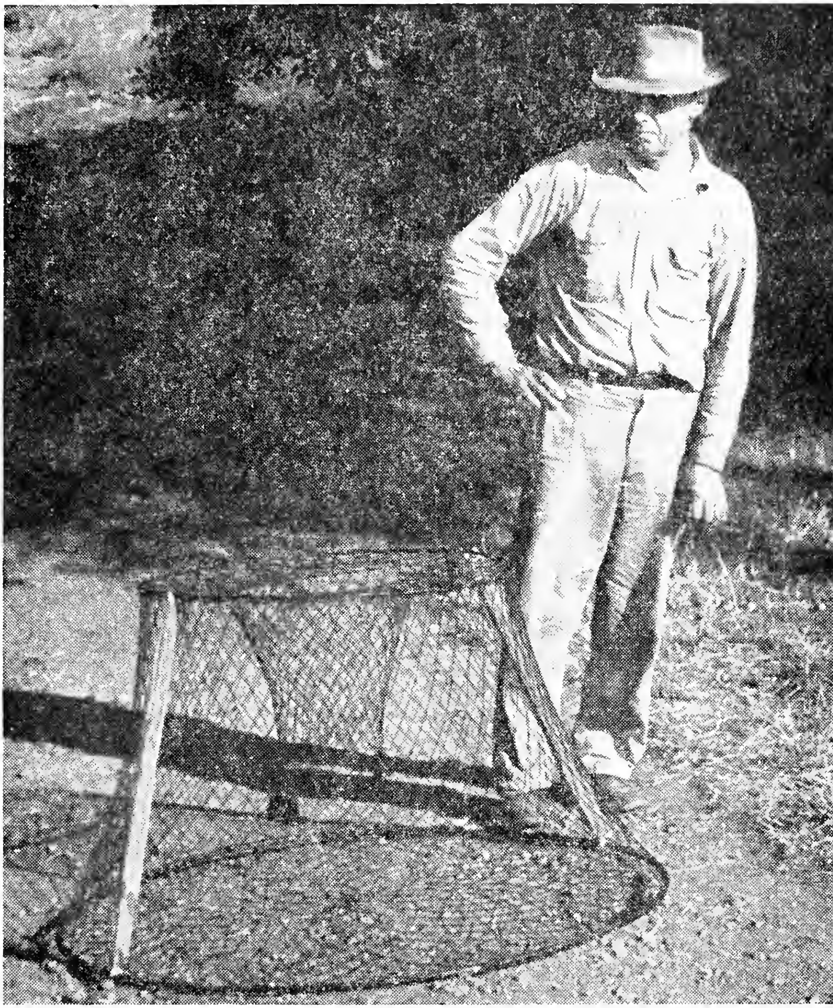

FIGURE 8. Henry Rauch with a carp trap he developed. *Photograph by the author, September 1961.*

FISHING SEASONS

Shore Seines

The best season for seining blackfish in Clear Lake is from October to April when they are feeding in shallow water near shore. During the rest of the year, they are believed to retreat to deeper, cooler water and cannot be taken readily with a shore seine. Throughout the winter, an average of 12,000 pounds of Clear Lake blackfish is delivered to markets monthly.

One fisherman is building a live-holding pond in Rodman Slough north of Clear Lake. He plans to stock the pond with blackfish in winter when fishing is good and, thus, supply markets the year around.

Carp sometimes are taken in late summer when irrigation canals in the Turlock and Modesto Irrigation Districts are drained. One permittee in southern California fishes in Washington and Idaho in the summer and seines carp in Los Angeles County reservoirs during winter when his summer waters are frozen.

Hardhead, hitch, splittail and silver-colored carp of the Modesto area are more easily captured in fall when the reservoirs are shallow.

Traps

Carp are taken more readily by trap from August through November. In December and January, when water temperatures drop, fish become semi-dormant and are less susceptible to trapping.

Hook and Line

No seasonal pattern is evident for best hook and line fishing since the catch varies more by whim of the fishermen than by season.

UTILIZATION

Blackfish, hardhead, hitch, splittail and small silver-colored carp are trucked alive to Chinatown, San Francisco and held in large aquariums (Figure 9). Fishermen supply filters, aerators and other accessories for the aquariums.

Chinese, the main consumers, will purchase only live fish. They pay up to 80 cents per pound for blackfish, hardhead, hitch, splittail and silver-colored carp since they resemble favorite species in their native land (Table 3). Silver colored carp and large goldfish *Carassius auratus* (Linnaeus), are in demand because they are good luck symbols.

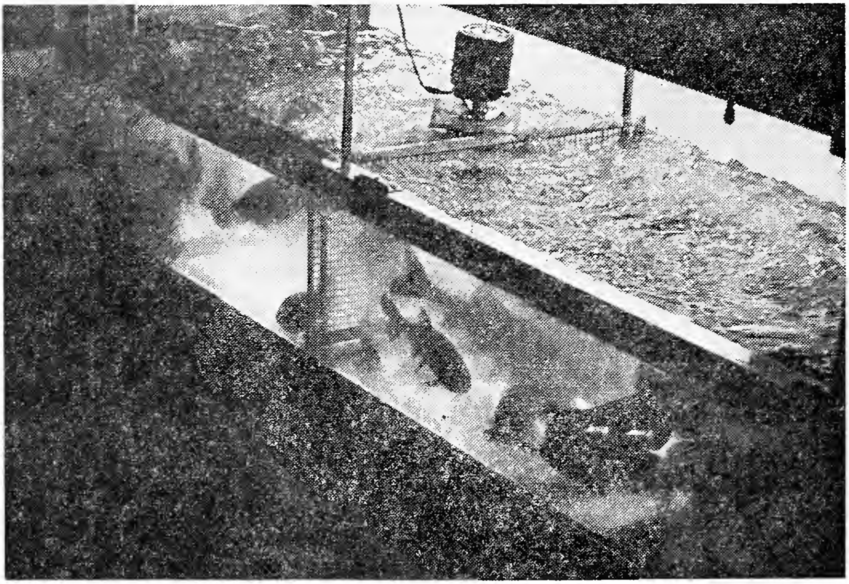

FIGURE 9. Live rough fish are retailed from aquariums in Chinatown, San Francisco. *Photograph by the author, June 1962.*

Carp are generally divided into three market sizes: large (10 to 20 pounds); medium (5 to 7 pounds); and small (3 to 5 pounds). Jewish people prefer large carp and suckers which are the main ingredient in Gefilte Fish. Most Jewish trade takes place in Los Angeles.

Negroes consume large quantities of carp or buffalo for which they will pay 25 to 30 cents a pound. These fish are packed 200 pounds per box, iced and shipped or trucked to markets in San Francisco, Oakland, Sacramento, Fresno, Bakersfield and Los Angeles.

An average of 100,000 pounds of rough fish, mostly carp, are sold for pet food each year. Pet food canners in the San Francisco and Monterey areas pay 1 cent per pound.

TABLE 3

Prices Paid for Freshwater Rough Fish in 1961

	Average price per pound		
Species	*To fisherman*	*Retail*	*Remarks*
Blackfish, Sacramento	$0.40	$0.80	Sold alive
Buffalo, bigmouth	.15-.20	.30	
Carp	.04-.10	.25-30	
Carp (with silver coloring)	.40	.80	Sold alive
Hardhead	.40-.45	.80	Sold alive
Hitch	.40	.80	Sold alive
Splittail	.40	.80	Sold alive
Sucker, western	.12	.30-.60	
Mixed (sold for pet foot)	.01		

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BRUSH MANIPULATION ON A DEER WINTER RANGE[1]

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INTRODUCTION

Brush manipulation is an old practice. Historically, the activities of miners, loggers, and ranchers had much to do with the extent and character of brush fields in California. Without intentionally doing so, these people manipulated the habitat of deer and other game animals. After legal protection was provided, deer numbers increased spectacularly throughout northern California following such incidental "management" (Longhurst et al., 1952).

Recently ranchers have made large-scale attempts to improve brush ranges for livestock grazing; first by control burning, later by burning in combination with mechanical and chemical treatments. Except where the goal of total shrub eradication was achieved—seldom feasible economically—ranges were improved for both livestock and deer. Resident deer herds are increasing rapidly in foothill areas where range improvement programs are active.

In either case, exploitative land management or livestock range improvement, natural vegetation is "set back" to earlier successional stages. High deer populations are associated with successional stages of vegetation rather than with climax (Leopold, 1950).

Broadcast methods of burning, bulldozing, and spraying, although already effective in improving deer habitat on brushy ranges, are easily made more effective by considering site and species responses. Brush stands usually have several species, each differing in reproduction, growth, palatability, and affinity for local sites. Manipulation of brushland for deer, or for deer and livestock together, requires knowledge of how plants of each species respond to manipulation and how they are affected by subsequent use. This study was undertaken to determine the effect of different kinds of manipulation on production and utilization of browse on a deer winter range. A primary objective was to accumulate information on the response of important browse species which will aid in the selection of manipulation techniques best suited for wildland areas devoted primarily to deer (Figure 1).

MANIPULATION METHODS IN RELATED STUDIES

Conversion of brushlands to grass for livestock has resulted in development of several techniques for brush removal. A basic procedure is to mash brush with a bulldozer, burn the mashed brush, revegetate by seeding grasses, and reburn at intervals to kill brush seedlings and surviving plants (Love and Jones, 1952). Chemicals have also

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FIGURE 1. View of an area in fall (top), five growing-seasons after an early spring burn, shows a good stand of sprouts and seedlings. Flannel bush (plants in center of picture) sprouted very well on this treatment and produced large amounts of browse. Flannel bush is well liked by deer as shown by appearance of the area the following spring (bottom).

been successfully used in brush eradication (Leonard and Carlson, 1957). Many types of machinery have been developed to control particular kinds of brush (Sampson and Schultz, 1957a). Burning techniques have been developed and described (Arnold *et al.*, 1951; Sampson and Schultz, 1957b). The more successful brush removal methods use combinations of all of these.

Manipulation of brushlands for game involves the same techniques used for conversion to grassland. However, the primary objective is not complete removal of brush cover but modification of shrub form and spatial distribution (Gibbens and Schultz, 1962). Mashing and burning have been successfully used in chamise brushlands of the coastal ranges in California to improve deer habitat (Biswell *et al.*, 1952; Biswell, 1961). Manipulation provided more available browse and herbaceous growth, resulting in more deer in better condition (Taber and Dasmann, 1958). Prescribed burning has also been suggested as a manipulation tool for increasing browse in ponderosa pine types (Biswell, 1959).

STUDY AREA

Studies were conducted on the San Joaquin deer winter range on the west side of the Sierra Nevada. The winter range lies west of the San Joaquin river between elevations of approximately 2,000 and 5,000 feet. Topography is rough, but there are level benches and ridgetops lying between precipitous slopes of the river canyon below and the steep slopes of adjacent mountains. Soils range from deep to shallow and there are numerous granite outcrops. Average yearly precipitation is about 34 inches.

Several vegetation types are found on the winter range: ponderosa pine forest with varying degrees of brush understory; digger pine and oak woodland with brush understory; oak woodland with shrub or grass understory; extensive areas of mixed chaparral with only scattered trees; and occasional open meadows. About 30 species of woody plants are represented. Two non-sprouting species of shrubs, wedgeleaf ceanothus *(Ceanothus cuneatus)* and Mariposa manzanita *(Arctostaphylos mariposa)*, are abundant. Wedgeleaf ceanothus is well liked by deer but manzanita is not a preferred browse plant. Two abundant species, which reproduce primarily by seed but also produce sprouts, are chaparral whitethorn *(Ceanothus leucodermis)* and yerba santa *(Eriodictyon californicum)*. Since their predominant response to manipulation is seed reproduction, they will be classed as non-sprouters in this report. Other sprouting shrubs which are abundant include western mountain mahogany *(Cercocarpus betuloides)* and flannel bush *(Fremontia californica)*, both excellent browse plants. Interior live oak *(Quercus wislizenii)*, a sprouter, is prominent but is not a preferred browse plant. Less abundant, though important as browse, are: redberry *(Rhamnus crocea* var. *ilicifolia)*; chaparral honeysuckle *(Lonicera interrupta)*; cherry *(Prunus subcordata)*; coffeeberry *(Rhamnus californica)*; poison oak *(Rhus diversiloba)*; buckeye *(Aesculus californica)*; and elderberry *(Sambucus caerulea)*. Currant *(Ribes roezlii)* and squawbush *(Rhus trilobata)* are frequent but not good browse. Mountain misery *(Chamaebatia foliolosa)* is an important source of browse in the pine type. Principal trees are ponderosa pine *(Pinus* *ponderosa)*, digger pine *(P. sabiniana)*, blue oak *(Quercus douglasii)*, and black oak *(Q. kelloggii)*. Both blue oak and black oak produce sprouts.

Growth ring counts indicated most brush plants were about 37 years old in 1960. The tall, often decadent, plants had been high-lined by deer and little browse was within their reach. A wide variety of understory plants contributed significantly to the food supply but were not studied in detail.

From about November 1st to the middle of May large concentrations of deer are present. Deer distribution on the winter range varies with weather, snow in particular tending to force the animals to lower elevations. Thus, the winter range may compress or expand between 60 and 30 square miles in area. This is in comparison to a summer range on the upper San Joaquin watershed of approximately 920 square miles (Hjersman *et al.*, 1957).

MANIPULATION PROGRAM

In the winter of 1954-55, the Department of Fish and Game initiated a brush manipulation program aimed at increasing browse for deer. Brush was mashed with a bulldozer; the blade was carried so plants would be pushed over or broken off, leaving root systems intact. The mashed brush was burned after fall rains, or in spring before rains ceased. Following burning, grasses were sown to provide cover and forage.

Brush mashed during winter, 1954-55, was treated in the following ways: (1) burned in early spring (first week in March); (2) burned in late spring (May); (3) burned in fall (first week in November); and (4) left unburned. Since operations were continued for several years, an unmanaged area was sampled in 1955. This area was mashed during winter, 1956-57, a portion burned in late spring (first week in April), 1957, and the remainder left as a mashed brush treatment. On the 1957 treatments, a record of vegetation before and after manipulation was obtained, whereas the 1955 treatments had no prior study.

METHOD OF STUDY

Studies were carried on from 1955 to 1960. To follow changes in cover and number of plants on manipulated areas, a series of transects was established in 1955. For two years, line intercept was used to record cover of woody plants but line points were used during the remainder of the study because this method was much faster and just as accurate (Heady *et al.*, 1959). Classes of ground cover—grass, herbaceous, litter, debris, and rock—were recorded for those points not occupied by woody vegetation.

Sprouts and plants were counted in a 5-foot strip, 2.5 feet on either side of the tape. Brush seedlings were counted in a 1-foot strip, 6 inches on each side of the tape. Pellet groups were counted on the 5-foot strip in the spring. Data from each 5-foot segment of line were recorded separately and punched on IBM cards. The same transects, totaling 10,490 feet, were sampled each spring and fall, allowing comparison of samples from year to year.

Browse production was determined by clipping and weighing samples of principal species. Yield was determined by multiplying the weight per unit area of sprouts times percent cover and the weight per individual seedling times density. All clipped samples were separated into leaf and twig components.

Sprout utilization was determined by tagging and measuring twigs in fall, and remeasuring the same twigs in spring. Leaf utilization was estimated on each bush with tagged twigs. Since, from yield clippings, the proportion contributed by leaves and twigs was known, average utilization could be calculated. Utilization of young seedlings was determined by clipping equal numbers in spring and fall and determining the difference in weight of current growth. When seedlings were 4 and 5 years old the twig tagging method was used.

Limited grass production sampling was carried out during three seasons. Measured strips were mowed and the grass collected and weighed.

COVER

Quantitative changes in cover (percent surface area covered by vertical projection of plant on ground) resulted from all treatments (Table I) but the magnitude of changes was primarily a function of the original species composition.

TABLE 1

Percent of Area Occupied by Sprouts and Seedlings on the Various Treatments in the Fall of the First Growing Season and in Fall of 1959

Year of treatment 1955	*Early spring burn*		*Late spring burn*		*Fall burn*		*Mashed brush*	
	1955	*1959*	*1955*	*1959*	*1956* [1]	*1959*	*1955*	*1959*
Sprouts	16	22	2	2	2	3	5	10
Seedlings	4	15	0	1	8	22	1	5
Total woody cover [2]	22	38	10	14	13	28	18	20
Grass and herbaceous cover	1	12	2	31	Not sampled	17	14	14

Year of treatment 1957	*Late spring burn*			*Mashed brush*		
	Before manipulation	*After manipulation*		*Before manipulation*	*After manipulation*	
	1955	*1957*	*1959*	*1955*	*1957*	*1959*
Sprouts	54	10	11	54	20	18
Seedlings	43 [3]	1	1	26 [3]	1	0
Total woody cover	76	11	11	65	20	17
Grass and herbaceous cover	14	1	33	12	23	20

[1] The fall of 1956 is the end of the first growing season after manipulation.
[2] Due to overlap of shrubs or presence of trees, total cover is often different from sum of sprout and seedling cover.
[3] Cover contributed by mature non-sprouting plants.

The first manipulation (mashing) reduced cover drastically and immediately. An occasional unsevered plant survived this treatment. Subsequent burning treatments further reduced cover. At the same time, however, these treatments differentially induced the reestablishment of cover. Thus, the net increase in browse canopy after initial reduction is of prime consideration.

On spring burns and mashed brush, sprouting species developed good cover in one growing season. On areas of live oak, whose sprouts are not always attractive to deer, cover increased steadily; heavily utilized sites of mountain mahogany and flannel bush made only small gains, or even lost cover, after the first season. Cover in areas of non-sprouters, except the fast-growing yerba santa, increased slowly.

On burned areas, herbaceous cover was sparse the first winter after manipulation; thereafter it increased, especially where grasses were seeded and where browse cover was low. Mashing alone did not greatly disturb herbaceous cover.

SPROUT DENSITY

For comparing the sprouting ability of shrubs when given different treatments, density (number of plants per unit area) is a more convenient criterion than cover. The number of plots (5-foot transect segments) containing mature plants (potential sprouters) before treatment was determined. These and other plots containing sprouts of the species in question two growing seasons after treatment, were considered the type area for each species (Table 2).

More mountain mahogany sprouts were produced on the mashed brush treatment, indicating that burning was not advantageous for this species. However, the age-form class of plants can influence sprouting. Mature, non-decadent plants with a tree-like form are the best sprouters and on the mashed brush site 32 percent of the plants were in this class, compared to 15 percent on the late spring burn site. Decadent plants, which are less likely to sprout, composed 12 and 19 percent of the plants on the mashed brush and late spring burn sites, respectively. The mashed brush site had a mountain mahogany population with a higher sprouting potential, and therefore, a better rate of sprouting after treatment.

Flannel bush is a prolific sprouter, giving rise to numerous adventitious sprouts from underground parts as well as stump sprouts. Burning greatly increased development of adventitious sprouts (Table 2). Both mashing and burning started redberry sprouting, although the response was slightly better on the mashed brush treatment. There were no significant differences in age-form classes for flannel bush or redberry.

Only the fall burn treatment had appreciable sprout mortality. Fall burning stimulated sprouting by some 12 percent, resulting in 740 sprouts per acre. However, many plants were weakened by being killed back after a season's growth and, with heavy browsing, a decrease of 40 percent occurred in four seasons.

TABLE 2

Number of Sprouts per Acre on Type Areas (see text for explanation)

	Mountain mahogany		*Flannel bush*		*Redberry*	
	Late spring burn	*Mashed brush*	*Late spring burn*	*Mashed brush*	*Late spring burn*	*Mashed brush*
Number of plots in sample	85	151	55	43	14	18
Number of mature plants per acre before manipulation	2,029	2,077	285	648	2,115	1,936
Number of sprouts per acre after manipulation	943	1,500	3,295	2,796	1,244	1,452
Before/after ratio × 100	46%	72%	1,156%	431%	59%	75%

SEEDLING DENSITY

The effect of manipulation on germination and establishment of brush seedlings is of prime importance because non-sprouters are a valuable source of browse. When counted, seedlings were separated into age groups as long as they could be so distinguished. When 3 years old, yerba santa seedlings produced many root sprouts; these were grouped with the seedlings.

All of the non-sprouting species responded to different treatments in the same manner. But treatment sites did not have an equal seed supply of each species so there were many differences in species abundance, independent of treatment.

Burning greatly increased brush seed germination. A nearly equal supply of wedgeleaf ceanothus seed was indicated on mashed brush and late spring burn treatment sites where the cover of wedgeleaf ceanothus was about 10 percent. Maximum seedling numbers after manipulation were 14,000 per acre on the late spring burn treatment and only 1,700 per acre on the mashed brush treatment. Even though an equal seed supply of a given species cannot be assumed for the other treatment sites, there were differences in seedling numbers which, by their very magnitude, indicated a significant treatment effect (Figures 2 and 3).

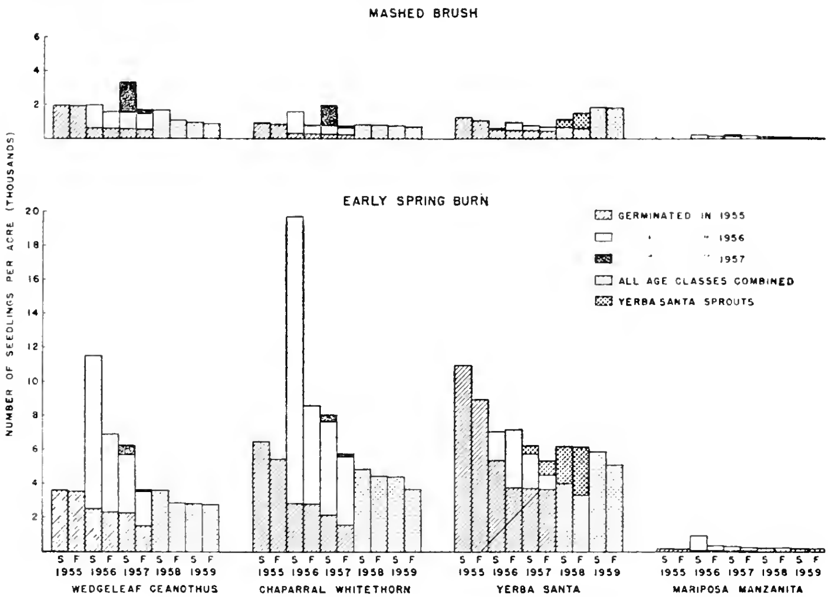

FIGURE 2. Number of brush seedlings per acre on mashed brush and early spring burn treatments in spring and fall of the first 5 years following manipulation. The same area was sampled each year.

Spring burns, both early and late, produced a "split crop" of seedlings. In the first year after manipulation only a few seedlings appeared, the number depending on the amount of rainfall after the burn. A much larger crop of seedlings emerged the second year. This nearly exhausted the seed supply and few seedlings appeared thereafter. Seedlings emerging the second season had to compete with established brush cover and with grasses which were more abundant than in the previous year. Consequently, mortality of the second-year crop was higher than that of the first-year crop.

Seeds germinated best on the fall burn treatment. Ample moisture and the stratification period following the burn resulted in nearly all seeds germinating the following spring. Although grass competition and heavy utilization caused high mortality, a dense population of seedlings remained after four seasons (Figure 3).

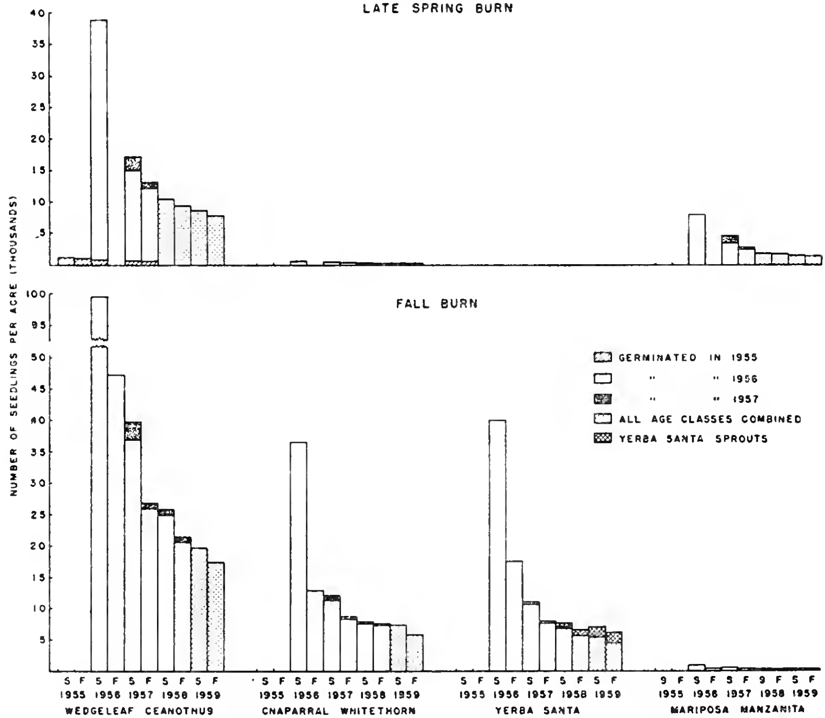

FIGURE 3. Number of brush seedlings per acre on late spring burn and fall burn treatments in spring and fall of each year following manipulation. Seedlings were not counted on late spring burn in fall 1956. The same area was sampled each year.

On mashed brush treatments, there was no fire to stimulate germination and few seedlings appeared the first spring. Seedlings continued to emerge each spring until 1959 when moisture was insufficient for germination. Germination and survival were best where herbaceous cover had been disturbed by the bulldozer.

Mountain mahogany, a sprouter, produces seeds prolifically which germinate readily without burning. A large seed crop was produced on treatment sites the year before manipulation and many mountain mahogany seedlings appeared the following spring. In an undisturbed stand of mature mountain mahogany, there were 1,900,000 seedlings per acre. Fire on the late spring burn treatment destroyed the seedlings.

On the mashed brush treatment some were killed due to mashing during the germination period but a large number survived. Mortality after two years was 98 percent in the undisturbed stand and 84 percent on the mashed brush treatment. Debris on the mashed brush treatment protected the slow growing seedlings from browsing, increasing survival.

SEEDLING MORTALITY FROM GRASS COMPETITION

An exclosure was constructed on the fall burn to determine the effect of grass competition and different intensities of use on brush seedling survival. One-half of the exclosure kept out deer and cattle; the other half, cattle only. Inside and outside of the exclosures 100, 1-year-old wedgeleaf ceanothus seedlings were tagged and these were measured in spring and fall for three years.

Under no use, or grass competition only, mortality was 46 percent after three years. In the cattle exclosure, where seedlings were subjected to browsing by deer in addition to competition from grasses, mortality was 68 percent. Since deer did not graze grasses enough to reduce competition appreciably, but did browse seedlings heavily, mortality was greater than where grass competition alone was a factor. Grasses, especially perennials, outside the exclosures were grazed heavily by cattle each spring. Here mortality was only 36 percent, indicating that reduced grass competition was more effective than protection from browsing in reducing mortality.

Unbrowsed seedlings in the deer-and-cattle exclosure made excellent growth and attained a maximum height of 35 inches and an average height of 16 inches in four growing seasons. Average height of browsed seedlings was 6 inches. There was no significant difference in height of seedlings outside and inside the cattle exclosures, indicating that cattle used seedlings very little.

SEEDLING MORTALITY FROM SHRUB COMPETITION

Grasses were not the only plants which competed with ceanothus seedlings for moisture, nutrients, space, and light. Areas where ceanothus seedlings were abundant often coincided with dense stands of yerba santa seedlings and sprouts. Yerba santa grows rapidly and quickly overtops ceanothus seedlings. On the fall burn treatment, 4-year-old yerba santa seedlings averaged 41 inches in height. Average height of 4-year-old wedgeleaf ceanothus and chaparral whitethorn seedlings was 6 and 17 inches, respectively.

In fall 1959, all 5-foot transect plots containing both yerba santa (at least 1 line-point hit) and ceanothus seedlings were selected. The number of ceanothus seedlings on these plots in spring 1956 was determined. Another group of plots, with no yerba santa cover in fall 1959, was matched with the first group as to number of ceanothus seedlings present in spring 1956. Thus two areas of equal size and containing equal numbers of ceanothus seedlings in spring 1956 were obtained. One of these areas developed a cover of yerba santa while the other did not.

The method of comparison described above was carried out for early spring burn and fall burn treatments. Mortality of ceanothus seedlings was greater on plots with a cover of yerba santa (Figure 4).

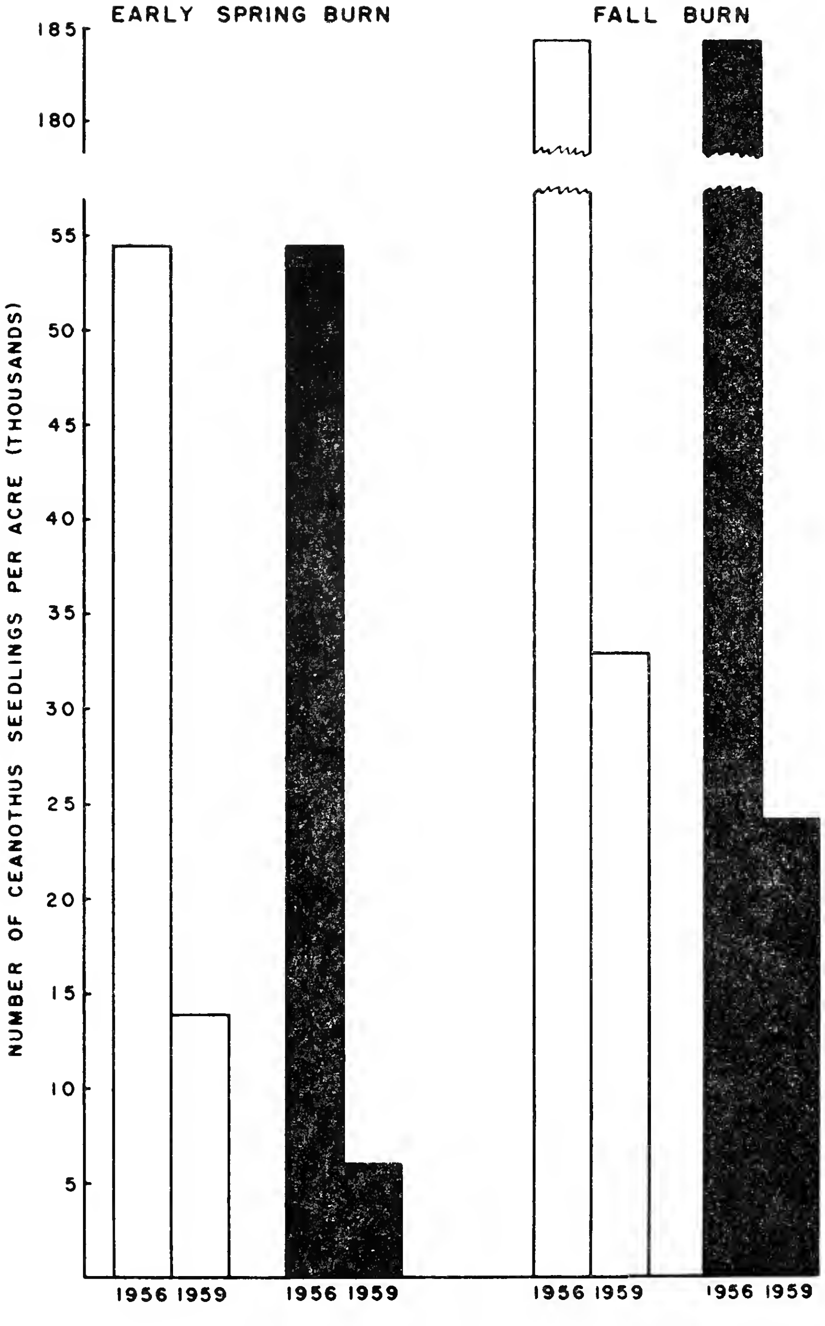

FIGURE 4. Number of ceanothus seedlings surviving on plots with yerba santa cover (black bars) and on matched plots without a cover of yerba santa (white bars).

EFFECTS OF MANIPULATION ON PLANT DISTRIBUTION

Because sprouts originate from stumps or roots of mature plants only minor changes in spatial distribution of sprouting species result from manipulation. The pattern of non-sprouters, with mobile seeds, is changed much more. By determining which 5-foot line segments or plots were occupied (either in terms of cover or presence of a plant) by wedgeleaf ceanothus and manzanita on late spring burn and mashed brush sites before manipulation and which plots contained seedlings after manipulation, spatial shifts could be determined.

Burning increased and mashing decreased the distribution of wedgeleaf ceanothus (Figure 5). Both burning and mashing reduced the area occupied by manzanita.

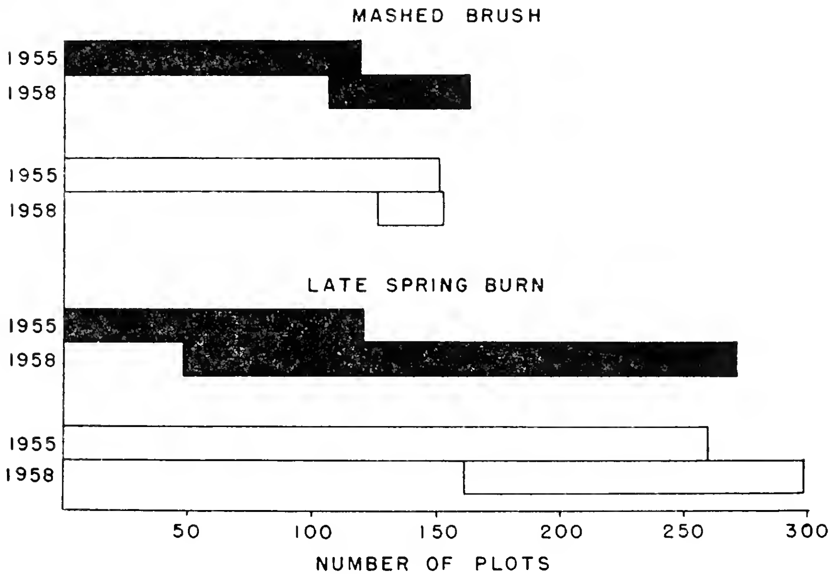

FIGURE 5. Number of plots occupied by wedgeleaf ceanothus (black bars) and manzanita (white bars) on 1957 treatments prior to manipulation (1955) and after manipulation (1958). Where adjacent bars are in contact, plots were occupied by the species both before and after manipulation. Where adjacent bars are not in contact, different plots are involved and area was either lost or gained.

YIELD OF BROWSE IN UNDISTURBED STANDS

Yields of browse were measured in undisturbed stands for two years prior to manipulation. All leaves and current twig growth were removed to a height of 5 feet on plots 5 feet square. The 60-odd plots used enclosed a different area each year.

Since there were several distinct vegetative types (in reference to browse production) the plots were divided into four groups: (1) manzanita type, including oak, pine, manzanita and grass mixtures as well as pure manzanita stands; (2) mountain mahogany type; (3) wedgeleaf ceanothus type; and (4) mixed brush type, where mountain mahogany, wedgeleaf ceanothus and manzanita were intermingled in approximately equal proportions.

All types had low yields (Table 3). However, factors operative during winter months may increase the amount of browse available in mature brush stands. Wet, heavy snow, for example, often bends or breaks branches, placing large quantities of browse within reach, at least temporarily. Also, it is not uncommon for deer to pull down branches, or stand erect, thereby gaining access to normally unavailable browse. When mature wedgeleaf ceanothus plants become decadent, branches often droop, allowing deer to reach leaves. Thus, even in highlined and decadent stands, browse may be replenished although young plants are absent.

TABLE 3

Browse Yields in Unmanaged Brush Stands for Two Consecutive Years (oven-dry weight)

Type	Percent of sample	Percent of total yield	Pounds per acre	Percent of type yield contributed by: Mountain mahogany	Wedgeleaf ceanothus	Manzanita	Other
1955							
Manzanita	46	48	27	12	3	36	49
Wedgeleaf ceanothus	10	12	54	26	73	0	1
Mountain mahogany	26	18	33	59	15	4	22
Mixed brush	18	22	58	53	32	9	6
Average yield			48				
1956							
Manzanita	49	12	13	8	0	58	34
Wedgeleaf ceanothus	11	21	106	0	97	0	3
Mountain mahogany	21	35	94	76	17	0	7
Mixed brush	19	32	94	24	53	18	5
Average yield			57				

YIELD OF BROWSE ON MANIPULATED AREAS

Browse yields from species which were abundant or highly preferred by deer were measured on manipulated areas. Samples of live oak, mountain mahogany, flannel bush, redberry, honeysuckle, cherry, wedgeleaf ceanothus, chaparral whitethorn, yerba santa and manzanita were clipped each fall. All of these except cherry are evergreen, thus their leaves are available to deer on winter range. Yields of minor browse species were estimated. Species such as currant and squawbush, which are only occasionally eaten, were not considered. The production figures are for browse commonly taken by deer and do not represent total productivity of woody plants in the ecological sense.

Cover and density obtained from transect lines were used in calculating yields. Therefore, yields reflect treatment differences which have already been presented. Yields are expressed in pounds per acre.

Total browse yields on all treatments were much greater than in undisturbed stands. Yields progressively increased until 1959 when dry weather restricted plant growth (Figure 6). For the first two years, yield of yerba santa was determined by multiplying yield per average bush times density but plants had become so large by the third season that yield per unit area was multiplied by percent cover. A reduction in total yield values resulted from this computation change (Figure 6).

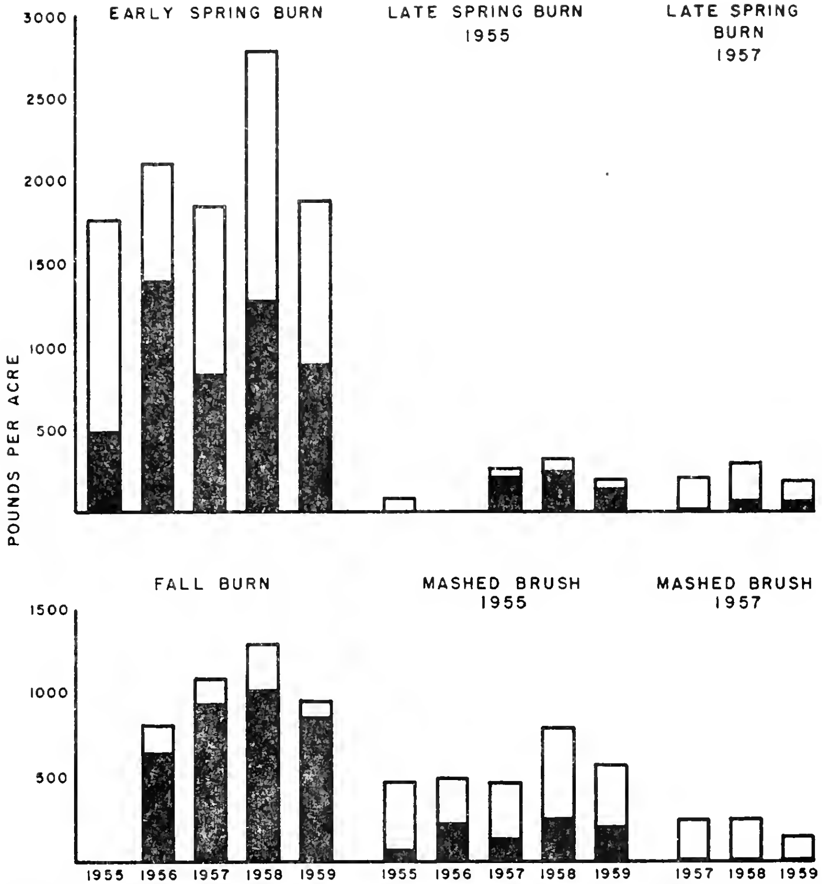

FIGURE 6. Total browse production (oven-dry weight) on treatments following manipulation. Browse furnished by seedlings is represented by black portion of bars; white portion represents sprouts. The 1955 late spring burn was not sampled in 1956.

Most of the browse on early spring burn, 1955 mashed brush and fall burn treatments, was furnished by live oak and yerba santa. These species were not abundant on other treatments; hence lower yields. Yields of individual species in pounds per acre on the early spring burn treatment after the fifth growing season were: live oak, 810; mountain mahogany, 30; flannel bush, 90; redberry, 25; other sprouts, 40; yerba santa, 370; chaparral whitethorn, 360; wedgeleaf ceanothus, 145.

Seedlings contributed progressively larger proportions of the total yield each year (Figure 6). Although seedling numbers decreased, seedling size increased, offsetting loss in numbers. Preferred sprouts, such as mountain mahogany, flannel bush and redberry, produced less each year. The decline was partly due to heavy use but dry weather also was a factor. Many sprouts, especially flannel bush, were reaching heights from which they could grow out of reach of deer in a single wet season. Once these sprouts begin to "escape," further reductions in yield are likely. Seedlings will remain available for a longer period and, if the plants continue to increase in size, yields will probably do likewise.

UTILIZATION OF BROWSE BY DEER

Browse utilized by deer during winter months was determined for species with measured production. All utilization percentages are based on weight and for purposes of this report were rounded to nearest 5 percent after calculation. Only minor differences in percent use were found between treatments for a given year. Number of deer present during winter and palatability of different browse species have more influence on degree of use than type of treatment.

Percent utilization of species during the winter of 1959-60 was: mountain mahogany, 85; flannel bush, 80; honeysuckle, 85; redberry, 65; wedgeleaf ceanothus, 55; chaparral whitethorn, 50; cherry, 20; yerba santa, 60; manzanita, 70; live oak, 15. These are in approximate order of deer preference. With the exception of cherry, which is deciduous, leaves made up the bulk of the browse consumed.

Although utilization during the winter of 1959-60 was the heaviest measured, utilization during preceding winters was rarely below 50 percent for preferred species. Dry weather restricted twig growth in 1959 and the proportion of leaves to twigs was high. Since leaves are preferred, use values were high. In other years, twigs contributed a larger part of the current growth and, since twigs are not browsed heavily, use values were lower. Practically all leaves of preferred species were used each winter.

Yerba santa, often considered low in palatability, received heavy but erratic use. Utilization on the fall burn treatment was 60, 60, 0, and 60 percent for the four winters following manipulation (Figure 7). Manzanita is usually not considered as good browse; nevertheless manzanita seedlings on manipulated areas were utilized heavily each year. The hard spiny leaves of live oak were not eaten in fall but in April and May new shoots were readily taken by deer.

By using percent utilization for the various species and their respective yields, an approximation of total use can be obtained. On early spring burn sites, from 20 to 35 percent of total browse produced was utilized each year. This is 410 to 715 pounds of browse per acre. Total use on other treatments ranged from 25 to 55 percent, being greatest on treatments with a high proportion of preferred species.

Except for live oak, the above figures do not take into account browse utilized during the spring growth period. During spring, use of live oak was obvious while for other species it was not. Close observation did not disclose appreciable use of new twigs on preferred species in spring. However, new leaves unfold very early and are utilized to some degree. Probably, in terms of weight, this use is not great, although it may affect plant growth.

Deer Days of Use

Pellet group counts made each spring furnished another measure of deer use on manipulated areas. Deer days were calculated on the basis of 13 groups per deer per day. In general, deer days were correlated

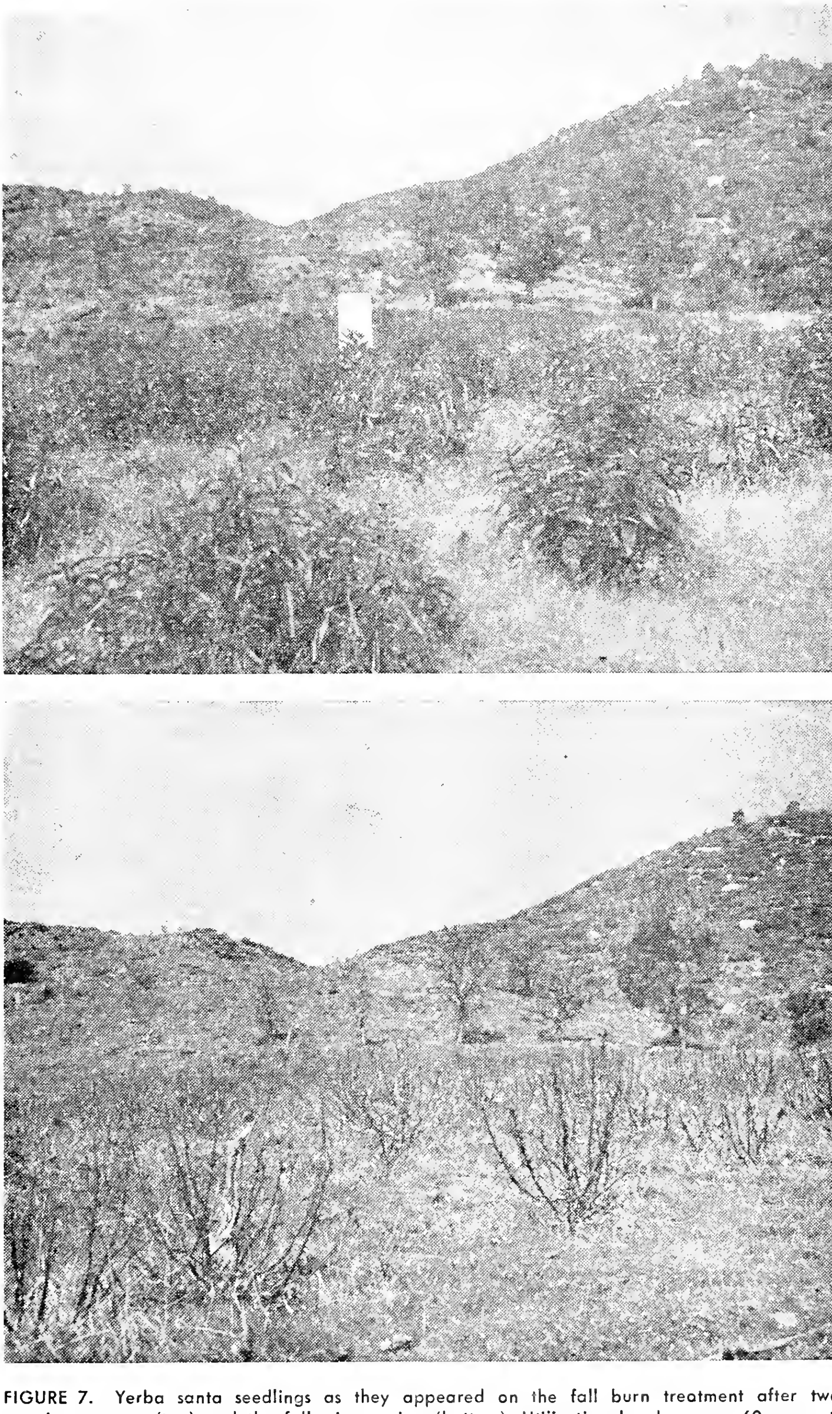

FIGURE 7. Yerba santa seedlings as they appeared on the fall burn treatment after two growing seasons (top) ond the following spring (bottom). Utilization by deer was 60 percent.

with the amount of browse available on treatments. The early spring burn treatment received from 115 to 152 deer days of use per acre each winter (Figure 8). The yearly increase in browse on the fall burn

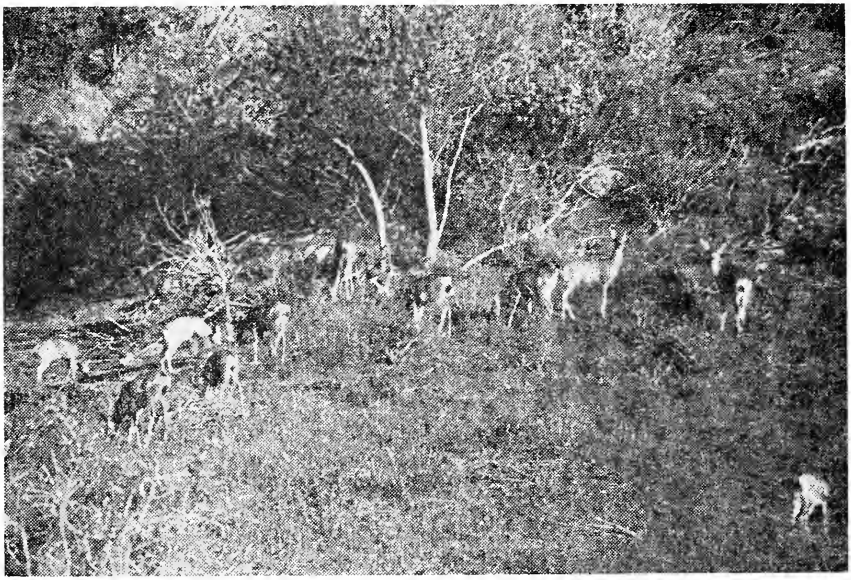

FIGURE 8. Deer feeding in open areas created by early spring burn treatment. Deer days of use on this area ranged from 115 to 152 per acre. Unmanaged brush appears in upper left.

treatment was accompanied by a progressive increase in deer use. During the four winters following manipulation, there were 56, 152, 186, and 218 deer days of use per acre, respectively.

In 1956, before manipulation, deer spent 95 and 111 days per acre on late spring burn and mashed brush sites, respectively. In 1958-59 deer spent 95 days per acre on the late spring burn treatment and 120 days per acre on the mashed brush treatment, only a slight increase.

UTILIZATION OF BROWSE BY LIVESTOCK

Cattle grazed the early spring burn, fall burn and 1955 mashed brush treatments each spring. Because use was during the period of rapid shrub growth, no attempt was made to make quantitative measures. The first spring after manipulation, before grasses were well established, cattle utilized new sprouts, particularly flannel bush, quite heavily. During the next three seasons, grass was plentiful and little browse was taken. In 1959 when dry weather restricted the grass crop, sprouts of flannel bush and mountain mahogany received considerable use. Evidence of this spring use was not visible in fall because plants had time to recover.

Cattle grazed during fall on the other treatments. Since grasses were dry, green browse plants were attractive. Measurements made during 1959 showed twig reduction in percent as follows: mountain mahogany, 22; flannel bush, 22; redberry, 2; cherry, 24. The growing season over, cattle use had reduced significantly the browse available to deer. Sheep were driven through the 1957 treatments each spring and browsed all species heavily. Browsing by livestock is not necessarily detrimental because it might be an effective method of maintaining sprouts in an available form for a longer period of time.

PRODUCTION AND UTILIZATION OF GRASS

Grasses were sown on burned areas to provide forage and control erosion. Pounds of seed used in mixtures was as follows: annual mix—wild oats, 13; annual ryegrass, 5; soft chess, 5; perennial mix—perennial ryegrass, 12; harding grass, 4; burnet, 9; intermediate wheatgrass, 1. Seeding rate was 3 to 6 pounds per acre.

Samples were collected early in June to determine forage yield. Filaree and burnet were the only non-grassy herbaceous plants included. Two exclosures provided ungrazed samples.

Excellent stands of perennial ryegrass became established on burned areas seeded with perennials in 1955. In 1957 and 1958, yields were about 1,700 and 1,200 pounds per acre, respectively, on ungrazed areas. Yields were reduced about 70 percent in 1959. Besides dry weather, another factor contributing to low yields on manipulated areas in 1959, was mortality of formerly abundant perennial ryegrass plants during winter, 1958-59. By summer 1960, few perennial ryegrass plants remained on seeded areas. Harding grass and intermediate wheatgrass were still present in spring, 1961, but neither was abundant. Of 17 grass species sown on trial plots only harding grass, big bluegrass and intermediate wheatgrass survived. Intermediate wheatgrass, although grazed so heavily it was never over 4 inches tall, formed an open sod and appeared to be spreading.

Use by deer and cattle in 1957, based on difference in production inside and outside of an exclosure on perennial seeded early spring burn treatment, was 85 percent. On the fall burn treatment, where both annuals and perennials were seeded, utilization was 65 percent. Cattle use was less in 1958 but in 1959 when forage was in short supply, cattle use was again very heavy. Deer utilized perennial grasses heavily each spring (Figure 9).

Many herbaceous plants, other than grasses, described by Sampson (1944) as occurring in successional stages following brush fires appeared on burned areas. These plants, along with more permanent associates from surrounding brush types, are important sources of food for deer. No quantitative measure of their yield was attempted.

DISCUSSION

The treatments studied were effective in increasing yield of available browse; however, this does not necessarily mean they were the best treatments for the areas in question. Treatments were applied with little regard for kinds of plants involved and included stands of several species. Due to differential response of species, maximum browse production can be attained only by manipulating on a species type basis. It would likely be uneconomical to repeat manipulation every few years. Furthermore, some species would not survive repeated treatment. For example, burning establishes a stand of ceanothus but this

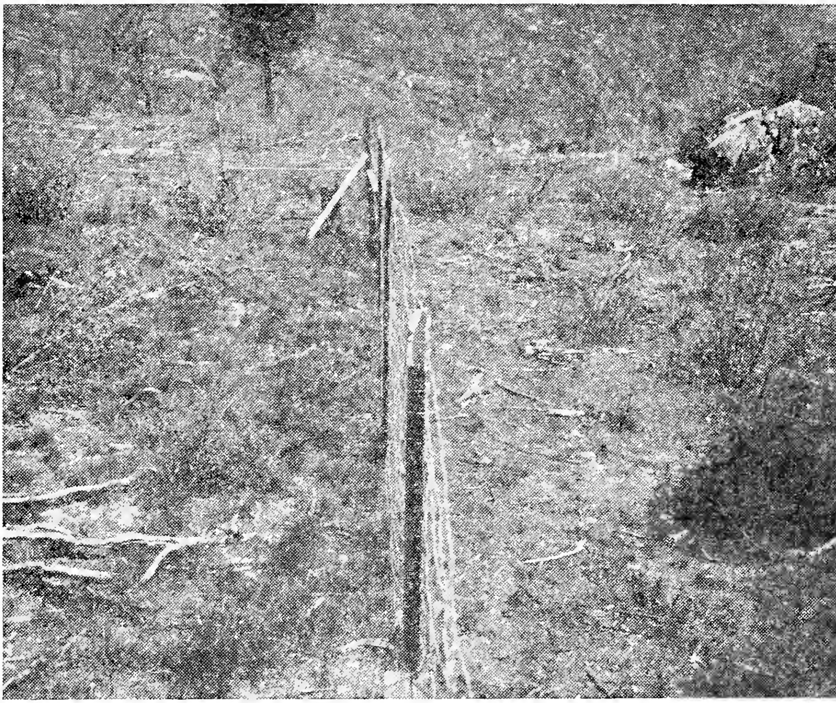

FIGURE 9. Stand of perennial ryegrass on early spring burn treatment in April of third season after manipulation. Area on left of fence was protected during the winter; area on right was grazed by deer. Picture was taken before livestock use.

exhausts the seed supply. If the area were burned again before a new supply of seed has been produced, the stand would be destroyed. It may take many years to produce a seed crop; therefore initial manipulation should be done to insure an adequate and lasting browse supply.

Fall burning is more effective than spring burning for non-sprouting species, particularly wedgeleaf ceanothus and chaparral whitethorn. The reason is quite simple. Burning, just as the artificial treatments of scarification or immersion in boiling water or acid, cracks the hard coat so the seed can imbibe water. After this has occurred, the seed needs a period of stratification in cool soil. As the soil warms in spring the seed germinates. Fall burning produces these conditions in exactly the right order. While spring burning satisfactorily cracks the seed coats, there is an insufficient interval of time for stratification following imbibition; the soil is too warm or already too dry to allow seedling establishment. Consequently many seeds lay over until the following spring before they germinate. Seedlings which do not emerge until the second season must compete with herbaceous vegetation and sprouts which have had a full season's head start. Since burning causes an increase in available nutrients (Vlamis *et al.*, 1959), seedlings which become established the first season after a burn can make better growth than those which emerge the second year, after nutrients have been tied up or leached out.

A disadvantage of fall burns is baring of soil to erosive action during the following winter. Excessive exposure of soil is avoided by mashing and burning alternate contour strips on successive years. If it is impractical to mash brush in strips, the whole area can be mashed at once and strips or patches burned at intervals. Ceanothus seedlings appear in large numbers even if burning is delayed for several years. Although some debris is desirable for ground cover, burning in pure ceanothus stands should be fairly clean, as unburned spots produce few seedlings and competing grasses are still present.

Two species studied, manzanita and yerba santa, are generally considered low in palatability and not worth manipulating. However, on such manipulated areas yerba santa was a major source of browse in 4 out of 5 years. This may indicate an excessive deer population but the importance of yerba santa as an emergency food should be emphasized. Its presence can be advantageous unless it competes with the more desirable ceanothus seedlings. Yerba santa is susceptible to herbicides and can be controlled easily by selective spraying. Judging from mature stands of ceanothus on old burns, where remnants of yerba santa indicate former abundance, enough ceanothus seedlings usually survive to provide a fully stocked stand.

Manzanita seedlings were eaten readily by deer on all manipulated areas but mature plants are less palatable and can be classed as an emergency browse. Although manipulation of mature manzanita stands will produce little browse, a cover of grasses can be established which will benefit both deer and livestock. In this case, spring burning is desirable to reduce the area occupied by manzanita.

Except for flannel bush, no conclusive evidence was obtained indicating that burning increases number of sprouts. Thus, where stands are composed primarily of sprouting species, mashing alone is an effective treatment. Mountain mahogany is well suited to mashing and if delayed until after a heavy seed crop, seedlings and sprouts will be established. Here burning is detrimental as it destroys both seeds (fall burn) and seedlings (spring burn) and eliminates debris which protects the slow-growing seedlings from being browsed. Competition from grasses takes a heavy toll of mountain mahogany seedlings. Grazing by livestock can be used to reduce competition and increase survival.

Flannel bush responds favorably to burning with sprouts and seedlings appearing in greater numbers on burned areas. The rapid growth exhibited by sprouts of this species make it a good candidate for fall burning. It takes only 5 to 6 years, even when used heavily, for sprouts to grow out of reach of deer. On fall burns and on small areas where burning was delayed for 1 to 2 years after mashing, flannel bush sprouts were killed back to the ground. Subsequent growth was still quite vigorous and few plants failed to resprout. Delayed burning slows down growth and sprouts are less likely to grow out of reach. Browse lost during one winter by fall burning is offset by a longer period of availability. Browsing by livestock is an effective method of prolonging the period of availability (Gibbens and Schultz, 1962).

Where plants occur in pure stands, manipulation on a species type basis is relatively easy. Even when sprouting and non-sprouting species are intermixed in equal amounts, selective manipulation is possible. Mashed ceanothus and manzanita plants furnish piles of fuel which are easily ignited. Mashed, mature plants of flannel bush and mountain mahogany, due to their widely-spreading tops, are more difficult to pile and also to burn. Therefore, if an area of mixed brush is burned when it is too wet for fire to spread readily, the non-sprouters will be consumed without damaging many sprouting plants.

When manipulating game ranges, it is desirable to maintain a diversity of species. Studies of browse species in other regions have shown that browse plants vary widely in chemical constituents (Dietz *et al.*, 1958; Lay, 1957; Gordon and Sampson, 1939). Due to such variation, one or even two browse species might not supply all the constituents necessary for ideal deer nutrition. Manipulation should not favor one species to exclusion of all others.

All treatments used have a common characteristic in that brush was mashed by a bulldozer. This is an effective method of creating dry brush which may be safely burned under wet conditions. However, it restricts manipulation to areas traversable by a crawler tractor. On the rough terrain commonly found on deer ranges only a small part of the total area may be manipulated. If fire alone were used as a manipulation tool, it would be possible to manage areas inaccessible to bulldozers. Only limited observations were made of burned standing brush but a multitude of wildfire burns attest to the effectiveness of fire alone in furnishing available browse in the form of sprouts and seedlings. Use of fire alone would, of course, mean burning under drier conditions and present difficult but not insurmountable control problems.

The desirability of manipulating more area than is possible with a bulldozer is well illustrated by the San Joaquin winter range. During the 3 years mashing operations were carried out, about 2,500 acres were mashed. This represents practically all terrain level enough to be bulldozed which, at most, is 20 percent of total winter range area. If deer are distributed evenly over the winter range, only a small number is benefited by increased browse. More likely, however, deer are overdispersed, concentrating in the spots of plentiful browse. This results in destructive utilization and the point is reached where increase in browse production has no measurable effect on deer productivity.

Bulldozers, fire, and livestock are not the only manipulation tools available. Fertilizers have been found to affect significantly the growth and palatability of shrubs on deer ranges (Gibbens and Pieper, 1962). Herbicides offer another means of manipulating composition of shrub cover. Kinds of grasses and rates of seeding have an influence on brush seedling survival (Schultz *et al.*, 1955). With knowledge of how different brush species react to various methods of manipulation it is possible to change the composition of brush ranges to any desired combination of brush and grass. This constitutes brush control and through such a control program the productivity of deer ranges can be greatly increased. To realize the full benefits of a brush manipulation program, control of the deer population is, of course, essential.

ACKNOWLEDGMENTS

The authors thank H. H. Biswell for his helpful advice and Peter A. Jordan for helpful suggestions and assistance in the field work.

SUMMARY

Effect of manipulation on production and utilization of browse plants was studied on the San Joaquin winter deer range in Madera County, California from 1955 to 1960. Areas of mature brush mashed during winter months were treated by burning in early spring; burning in late spring; burning in fall; and leaving unburned.

Production of available browse in unmanaged brush stands ranged from 13 to 106 pounds per acre. Yields of browse were increased by all treatments. The magnitude of increase depended largely on kinds and density of plants; yields ranged from 80 to 2,765 pounds of browse per acre on manipulated areas.

The principal browse species and their responses to manipulation were:

Western mountain mahogany—This species sprouted vigorously on all treatments. Burning did not increase sprouting appreciably so mashing is an adequate treatment. Debris created by mashing protected seedlings which were destroyed on burned areas. It is highly palatable to deer and from 35 to 85 percent of current growth was utilized each winter.

Flannel bush—A very vigorous sprouter. Increase of sprouts over original number of plants was eleven-fold on burned areas and four-fold on mashed areas. The sprouts grow very rapidly and delaying burning until after a season's growth would increase the period of availability. Leaves are relished by deer and 50 to 80 percent of current growth was utilized.

Redberry—This species was not abundant but sprouted well on all treatments. It is well-liked by deer and utilization ranged from 40 to 70 percent.

Honeysuckle—A vigorous sprouter on all treatments and very heavily utilized, with 60 to 85 percent of current growth removed each winter.

Cherry—A deciduous species which sprouted well when either mashed or burned. Only twigs were available as winter browse and utilization ranged from 5 to 25 percent.

Interior live oak—An extremely vigorous sprouter on all treatments. It was the most abundant plant on several areas but was browsed by deer only in spring when new growth appeared.

Wedgeleaf ceanothus—An abundant and very palatable non-sprouting species. Seedling establishment was greatly favored by fall burning. Spring burns resulted in two seedling crops and greater mortality. Yields were still increasing at the end of 5 years. Deer utilized 50 to 70 percent of current growth each winter.

Chaparral whitethorn—This species sprouts to some extent but the principal means of reproduction is by seed. Like wedgeleaf ceanothus, seedling establishment was favored by fall burning. It grows more rapidly than wedgeleaf ceanothus and its stiff, spiny twigs deter browsing animals to some extent. Utilization ranged from 10 to 60 percent.

Yerba santa—Like other species reproducing by seed, yerba santa appeared in greatest numbers on the fall burn treatment. During their third growing season, seedlings produced numerous root sprouts. The rapidly-growing plants overtopped, and increased mortality of ceanothus seedlings. Although not well liked by deer, use was heavy in 4 out of 5 years. Up to 80 percent of current growth was eaten.

Mariposa manzanita—This non-sprouting species, although locally very abundant before treatment, was greatly reduced in area occupied by both mashing and spring burns. Since only seedlings of this species are readily eaten by deer, treatments which do not favor its establishment are best.

Grasses and herbaceous plants under mature brush stands yielded from 400 to 895 pounds per acre. Grasses were sown on burned areas and yields increased to about 1,500 pounds per acre. Death of perennial grasses after the fourth season caused a sharp reduction in yield. Perennial grasses were heavily utilized by deer and cattle.

To obtain maximum returns from manipulation, treatments should be selected on the basis of species present in a particular stand.

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NOTES

THE NAMES OF TUNAS AND MACKERELS

In the most recent list of approved names for California fishes (Roedel, 1962), I noted that the problem of tuna systematics and nomenclature was receiving careful scrutiny but that we were retaining the "traditional" names for members of this group pending results of work then in progress. Evidence presented at the World Scientific Meeting on the Biology of Tunas and Related Species (La Jolla, Calif., July 1962, sponsored by the Food and Agriculture Organization of the United Nations) demonstrated that albacore, bigeye, bluefin, and yellowfin tunas are best regarded as single, world-wide species properly belonging in genus *Thunnus*. Resolution 1 of the Meeting recommended using the four names which follow for these fishes, and these will be employed henceforth in Departmental publications.

Albacore, *T. alalunga* (Bonnaterre)
Formerly Pacific albacore, *T. germo*

Bigeye tuna, *T. obesus* (Lowe)
Formerly Pacific bigeye tuna, *Parathunnus sibi*

Bluefin tuna, *T. thynnus* (Linnaeus)
Formerly California bluefin tuna, *T. saliens*. Two subspecies apparently exist, one Atlantic *(thynnus)*, the other Indo-Pacific, including the Japanese and North American bluefins *(orientalis)*

Yellowfin tuna, *T. albacares* (Bonnaterre)
Formerly Pacific yellowfin tuna, *Neothunnus macropterus*

We retain *Katsuwonus pelamis* for the skipjack tuna, though some systematists feel it should be placed in genus *Euthynnus*.

The La Jolla Meeting also agreed that genus *Pneumatophorus* was at best worthy of subgeneric rank, though the question of speciation among the mackerels remains to be determined. The Pacific mackerel becomes *Scomber diego* Ayres, pending resolution of its relationship to the Oriental *japonicus*.

Fitch and Roedel (1962) presented evidence at the meeting that the *Auxis* sp. in Roedel (1962) is *A. rochei* (Risso), the only cosmopolitan species and the one widely called frigate mackerel. *A. thazard*, limited to the Pacific and Indian Oceans, is the bullet mackerel of California fishermen.

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—Phil M. Roedel, California Department of Fish and Game, November 1962.

BOOK REVIEWS

Abyssal Crustacea

By J. Laurens Barnard, Robert J. Menzies and Mihai C. Bacescu, Columbia University Press, New York, 1962; ix + 223 p., 160 figs.; $10.

Abyssal Crustacea in actuality is the first number of a new serial publication, *Vema Research Series*, presenting the findings of the *Vema*, research vessel of the Lamont Geological Laboratory. In this number, three authors describe new and previously known amphipods (Barnard), isopods (Menzies) and cumaceans (Bacescu) from abyssal Atlantic depths.

Future numbers will decribe new instruments and techniques devised and perfected on the *Vema*, list extensive series of data, show numerous ocean-bottom photographs, report submarine canyon and other bathymetry studies, and so forth.

Abyssal Crustacea is 9 by 12 inches, outside bound dimensions. Its text, including references, is in double columns on each page; however, each figure is arranged according to its space requirement, thus some are full-page presentations. In the 78 pages devoted to amphipods, Barnard describes 38 new species and 9 new genera. He also gives excellent data on adaptations, food, and endemism, and summarizes the known world abyssal amphipods.

Menzies in 128 pages describes 107 new species and 9 new genera of isopods, reviews previous work, defines the area sampled and lists and keys out most of the species from depths greater than 2000 meters.

Bacescu's report (in French) is only 17 pages long but describes six new cumaceans in the genus *Makrokylindrus* and keys out the 25 species assigned to it.

All three papers present excellent bibliographies.—*John E. Fitch, California Department of Fish and Game.*

Between Pacific Tides

By Edward F. Ricketts and Jack Calvin, Revised by Joel W. Hedgpeth, Stanford University Press, Stanford, Calif., 1962; xiii + 516 pp., profusely illustrated with black and white text figures and photos plus colored frontispiece; $8.75.

As nearly as I can tell, none of the text of this latest revision differs from the arrangement of the 1952 edition until page 345. From there to the end of the volume, a few chapters have been reshuffled, a new one has been added and the list of references has been made more helpful by bringing it fairly well up-to-date.

The new chapter, "Beyond the tides: the uncertain sea" is based primarily upon the work of the California Cooperative Oceanic Fisheries Investigations and other research conducted along the Pacific Coast during the past decade or more. In presenting the historical background of CalCOFI, Joel Hedgpeth is slightly in error, especially with respect to dates and organizations involved. His refreshing approach to marine pollution problems along our coast more than vindicates him, however. I was very pleased to see that he feels much the same about present-day pollution, polluters and "control" efforts as I do and wasn't afraid to say so.

This latest work is unquestionably the best of this impossible-to-do-without reference that has yet appeared. It is my fond hope that Stanford University Press will see fit to bring all the scientific names and some miscellaneous life-history data in the text up-to-date with the next revision.—*John E. Fitch, California Department of Fish and Game.*

Discovery—Great Moments in the Lives of Outstanding Naturalists

Edited by John K. Terres, J. B. Lippincott Co., New York, 1961; xiii + 338 pp., wood engravings by Thomas W. Nason; $6.50.

Those familiar with the field of natural history and its literature, will immediately recognize among the 36 authors of this book many outstanding contemporary naturalists. Most of these are ornithologists. Each has contributed to this anthology an outstanding anecdote from his outdoor experiences. The result makes fascinating reading of worldwide adventure. A brief biographical sketch precedes each article.—*Willis A. Evans, California Department of Fish and Game.*

Island in Time: The Point Reyes Peninsula

By Harold Gilliam, Sierra Club, San Francisco, 1962; 87 pp., black and white plus 10 color photographs; $7.50.

People who appreciate the out-of-doors will find reading this book an informative, as well as pleasurable experience.

Its large size (9″ x 12″), fine paper, outstanding photo reproductions and organization of contents are of a quality that has, in recent years, given the Sierra Club an enviable reputation for publishing fine books. The 42 photographs, 10 in color by Mr. Philip Hyde, are excellent.

Have you seen the Point Reyes Peninsula? If not, this book will arouse in most persons a strong desire to see this outstanding area that time has passed by and allowed to remain largely in its primeval state. Those who have seen it will appreciate the manner in which author Gilliam has captured the natural beauty and heritage of this recently proposed addition to our national park system.

The various chapters cover such subjects as: historical background (Did Sir Francis Drake actually careen his ship on the sands of Drakes Bay?), early Indian inhabitants, flora and fauna, climate and geology.

One of the best chapters is the understandable explanation of the rather complex geology of the area. This unique "island in time" has an entirely different geologic history from the adjoining land mass from which it is divided by the great rift of the San Andreas Fault.

In its brief 87 pages, it makes no attempt to present a detailed documentary of this scenic area but basically provides a rich aesthetic experience in exploring our natural outdoor heritage.—*Willis A. Evans, California Department of Fish and Game.*

Management of Artificial Lakes and Ponds

By George W. Bennett, Reinhold Publishing Corp., New York, 1962; 283 pp., illustrated; $8.

A more appropriate title for this book would have been *Management of Warm-water Artificial Lakes and Ponds*, since trout reservoir management is not discussed.

The author first reviews the history of fish management and then discusses types of artificial impoundments, the dynamics of the populations inhabiting them, and management theories and techniques. There are also chapters on fish behavior and angling, and on the commercial aspects of sport fishing. The chapter on fish behavior is very pertinent and a subject frequently overlooked in a treatment of this type, but the latter chapter is superfluous.

The book is very readable and serves important functions in collating information widely scattered in the literature and in presenting the knowledge the author has gained from wide experience with the subject.

At the same time, it has important deficiencies. One is the incomplete treatment of several subjects. Examples are the omission of Hassler's work on artificial lake circulation, and Ridenhour's work on measuring abundance of young-of-the-year populations by seining, the limited consideration of pulsating units in electrofishing, and listing the maximum time for toxaphene detoxification as nine months.

Also, questionable theories are presented as facts without adequate supporting data. For example, on page 107 he states that largemouth bass need assistance to control bluegills indefinitely because bass prefer to feed on crayfish and their own young but he presents no supporting data.

In several instances, invalid conclusions are drawn from data. For example, the author attempts to establish a relationship between fishing pressure and success and then use the relationship to predict such things as the size of a lake necessary to support satisfactory fishing for a given amount of effort. The relationship (Figure 7.2) appears to be invalid, since it is based on two different groups of ponds—one in which fishing was poor irrespective of angling pressure and another in which success varied greatly while pressure was uniformly low. Even if the relationship were accurate, the prediction would seem to be of little value, since many other variables particularly geographic ones are involved in determining angling success.

Some conclusions reached are not applicable to problems in California and adjacent areas. This is quite understandable, since the literature from this area is limited and the author has not had firsthand experience in it. This is evident in his discussion of artificial water level fluctuation, in which he does not consider fluctuations of the magnitude normally found in many of California's reservoirs.—*H. K. Chadwick, California Department of Fish and Game.*

Meet Flora Mexicana

By M. Walter Pesman, Dale S. King, Publ., Globe, Arizona, 1962; 280 pp., 270 drawings plus 9 black and white photos and 1 colored map; vinyl cloth on boards $6.

On the inside of the front cover is a beautiful fold-out map of the vegetation zones and main roads of Mexico. From this, readers and travelers alike can determine where they are, in fact or fancy. A long list of plants is arranged by zone, making identification a pleasure. The drawings point out primary identification characteristics very effectively. Several scratch drawings are works of art. Plant zones include desert, mesquite and grassland, thorn forest, chaparral, pine-oak forest, tropical deciduous forest, savanna, tropical evergreen forest, and rain and cloud forests. Introduced and cultivated plants are also given ample space, answering inevitable questions that arise when such plants are seen in dooryards or in the wild. A thorough bibliography and a bilingual index complete the book.

The author of this outstanding book has had extensive landscaping and writing experience with the plants of southwestern United States. Although a brief systematic listing of all the plants is included, the emphasis is upon identification of a specific plant in a specific zone. The publisher makes the contents available in 3 different bindings: 3-color thin card cover $4, wir-o-bound thin card cover $5 and 3-color vinyl cloth on boards $6.—*Parke H. Young, California Department of Fish and Game.*

Methods of Testing Chemicals on Insects. Vol. II.

Edited by Harold H. Shepard; Burgess Publishing Co., Minneapolis, Minn., 1960; iii + 248 pp., illus.; $5.

As in Volume I (see *California Fish and Game*, 46 (2) :234), concern is directed toward the chemical warfare which is constantly being waged against insects. The emphasis here is upon factors affecting experimental results, although numerous chapters are devoted to screening potential insecticides.

The papers in this volume should be of special interest to fish and wildlife laboratory workers who could put some of the tests and techniques to good use in assaying minute amounts of chemicals in the tissues of fish and game animals.

Because of the problems caused by the continued development of new and deadlier compounds and the very widespread use of pesticides, there has been a need to prepare a manual of test methods. The editor hopes that these two volumes and the ones which will appear later will not only fulfill this need, but also fulfill the goal of the recently discontinued Chemical-Biological Coordination Center of the National Research Council.

Although Volume II had many of the same shortcomings as Volume I, subsequent volumes may contain material which has thus far been overlooked. On the other hand, the papers have again been well documented (over 550 references) and the format is neat and clear. It is rather surprising, however, that both volumes have been so well and sturdily bound, as if to imply these books would be subject to field use and exposure to the elements.

It is impossible to conclude this review without expressing wonder as to the impact of this book upon some of the readers of Rachel Carson's *Silent Spring*. Their comments should be most interesting.—*Herbert E. Pintler, California Department of Fish and Game.*

Shark! Unpredictable Killer of the Sea

By Thomas Helm, Dodd, Mead & Co., New York, 1962; xvii + 260 pp., 21 black and white photographs plus 22 text figures; $4.

This book is written in an interesting narrative style that will be of more value to the layman than to the serious student of shark biology. Much of the book is taken up with the author's personal experiences and he has a tendency to get widely off the subject of his chapter headings. Three of the ten chapters do not discuss sharks, but deal with such diverse groups as porpoises, barracudas, octopi, rays, and other dangerous or harmful marine animals.

The book is of little value to the taxonomist as there is a complete lack of discussion or drawings dealing with shark dentition, and the drawings which accompany the text are not of sufficient quality to aid in accurately identifying sharks. References mentioned in the text are not all listed in the bibliography and several important papers dealing with sharks are completely omitted in both the text and the bibliography.

One of the more informative portions of the book discusses the patterns of shark feeding and attacking behavior. The appendix is, perhaps, the most informative section since it lists and gives pertinent information on all confirmed shark attacks taking place in the coastal waters of the United States between 1907 and 1960.—*Michael L. Johnson, California Department of Fish and Game.*

Silent Spring

By Rachel Carson, Houghton Mifflin Co., Boston, 1962; xvi + 368 pp., numerous text drawings, $5.

This work by Rachel Carson will probably prove to be the most talked about and controversial of any book she has written so far.

She starts her book by explaining the ecosystem within which we live. She tells how, before man entered the picture, "Nature" kept everything within this system balanced. From the perfect world God created, she brings into view man's efforts to remove harmful insects and weeds by chemical means.

These chemical products, their properties, and various uses are described in detail. She tells how these pollutants affect the land in general plus the wildlife and birds; inland streams and waterways plus the fish and waterfowl; and the oceans plus the fish and shellfish. Using these hydrocarbon insecticides has a permanent effect on all these areas and their inhabitants; an effect that is accumulative in many instances.

The author goes on to describe not only the effects on birds, animals, and fish, but the problems which are arising in the human race from poisonings, gene mutations, and the possibilities of cancer forming through the indiscriminate use of certain of these chemicals.

Toward the end of the book she explains how the insects already are way ahead of science; they are breeding new, super-hardy types which can resist the superchemicals. The last chapter brings out the only logical conclusion which we can reach as a world of people: biological control. Biological controls have been tried and proved in many areas, and it seems like the only answer to this insurmountable problem.

The book is very well written, interesting, and enlightening. It will be easily understood by layman and scientist alike. To some it will sound like an alarmist's tale, but it should not be treated lightly. It is well documented and every item is based on fact, backed up by scientific papers or articles listed in the book's 55-page bibliography. This book should be in the library or at least read by all persons who are interested in conservation.—*Hugh L. Thomas, California Department of Fish and Game.*

The Saltwater Fisherman's Bible

By Erwin A. Bauer, Doubleday and Company, Inc., New York, 1962; 192 pp., illustrated; paperbound, $1.95.

This is the sixth paperbound volume in a recently published series of Doubleday "Bibles" dealing with various phases of hunting, fishing, and camping.

The author, Erwin Bauer, is an easterner and a former editorial staff member of the now defunct *Fisherman* magazine. Hence, it is not too surprising to find emphasis and the personal touch on Atlantic coast sportfishing. The lesser portion of the book is devoted to fishing on the Pacific coast and here, he has drawn freely from the works of several California authors without one word of credit or acknowledgment.

The book itself consists of a well illustrated version of the usual what to catch, and where to catch it. Also included are short chapters on such subjects as: tackle, lures, baits, recipes, boating safety, and a brief glossary of saltwater fishing terms.

Pricewise, this "Bible" is more attractive than many of its hard-bound, contemporary counterparts. It will be interesting to readers and collectors of fishing stories but would hardly fall in the category of a text or library reference.—*William L. Craig, California Department of Fish and Game.*

Whales

By E. J. Slijper (translated from the Dutch), Basic Books Publishing Co., Inc., New York; 475 p. 229 figures; $12.50.

This book comes as a great boon to biologists wishing specific information about whales. In my case, I found the answers to a number of questions in connection with something I was writing: how many pelvic bones Cetaceans have, for example, and just which species have which; which ones have vestigeal hair, and how much; which barnacles and other parasites are commonly found on whales?

In addition to being a valuable reference for information such as the above, this book is very enjoyable reading. It covers the history of whaling, and the past and present uses of whale products; the evolution of whales; locomotion; respiratory and circulatory systems, with explanations for the adjustments that make possible deep diving and long stays under water; food; reproduction; distribution and migration; sense organs; sound-making; behavior; and other aspects of the lives of these fascinating creatures. The many black and white drawings and photographs are eye-catching and do a lot to help tell the author's story, and they are well reproduced.

A few minor errors were noted in regard to American things, as the statement that the grey whales winter in the bays and lagoons of California, rather than Baja California; and a reference to the Pacific white-sided (or striped) dolphins kept by Marineland of the Pacific as white-beaked dolphins. But such errors as these are unimportant in view of the overall excellence of this book, which fills a need and does it in a thoroughly enjoyable way.—*Anita E. Daugherty, California Department of Fish and Game.*

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Notice is hereby given that the Fish and Game Commission shall meet on April 5, 1963, at 9.30 a.m., in the Old State Building, First and Broadway, Los Angeles, California, to receive recommendations from its own officers and employees, from the department and other public agencies, from organizations of private citizens, and from any interested person as to what, if any, orders should be made relating to birds or mammals, or any species or variety thereof, in accordance with Section 206 of the Fish and Game Code.

FISH AND GAME COMMISSION
Monica O'Brien, *Secretary*

Notice is hereby given that the Fish and Game Commission shall meet on May 24, 1963, at 9.30 a.m., in the main floor auditorium, State Employment Building, 722 Capitol Avenue, Sacramento, California, to hear and consider any objections to its determinations or proposed orders in relation to birds and mammals for the 1963 hunting season, such determinations resulting from hearing held on April 26, 1963, commencing at 9.30 a.m. in Room 39, Highways Building, 150 Oak Street, San Francisco. This notice is published in accordance with the provisions of Section 206 of the Fish and Game Code.

FISH AND GAME COMMISSION
Monica O'Brien, *Secretary*

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