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"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 40 OCTOBER, 1954 NUMBER 4

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VOLUME 40 OCTOBER, 1954 NUMBER 4

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THE USE OF A BLANKET NET IN SAMPLING FISH POPULATIONS[1]

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INTRODUCTION

Purpose

For a long time, there has been a need for a quick yet safe and efficient method of sampling pelagic marine fish populations. Since 1950 the Marine Fisheries Branch of the California Department of Fish and Game has employed small explosive charges to stun fish, which were subsequently dip netted, while floating at the surface. This method, although meeting with some success, was dangerous, and in October, 1953, an accident occurred that precipitated experimentation to discover an alternate method of sampling fish populations. After approximately seven months it is believed that a sampling method which is not only safer, but also quicker and more efficient, has evolved. It also shows considerable promise of becoming a valuable aid in the capture of live bait, as well as of other commercial species.

A Brief Historical Review

The principle of lift nets and blanket nets is simple and undoubtedly such nets have been employed in primitive fisheries for centuries. Although they have been replaced with more efficient gear in many industrial regions, today this principle is still used in many areas of the Pacific Ocean. There are a great many variations in this type of device and, since similar gear has had such wide usage, it is difficult to credit any one country with its origin.

Because of the simplicity of principle, relatively low cost, and ease of operation, various techniques have been devised by fishermen unaware that their method may have been tried before, or was being used in some remote area.

Off Southern California many ideas and devices have been reoriginated. The fishery for Pacific mackerel sponsored many such methods. Hoop lift nets, blanket nets, and other similar types of gear were tried. Some were used to capture fish attracted to chum, others were used in conjunction with a night light, and some incorporated both methods of attracting fish.

The Japanese have been quite successful with a net of this type in catching saurics and other fish for bait as well as for food. The Japanese bait net is rectangular, about 32 feet long and 27 feet wide.

[1] Submitted for publication June, 1954.

The net is set to hang vertically (curtain-like) from a long bamboo float which is kept about 20 feet from the vessel by two bamboo poles. A night light is then set out to attract fish, which are subsequently captured by lifting the bottom of the blanket net to the vessel. Although this net is efficient in catching saurics and certain other small fishes, some species seem to avoid this curtain of webbing.

In the Philippines, a blanket net, which differs from the Japanese net in that it is suspended from a pole rigidly secured between two pilings, is used in shallow water. This net is also pulled by lifting the bottom edge.

The Division of Fish and Game, Territory of Hawaii, has been experimenting with the Japanese lift net, with one major modification. Instead of suspending the net from a float, the net is set from the side of the vessel and the bottom edge is lifted by two lines, one at each lower corner, leading through blocks at the ends of two rigid outriggers. The advantage of this method lies in the fact that there is no curtain of webbing in the water while the fish are being attracted to the light. This net has been further modified, recently, by enlarging it to 43 by 48 feet (from 32 by 27 feet) and using minnow webbing extensively. It is used primarily in catching bait, and has been somewhat successful with fish of about 2½ inches in length.

THE DEVELOPMENT OF THE BLANKET NET FOR SAMPLING FISH POPULATIONS

The California Department of Fish and Game has been working with various devices to sample fish populations since 1949. After experimental attempts to sample sardines with such types of gear as beach seines, gill nets, a mid-depth trawl, and dynamite, two standard routines were inaugurated in 1950. One consisted of scouting for and locating schools of fish at night, either through the biolumenescence they created, or by the use of echo-sounding equipment. Upon location of a school, sampling was accomplished by detonating a light explosive charge under water and picking up the stunned fish with dip nets.

The other routine employed a 750-watt light suspended above the surface of the water at regular intervals while the vessel drifted at night. After a given length of time, any fish that had been attracted to the light were sampled with an explosive charge.

These methods were dangerous to the person handling the explosives, yielded relatively small samples of fish, and were extremely time consuming (often more than 45 minutes were required to maneuver the vessel to pick up a few fish). Occasionally many more fish were killed than were needed.

After the occurrence of an unfortunate accident, the result of handling explosives, emphasis was again placed on development of a safer sampling method.

A trap lift net was constructed to the specifications described by Siebenaler (1953) for one which had been used with some success in the Gulf of Mexico during 1952 by the U. S. Fish and Wildlife Service vessel OREGON. This net was essentially a rigid, box-like pipe frame, 8½ feet on a side, with a light frame that slid up and down between a fixed bottom and top. The entire device was submerged with the top just clear of the surface of the water, and a night light was suspended

above the surface of the water. After fish had been attracted the trap was sprung by pulling up the sliding frame, which in turn pulled a wall of webbing along the rigid frame, thus entrapping the fish.

Before completion of the initial cruise to test this gear, it had become apparent that its use in a routine sampling survey was limited. The gear, heavy and cumbersome, was somewhat dangerous, except in sheltered waters. Even a slight roll of the vessel caused enough disturbance to frighten the fish away. Anchovies and smelt were sampled inside the shelter of the San Pedro Breakwater, but in the open ocean, outside the breakwater, the motion of the frame kept the fish away and, though they could be seen milling in a large circle around the net, none could be captured.

Captain Paul D. Petrich, Master of the Department's survey vessel YELLOWFIN, conceived the idea of a blanket net. The idea seemed promising and a net was constructed of 1½-inch stretched mesh webbing from an old gill net.

Under the supervision of Andrew Felando, Netman-Boatswain of the YELLOWFIN, the crew further modified and rehung the net several times during the initial and subsequent cruises.

The blanket net seems to be a more successful means of sampling than the former method entailing the use of explosives. It is not only faster and safer, but results in larger individual samples of fish.

Although the principle of setting the net is essentially the same as that developed by the Hawaiian Division of Fish and Game, the idea occurred independently and the Hawaiian experiments were not known at the time. The weighted bag, over-all size, and method of hanging make this net somewhat different from other types of blanket nets.

CONSTRUCTION OF GEAR

Blanket Net

Constructed of three sections of cotton twine webbing, the over-all dimensions of the blanket net are 50 by 66 feet. One section is made of three-inch stretched mesh and the other two of three-quarter-inch stretched mesh. These latter two sections are bound on their edges by a selvage of two-inch stretched mesh, six meshes deep, attached to number 21 manila line which forms the edges of the net.

For convenience in discussing the blanket net, future reference to the line forming the perimeter of the net will be given in relation to its position on the net. The line on the 50-foot side next to the vessel will be called the inboard line, the line on the opposing side the lead line, and the two lines on the 66-foot sides the fore and aft sidelines. Three weighted rib lines sewed in the bag of the net, together with the lead line, facilitate rapid sinking of the net. Further dimensions and specifications are shown in Figure 1.

Rigging

The outriggers were constructed of eucalyptus poles cut to 55-foot lengths, with diameters at the butt and tip approximately eight and three inches, respectively. Each outrigger was secured at its base by a two-inch chain through the butt and suspended by a topping lift.

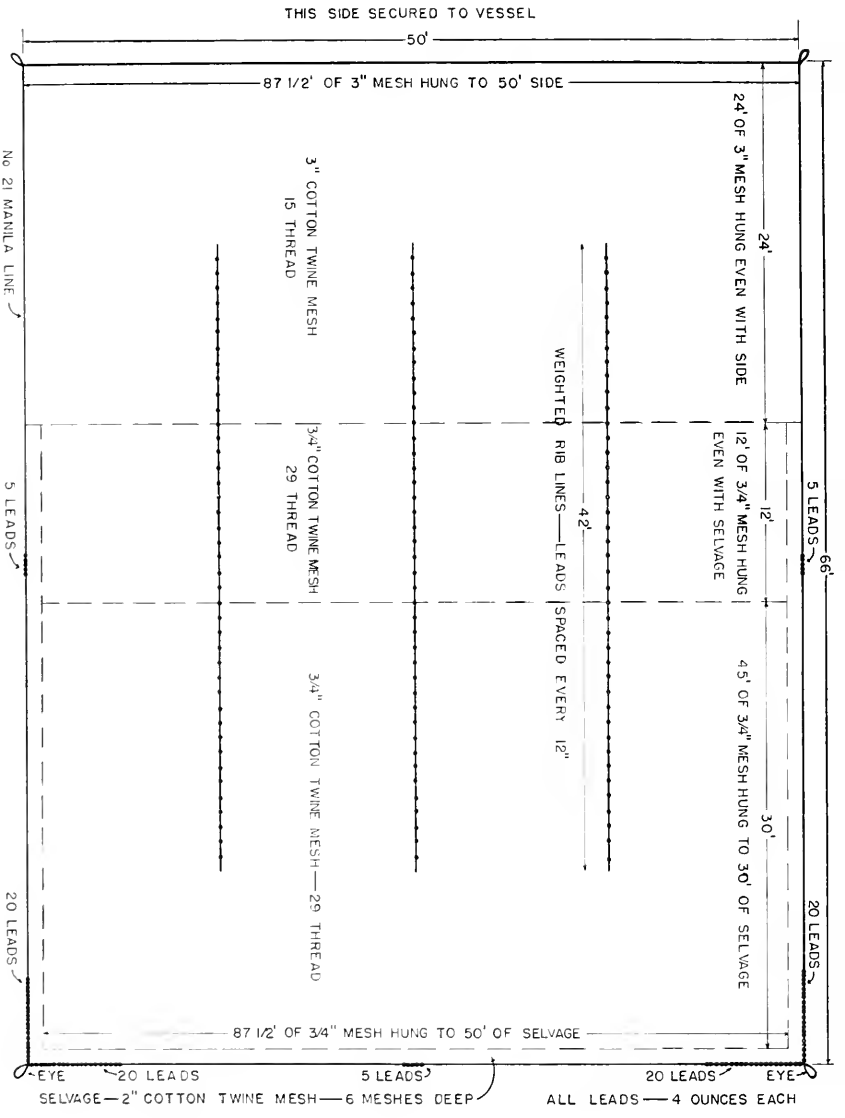

FIGURE 1. Diagram showing construction of the blanket net.

Each topping lift was rigged as follows: a six-inch double block was fastened to the mast and a two-inch manila line was reeved from the double block through two six-inch single blocks. Each single block was connected by a one-quarter-inch wire pennant to a one-quarter-inch wire bridle which was secured to the outrigger. Each outrigger, thus suspended by a topping lift, could be raised or lowered as desired. Guy lines, running fore and aft, were secured to the outboard end of each outrigger, controlling the horizontal position of each pole.

OPERATION OF THE BLANKET NET

The net is lowered vertically into the water until it has reached its maximum depth (Figure 2). Lifting lines, attached to the corners of the lead line, are then pulled in through blocks at the end of each outrigger. As the net is drawn through the water, the weighted rib lines and the resistance of the net to the water cause a bag to form (Figure 3).

After the lead line is out of the water, the fore and aft sidelines are shortened until they are also above the surface. The net is then completely set (Figure 4). The net then may be brought alongside the vessel by slackening the lifting lines while pulling on the fore and aft sidelines, keeping all edges above the surface of the water (Figure 5).

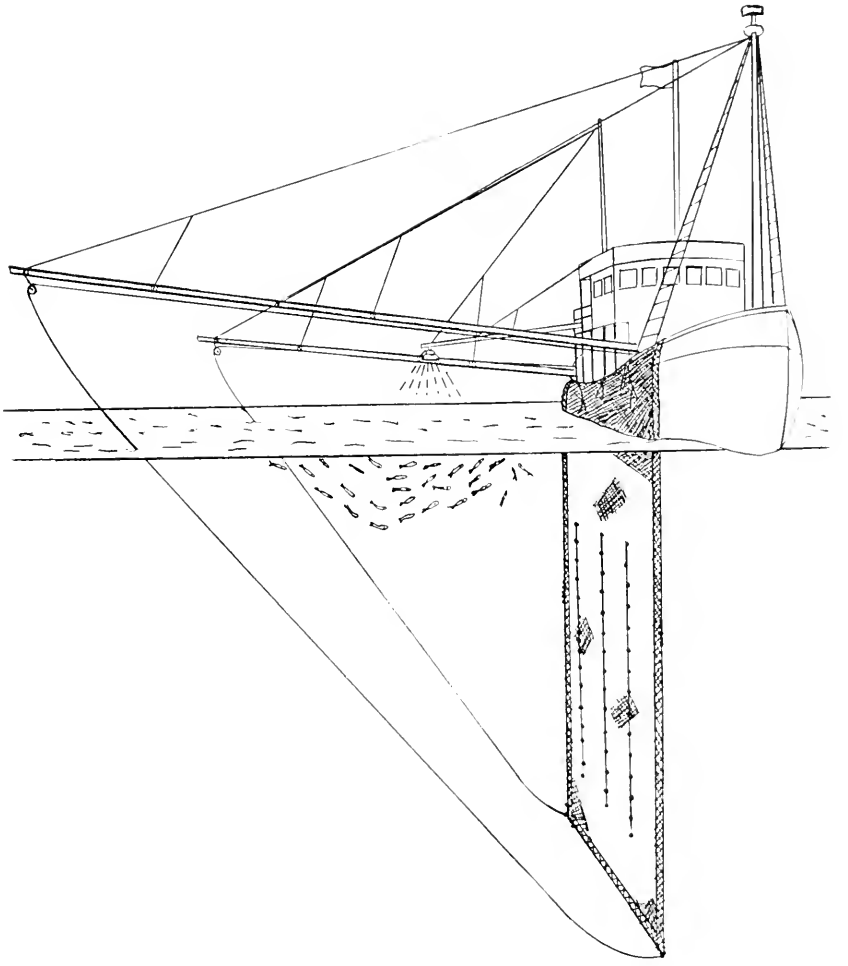

FIGURE 2. Net in the water prior to pulling on the lifting lines.

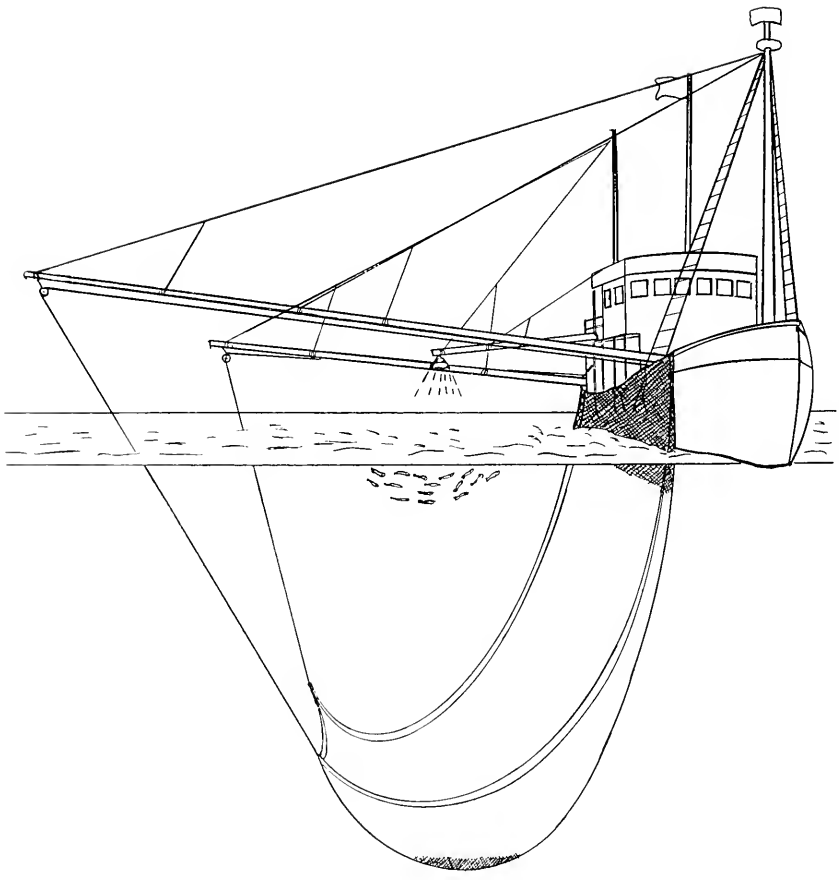

FIGURE 3. Lifting the lead line. The bag is forming as the lifting lines are pulled.

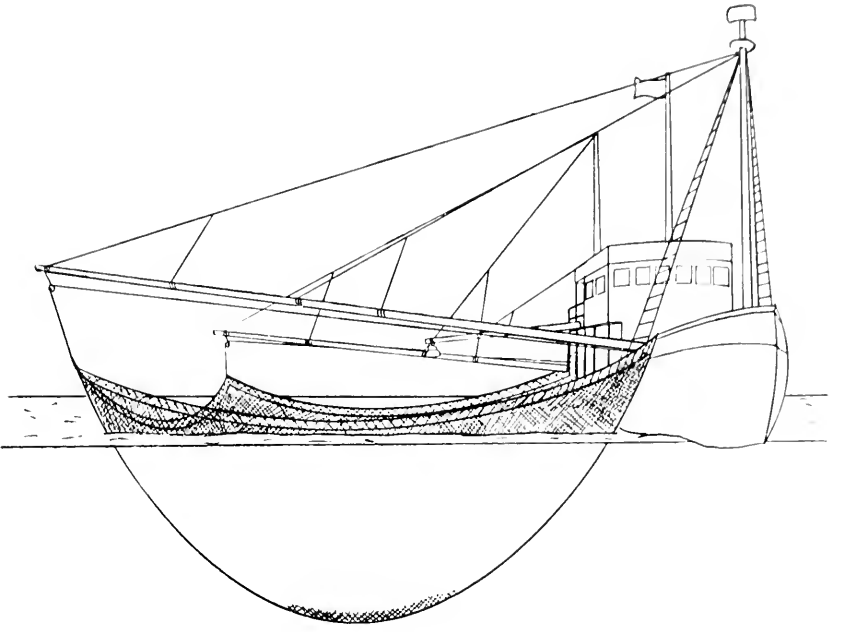

FIGURE 4. Net completely set. The bag is about five fathams below surface of the water.

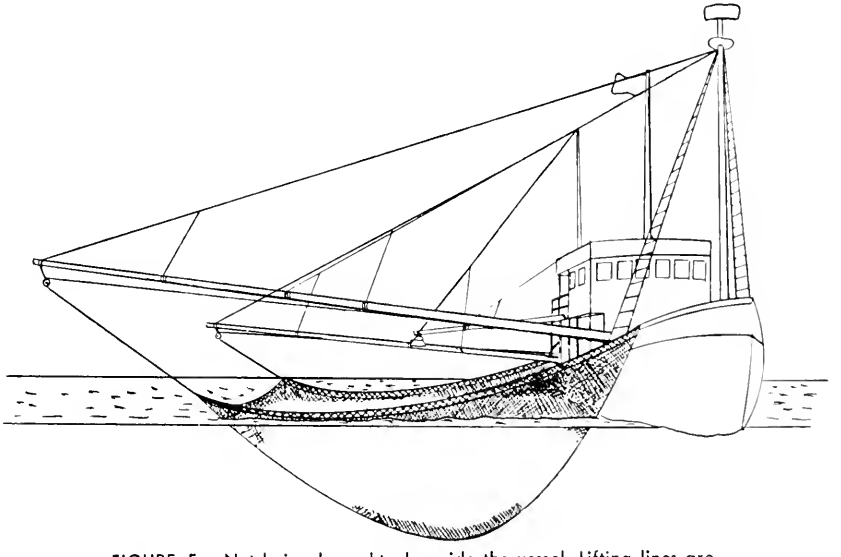

FIGURE 5. Net being brought alongside the vessel. Lifting lines are slackened, and sidelines are taken in.

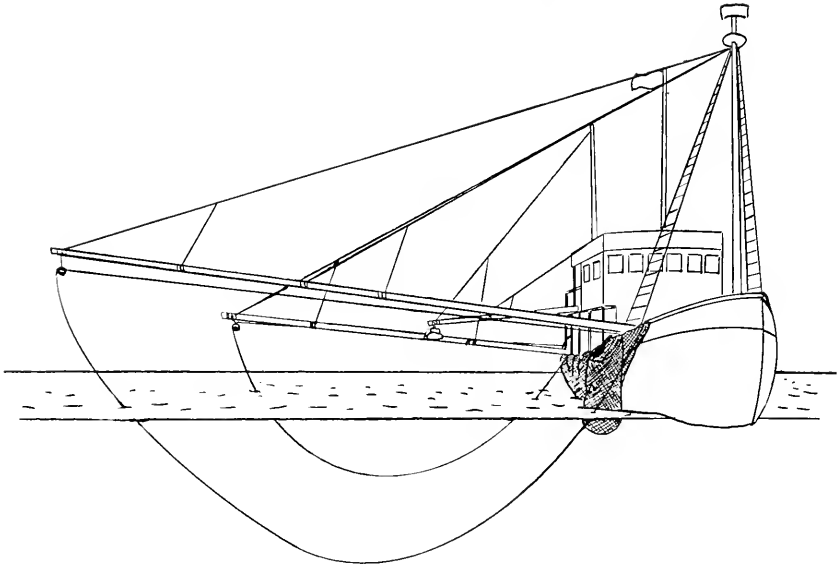

FIGURE 6. Ready for brailing. The bag becomes a pocket as the slack webbing is gathered.

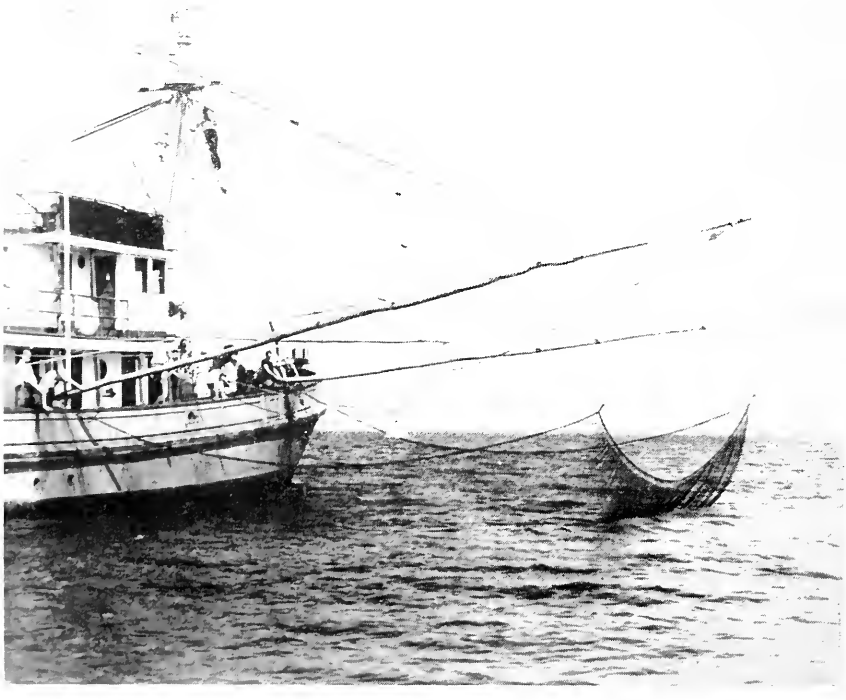

FIGURE 7. The blanket net set from the survey vessel YELLOWFIN.
Photograph by R. Collyer, February, 1954.

As the net is brought alongside the vessel, the excess webbing is gathered, keeping intact a bag from which the fish may be brailed (Figure 6).

The entire operation, excluding time for brailing, can be completed within 5 to 10 minutes with five or six men.

Some factors that should be considered for the successful operation of the blanket net are summarized as follows:

1. The vessel should be headed so that it cannot drift over the net. Under most conditions this can be accomplished by stopping the vessel with the net on the windward side.
2. To facilitate its sinking the net should be wetted down thoroughly prior to its operation.
3. To avoid bunching, and to allow the bag to form uniformly, the net should be paid out evenly.
4. While the net is being brought alongside the vessel, the excess folds of webbing should be gathered continously, thereby keeping the fish intact in the bag. This is especially important when the fish are to be retained for live bait.

RESULTS OF EXPERIMENTAL CRUISES

The ¾-inch, Cotton Twine, Blanket Net

Throughout four experimental cruises (November 7, 1953—April 14, 1954) two primary factors were considered: the ability of the net to capture fish and its efficiency of operation under the various conditions of wind and sea.

Recorded observations on the operation of the blanket net to date indicate it to be a satisfactory means of sampling fish, as well as of capturing live bait.

The initial trial of the original net was made off Cedros Island, Baja California, on the afternoon of November 9, 1953, so that its operation could be observed during daylight hours. The first set yielded 20 blacksmith, 2 halfmoon, and 1 rock wrasse, although the set was made with no intention of catching fish.

Seven sets were made that night on schools of sardines, mackerel, and jacksmelt, but because of the large webbing a great percentage of these fish was either gilled or escaped. The following day the net was rehung, using smaller three-quarter-inch stretched mesh, and additional weights were added to aid in sinking the net.

Thirty sets were made with the blanket net on this first cruise (November 7-17, 1953) and approximately 15,000 fish representing 22 species were taken. Of these, sardines and northern anchovies comprised about 55 percent.

In subsequent cruises the net was rehung several times and additional weights were added, until the present specifications evolved.

A total of 191 sets made with the blanket net during the four cruises yielded approximately 90,000 fish. These sets were made in seas varying from calm to moderate and in winds up to 25 miles per hour. Of the 90,000 fish taken, some 50,000 were sardines, which were taken in 99 sets, 20,000 atherinids, and 16,000 northern anchovies. A list of the species taken is presented by common and scientific name in Table 1.

TABLE 1

Common and Scientific Names of Species Taken by the Cotton Twine Blanket Net Off the Coast of Baja California (November 7, 1953, to April 14, 1954)

Common name	Scientific name	Common name	Scientific name
Pacific round herring	*Etrumeus acuminatus*	California barracuda	*Sphyraena argentea*
Pacific sardine	*Sardinops caerulea*	Gulf barracuda	*Sphyraena* sp.
Pacific thread herring	*Opisthonema libertate*	Jack mackerel	*Trachurus symmetricus*
Northern anchovy	*Engraulis mordax*	True pompano	*Trachinotus paitensis*
Slough anchovy	*Anchoa delicatissima*	California pompano	*Palometa simillima*
Deepbody anchovy	*Anchoa compressa*	Pacific mackerel	*Pneumatophorus diego*
Pacific saury	*Cololabis saira*	California bonito	*Sarda lineolata*
Halfbeak	*Hyporhamphus unifasciatum*	Sierra	*Scomberomorus sierra*
California needlefish	*Strongylura exilis*	California salema	*Xenistius californiensis*
California flyingfish	*Cypselurus californicus*	Queenfish	*Seriphus politus*
Sharpchin flyingfish	*Fodiator acutus*	Blacksmith	*Chromis punctipinnis*
Yellow snake-eel	*Ophichthus zophochir*	Rock wrasse	*Halichoeres semicinctus*
Jacksmelt	*Atherinopsis californiensis*	Halfmoon	*Medialuna californiensis*
Topsmelt	*Atherinops affinis*	Cabezon	*Scorpaenichthys marmoratus*
California grunion	*Leuresthes tenuis*	Squid	*Loligo opalescens*

The number of sardines and percentage of sets in which this number was taken in 99 sets is presented in Table 2. The largest yield of a single set was approximately 15,000 sardines. On only one occasion were sauries observed in quantity under the light. At this station, one set yielded approximately 1,000 sauries, which seemed to be the entire school. Atherinids were common throughout the area and large numbers were taken, frequently over 1,000 fish per set.

TABLE 2

Number of Sardines and Percentage of Sets in Which This Number Was Taken in 99 Trials

Number of sardines	Percentage
1-100	55.5
101-500	29.4
501-1,000	5.0
1,001-5,000	8.1
Over 5,000	2.0
Total	100.0

Table 3 compares the size of sardine samples taken by dynamite with samples obtained by the blanket net. The dynamite data were taken from three regular survey cruises in the fall of 1953, preceding the four experimental cruises. The dynamite stations represent approximately the same area, but differ in time of year. Although this comparison indicates that the blanket net yields larger samples of sardines than did the previous method, this was more dramatically demonstrated in the large samples of fish that were taken at some stations which, had dynamite been used, probably would have yielded less than 100 fish. Eighty sets were made with the blanket net to obtain the 48 samples shown in Table 3 and 65 percent of these samples were taken by single sets. On three occasions sardines were observed under the light, but were not taken. There was no difficulty in keeping the vessel's bait tanks supplied with live bait during the cruises. Sardines in excess of those needed for a sample were kept for live bait and this aided in the catching of 621 yellowtail (*Seriola dorsalis*), which were subsequently tagged and released. In addition to those fish used for bait and samples, approximately 1,500 live sardines were delivered to the Steinhart Aquarium in San Francisco for experimental studies.

TABLE 3

A Comparison Between Dynamite and the Blanket Net for Obtaining Sardine Samples. The Number of Samples and Percentages Are Shown at Different Sample Sizes Up to 100 Fish Per Sample. At Some Stations More Than One Set Was Made to Obtain the Sample.

Number of sardines in sample	Dynamite		Blanket Net	
	Number of samples	Percentage	Number of samples	Percentage
1-20	37	74.0	17	35.4
21-40	4	8.0	4	8.3
41-60	2	4.0	2	4.2
61-80	1	2.0	1	2.1
81-100	6	12.0	24	50.0
Totals	50	100.0	48	100.0

Marlon Blanket Net

A new blanket net, essentially the same as the experimental model but with several minor modifications, was constructed in May, 1954. The basic changes were the substitution of one-half-inch mesh marlon webbing for the three-quarter-inch mesh cotton webbing, the ratios of hanging, and the addition and placement of weights.

The dimensions and specifications of the new net are shown in Figure 8.

The marlon net was used on an experimental cruise, May 24 to June 11, 1954, off the coast of California by the survey vessel Yellowfin. On this cruise 23 species were taken (Table 4).

The largest number of fish taken from a single set was approximately 100,000 juvenile northern anchovies. One set yielded approximately 50,000 juvenile northern anchovies and 20,000 juvenile Pacific herring.

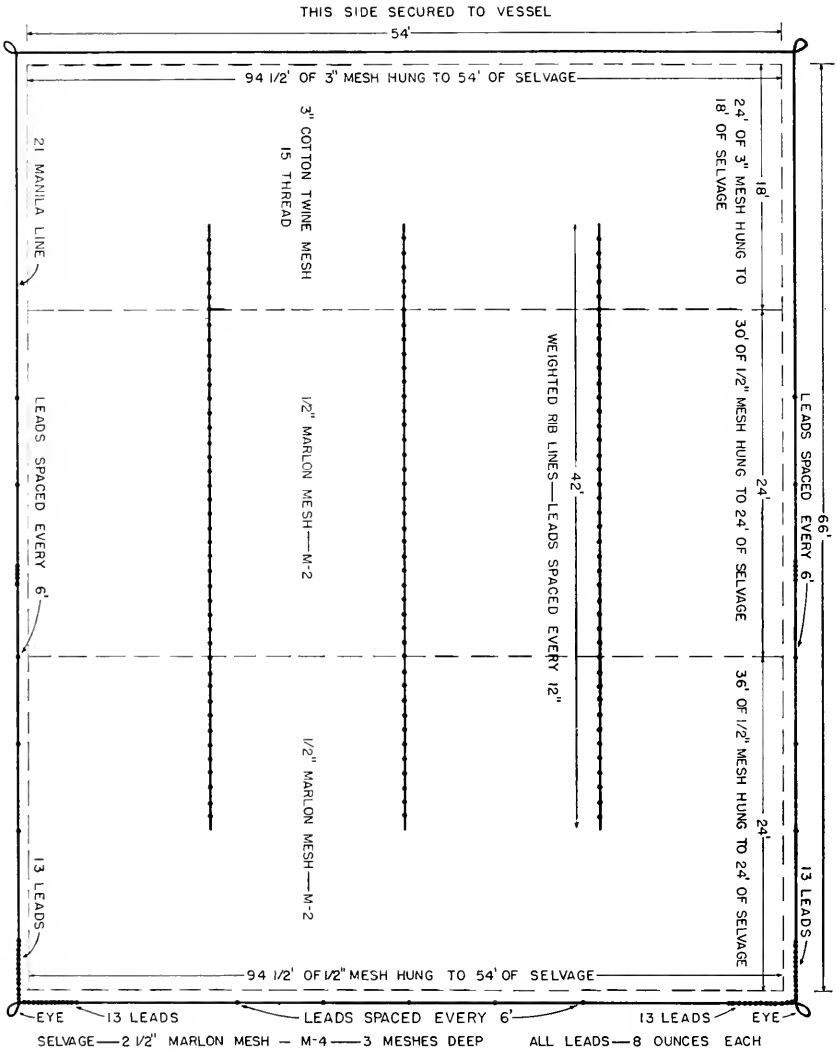

FIGURE 8. Diagram showing construction of the one-half-inch mesh, marlon webbing, blanket net.

Fish as small as 50 mm. in length were taken in the one-half-inch mesh marlon net without gilling.

At four stations between Santa Cruz and Halfmoon Bay a total of eight juvenile king salmon was taken, 81 to 130 mm. fork length.

Squid were numerous and catches up to 500 pounds per set were made. In some locations it was apparent that sets could have yielded continuously between 300 and 500 pounds.

In general, the marlon net proved successful, especially for smaller sizes of fish.

TABLE 4

Common and Scientific Names of Species Taken by the Marlon Blanket Net Off the Coast of California (May 24 to June 11, 1954)

Common name	Scientific name	Common name	Scientific name
California electric ray	*Torpedo californica*	Queenfish	*Seriphus politus*
Pacific sardine	*Sardinops caerulea*	Walleye surfperch	*Hyperprosopon argenteum*
Pacific herring	*Clupea pallasi*	Shiner perch	*Cymatogaster aggregata*
Northern anchovy	*Engraulis mordax*	Bocaccio	*Sebastodes paucispinis*
Night smelt	*Spirinchus starksi*	Yellowtail rockfish	*Sebastodes flavidus*
Surf smelt	*Hypomesus pretiosus*	Sablefish	*Anoplopoma fimbria*
King salmon	*Oncorhynchus tshawytscha*	Greenling scatrout	*Hexagrammos decagrammus*
Pipefish	*Syngnathus* sp.	Lingcod	*Ophiodon elongatus*
Jacksmelt	*Atherinopsis californiensis*	Cabezon	*Scorpaenichthys marmoratus*
Topsmelt	*Atherinops affinis*	Blenny-eel	*Ulvicola sanctaerosae*
California grunion	*Leuresthes tenuis*	Squid	*Loligo opalescens*
Jack mackerel	*Trachurus symmetricus*		

ACKNOWLEDGMENT

It is ironic indeed that a better sampling technique should be developed as a result of an accident which occurred while using the old technique. If a name be given to this net, it seems only proper to call it the Bevington Net, after Mr. C. L. Bevington, marine biologist of the California Department of Fish and Game who was critically injured in October, 1953, while working with explosives in sampling fish populations.

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A PORTABLE DEER TRAP AND CATCH-NET[1]

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Game Management Branch
California Department of Fish and Game

INTRODUCTION

Trapping deer for the purpose of tagging and taking measurements is a useful research technique in the study of proper management procedures. Formerly bulky wooden box or corral-type traps were used in California. These traps had the disadvantages of requiring numerous personnel for operation and were difficult to move on winter ranges where there is an ever changing deer concentration pattern. Further, a problem of deer suffering injuries while confined in wooden traps was encountered. Because of these difficulties, trapping operations were limited. With the objective of overcoming these difficulties, a trap has been designed and used successfully for two trapping seasons. At the time of writing, 115 deer have been handled successfully with the Clover deer trap, with the loss of only one deer due to injuries.

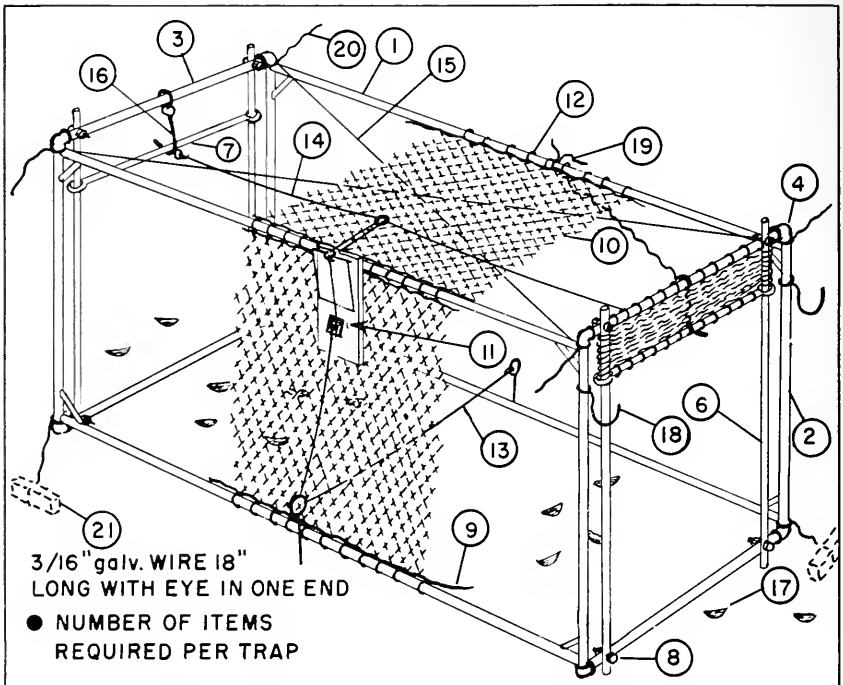
Prior to actual operations, an experimental trap was tested near Sequoia National Park. Some of the deer trapped were camp ground habitues and readily captured. The reactions of the deer being trapped were watched. Some resultant escapes furnished the clues needed to perfect the trap. It was of interest to note that there was no noticeable difference between tame deer and wild deer in their trap-fighting reactions when frightened by people or passing animals.

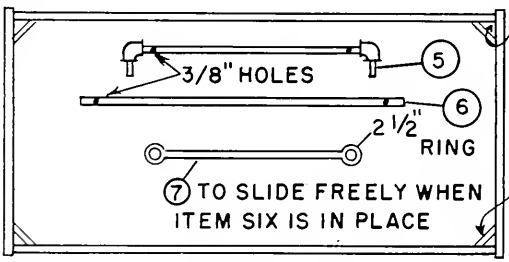
The first trap was constructed of $1\frac{1}{4}$-inch water pipe. Weighing 185 pounds, it hardly met the portability requirement. However, it was found that $\frac{3}{4}$-inch black pipe had sufficient strength, and the complete trap weighed 80 pounds. The trap can be constructed of high tensile strength aluminum tubing to weigh about 35 pounds, but the cost is doubled.

CONSTRUCTION DETAILS

The Clover deer trap, Figures 1 and 2, is basically a pipe framework box covered with tuna netting, or manila trawl netting with a $4\frac{1}{2}$-inch mesh. To the trade the latter is known as Intermediate Bag Trawl Webbing $4\frac{1}{2}$-inch mesh. To meet the requirements for each trap the following pieces of netting are required: two pieces 17 by 9 meshes, one piece 17 by 8 meshes, and two pieces 9 by 8 meshes. These are laced to the pipe framework with $\frac{1}{4}$-inch manila line. Other materials required and construction details are shown in Figure 1.

[1] Submitted for publication February, 1954. Financed in part by Federal Aid in Wildlife Restoration Project California W-41R, "Big Game Studies," and in part by the Fresno County Sportsmen. Grateful acknowledgment is extended to all personnel of the U. S. National Park Service and of the Department of Fish and Game who aided and encouraged this work.





C.E.C.

No.	MATERIAL	lgth.	●
1	3/4" BLACK PIPE	84"	4
2	3/4" BLACK PIPE	44"	4
3	1/2" BLACK PIPE	36"	4
4	1/2" ELBOW		8
5	3/4" ROLLED STEEL	3"	8
6	1/2" BLACK PIPE	48"	4
7	3/4" BLACK PIPE	30"±	2
8	3/8" BOLT	2 1/2"	8
9	1/4" ROPE	100'	
10	1/4" TUNA NETTING	100 sq. ft.	

No.	MATERIAL
11	VICTOR RAT TRAP
12	HEAVY WRAPPING TWINE
13	BLACK NYLON THREAD
14	10' HEAVY CORD
15	1/4" PLAIN galv. WIRE
16	HANDMADE HOOKS
17	APPLES OR ALFALFA HAY
18	CATCH NET HOOK- ONE END
19	1/4" GATE LIFTING ROPE
20	1/4" ROPE TO TREE or equiv.
21	1"X 2"X 5" DEADMAN TIED WITH 1/4" ROPE – opp. cor.

FIGURE 1. Diagram showing construction details of the Clover deer trap. *Drawing by Cliffa Corson.*

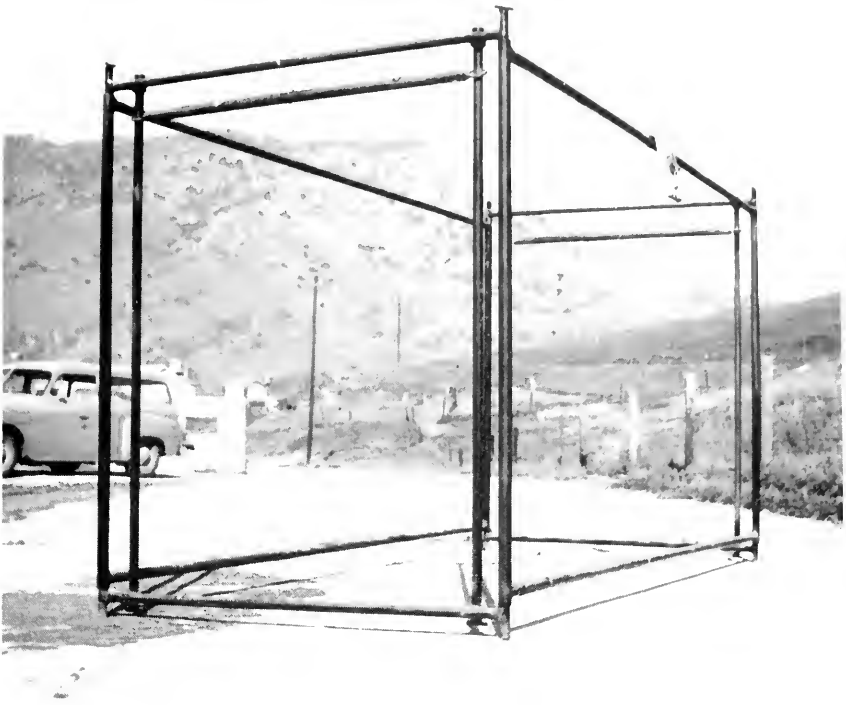


FIGURE 2. Photograph of the assembled pipe frame of the Clover deer trap.
Photograph by Homer F. Bryan.

The primary supports for the trap are the side frames. These are made by carefully butt-welding the 7-foot lengths of pipe (1) * to the 44-inch lengths (2). The corner bracing of the $\frac{3}{4}$-inch rod requires sturdy welds to prevent frame distortion. The next step is to make the spacers (3) which hold the sides apart. Elbows (4) are fitted to the three-foot, $\frac{1}{2}$-inch pipes, and short rods (5) threaded and fitted to the other end of the elbows. The rod ends should then slide into the open pipe ends of the sides frames. The 4-foot runner bars (6) guide the drop bars (7) and provide rigidity to the trap.

Prior to belting the runner bars to the spacers, the drop bars are made by welding $2\frac{1}{2}$-inch rings to each end of the 30-inch lengths of $\frac{3}{4}$-inch pipe. As these must drop freely along the runner bars, it is preferable to drill the bolt holes after a free movement is assured by proper positioning of the runner bars. The measurements of length and bolt hole spacing must be made carefully if it is desired to fold the trap.

The netting may then be laced to the side frames and top. These should be separate pieces, since the top piece must be removed in order to allow the trap to fold. When folding the trap longitudinally, the resulting package measures $9\frac{1}{2}$ by 4 feet by 3 inches (Figure 3).

* Numbers in parentheses refer to items in Figure 1.

Several may be loaded on the bed of a half-ton pickup truck. With the drop bar in position, thread each side mesh of the netting onto the runners. The top of the netting is laced to the spacer bar and the bottom to the drop gate. Thus, the fall of the drop gates closes the open ends. Hooks (16) are made of soft wire to suspend the drop gates. Cords tied to the hooks pass through a ring fastened to the top netting and then to the bar of a rat trap tied about 6 inches below the top of one of the side panels. A black nylon thread is tied to the rat trap trip and led through a ring stake across the center of the trap to an anchor ring stake at the opposite side. These rings are used to prevent accidental tripping resulting from the trip thread rubbing on the side net. This is especially prone to occur during windy conditions.

Dyeing the netting with green shingle stain was found desirable.

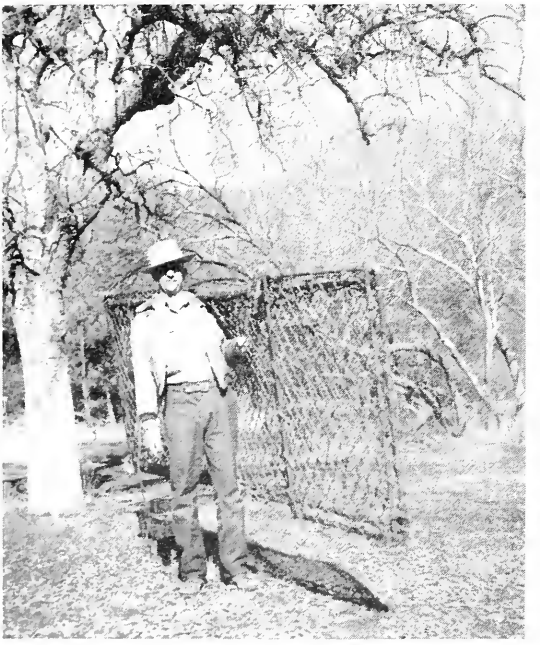


FIGURE 3. Folded Clover deer trap being held by the author, showing ease of portability. *Photograph by Homer F. Bryan.*

A loose net with a purse line was found to immobilize the trapped animals, with escapes a negligible factor. A piece of 5-inch mesh cotton tuna netting is cut into a 7-foot by 7-foot square. A 13-foot length of $\frac{1}{4}$-inch manila line is woven through alternate meshes on the perimeter of the net. The ends are tied and a harness snap secured to the tied ends of the line.

Another method is to construct the catch-net in the shape of a box. In this case a piece of netting is cut to just fit the trap opening. A piece of netting 12 feet by 2 feet is tied around the smaller piece, thus forming a box just fitting the end of the trap and extending out 2 feet.

As in the previous design, a 13-foot purse line is strung around the opening.

USE OF THE TRAP

The placement of the trap varied with local conditions, but open feeding areas were usually preferred. It was found that the deer most susceptible to trapping were those moving alone or in small groups. Spookiness was more apt to be evidenced when deer were in large groups. If one deer was frightened by the trap, its bolting usually caused the others to run away.

After the trap has been positioned, tie guy wires (15) to top corners, joining them diagonally across the top. Opposite bottom corners are tied to deadmen (21) placed in the ground at a minimum depth of 12 inches. The opposite top corners are tied to whatever is handy to prevent the trap from upsetting.

A $\frac{1}{4}$-inch line is tied to the center of the drop bar and threaded through each mesh of the netting to the top and then secured to either side. This is the lift rope (19) used for raising the gate in order to release the trapped animal. The trap is now ready to set. Lift the gates and slip the hooks into holding position. Set the rat trap and adjust the cords (14) for proper length.

It was found that pre-baiting the area with a salt block, followed by pre-baiting with alfalfa hay a few days prior to setting the trap, produced the best trapping results. The hay would usually lie untouched for two or three nights, unless the deer were accustomed to this type of food. It was found that good success was obtained if two traps were set close together. With success in each trap, the removal was complicated as one deer would fight the trap excessively while the other was being handled. Therefore it is wise to place the two traps so that they are separated by some natural sight barrier. Noise and rapid movements should be avoided when approaching a trapped animal.

Baiting with alfalfa and cut apples was found to produce excellent catches. It is important to keep the bait well away from the trip thread, since the deer should hit the thread with its forelegs. This insures that the animal will be well within the trap and not block the movement of the drop-gate.

When a deer is captured, fold and hang the catch-net on the wire hooks (18) secured to the end of the trap. These hooks must be rigid enough to support the catch-net, but soft enough to bend when subjected to stress. Snap the purse line to the trap. It is important that the catch-net be centered over the opening, or the deer might escape to one side of the catch-net. Pull the drop gate up with the lift rope and walk around the trap to the other end (Figure 4). The deer normally bolts for the opposite end, hitting the catch-net. The final position of the deer is about 10 feet from the trap, neatly pocketed in the catch-net. If the operation involves ear tagging only, the ears may be pulled through the netting for this purpose.

If the animal is to be weighed and or if body measurements are to be taken, it is necessary to remove it from the net. Straddle the deer to hold it down, working so that the deer's hoofs are kept to the front. Work the netting carefully from around the legs and hobble securely.

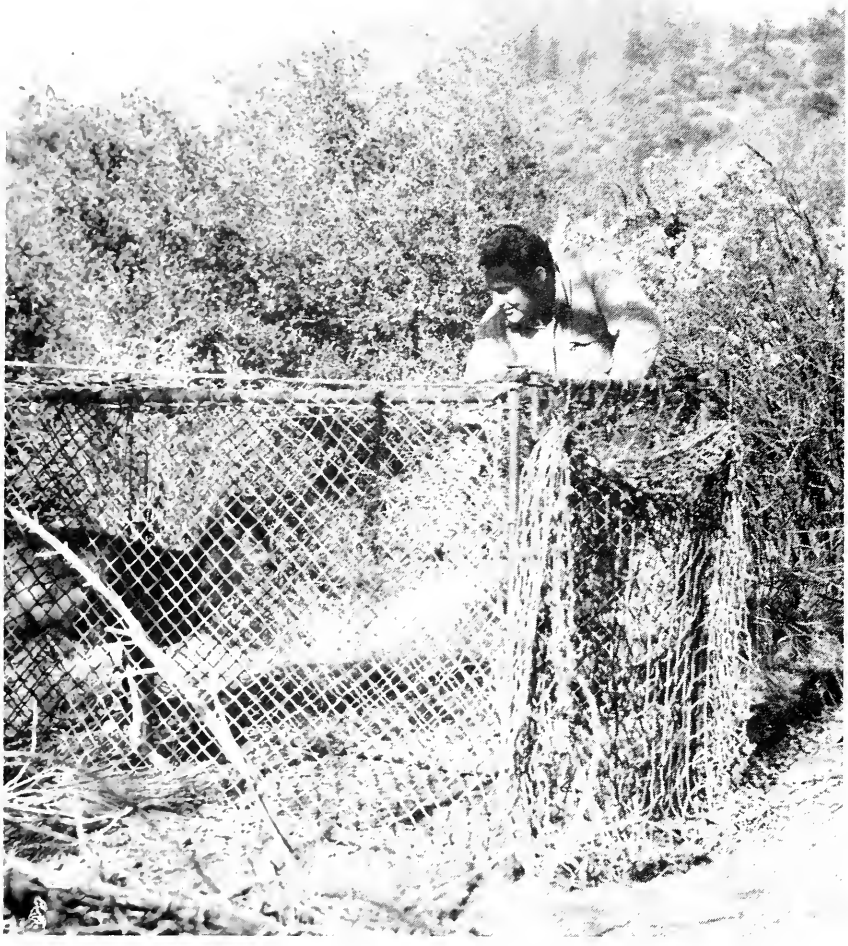


FIGURE 4. Clover deer trap in use, showing catch-net in place.
Photograph by Homer F. Bryan.

As the animal is now helpless, the netting may be removed and the animal processed.

When the deer is ready for release, it is good practice to cover its head with a small piece of canvas before removing the hobbles. Back away quietly and, if the deer hasn't already departed, break a small stick or whistle. Moving to a safe position is a good precaution if a buck is being handled during the rutting period.

It is possible that intensive predator control is helpful to successful operations. An abundance of coyotes apparently made deer difficult to catch in the San Joaquin River area. The removal of 31 coyotes from

the area in a short period of time was followed by good deer trapping success.

A larger sized Clover trap was constructed which successfully caught a bull tule elk (*Cervus nannodes*) an hour after the trap was set. A total of seven elk was caught and crated by the author without assistance, demonstrating the ease of employment of the Clover trap.

SUMMARY

The Clover deer trap was designed for good trapping characteristics, ease of operation, the use of minimum personnel, ease of portability, and minimum of injury to trapped animals. It has met these objectives under field tests and gives promise of being a practical device for live-trapping many species of animals if constructed in varying sizes.

RECENT EXTENSION OF THE RANGE OF MUSKRATS IN CALIFORNIA[1]

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INTRODUCTION

A study of the annual fur catch reports of the licensed trappers has revealed an extensive spread of muskrats into Central California in the last decade. During this period, 1943-52, the muskrat has risen to the status of the most important fur bearer in the State, both in number of animals taken and in total value of the raw furs. The most recent figures available, for the 1952-53 trapping season, show that 91,266 animals, of which 83,053 were muskrats, were taken by commercial trappers. The estimated value of the 1952-53 fur catch is placed at $104,500, of which $83,000 or 79 percent derives from muskrats.

The origin and distribution of muskrats has been reported in detail by Storer (1938) and by Twining and Hensley (1943). According to Storer two varieties of native muskrats were found in California: the Nevada muskrat (*Ondatra zibethica mergens*) of that portion of California east of the Cascade-Sierra divide, and the Colorado River muskrat, commonly known as the sandrat (*O. z. bernardi*), of the Colorado River.

EXTENSION OF THE MUSKRAT RANGE

Imperial Valley Area

The first major extension of muskrats from their native range in California was recorded by Dixon (1922). The completion of the International Canal from the Colorado River to the Imperial Valley in 1901 opened the entire Imperial Valley area to the establishment of sandrats along irrigation ditches and drainage canals. The animals quickly took advantage of these man-made watercourses to spread into new territory. The muskrats thrived so well that an estimated 25,000 pelts were sold from the Imperial Valley area in 1919. By this time the farmers in the valley were beginning to suffer damage to ditch banks and levees caused by the burrowing activities of the animals. In order to alleviate the damage, a program of muskrat control was initiated. This consisted of destroying the muskrat habitat by cleaning the ditch banks of vegetation, mainly by spraying heavily with oil. The success of this procedure is attested by the fact that the number of animals reported taken by trappers has gradually decreased in Imperial County

[1] Submitted for publication April, 1954.

to a present reported take of around two to three thousand per year. Actually, at present there is little trapping in the Imperial Valley due to the clean, vegetation free condition of the ditches. The trapping that is now available in the county is mostly along the Alamo and Colorado Rivers.

Early Extension of Range in Northern California

The high prices offered the trappers for muskrat pelts in the 1920's stimulated trapping and general interest in the animals. Trappers began to plant muskrats in suitable habitat where they were not present naturally. In addition, muskrat farming was started. For this purpose, animals were imported from the northern and eastern states, since the furs from these areas were of better quality than the native varieties.

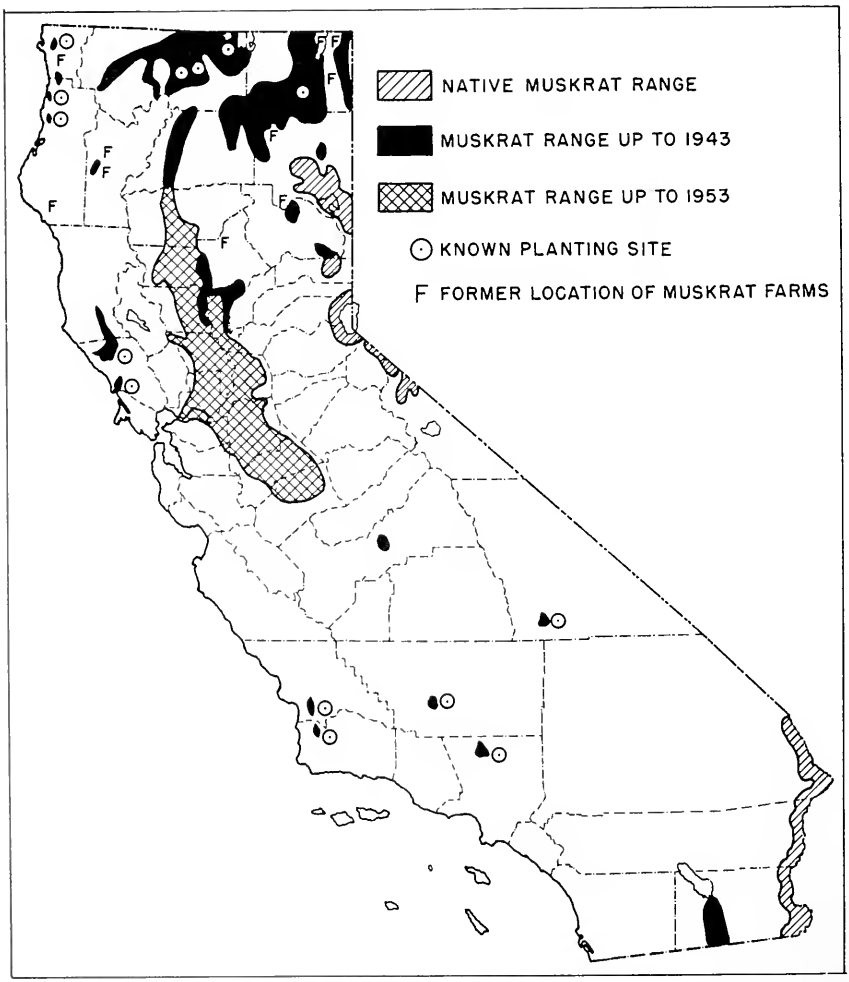

FIGURE 1. Distribution of muskrats in California up to 1953, based on trapping records and field observations. *Drawing by Cliffa Corson.*

The Nevada muskrat is only average in size and quality and the sandrat normally brings only one-third the price of a good northern pelt.

Muskrat farming was of two main types. Sometimes a penned farm was set up for the animals, but more often the animals were merely turned loose in ponds and marshes to fend for themselves. In this manner, most of the suitable habitat in Modoc, Siskiyou, Trinity, and Shasta Counties became well stocked with muskrats.

Restrictive Legislation

The muskrat complaints registered by the Imperial Valley Irrigation District brought into focus the damage problems in Imperial Valley, and on May 15, 1929, the Department of Fish and Game (then the Division of Fish and Game), at the suggestion of the State Department of Agriculture, gave notice that no more muskrat farming would be allowed west of the Cascade-Sierra mountain system. In 1933, legislative action incorporated the 1929 commission regulations into the Fish and Game Code. However, these restrictive measures came too late to prevent the spread of muskrats into the Central Valley, for by this time fur farms in the upper reaches of the Sacramento River system in Shasta and Butte Counties had opened the entire Sacramento River drainage system to muskrat colonization. The earliest trapping record for the Sacramento Valley was for three muskrats caught near Oroville in 1929 by H. S. Anderson. They were probably the result of plants or escaped animals from some of the early fur farming efforts in Butte County.

Present Distribution

Figure 1 gives the present range of muskrats in California and shows the extension of the range to 1953. The period 1943-52 has been characterized by a marked increase in the muskrat catch in the Central Valley area. Figures 2 and 3 compare the catch records in 1940 with 1952.

It is of interest to note that the recent spread of muskrats in the Central Valley has occurred simultaneously with the increase in rice culture and irrigated pastures in the area. Rice acreage has risen from 237,000 acres in 1943 to 429,000 acres in 1953, an increase of 81 percent. Rice culture, especially, creates favorable habitat for muskrats. An abundance of water with resulting weed filled drainage ditches provides excellent habitat for the animals. Figure 4 shows a typical drainage ditch in the rice-growing districts. Once the animals entered the Central Valley, it was an easy matter for them to spread in the irrigation systems and along stream courses.

CATCH RECORDS

The catch of muskrats in California since 1939, when county catch figures were first recorded, is shown in Table 1. A further breakdown of the catch is shown in Table 2. This table shows the catch in the Central Valley area only, and points up the recent rapid extension southward in this area. As noted from Table 2, such counties as Contra Costa, Solano, and San Joaquin have been major muskrat producers only since 1950 and 1951.

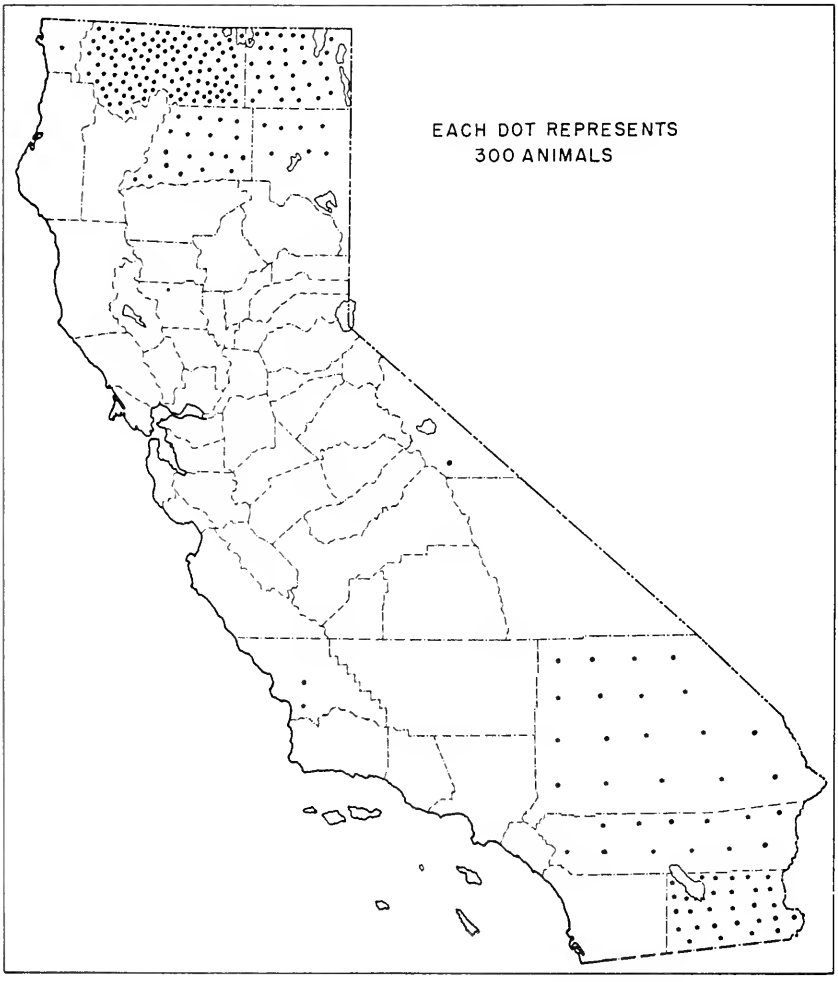

FIGURE 2. The muskrat catch as reported by commercial trappers for the 1940-41 trapping season. *Drawing by Cliffa Corson.*

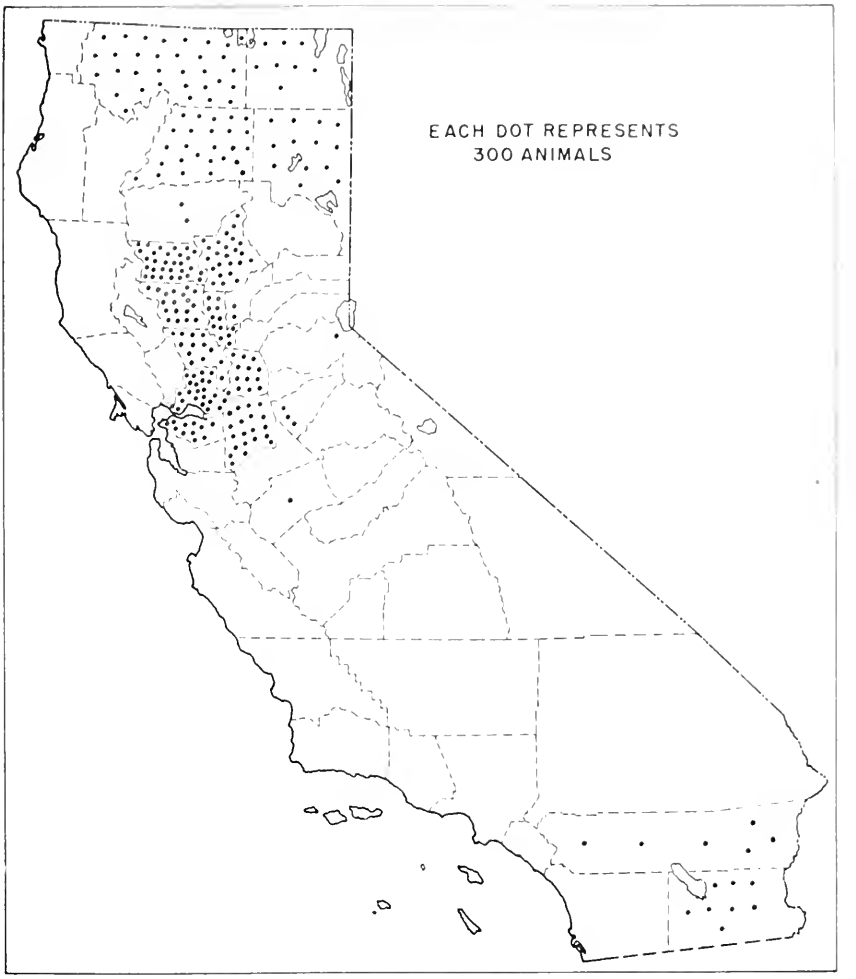

FIGURE 3. The muskrat catch as reported by commercial trappers for the 1952-53 trapping season. *Drawing by Cliffa Corson.*

TABLE 1

Muskrat Catch as Reported by Licensed Trappers From 1939 to 1952—Prior to 1939 No Statistics Are Available on a County Basis

County	1939–40	1940–41	1941–42	1942–43	1943–44	1944–45	1945–46	1946–47	1947–48	1948–49	1949–50	1950–51	1951–52	1952–53
Alameda	None	reported												
Alpine	None	reported												
Amador	--	--	--	1	--	--	--	--	--	--	--	--	--	--
Butte	13	75	135	83	195	943	937	3,029	3,067	5,000	1,963	5,604	3,663	7,301
Calaveras	--	--	--	--	--	--	--	--	--	--	--	--	--	547
Colusa	--	--	--	--	--	--	1,617	982	2,161	5,598	3,602	5,694	8,244	5,502
Contra Costa	2	--	--	--	--	--	--	2	--	--	49	188	2,375	3,093
Del Norte	139	271	222	325	68	20	37	21	16	10	62	143	96	17
El Dorado	215	--	--	--	35	130	--	--	52	17	43	--	--	--
Fresno	--	--	--	--	--	--	--	--	--	--	8	--	1	22
Glenn	1	--	--	--	--	11	153	1,428	4,884	11,009	8,970	5,750	9,117	9,197
Humboldt	1	9	--	--	--	--	--	--	--	3	2	--	--	20
Imperial	14,120	7,700	10,701	4,889	4,323	1,326	8,632	5,866	4,413	4,628	2,153	3,516	2,052	2,426
Inyo	None	reported												
Kern	--	18	13	--	--	--	--	--	--	3	--	26	--	1
Kings	None	reported												
Lake	--	2	--	--	--	--	--	--	--	--	--	1	--	--
Lassen	2,447	2,050	4,099	3,027	3,332	3,573	3,743	2,512	4,372	3,065	1,621	3,908	2,353	1,014
Los Angeles	--	12	--	--	--	3	--	--	--	--	--	--	7	24
Madera	--	--	--	--	--	--	--	15	--	--	--	--	--	27
Marin	None	reported												
Mariposa	None	reported												
Mendocino	12	17	5	3	5	--	23	12	24	10	1	1	1	2
Merced	--	--	--	--	--	--	--	--	--	--	--	1	9	--
Modoc	5,746	8,805	7,914	4,446	4,411	3,031	4,490	3,189	2,187	2,589	1,603	1,540	1,987	2,515
Mono	183	506	443	400	369	489	166	164	161	121	163	48	80	68
Monterey	None	reported												
Napa	--	--	--	--	--	--	--	--	--	--	--	--	9	--
Nevada	--	1	1	--	--	--	13	1	--	1	--	8	--	40
Orange	None	reported												
Placer	--	22	27	--	2	2	21	146	--	1	78	464	84	418
Plumas	149	70	185	53	154	160	150	231	199	135	193	236	52	223

TABLE 1—Continued

Muskrat Catch as Reported by Licensed Trappers From 1939 to 1952—Prior to 1939
No Statistics Are Available on a County Basis

County	1939–40	1940–41	1941–42	1942–43	1943–44	1944–45	1945–46	1946–47	1947–48	1948–49	1949–50	1950–51	1951–52	1952–53
Riverside	1,096	3,234	5,127	3,081	3,734	4,464	4,045	2,317	2,577	2,752	1,343	1,866	1,925	1,744
Sacramento	6	--	--	-	--	--	--	--	68	203	377	828	2,972	5,809
San Benito	None	reported												
San Bernardino	2,599	5,398	3,087	1,239	2,125	2,482	2,762	4,648	170	--	--	-	-	107
San Diego	-			--	-		--	22	--	--	--			--
San Francisco	None	reported												
San Joaquin	6		-	--	-	--	--	--	--	8	80	1,315	3,146	6,400
San Luis Obispo	253	548	1,188	718	541	262	711	503	178	108	86	128	16	--
San Mateo	None	reported												
Santa Barbara			--	--	--	--	--	--	--	--	110	--	--	--
Santa Clara	None	reported												
Santa Cruz	None	reported												
Shasta	1,270	5,700	8,083	6,602	9,760	4,420	7,027	7,470	8,361	6,863	3,368	5,205	9,550	7,873
Sierra		5	19	7	14	8	5	53	81	57	160			6
Siskiyou	38,239	33,703	27,611	10,520	27,962	31,701	14,279	12,063	13,186	5,589	5,458	7,638	12,807	10,194
Solano						3	-	--	8	13	39	117	3,727	6,396
Sonoma	36	165	136	82	20	-	2	25	15	7	9			--
Stanislaus			178	--		--	--	--						289
Sutter	59	3	12	14	154	371	949	1,315	1,738	1,929	2,019	1,976	2,999	3,516
Tehama			-	1		15	34	33		133	120	312	512	676
Trinity	1	1	1	3	--	1	--	--		--				
Tulare	None	reported												
Tuolumne			-		-	7	-	--						
Ventura	None	reported												
Yolo			-	--			-	89	688	619	956	3,724	3,176	3,931
Yuba			-	--	5	-	1	51	178	12	915	91	560	525
Total Catch	69,596	68,318	69,217	65,521	57,209	56,125	19,800	16,217	19,081	50,513	38,581	50,661	71,553	83,053
Average price	$2.17	$1.29	$1.20	$1.65	$1.99	$1.65	$2.05	$1.30	$2.00	$1.20	$0.76	$1.53	$1.08	$1.00
Total value	$151,000	$88,100	$83,100	$108,100	$113,800	$93,100	$102,100	$60,100	$98,200	$60,600	$29,300	$77,500	$77,300	$83,100

TABLE 2

Rapid Expansion of Muskrats Throughout the Sacramento and San Joaquin Valleys, as Indicated by the Reports of Licensed Trappers

County	1939–10	1940–41	1941–42	1942–13	1943–44	1944–45	1945–46	1946–47	1947–48	1948–49	1949–50	1950–51	1951–52	1952–53
Tehama	--	--	--	1	--	15	34	33	--	133	120	312	512	676
Butte	13	75	135	83	195	943	937	3,029	3,067	5,000	1,963	5,604	3,663	7,301
Glenn	1	--	--	--	--	11	153	1,428	4,884	5,598	8,970	5,750	9,147	9,497
Colusa	--	--	--	--	--	--	1,617	982	2,161	11,009	3,602	5,694	8,244	5,502
Yuba	--	--	--	--	5	--	1	51	178	42	945	91	560	525
Sutter	59	3	12	44	154	371	949	1,345	1,738	1,929	2,019	1,976	2,999	3,546
Yolo	--	--	--	--	--	--	--	89	688	619	956	3,724	3,176	3,931
Sacramento	6	--	--	--	--	--	--	--	68	203	377	828	2,972	5,809
Solano	--	--	--	--	--	3	--	--	8	13	39	447	3,727	6,496
San Joaquin	--	--	--	--	--	--	--	--	--	8	80	1,315	3,146	6,400
Contra Costa	--	--	--	--	--	--	--	2	--	--	49	188	2,375	3,093
Stanislaus	--	--	--	--	--	--	--	--	--	--	--	--	--	289
Fresno	--	--	--	--	--	--	--	--	--	--	8	--	1	22
Merced	--	--	--	--	--	--	--	--	--	--	--	1	9	--
Calaveras	--	--	--	--	--	--	--	--	--	--	--	--	--	547
Madera	--	--	--	--	--	--	--	45	--	--	--	--	--	--
Kern	--	18	13	--	--	--	--	--	3	--	--	26	--	1
TOTALS	79	96	160	128	354	1,343	3,691	7,004	12,795	24,554	19,128	25,956	40,531	53,335

FIGURE 4. Drainage canal in rice-growing area which is typical muskrat habitat. The dominant vegetation is the common cattail, which furnishes a major portion of the food of the animals. *Photograph taken November, 1948, in Yolo County, California, by George Metcalfe.*

Value of the Catch

The value of the state-wide catch the last 10 years is shown in Table 3. Over this period, 1943 to 1952, muskrats have provided income of over three-quarters of a million dollars. The lowest yearly income in the period was $29,300 in 1949, and the best year was 1943, when nearly $114,000 was realized. The past three years (1950-52), over 500 trappers per year have reported selling pelts.

TABLE 3

Numbers of Muskrats Reported Caught From 1943 to 1952 and Average Prices Paid

Season of catch	No. of trappers reporting	No. of muskrats caught	Average price paid	Totals
1943-44	1,152	57,209	$1.99	$113,800
1944-45	1,101	56,425	1.65	93,100
1945-46	1,116	49,800	2.05	102,100
1946-47	1,113	46,247	1.30	60,100
1947-48	843	49,084	2.00	98,200
1948-49	649	50,513	1.20	60,600
1949-50	625	38,581	0.76	29,300
1950-51	555	50,661	1.53	77,500
1951-52	572	71,553	1.08	77,300
1952-53	517	83,053	1.00	83,100
Totals	----	553,126	----	$795,100

DISCUSSION

Muskrats are now the number one fur producer in California, both in total number of animals caught and in total value of the furs, and as such are a valuable resource. They provide income for over 500 individuals a year at the present time. Unfortunately, under certain circumstances, they can cause damage to farm irrigation systems. In areas of light or sandy loam soils, such as the Imperial Valley, muskrats have caused considerable damage to small levees and canal banks by their burrowing activities. Water seeps through the burrows and caving in of the burrows further aggravates the damage. Where heavy clay soils are prevalent, as in the Sacramento Valley, this type of damage is proportionately small. In the Sacramento Valley, investigations have indicated that such damage as honeycombed check levees and gnawed headgates, blamed on muskrats, has actually been done by Norway rats (*Rattus norvegicus*).

The author believes that where muskrats have been proved to be causing extensive damage, control measures should be taken to reduce their numbers. However, in many situations the animals can live compatibly with agricultural practices. Muskrats have not been a problem with respect to feeding on agricultural crops in California. In fact, their main item of food is the roots and tender shoots of the common cattail (*Typha latifolia*), a troublesome weed of ditches and waterways. Where muskrats achieve sizable numbers, trappers readily take off most of the annual increase of the animals.

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THE SAGE GROUSE IN CALIFORNIA, WITH SPECIAL REFERENCE TO FOOD HABITS[1]

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California Department of Fish and Game

INTRODUCTION

The sage grouse or sagehen (*Centrocercus urophasianus*), although the largest native upland game bird in California, is one of the least known to the sportsman. The sage grouse by nature of its habitat is restricted to the semiarid sagebrush ranges of eastern California, and as a result is far removed from the metropolitan areas. Grinnell and Miller (1944) list the sage grouse in California as occurring from the Nevada line west through Modoc County to the west side of Lower Klamath Lake in eastern Siskiyou County; and south along the east side of the Sierra Nevada, as far as the vicinity of Big Pine in Owens Valley, Inyo County (Figure 1). The altitudinal range is from 3,500 feet near the Pit River, in extreme northeastern Shasta County, to 12,000 feet in the White Mountains of Mono County.

HISTORY OF THE SAGE GROUSE REGULATIONS

The first legal protection afforded the sage grouse in California was in 1901, when a closed season was enacted, making it unlawful to possess them between February 1 and October 1. At the same time the sale of sage grouse was prohibited and the shipment of more than 25 by any one person in one day was made illegal. In 1903, the closed season extended from February 15 to September 1. In 1911, a bag limit of four per day and eight per week was put into effect, and the open season reduced to the period from September 1 to December 1. In 1918 the open season was further reduced to the period from August 15 to September 30.

Despite the enactment of this early legislation governing the take of sage grouse, they rapidly diminished in numbers. The United States Forest Service report on game conditions in California for 1921 stated that the birds were so reduced in Mono and Inyo Counties that a closed season there was recommended (Anon., 1922). On the basis of this report, District 4½ (Inyo and Mono Counties) was closed to sage grouse hunting in 1921. Courtright (1923) reported that the birds

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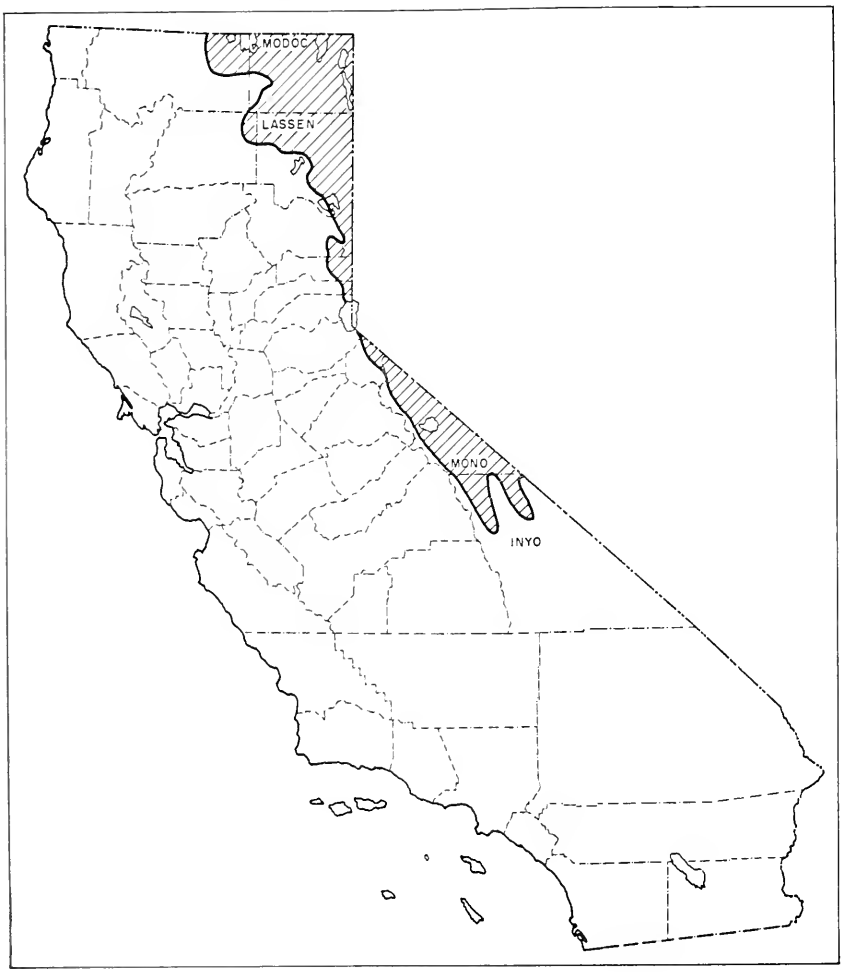

FIGURE 1. The range of sage grouse in California (shaded area). *Drawing by Cliffa Corson.*

were almost extinct in Modoc County. In 1925 all counties were opened to hunting for a 15-day period from August 1 to 15. The State Legislature set aside Game Refuge IQ in Lassen County as a sage grouse and antelope refuge in 1928. A 15-day season with a bag limit of four per day and eight per season was held from 1925 to 1931, at which time the season was closed state-wide. In 1944, the season was opened for three days. It was not opened again until 1950, when a two-day season, September 1-2, with a two-bird season bag limit, was authorized in Mono County. This season continued in effect the following year. In 1952 a one-day season (September 1) with a three-bird bag limit was held in Mono County, and a similar season with a two-bird bag limit in Modoc and Lassen counties. This report is based on data gathered from the 1950, 1951, and 1952 sage grouse seasons.

HUNTER SUCCESS

Checking stations were set up in Mono County during the 1950, 1951, and 1952 seasons, primarily to check the hunting pressure and to determine the approximate kill of birds. Successful hunters were requested to fill out a questionnaire. In addition, hunters were checked in the field. No attempt was made to determine the total number of hunters participating in the hunts. Table 1 is a comparison of the hunter success over the three years, as compiled from checking station records.

TABLE 1

Comparison of Hunter Success, Mono County, Seasons of 1950, 1951, and 1952

	1950	1951	1952
Number of hunters checked	893	984	1,760
Number of successful hunters checked	750	598	819
Percentage of successful hunters	84	60	48
Number of birds checked	1,026	971	1,665
Average number of birds checked per hunter	1.2	1.01	0.96
Average number of birds per successful hunter	1.34	1.62	1.96
Average number of hunter hours to bag a bird	2.33	3.40	1.60

The trend over the three years was one of increase in hunting pressure and a decrease in the percentage of successful hunters. In 1950, a total of 893 hunters was checked, of whom 84 percent was successful, bagging 1,026 birds. The 1951 hunting check listed 984 hunters, of whom only 60 percent were successful, taking 971 birds. In 1952, of the 1,760 hunters checked, only 48 percent bagged the 1,665 sage grouse taken.

The percentages of hunters by counties of origin are shown in Table 2. It is evident from these figures that over 50 percent of the hunters seeking sage grouse in Mono County were from other counties. Los Angeles County contributed the most hunters of any one county.

TABLE 2

Residence of Hunters Checked, in Percentages

County	1950	1951	1952
Los Angeles	37	39	33
Inyo	26	26	24
Mono	21	15	12
Other	16	20	31

BIOLOGICAL DATA

Age Ratios

An age classification to determine the ratio of adult to young was made of birds checked through the checking stations. The characters used in age classification were as follows:

1. *Size of Bird.* Especially the head and feet of adults are larger than those of immature birds.
2. *Differential Plumage.* Juvenile birds of both sexes have a triangular patch of finely streaked feathers on the upper portion of the breast and in general have a softer plumage than adult birds.
3. *Coloration of Toes.* Toes of juvenile birds are colored light green, in contrast to the dark colored toes of adult birds.
4. *Flexibility of Mandible.* The lower bill of juveniles is more flexible than that of adults.

Table 3 is the composition of the ratio of adult to young birds over the three years.

The ratios of adult birds to young birds indicate a relatively poor hatch or brood survival in 1951, but an excellent one in 1952. The preseason sample brood count made in June and July of 1952 gave a ratio of one adult hen to 4.4 young.

TABLE 3

Age Ratios of Birds Inspected

Year	Ratio	Birds checked
1950	100 adults to 284 young	1,026
1951	100 adults to 131 young	971
1952	100 adults to 304 young	1,665

Weights

Weights were taken of a small sample of birds by means of a spring scale. The weights of two adult males were 4 pounds and 4 pounds 12 ounces. Of the three adult females weighed, one was 2 pounds 8 ounces and two were 2 pounds 12 ounces. The weights of 70 juvenile birds varied from 1 pound 3 ounces to 2 pounds 7 ounces, the average juvenile weight being 1 pound 15 ounces.

Patterson (1952) in his study of the sage grouse in Wyoming found that, unlike many other upland game birds, sage grouse of both sexes attain their maximum weights not in the fall, but in the early spring. Weights of mature males during the strutting season varied from 5 pounds 2 ounces to 7 pounds. Weights of females during the breeding season were found to average slightly over 3 pounds. The weight of California sage grouse as given by Dawson (1923) is 4 to 8 pounds for the males and 3 to 5 pounds for females.

Food Habits

Patterson (1952) speaks of the sage grouse as representing a true climax inhabitant of a climax vegetative type. Although the original range of the sage grouse extended over much of the western states as far east as Kansas, Nebraska, the Dakotas, and northward to southwestern Canada, its distribution coincided with that of the geographical range of sagebrush (*Artemesia* spp.). Unlike most upland game birds, which are primarily granivorous, the sage grouse depends in

large part upon the leafage of sagebrush for its sustenance. This in effect may account for the lack of the hard muscular gizzard so typical of the other gallinaceous birds. Dawson (1923) went to the extent of saying that the sage grouse has so long depended upon the leaves and tender shoots of the sagebrush and greasewood for subsistence that it is inacapable of digesting grain. However, Patterson by definition classified the stomach of the sage grouse as being a gizzard. It is likely that such an organ is capable of digesting many of the softer shelled seeds or achenes identified in the stomachs of the 175 sage grouse herein reported. Eighteen species of seeds were identified.

A total of 22 sage grouse stomachs was collected from hunter kills in Mono County in 1950 and an additional 113 stomachs were collected in 1951. The results of the analysis of these stomachs are shown in

TABLE 4

Food Items Eaten by 135 Sage Grouse Collected in Mono County, California September, 1950-51

Scientific name	Common name	Parts eaten	Volume (percentage)	Frequency of occurrence (percentage)
Plant Food				
Artemisia tridentata	Common sagebrush	Leafage, flowers	63.9	91.1
Trifolium sp.	Clover	Leafage	8.0	35.6
Juncus sp.	Rush	Leafage	7.6	43.0
Forbs	Unidentified	Leafage	6.7	45.9
Symhoricarpos rotundifolius	Snowberry	Leafage, fruits	4.6	28.9
Taraxacum vulgare	Dandelion	Leafage, flowers	2.3	8.9
Tetradymia spinosa	Cottonthorn	Leafage, flowers	1.8	2.2
Chrysothamnus viscidiflorus	Rabbitbrush	Leafage	1.1	27.4
Gramineae	Grass family	Leafage	1.1	19.3
Chrysothamnus sp.	Rabbitbrush	Leafage	0.9	8.9
Artemisia cana	Hoary sagebrush	Leafage	0.7	0.7
Perideridia sp.*	Yampah	Seeds	0.1	3.7
Ribes sp.	Gooseberry	Seeds	0.1	5.9
Bryophyta	Moss	Leafage	trace	0.7
Equisetum sp.	Horsetail	Stems	trace	0.7
Hordeum sp.	Wild barley	Florets	trace	0.7
Cyperaceae	Sedge family	Leafage	trace	0.7
Carex sp.	Sedge	Seeds	trace	1.1
Liliaceae	Lily family	Seeds	trace	0.7
Eriogonum sp.	Buckwheat	Leafage, seeds	trace	0.7
Rumex sp.	Dock	Seeds	trace	0.7
Cleomella parviflora	Cleomella	Seeds	trace	0.7
Cruciferae	Mustard family	Seeds	trace	3.7
Rosa sp.	Wild rose	Seeds	trace	1.4
Astragalus sp.	Rattle-weed	Leafage	trace	1.4
Lupinus sp.	Lupine	Leafage	trace	0.7
Phlox sp.	Phlox	Leafage	trace	0.7
Convolvulus sp.	Morning glory	Leafage	trace	0.7
Scrophulariaceae	Figwort family	Seed pods	trace	0.7
Achillea millefolium	Yarrow	Leafage	trace	0.7
Chrysothamnus nauseosus	Rabbitbrush	Leafage	trace	0.7
Compositae	Unidentified	Flowers, seeds	trace	2.9
Animal Food				
Formicidae	Ants		1.1	69.6
Other Insecta	Insects		trace	32.6

* Perideridia = Eulophus of Jepson.
A trace of grit was found in but 7.1 percent of the stomachs.

TABLE 5

Food Items Eaten by 40 Sage Grouse Collected in Lassen County, California
September, 1952

Scientific name	Common name	Parts eaten	Volume (percentage)	Frequency of occurrence (percentage)
Plant Food				
Artemisia tridentata	Common sagebrush	Leafage	29.3	95.0
Lactuca scariola	Prickly lettuce	Flowers	21.0	65.0
Eriophyllum lanatum	Woolly sunflower	Leafage	6.3	37.5
Helianthus annuus	Common sunflower	Leafage, seeds	3.6	20.0
Forbs	Unidentified	Leafage	2.1	15.0
Cleome platycarpa	Stink-clover	Seeds	2.0	42.5
Gramineae	Grass family	Leafage	1.9	15.0
Cruciferae	Mustard family	Leafage, flowers	1.1	17.5
Eriogonum sp.	Buckwheat	Leafage	0.1	12.5
Bromus tectorum	Cheatgrass	Florets	trace	32.5
Ribes sp.	Gooseberry	Seeds	trace	5.0
Agoseris sp.		Flowers	trace	2.5
Chrysothamnus viscidiflorus	Rabbitbrush	Leafage, flowers	trace	10.0
Chrysothamnus nauseosus	Rabbitbrush	Leafage	trace	5.0
Compositae	Sunflower family	Seeds	trace	5.0
Plant galls			trace	7.5
Animal Food				
Melanoplus spp.	Grasshoppers		32.5	97.5
Lepidoptera larvae	Moths, butterflies		0.1	10.0
Other Insecta	Insects		trace	30.0

Table 4, which is a summary of the food items eaten by the 135 sage grouse collected in Mono County expressed in terms of volume and frequency of occurrence. Table 5 is a summary of the food items eaten by 40 sage grouse collected from the Bull Flat and Line Spring areas east of Honey Lake, Lassen County, during the 1952 season (Figures 2 and 3).

The stomachs were collected in the field from hunter killed birds and preserved in formaldehyde. Upon receipt of the material in the Department's Food Habits Laboratory the contents were removed and washed in fine mesh screen and the excess moisture removed. An individual analysis was made by separating and identifying the items of food. The quantity of each item was measured in a graduated cylinder by water displacement to determine the percentage composition of each stomach. These data were summarized by use of the aggregate percentage method described by Martin, Genseh, and Brown (1946).

The leafage of sagebrush was the most important item in the diet of the sage grouse collected in Mono County (Table 4). Sagebrush was found in 91.1 percent of the stomachs and made up 63.9 percent of the volume of the total food taken. There was one occurrence of the leafage of hoary sagebrush, which made up 88 percent of the stomach contents of one bird. Most of the birds collected by the hunters in Mono County during the two hunting seasons of September 1-2, 1950 and 1951, were evidently collected in close proximity to water. The localities from which the birds were collected were as follows: Rough Creek, 10; Mono Lake, 29; Sumner's Meadows, 8; Masonic, 5;

Lobdel Lake, 27; Long Valley, 24; Bodie, 6; Bridgeport, 9; and unknown locality, 17. It was apparent that the majority of the sage grouse were supplementing their diet of sagebrush with the leafage of several species of riparian or marsh growing plants available about sources of water. These included such plants as clover, rush, dandelion, green grass, horsetail, and snowberry. Both the leafage and berries of snowberry were eaten. In all, these plants contributed 23.6 percent to the diet. In addition, unidentified green forb leafage made up 6.7 percent of the food. The leafage and flowers of both cottonthorn and rabbitbrushes were eaten, contributing 1.8 percent and 2.0 percent to the diet, respectively. The only seeds contributing materially to the diet were those of yampah (0.1 percent) and a gooseberry (0.1 percent). Several species of weed seeds were identified in the stomachs; however, no species was found in sufficiently great bulk or frequency of occurrence to be considered an important item of food. The animal diet consisted entirely of insects. Of the insects eaten, ants were the only item contributing materially to the food, being found in 69.6 percent of the stomachs and making up 1.1 percent of the total diet.

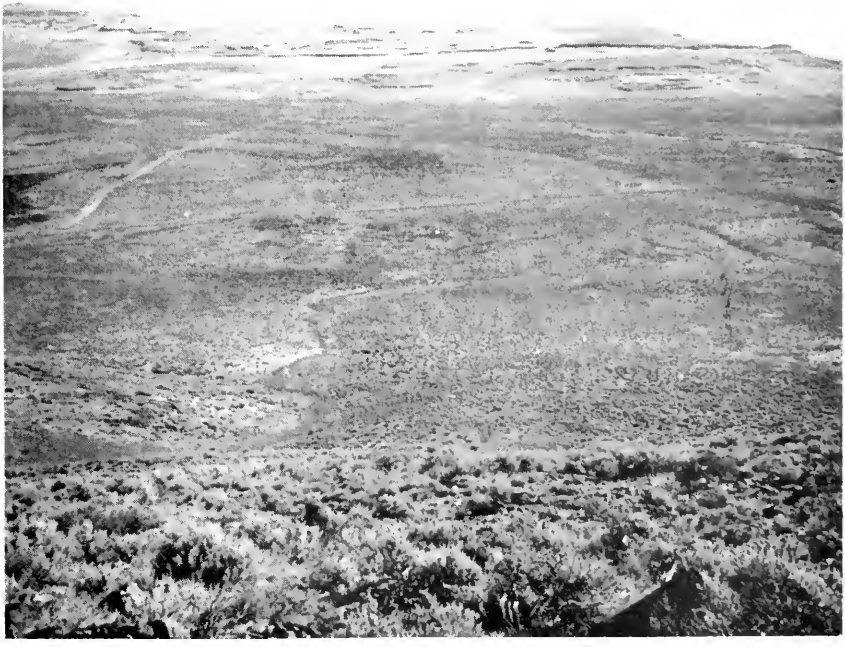

FIGURE 2. General view of the Bull Flat area of Lassen County, California, showing typical sage grouse habitat. The area shown was a favored hunting spot during the September 1, 1952, season. *Photograph taken September, 1952, by H. D. Bissell.*

The analysis of the 40 sage grouse stomachs collected in Lassen County in 1952 is shown in Table 5. Thirty-six of these sage grouse were collected from hunter kills near Bull Flat on September 1st. Most of these birds were killed in a small area of a dry mud flat that was covered extensively by sunflowers. It was thought at the time that the birds were concentrating in this area because of the abundance of sunflowers; but when the stomachs were analyzed, it became evident that the sage grouse were seeking grasshoppers, which were abundant in the area. Grasshoppers were found in 97.5 percent of the stomachs and contributed 32.5 percent to the total diet. Of the other insects eaten only the larvae of a lepidopterous insect were eaten in a measurable amount, contributing 0.1 percent to the diet. Available in the mud flat were the flowers of prickly lettuce, which evidently were avidly sought by the birds, making up 21.0 percent of the food and occurring in 65.0 percent of the stomachs. The leafage of woolly sunflower and the leafage and seeds of common sunflower made up 6.3 percent and 3.6 percent of the diet. The seeds of stink-clover contributed 2.0 percent to the diet and were found in 42.5 percent of the stomachs. The staple item of diet, sagebrush leafage, was found in 95.0 percent of the stomachs and bulked 29.3 percent of the diet. The remainder of the bulk of food taken by these sage grouse consisted of: forb leafage (2.1 percent), grass (1.9 percent), leafage and flowers of

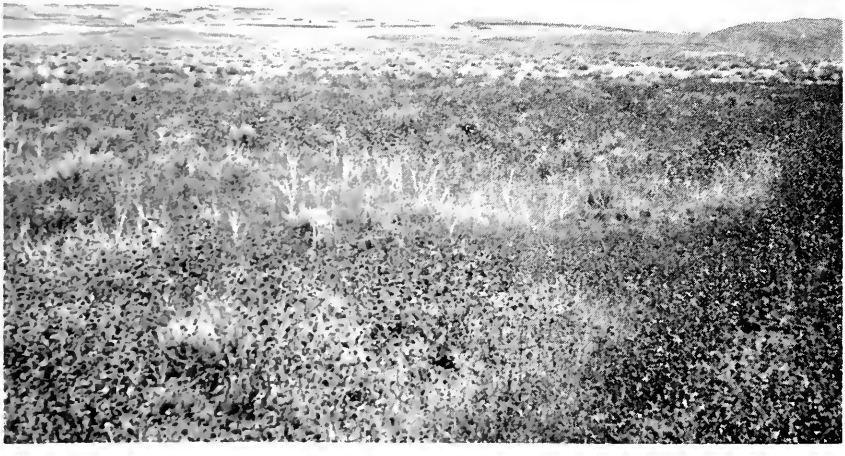

FIGURE 3. A sunflower covered mud flat in the Bull Flat area in which sage grouse were concentrated, apparently because of the abundance of grasshoppers, a favorite food item. *Photograph taken September, 1952, by H. D. Bissell.*

an unidentified Cruciferae (1.1 percent), and the leafage of buckwheat (0.1 percent).

Not included in the summaries of the above sage grouse food habits data was a stomach collected in October, 1953, by Nick Ermacoff of the Department of Fish and Game at the Madeline Waterfowl Management Area in Lassen County. It is noteworthy that this bird had eaten 114 grains of cultivated wheat (*Triticum aestivum*), which formed 100 percent of its stomach contents.

DISCUSSION

Food habit studies by other workers conform closely with the results of the analysis of California sage grouse stomachs in this report. Girard (1937) reported on the analysis by the Food Habits Section of the U. S. Bureau of Biological Survey of 33 sage grouse stomachs collected in July and August, 1934, in Sublette County, Wyoming. Vegetable matter made up 88.5 percent and animal food 11.5 percent of the total diet. Of the vegetable food, the Compositae, represented mainly by six species of sagebrush, furnished 73.1 percent of the food taken. Dandelion occurred in nine of the 33 stomachs examined. The Leguminosae, consisting principally of white clover, supplied 11.2 percent of the total food and the remainder of the vegetable diet was represented by 10 other families. Ants were found to have been the most important of the insect food taken, having contributed 9.6 percent of the total food contents.

Rasmussen and Griner (1938), in their study of Utah sage grouse, cited the analysis of 61 stomachs analyzed by the U. S. Biological Survey. These sage grouse were collected from the Strawberry Valley Federal Refuge in northeastern Utah from May to October. It was found that 97.6 percent of the adult birds' diet was plant material and of this 77.5 percent consisted of two species of sagebrush (*Artemisia tridentata* and *A. cana*). Of the total diet, 85.8 percent proved to be plants of the Compositae. Other important foods were grasses, which made up 3.9 percent of the total contents; Leguminosae (principally *Trifolium*), 2.4 percent; and Ranunculaceae, 3.0 percent. Only 2.4 percent of the adults' summer food was animal material, and this consisted almost entirely of ants. It was found that the young sage grouse diet in June consisted of 47.5 percent animal food and 52.5 percent plant material. However, by August the consumption of plant food by juvenile birds increased to 95.5 percent, which seemed to indicate that young grouse adapt themselves to an adult grouse diet when they are about three months old.

Patterson (1952), in his study of Wyoming sage grouse, presented a summary of the analysis of 104 stomachs. The year-round diet of the adults was comprised of nearly 96 percent plant material, the remainder being animal matter. Sagebrush, principally *A. tridentata*, *A. nova*, and *A. cana*, furnished 77 percent of the adult diet and over 46 percent of the diet of immature birds. The animal matter consisted wholly of insects, of which ants, grasshoppers, and beetles bulked the largest in the insect diet. Many of the same species of plants identified

by Patterson in the Wyoming sage grouse stomachs were found to have been eaten by California sage grouse. These plants included sagebrush, rabbitbrush, dandelion, prickly lettuce, gooseberry, and clover.

The close similarity between diets of California sage grouse and those reported from Utah and Wyoming can be attributed to the fact that the distribution of sage grouse coincides with the sagebrush climax characterized by similar plant associations.

SUMMARY

The opening of a limited hunting season on sage grouse in California in 1950 and 1951 in Mono County and in 1952 in Mono, Lassen, and Modoc Counties afforded an opportunity to collect data relative to hunting success and food habits of a game bird of which little was known. The increased number of hunters in 1952 over those in 1950 attests to the growing interest of California sportsmen in sage grouse hunting. The analysis of 175 sage grouse stomachs collected from hunter kills revealed that 38 food plants were utilized by the sage grouse and that insects, notably ants and grasshoppers, were important items of food. The staple item of diet was the leafage of sagebrush, which was supplemented by the leafage of such plants as clover, dandelion, green grass, green forbs, snowberry, woolly sunflower, and common sunflower.

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THE LIFE HISTORY OF THE TUI CHUB, *SIPHATELES BICOLOR* (GIRARD), FROM EAGLE LAKE, CALIFORNIA[1]

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INTRODUCTION

For some years the Eagle Lake Rainbow Trout (*Salmo gairdneri aquilarum*) has been on the verge of extinction. In 1948 a program of investigation was started to determine what measures should be taken to preserve this interesting species. It soon became apparent that the relationship of the other fish species in the lake to the trout would have to be determined before an adequate management program could be formulated. The Tui Chub, *Siphateles bicolor* (Girard), is the most abundant species and so was selected for the initial study.

This is the fifth life history study of native California fishes of the minnow family (Cyprinidae). Studies have been completed on the Venus Roach, *Hesperoleucus venustus* (Fry, 1936), Sacramento Hitch, *Lavinia e. exilicauda* (Murphy, 1948), Greaser Blackfish, *Orthodon microlepidotus* (Murphy, 1950), and Sacramento Squawfish, *Ptychocheilus grandis* (Taft and Murphy, 1950). Harry (1951) has described the embryology and early development of the Tui Chub from Eagle Lake. The above studies have been helpful in analyzing the forage potential of these minnows for warmwater fishes.

DESCRIPTION OF EAGLE LAKE

Eagle Lake (Figure 1) lies in northeastern Lassen County at an elevation of 5,100 feet, and has a surface area of approximately 15,000 acres (1941). The closed drainage basin of 498 square miles has a mean seasonal runoff of 91,000 acre-feet. The principal tributary stream is 26-mile long Pine Creek, which has its origin in a spring area above Stephens Meadows, about six miles west of Bogard Ranger Station. The lower 20 miles of Pine Creek, below Bogard, and several smaller inlet streams are intermittent.

An irrigation project that began delivery of water through a tunnel to Willow Creek Valley in 1924 has lowered the lake about 30 feet. This project is no longer operating and the tunnel is now blocked.

Although the latest period of near desiccation was caused by the irrigation project, there is evidence that the lake had great natural fluctuations and has in the past reached a much lower level than at present. Conversely, several much higher levels in the past are indicated by wave-cut terraces. The most definite of these is about 50 feet above the level of 1924. Other more indefinite terraces are situated

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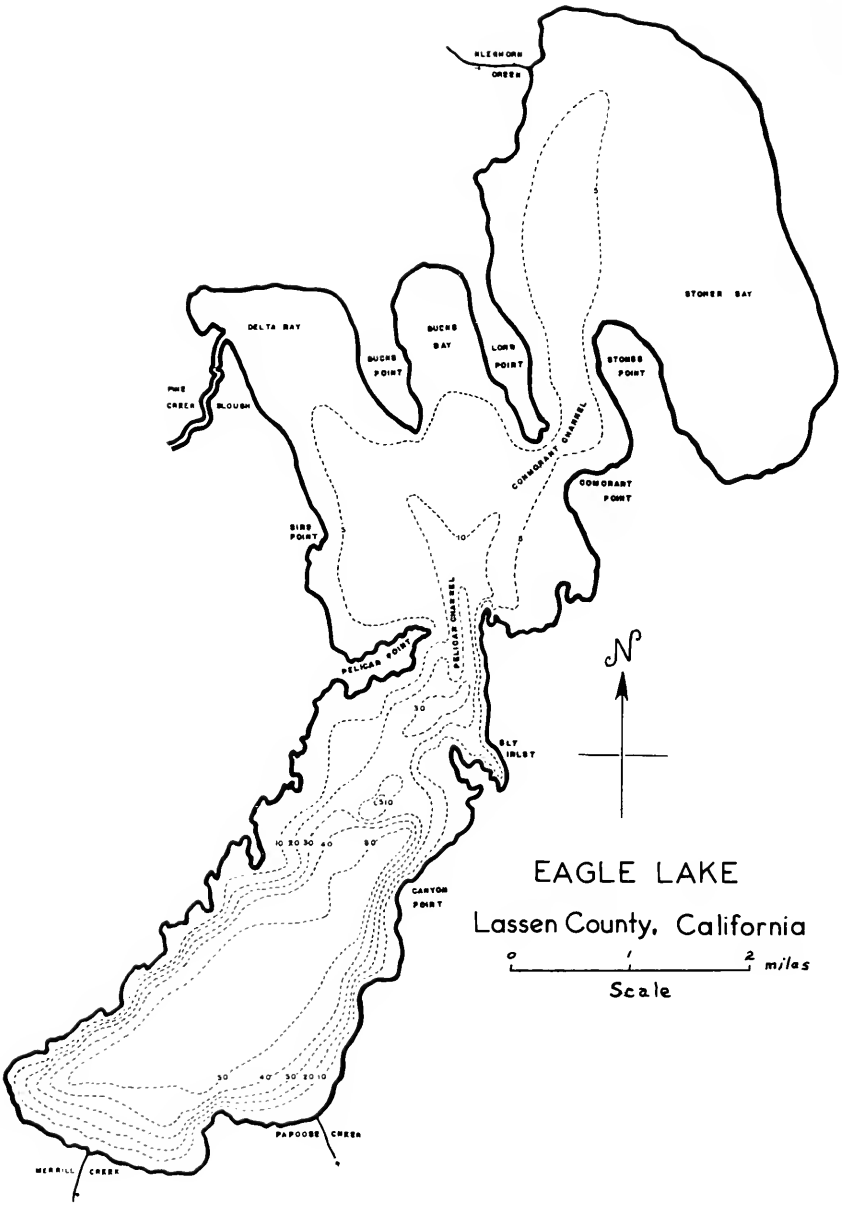

FIGURE 1. Map of Eagle Lake. The contours are at 10-foot intervals.

about 30 feet higher than this. Hubbs and Miller (1948) made similar observations and in addition noted a gravel beach about 60 feet above the 1924 level. During the Pleistocene these higher levels very probably caused a surface discharge to Lake Lahontan via Willow Creek Valley. This surface discharge is further indicated by the fact that four of the five native species of fishes are of Lahontan origin.

Total alkalinity of the lake varied in 1948 from 534 p.p.m. at the mouth of Pine Creek in June to 900 p.p.m. in the shallow northern section in August. Average total alkalinity was approximately 709 p.p.m. for all stations in 1948. The pH varied from 8.4 to 9.6.

Surface temperatures range from much below freezing in winter, when as much as 18 inches of ice may form, to a summer maximum of 70 degrees F. recorded in August, 1948. Oxygen is plentiful in the upper layers, but below the 35-foot level during the summer months it is frequently nonexistent or too low to support fish life. The oxygen regime during the winter stagnation period, when the lake is frozen over, is not known. An ill-defined thermocline is formed during the summer months and fluctuates between the 35- and 50-foot levels. Strong southerly winds which occur almost daily during the summer usually cause enough circulation to prevent the formation of a clear-cut thermocline. Temperature and oxygen data for a station in the southern part of the lake are given in Table 1.

TABLE 1

Temperatures and Dissolved Oxygen at a Station Off Canyon Point

Depth in ft.	April 12, 1949		June 23, 1949		Sept. 9, 1948		Nov. 8, 1949	
	Temp. in degrees F.	Dissolved oxygen in p.p.m.	Temp. in degrees F.	Dissolved oxygen in p.p.m.	Temp. in degrees F.	Dissolved oxygen in p.p.m.	Temp. in degrees F.	Dissolved oxygen in p.p.m.
Surface	41	10.2	65	10.7	67.5	10.2	56	12.2
5	--	--	64	9.2	66.9	10.7	50	10.0
10	40	*	64	9.2	66.6	9.3	48	10.2
15	--	--	64	9.1	66.6	9.1	12	10.2
20	40	*	64	9.2	64.9	9.0	42	9.6
25	--	--	63	9.1	64.6	9.0	42	9.2
30	40	*	62	8.7	64.0	8.2	42	8.4
35	--	--	58	5.2	64.0	5.3	45	8.4
40	40	*	56	1.2	62.1	2.1	42.5	8.4
45	--	--	56	2.8	*	.65	41.5	6.4
50	40	*	54.5	2.3	60.4	1.3	40.5	6.2
55	--	--	54	.8	60.1	.4	--	--

* Not taken.

BIOLOGY

Systematics

The genus *Siphateles* is represented by two species in California, one of which, *Siphateles bicolor*, has four subspecies.

Snyder (1917) reported collecting two species of *Siphateles* in Eagle Lake, a fine gill-rakered form (*Siphateles pectinifer*) and a coarse gill-rakered form (*Siphateles obesus*). Meristic data for 292 specimens collected during the current study indicate that a population of intergrades between these two species exists. The gill-raker count of this population exhibits a bimodal curve (Figure 2), but all other characters upon which the two species are differentiated show a uniform intergradation.

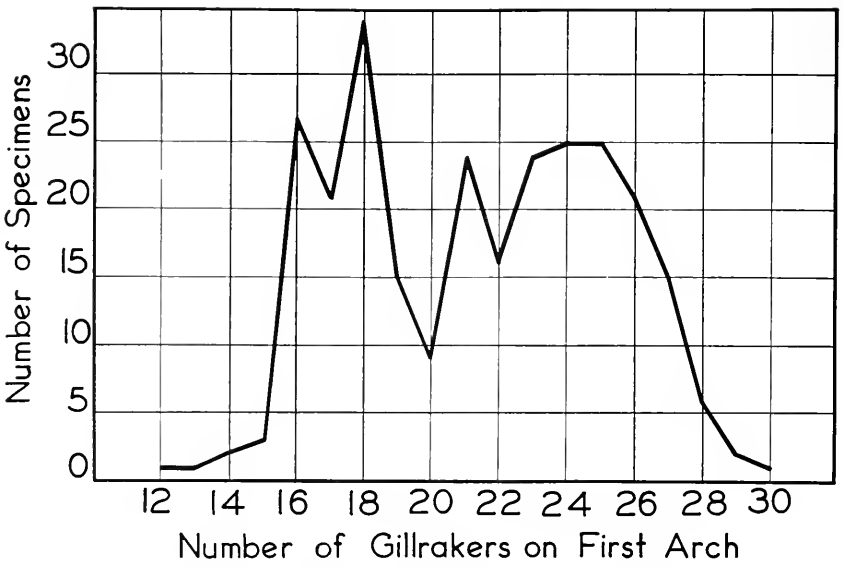

FIGURE 2. Distribution of the number of gill rakers on the first gill arch for 272 tui chubs from Eagle Lake.

The population now occurring in Eagle Lake is best described by the scientific name *Siphateles bicolor*: *obesus* x *pectinifer*. Two body forms, one obese with an obvious nuchal lump and the other slender, also occur in the population but cannot be correlated with gill-raker counts.

Distribution Within Eagle Lake Basin

The *Siphateles* of Eagle Lake (Figure 3) is typically lacustrine in habit. It was not observed in the tributary streams at any time, except in Pine Creek below the lowermost rapids. Pine Creek has a long estuary-like channel which remains connected with the lake after the creek ceases to flow. For all practical purposes, this channel is a part of the lake, since no perceptible flow can be noted in it. Gill nets placed in the channel in 1948 and 1949 produced no adult *Siphateles*. Pine Creek empties into Delta Bay, where the tui chub spawns very heavily, so it is possible that some of the post-larval fish may find their way into the estuary; several individuals four or five inches long were seined there in November, 1947. Since the estuary supports a heavy plant growth, similar in character to that of the open lake, a few fish may even spawn there.

No *Siphateles* were found in the lowermost semipermanent pools of Pine Creek above the estuary in 1947, 1948, 1949, or 1950. They were taken from the upstream side of the Pine Creek slough fish counting weir in 1953 and 1954, indicating that they may have migrated from an upstream area. It is believed these fish either resulted from recent bait introductions or had migrated into the area above the weir when it was open.

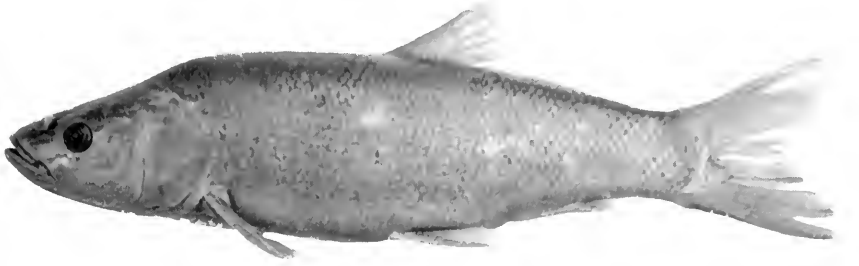

FIGURE 3. The obese form of the tui chub from Eagle Lake.

Movements

Observations in the open waters of the lake indicate that fish of the same year class school together, with only a few older and younger fish present until the first spawning. The schools break up on the spawning grounds and become well mixed thereafter. During the spawning period the immature one- and two-year classes are scattered in the lake, while the older fish are concentrated on the spawning grounds.

Gill netting in the deeper south end of the lake during the spawning period produced a few large individuals not in spawning condition. There was no indication that these fish were spawned out. Fish of the same size range were noted actively spawning in Delta Bay.

No observations were made from the latter part of December through March. However, it is inferred from observations made during the fall and spring that the adults confine themselves largely to the deeper portions of the lake during the winter.

The ice was off the northern and middle sections in 1949 by April 2, but did not go off the southern section until April 11. Nets placed in the shallow middle section of the lake on April 9 caught only suckers (*Catostomus tahoensis*). On April 10, two gill nets placed in the channel between the middle and southern sections at the edge of the ice took 114 adult *Siphateles* during a 12-hour period. The position of the netted fish indicated that a mass exodus was under way from the deeper ice-covered southern section into the shallow ice-free northern and middle sections. Examination showed the fish to be sexually mature, but not ready to spawn. Snyder (1917) observed a similar seasonal movement of *Siphateles* from deep to shallow water in Pyramid Lake, Nevada.

After about May 1, gill nets placed in the shallow northern and middle sections of the lake were filled rapidly with adults. This continued through the spawning period, until late September, when almost no adults were observed. At this time, however, the shallow shore areas were swarming with young of the year.

In general, the largest fish are in the deep south portion of the lake. From May through August only a few very large individuals were found in this part of the lake. In the latter part of August noticeably larger numbers of smaller fish were taken, and in September nets were quickly loaded to capacity with fish of all sizes. The area in the deeper sections of the lake suitable for fish life is limited by the scarcity of oxygen below 35 feet during most of the summer months.

Fish occasionally venture into the low oxygen regions, since a few were always found in nets set at those levels. Such fish, unlike shallow-water specimens, were invariably dead and of the pale silvery color usually associated with asphyxiation.

The schools can often be located by the large flocks of white pelicans and cormorants which feed on them. The movement of these birds to the southern portion of the lake, coincident with the first poor net catches of *Siphateles* in the northern and middle sections, is further indication of the seasonal movement of the fish.

Parasites

This fish appears to be lightly parasitized in Eagle Lake. Several nematode and cestode intestinal parasites were found and stages of one or both of these were occasionally noted in connective tissue and the mesentery, with no apparent ill effects. A large ulcerous swelling was found on the nape of one fish. Individuals taken in the estuary of Pine Creek were noticeably more heavily parasitized than those of the open lake.

Food Habits

The newly-hatched fish begin to feed almost immediately upon rotifers, diatoms, desmids, and other microscopic material.

In July, 1948, 30 specimens ranging in size from 12.0 to 26.8 cm. (4.7 to 10.5 inches) standard length were taken for stomach analysis from gill nets in which they had been held for as long as 12 hours. Because of the long period in the nets, many of the stomachs were empty, and it was necessary to examine intestinal contents as far as the first bend beyond the stomach. The intestinal tract is about as long as the fish and the stomach is only slightly muscular.

TABLE 2

Foods Eaten by 30 Tui Chubs Collected in July, 1948—Average Standard Length 17.4 cm. (Range 12.0-26.8 cm.)

Number of gill rakers	Number	Plant remains	Plankton	Caddis-fly cases	Chiron-omid larvae	Surface Insects	Hydra-carinae
15	1	1	--	--	--	1	--
16	1	--	1	--	--	--	--
17	2	1	--	--	--	--	--
18	3	3	2	--	--	1	1
19	3	1	3	--	--	--	--
20	1	1	1	--	--	--	--
21	1	1	1	--	--	--	--
22	1	--	1	--	--	--	--
23	3	1	2	1	1	--	--
24	3	2	3	--	--	1	--
25	6	2	6	--	1	--	2
26	0	--	--	--	--	--	--
27	3	--	3	1	--	1	--
28	1	1	1	--	1	1	1
29	1	--	1	--	--	--	--
Totals	30	11	25	2	4	5	4
Percentage of occurrence		36.6	83.3	6.6	13.3	16.6	13.3

The range of the gill-raker counts showed the typical bimodality of this character in the population. However, no correlation was found between the number of gill rakers and the food selected. The results of the stomach content analysis, together with the gill raker data, are presented in Table 2.

Animal plankton occurred in 83.3 percent of the stomachs. Copepods and cladocerans were the most numerous of these organisms and the contents of the entire gut were often dyed a bright orange red from the pigment of copepods. The remains of higher plants, principally *Potamogeton*, occurred in 46.6 percent of the stomachs. Because the individuals in this examination were taken on the spawning grounds, where large numbers of these plants occur, the amount of plant remains in this sample is probably greater than normal. Phytoplankton was not found in any of the adult stomachs. However, it is quickly rendered unrecognizable by digestion. Surface insects occurred in 16.6 percent of the cases. In one instance, during a hatch of small black-winged mayflies a whole school appeared to be feeding exclusively on that item. The caddisfly cases and the chironomid larvae may be classed as bottom foods and occurred 6.6 and 13.3 percent of the time, respectively.

With the exception of a few scales found in three stomachs, no fish remains were noted. These scales may inadvertently have been included during dissection or ingested by the fish during their struggles in the gill nets. They are not believed to be indicative of piscivorous tendencies.

Spawning

The tui chub of Eagle Lake typically spawns for the first time in the spring of its third year. The earliest date on which ripe spawners were taken in nets was June 16, 1949. The scarcity of ripe females at that time, and the occurrence of newly-hatched *Siphateles*, indicate that spawning begins about the middle of May. On May 10, 1950, a male dropped by an osprey was found to be sexually mature (flowing milt). The water temperature at that time was 57 degrees F. After about the first of July fish in spawning condition no longer occurred.

The most obvious changes in the female associated with spawning are a slight enlargement of the anal region and protrusion of the genital papilla, a deepened body, and a reddish tinge of the fins. The male's fin coloration is intensified in the same way and, in addition, he becomes covered with small, white tubercles.

Fertilization and deposition of the eggs were not observed. At various times during the spawning period, however, a group of fish was noted swimming slowly and crowded together near the bottom. In each instance they were in water not over three feet deep, where numerous aquatic plants were growing. Periodically the fish became excited and milled around, often stirring up clouds of silt which obscured the scene. Plants and bottom material collected after such an occurrence on June 25, 1948, included incleaved eggs which hatched into *Siphateles* on or about July 3, 1948. No attempt was made to observe spawning activities at night.

Newly extruded eggs are from 1.5 to 1.9 mm. in diameter, increasing slightly in size after fertilization. Their color is at first a pale orange-yellow, which changes to a light straw-yellow. They are very adhesive, and when spawned artificially stick to the pan and hands individually and in clumps, whether fertilized or not.

A series of six screen-topped quart jars was placed in the lake, each containing approximately an equal number of fertilized *Siphateles* eggs. Some of the eggs were free, others attached to plants. Into three jars bottom mud was introduced, while the others were allowed to remain clear. The results, presented in Table 3, suggest that only eggs attached to plants or otherwise kept off the bottom and out of the mud will develop normally.

TABLE 3

Results Obtained From Experimental Hatching of Tui Chub Eggs in Eagle Lake Under Different Conditions

Jar No.	Eggs	Mud or Clear	Results after 72 hours
1	Free	Clear	Alive
2	Free	Mud (eggs submerged)	Dead
3	Free	Mud (eggs on surface)	Alive (covered with Saprolegnia)
4	Attached to plants	Clear	Alive
5	Attached to plants	Mud (eggs submerged)	Dead
6	Attached to plants	Mud (eggs on surface)	Alive

Eggs were found on three species of rooted aquatic plants: *Myriophyllum spicatum* L. var. *exalbescens* Jepson, *Ceratophyllum demersum* L., and *Potamogeton* sp. These plants, particularly the *Potamogeton*, are often torn from the bottom by various diving birds. *Siphateles* eggs were occasionally found attached to floating masses of this plant material in the open lake. This may explain why newly-hatched *Siphateles* were taken in surface plankton tows in the middle of the lake, far from known spawning areas.

An 11-inch female produced 11,200 ripe eggs (measured volumetrically). This figure is probably low, since only ripe eggs were found. Dissection of other females indicates that the eggs do not all mature at the same time.

The incubation period of the eggs in the lake is not known. Newly-fertilized eggs collected July 25, 1948, and left in a quart jar in the laboratory, where the air temperature varied from 40 to 90 degrees F., hatched and the fry were found actively feeding in nine days. The hatching time at the more stable lake temperature is probably less.

Postlarval Life

Upon hatching the yolk sac has been absorbed and the larvae are well developed. They remain in plant beds until they are about 1 or 2 cm. long, at which size they first begin to appear along the shore in numbers. Most of the small fish occur where the plant beds are not very thick and at this time their numbers do not appear impressive. As they increase in size, however, the tremendous numbers become apparent. Along the shore of Delta Bay in late August, 1949, a black belt

of these small fish moved away as we approached, and returned to the shallow shore line as soon as we had passed. This plant bed and shore line existence continued until late September, when the air temperature reached 40 degrees F. during the early morning hours. In December, 1950, no fish were seen in the shallows of the western section of Stones Bay, where in late August, 1948, tremendous schools of tui chubs of the year had occurred. It therefore appears that the young of the year migrate into the open waters at the onset of their first winter and in subsequent years return to the shallows only during spawning periods.

FIGURE 4. Scale of tui chub in its fifth year, from Eagle Lake.

Growth

Growth rates were calculated from scales of 121 specimens. Scale samples were taken from approximately halfway between the lateral line and the origin of the dorsal fin. A typical scale is shown in Figure 4.

The length of the anterio-lateral radius on 67 scales was plotted against the standard length, giving a correlation coefficient of 0.97 (Figure 5). Scales were found to be forming on individuals 2 to $2\frac{1}{2}$ cm. (0.78 to 0.97 inches) long.

Little difficulty was experienced in reading the scales to the fifth annulus. An unusually large number proved to be regenerated, even though they are firmly embedded in the adult. A number of adult fish with large scars from wounds apparently inflicted by water birds were found, but this would not seem to account for the large number of scales lost by smaller fish. It appears that the scales are more deciduous when the fish are small, since the greatest loss appeared to be about the time of the formation of the first annulus. Fish shorter than 12 cm. (4.7 inches) lost more scales during their struggles in the gill net than did the larger ones.

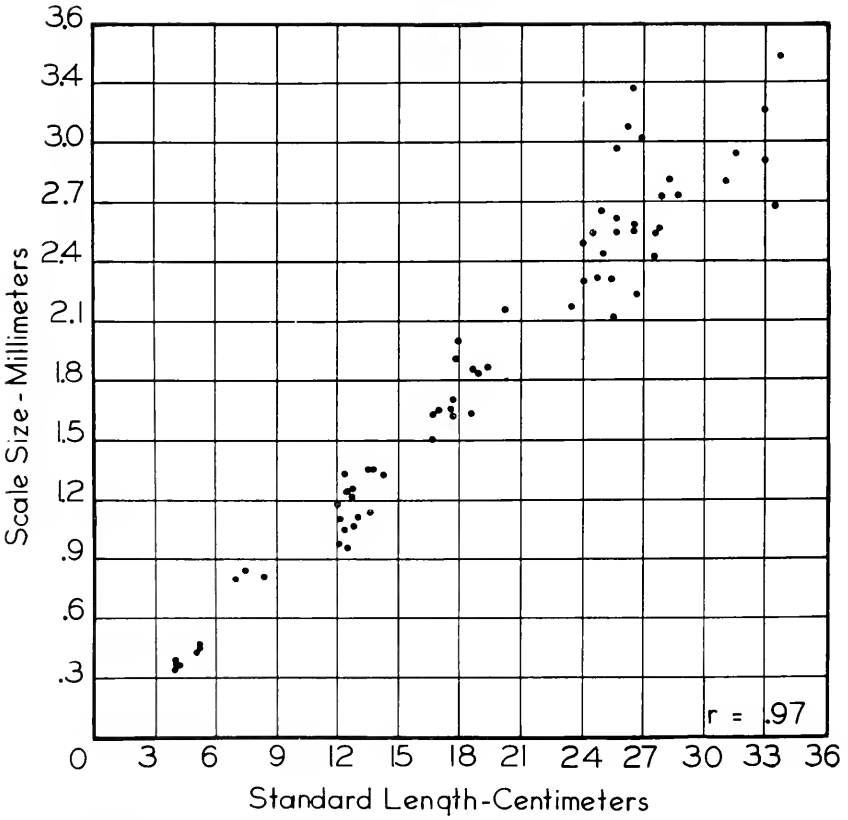

FIGURE 5. Regression of scale size and fish length for the tui chub in Eagle Lake.

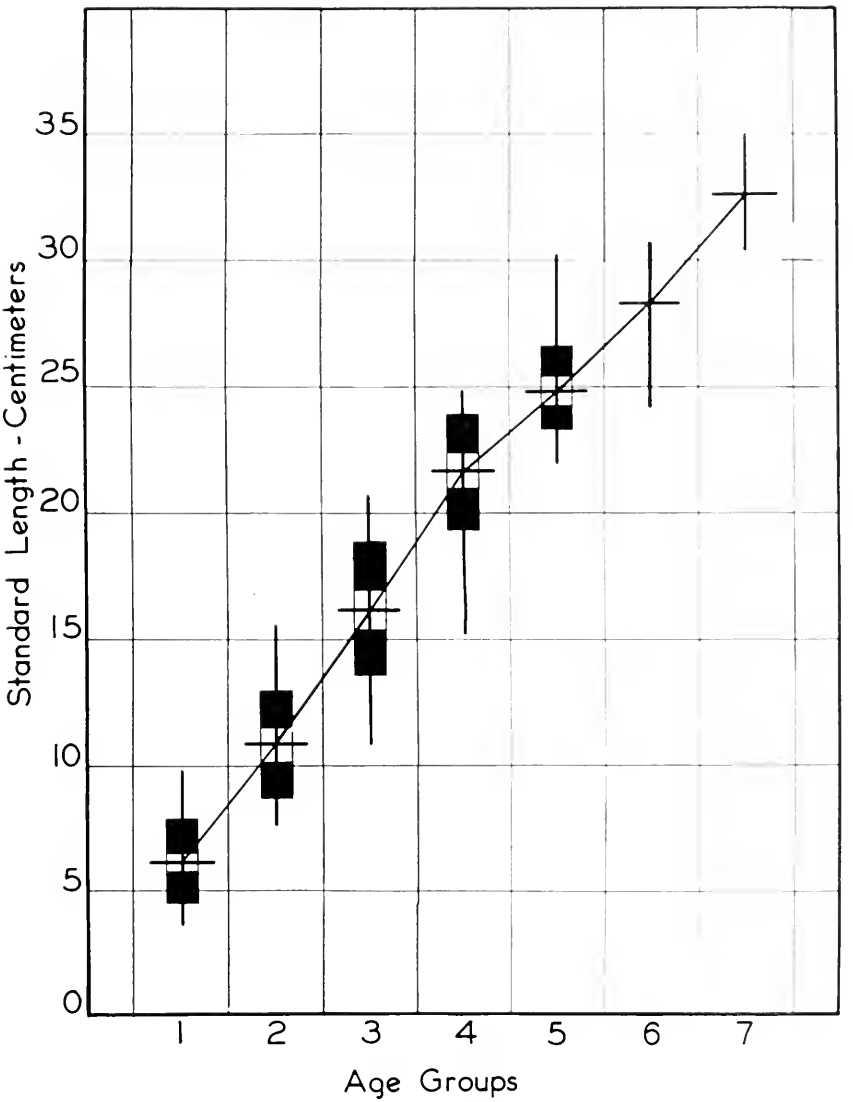

FIGURE 6. Growth rate of the tui chub in Eagle Lake. The fine vertical line is the range, the black portion of the box one standard deviation, the horizontal line the mean, and the clear box three times the standard error of the mean.

From Figure 6, it can be seen that growth is regular until the fourth year, when it begins to taper off .The wide overlap in size ranges of year classes is probably caused by the extended spawning period.

Means for the sixth- and seventh-year classes may be considered tentative, due to the small numbers of individuals. Because of spawning checks and erosion from other causes, the scales become very difficult to read beyond the five-year-age group. The largest aged individual was a female 40.9 cm. (16 inches) standard length.

Fish of the year collected September 10, 1948, varied in length from 2.2 to 4.2 cm. (0.85 to 1.6 inches) standard length. The lake freezes over during December and the formation of the annulus probably occurs about the time the fish migrate into the shallow waters, just after the ice goes off. This is about one month prior to spawning.

The length-weight relationship curve is shown in Figure 7.

The condition factor (K) was calculated for 139 specimens ranging in standard length from 12.4 to 34.9 cm. The average value for K was 1.92 (range 1.04-2.94). The lower values were consistently associated with the smaller sizes. The average of 61 values taken from spawners between June 16 and June 25, 1948, was 1.98 (range 1.42-2.94). Immediately after spawning the condition index dropped slightly, making the average for 42 specimens taken between July 17 and July 27, 1948, 1.82 (range 1.04-2.39). A series of 36 examples taken well after spawning between August 3 and August 27, 1948, had begun to recover and had an average K of 1.94 (range 1.20-2.73). The differences are admittedly slight, but indicative of the effect of spawning.

ECONOMICS

The average fisherman considers any non-game fish a "rough fish" and therefore unfit for human consumption. This feeling is particularly strong because chemical treatment of lakes has made it possible to eradicate all "rough fish" in a lake and then to substitute a pure population of "game fish." This negative attitude is relatively new, as most of the early settlers utilized any fish at hand for food, whether it be sucker, minnow, or trout.

The tui chub of Eagle Lake has an excellent flavor, although it is somewhat bony, particularly in the caudal area. Cooked immediately after being caught, it is excellent in every way. Many of the local people at Eagle Lake utilized it and considered it to be very good. A large series was canned, using a variety of methods. A water pack proved best. The meat, when properly brined, was white and firm, and in the canning process the bones became quite soft. The resulting product was quite palatable and was used in much the same way as canned tuna.

Some sport fishing is furnished by the species. The best fishing area is in the south section of the lake, where the fish are easily taken with worms. When caught in this fashion, their bite is a gentle tug, but they furnish some good action when taken on light tackle. More active fishing was reported on moonlight nights, when surfacing schools were fished with a small spinner.

In 1942, 1943, and 1944, a permit was obtained by a commercial fishing concern to seine and transport rough fish from Eagle Lake for market. A letter from a representative of this company states that commercial quantities of tui chubs were netted in only one year (1943). They were taken during the month of May from spawning concentrations in Delta Bay. About 8,000 pounds were obtained for export overseas. The company interested in exporting them canceled their order, thereby forcing the fish onto the local market. Since people complained

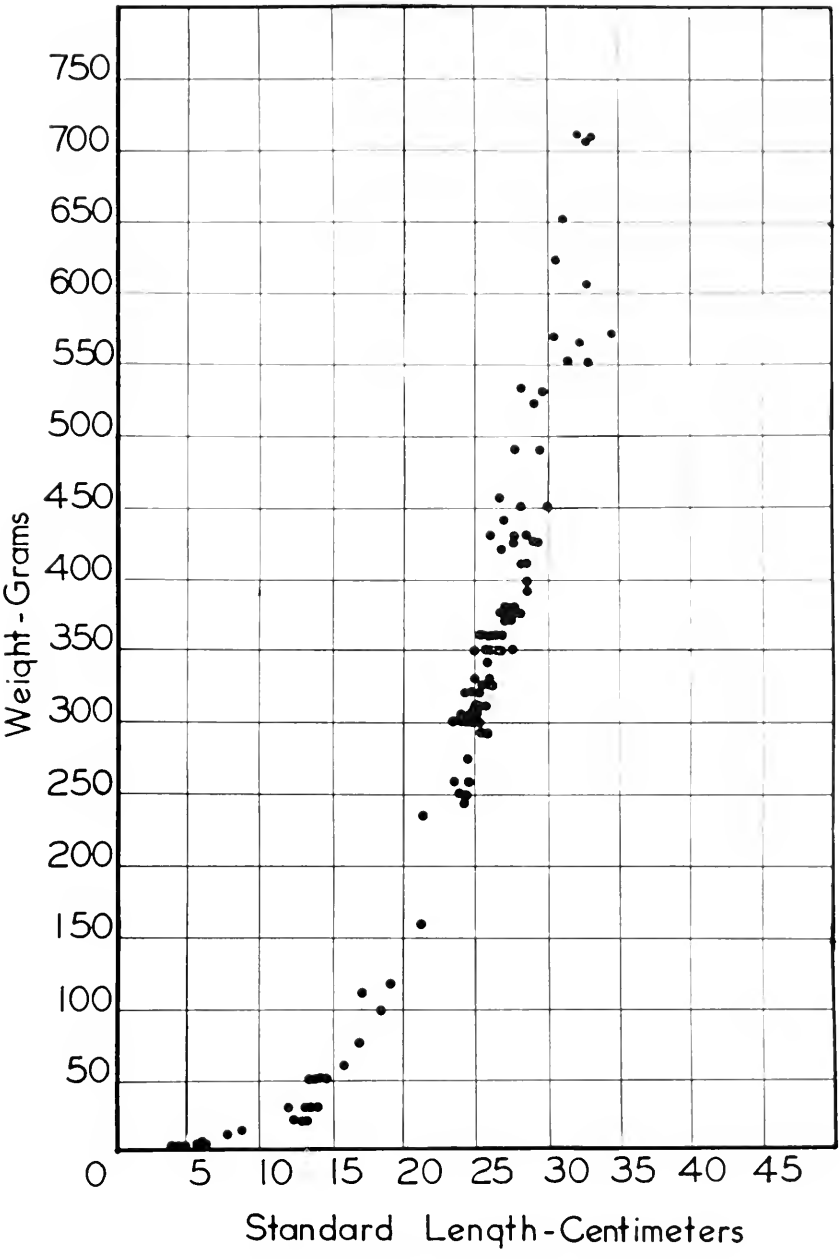

FIGURE 7. Length-weight relationship of the tui chub in Eagle Lake.

the fish were too bony, only a few hundred pounds were ever used for food and the remainer had to be dumped. In 1949, the company considered using them only for reduction purposes, the maximum value being placed at $20 a ton.

MANAGEMENT

When the tui chub is considered as a factor in warmwater fish management, it appears to fall in about the same category as the greaser blackfish. *Orthodon microlepidotus* (Murphy, 1950).

The only marked difference is in food habits. *Orthodon* adults feed primarily on a combination of plankton and bottom materials, with a preponderance of vegetable matter. *Siphateles* takes primarily animal foods feeding upon zooplankton, some higher plants, and larval insects which are found on the plants. The young blackfish and tui chub feed upon nearly the same food items. The slower growth rate of *Siphateles* may be attributed to the more rigorous climate of Eagle Lake.

The spawning time, as based upon temperatures, is about the same as for the largemouth black bass, or about 60 degrees F. The spawning areas and habits of the black bass and the tui chub do not conflict.

In Eagle Lake this fish, along with several others, is an important buffer species for the Eagle Lake Rainbow Trout. This trout, an endemic species, migrates up Pine Creek about April of each year to the area above Bogard to spawn. Many of the adults are trapped in that area when the creek ceases flowing in its lower reaches. It seems likely that all of the newly-hatched fish are caught in that area, to remain there until the next year's spring freshets. When these yearling trout enter Eagle Lake they are about 5 to 7 inches long. Large flocks of pelicans, mergansers, and other fish-eating birds concentrate at the shallow sand bar found at the mouth of the stream.

At this time the spawning migration of Tahoe Suckers (*Catostomus tahoensis*), Lahontan Red Sided Shiners (*Richardsonius egregius*), and the Lahontan Speckled Dace (*Rhinichthys o. robustus*) into Pine Creek is in progress and they buffer against predation on the trout by the water birds. As the trout enter the lake this role is assumed by the myriads of tui chubs then moving into the shallow Delta Bay area prior to spawning. This buffer action is not a matter of the min-

FIGURE 8. A catch of tui chubs taken by sports anglers from Eagle Lake in September, 1948.

nows and suckers being more acceptable to the predators, but rather one of tremendous availability at a time when the Eagle Lake rainbow is most vulnerable.

Since tui chubs frequently swim near the surface, they are available to the birds virtually all the time they are present and again buffer the trout in the open lake.

Should the trout enter the lake as fingerlings or fry, there would be competition for food and the tui chub probably would depress the trout population.

Siphateles has developed into a rather spectacular nuisance when introduced into waters to which it is not native. This has been especially true when it occurs in trout lakes in which angling is maintained by fingerling plants. This writer believes that this phenomenon is due primarily to the poor trout spawning facilities of most of these lakes and the subsequent unfavorable position of the predator trout population. Competition between small planted trout and *Siphateles* is believed to be severe. In larger lakes, where *Siphateles* is native, a good trout fishery often exists.

Field observations indicate the tui chub does not reach as large a size in waters of lower productivity, such as Donner Lake, Nevada County. It may prove to be a good forage fish for largemouth black bass in certain fluctuating reservoirs.

ACKNOWLEDGMENTS

The study was initiated at the suggestion of Mr. Harry A. Hanson as part of a general biological survey of Eagle Lake being directed by him. The facilities of the Chico State College Eagle Lake Biological Field School were made available by Drs. Vesta Holt and Thomas L. Rodgers. Dr. Robert R. Harry made available data collected during his study of the embryonic and early larval stages. Dr. Paul R. Needham aided in the preparation of the material presented as partial requirement for the Master of Arts degree at the University of California. Messrs. Sam Webb, L. L. Dahl, and J. W. Cavanee were most helpful during the field work. Mrs. Barbara Thoma Kimsey carried out the experimental canning.

SUMMARY

Eagle Lake, Lassen County, California, is an alkaline lake lying in a closed basin, with only intermittent inlet streams. Although the lake surface is now lowered as a result of both evaporation and irrigation, it has fluctuated widely in the past through natural causes.

The writer considers the tui chub of Eagle Lake a hybrid population, *Siphateles bicolor: obesus* × *pectinifer*, in which a peculiar bimodal gill-raker pattern exists. No correlation could be detected between the gill-raker counts and any other character ordinarily used to differentiate these forms.

The adults feed primarily upon the larger zooplankton, higher plants, and insect larvae. Newly-hatched fish begin to feed almost immediately upon rotifers, desmids, diatoms, and other microscopic material.

The tui chub spawns when the water temperatures are approximately 60 degrees F., laying its adhesive eggs on plants in water not over three or four feet deep.

It inhabits the shore areas and shallows during its first year. After that, it returns to these areas only during the spawning period.

In Eagle Lake it attains a mean standard length of 6.6 cm. (2.7 inches) at the end of the first year, 11.2 cm. (4.4 inches) in its second year, 16.7 cm. (6.6 inches) in its third, 21.6 cm. (8.5 inches) in its fourth, 24.9 cm. (9.8 inches) in its fifth, 28.1 cm. (11.1 inches) in its sixth, and 32.5 cm. (12.8 inches) in its seventh. The maximum size recorded (unaged) was 40.9 cm. (16.0 inches). Lengths of age groups were calculated from scale measurements.

The species may prove useful as a forage fish in fluctuating reservoirs.

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A COMPARISON OF JAPANESE AND HAWAIIAN SPECIMENS OF THE BLACK SKIPJACK, *EUTHYNNUS YAITO*[1]

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The black skipjack of the Hawaiian Islands was described and its relationship to the tunas discussed by Godsil (1954). The findings were compared with Kishinouye's (1923) description of *Euthynnus yaito* from Japan, and as no differences were detected, the Hawaiian specimens were assigned to that species.

After the work had been completed, three specimens of *E. yaito* were received from Japan. These specimens were secured from the Tokyo fish markets and sent to the California State Fisheries Laboratory by Dr. Bruce W. Halstead, School of Tropical and Preventive Medicine, Loma Linda, California, whose cooperation is gratefully acknowledged. An examination of these three specimens showed that they agreed essentially with the Hawaiian specimens, so that there can be no doubt as to the specific identity of the Japanese and Hawaiian fish.

In external appearance the Japanese specimens were indistinguishable from the Hawaiian. The proportional measurements (Table 1) conformed closely to those of the Hawaiian specimens, although in many instances they showed a tendency toward higher values. The differences were slight and with but two exceptions could be attributed to the effects of freezing and prolonged cold storage.

Fin ray and gill raker counts agreed in general with those of the Hawaiian sample. All three specimens possessed 15 first dorsal rays, 8 dorsal finlets, 14 anal rays, and 7 anal finlets. Two specimens had 12 second dorsal rays and the third one 13. The gill raker count was $8 + 1 + 22\text{-}24 = 31 - 33$. In the count of gill teeth, two of the Japanese specimens had 26, which is one less than the recorded minimum in the Hawaiian sample. The third Japanese specimen had 28 gill teeth. The comparable counts in the Hawaiian sample (8 fish) were: first dorsal rays 14-15; second dorsal rays 12-13; dorsal finlets 8; anal rays 13-14; anal finlets 7; gill rakers $7\text{-}9 + 1 + 22 - 24 = 29 - 34$; gill teeth 27-29.

While the general view of the viscera, *in situ*, was similar to that of the Hawaiian specimens, a detailed examination of the visceral organs was not made; neither were the specimens arterially injected. The condition of the specimens rendered this impractical. However, the specimens were skeletonized, and a positive identification was made on the basis of the diagnostic characters of the vertebral column.

[1] Submitted for publication May, 1954.

TABLE 1

Measurements Made Upon Three Japanese Specimens of Euthynnus yaito and the Resulting Proportions in Relation to Body Length. The Values Obtained From Hawaiian Specimens (Godsil, 1954) Are Shown for Comparison.

	Fish No. 9	Fish No. 10	Fish No. 11	Range in ratios, Japanese	Range in ratios, Hawaiian
Body length	399 mm.	405 mm.	401 mm.		
Head length	108	109	109.5	3.66– 3.72	3.44– 3.60
1st dorsal insertion	126	124	130.5	3.07– 3.27	3.11– 3.23
2d dorsal insertion	243	243	242	1.64– 1.67	1.65– 1.70
Anal insertion	260	265	261	1.53– 1.54	1.48– 1.52
Ventral insertion	118	118	120.5	3.33– 3.43	3.07– 3.24
Greatest body depth	--	--	105	--	3.55– 3.99
Dorsal-ventral distance	99	97	101	3.97– 4.18	3.86– 4.18
Dorsal-anal distance	173	171	169	2.31– 2.37	2.28– 2.38
Ventral insertion to vent	145	146	140	2.75– 2.86	2.75– 2.95
Length of 1st dorsal base	123	124	117.5	3.24– 3.41	3.23– 3.53
Length of 2d dorsal base	25	26	28.5	14.07–15.96	14.29–15.53
Length of anal base	29	28	28.5	13.76–14.46	14.02–17.38
Pectoral length	58	65	61	6.23– 6.88	5.54– 6.05
Height of 1st dorsal	57	59	57.5	6.86– 7.00	6.41– 7.00
Height of 2d dorsal	27	--	29	13.83–14.78	12.10–14.15
Height of anal	27	27	29	13.83–15.00	11.91–14.15
Diameter of iris	14	15	14	7.27– 7.82*	6.06– 8.00*
Maxillary length	43	43	44	2.49– 2.53*	2.31– 2.51*
Snout to posterior margin of eye	46	46	46	2.35– 2.38*	2.14– 2.34*
Fleshy interorbital distance	31	31	32	--	--
Snout to above plane	30	30	32	--	--

* Ratio of this measurement is to head length. All other measurements are related to body length.

The possession of 39 vertebrae and the absence of any trace of protuberances on the 33d and 34th vertebrae unmistakably identified these specimens as *E. yaito*.

In the examination of the Japanese specimens, several minor differences were apparent. The ratio of body length divided by head length ranged from 3.66 to 3.72, whereas in the Hawaiian specimens the comparable range in eight specimens was from 3.44 to 3.60. This cannot positively be attributed to the effects of prolonged cold storage because the Hawaiian specimens were also frozen, although stored for a lesser time. Similarly, the recorded difference in the proportion body length divided by ventral insertion was appreciably higher in the Japanese fish. The significance of these differences must await further investigation.

A slight difference exists in the ratio of head length divided by the distance between the snout and the posterior margin of the eye. Neither of these measurements are perceptibly affected by cold storage. The range in the Hawaiian sample was from 2.14 to 2.34, whereas the Japanese specimens varied from 2.35 to 2.38.

Each skeletal element of the Japanese specimens was compared with the comparable structure in Hawaiian specimens. In only two char-

acters were potential differences noted, and both of these were relative. Of the bones examined no differences were observed in the following:

Pterygoid	Articular
Premaxillary	Preorbital
Posteleithe	Glossohyal
Opercular bones	Posttemporal
Clavicle, and contiguous bones	Dentary
Maxillary	Hyomandibular
Hyal assembly	Pelvic girdle
Palatine	Mesopterygoid
Auxiliary maxillary	Quadrate
	Vertebral column

The teeth on both jaws appeared smaller and more bristle like in the Japanese fish. The difference, though slight, was visually apparent when specimens of the same size were directly compared.

The posterior portion of the parasphenoid differed in shape in the two samples. This difference can best be described as two characters. Those portions of the parasphenoid forming the lateral margins of the posterior aperture of the myodome were distinctly circular in appearance in all of the Japanese specimens, whereas in the Hawaiian specimens they were relatively straight and slightly divergent posteriorly. Moreover, in ventral view the shape of this aperture of the myodome appeared different. In the Hawaiian specimens it was shallow, while in the three Japanese specimens it was deeper.

The second character concerns the same bone. The total extent of the parasphenoid (ventral view) posterior to the orbit is visually divided into two portions by a low, sharp transverse ridge in small specimens of the Hawaiian *yaito*. In large specimens this ridge develops into a short, blunt but unmistakable process on each side. Such ridges or processes are lacking in the Japanese *yaito*, and this portion of the bone is not visually divided. It is perhaps worth recording that the single specimen of *E. yaito* taken in California waters (Godsil 1954) agreed in general in the above characters with the Hawaiian rather than the Japanese specimens.

All of the above differences are relative. In no case could a specimen be positively identified by any one of them. It is possible that they are merely extreme variations of the specific pattern. If they should prove to be associated with locality, they are merely indicative of population differences, and by no means justify a specific separation. The similarity in the anatomy of the two forms indicates overwhelmingly that they are of the same species, and individually indistinguishable.

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THE EFFECT OF AUROFAC-ENRICHED DIET (AUREOMYCIN AND B_{12}) UPON YOUNG KING SALMON

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During the past few years many aquarists and aquatic biologists have been experimenting with the antibiotics, as both therapeutic agents and dietary supplements. This has resulted in a variety of claims and statements—many of conflicting nature. Upon examination of these two phases as they relate to fishes, a prompt conclusion is reached that some of the antibiotics are certainly effective as therapeutic agents—but under specific conditions. The big question at present concerns their value as dietary supplements. Our preliminary studies at Steinhart Aquarium have dealt with this dietary problem, and will be described later in this paper. It should be pointed out that our primary interest is in the use of antibiotics as growth supplements and not as a source of protein or of carbohydrates.

Aureomycin (chlorotetracycline) and vitamin B_{12} have been reported to achieve spectacular growth results when added to the normal feed of such animals as chickens, turkeys, pigs, and young cattle (Anon., 1949; Cravens, 1950; Stokstad, 1952). Of considerable significance is the effect of these agents in producing an even growth rate, with no runtiness among the animals under treatment. However, aureomycin and vitamin B_{12} have one serious disadvantage when considered for use as a dietary supplement—they are too costly. In order to overcome this problem and to meet a low-cost criterion for a suitable antibiotic food supplement, Aurofac was developed, and is now marketed by the Lederle Laboratories Division of the American Cyanamid Company.

To determine whether or not these same growth benefits could also be obtained in routine aquarium practice, it was decided to experiment first with young king salmon. The results were so unexpected that it seems advisable to present them here, together with a summary of certain similar experiments which have been carried out at other places.

[1] Submitted for publication January, 1954. The chemically descriptive generic name chlorotetracycline has replaced aureomycin. "Aureomycin" is the trade name for the product of Lederle Laboratories Division of the American Cyanamid Company. We are using the term "aureomycin" in this paper because it is more familiar

PREVIOUS INVESTIGATIONS WITH AUREOMYCIN AND OTHER ANTIBIOTICS

Brown Trout

Wolf (1952) has reported a series of experiments with aureomycin, vitamin B_{12}, and terramycin (oxytetracycline)[2] as supplements to the diet of brown trout fingerlings. The tests, with ten lots of 200 fish each, covered a 16-week period (May 11-August 30). When Aureomycin and B_{12} in the form of Aurofac were added to a basic diet, there was no apparent increase in the size of the fish. A slight growth advantage, however, was believed to result from the addition of this agent to a poor diet of vegetable meals. Aurofac did not have any effect on the mortality. At the onset of these tests, Aurofac was used according to the manufacturer's recommended dosage for farm animals of 0.8 percent by weight. This corresponds to a concentration of 32.6 p.p.m. After a few weeks with no apparent effects, this amount was doubled, and later doubled again. The small amount of growth advantage discernible with an Aurofac and vegetable meal diet occurred only when the aureomycin was used at a concentration of 65.7 p.p.m. or higher and, according to Wolf, the data were not sufficient to establish statistical validity. Addition of 18.0 to 71.8 p.p.m. of terramycin in the diet did not stimulate growth, but may have lowered the mortality slightly in both series of diets. Wolf concludes that his experiments raise little hope that antibiotics and vitamin B_{12} will prove beneficial in the diets of brown trout.

Cutthroat Trout

Mr. Jack E. Bailey, biologist for the Montana Department of Fish and Game, writes of their preliminary tests at the Arlee Hatchery with Aurofac fed to cutthroat fingerlings. These tests were initiated with four-week-old fish, in four groups of 10,000 fish each, and using a six-day-per-week feeding schedule. The first group was fed liver mixed with Aurofac 2-A, at the 2.5 percent level. The second group received the same diet plus a weekly one-hour treatment of 1:500,000 PMA (Pyridylmercuric acetate). The third was the control group, receiving a straight liver diet, while the fourth group received the liver diet plus PMA. The tests were continued for 11 weeks, at which time a bacterial gill disease caused partial cessation of the experiment. Aurofac did not inhibit the disease, and there was no visible effect on the growth, although accurate measurements were not made. There seems to have been a very slight decrease in mortality in the Aurofac group in comparison with the control.

Rainbow Trout

The effects of terramycin, arsanilic acid, chloromycetin, penicillin, and aureomycin on rainbow trout were tested in a controlled experiment by Wagner (1954). The drugs were given in the form of commercial feed supplements in the concentration of 22.0 p.p.m. of the food, except for the arsanilic acid. The arsanilic acid was administered in the concentration of 21.8 p.p.m. of the food. At the beginning of the

[2] The chemically descriptive generic name oxytetracycline has replaced terramycin. "Terramycin" is a trade name of Charles Pfizer and Company, Incorporated. We have used "terramycin" because it is better known.

experiment, the trout ranged from 31 to 51 mm. in length. None of the fish on the supplemented diets showed as rapid an increase in weight as the control group over the whole time of the experiment. The author believes that the supplements inhibited the normal increase in growth.

Mr. Horace G. Frantz, Jr., of the Franzhurst Rainbow Trout Company, Inc., of Salida, Colorado, writes that they are using Aurofac routinely as a dietary supplement for fingerlings up to three and one-half inches long. Although they have not observed any beneficial growth effect as a result of Aurofac, they have found that it reduces mortality in these young fish to about one-tenth the normal rate. Aurofac was used at the 2 percent level.

Mr. M. J. Madsen, Chief of Fisheries Division, Utah Fish and Game Commission, has summarized the State of Utah's feeding experiments with Aurofac, aureomycin, bacitracin, and terramycin. These tests were conducted at Glenwood State Fish Hatchery by Mr. Madsen and June F. Powell. The tests were started in 1950 on small lots of rainbow trout and no ill effects were attributed to the use of the antibiotics. In 1951, all the fish in the hatchery were fed food supplemented with 55.5 p.p.m. of bacitracin. The young trout of 1951 averaged seven fish to the pound on August 1, 1951, while fish the same age had averaged 10 to the pound on August 1 of the preceding year. It was also noted that the Glenwood brood of 1951 did better than did the fish from another lot of eggs from the same source reared in another hatchery without antibiotic supplements in their food.

In 1952, Aurofac, aureomycin, and bacitracin were used in the food supply of all trout reared at Glenwood. The mortality of two- to six-inch fish was considerably reduced, and more uniform growth with a reduction in the number of "runt" and "pinhead" fish was observed.

June Powell conducted a series of experiments at Glenwood Hatchery that extended over a period of 12 weeks in 1952. In these experiments varying amounts of terramycin and bacitracin in combination with vitamins were used in the feed mixtures of all lots. In the case of one lot, the composition of the feed mixture was not reported. This lot contracted "red gill" and presumably was dropped from the experiment.

Mr. Madsen states that "In fish there is seldom found an absolutely healthy individual; some are just sicker than others. The use of antibiotics in feed nearing the spoiling stage because of bacteria has proved quite helpful in rendering this feed usable." He concludes that any evaluation of antibiotics as food supplements for trout must be considered preliminary.

Eastern Brook Trout

Mr. Royall Scott (personal communication, 1953), of the Clear Springs Trout Farms, West Buxton, Maine, writes that they have been experimenting with Aurofac as a means of controlling ulcer disease but that he is not yet ready to make definite statements on that point. He does say that Aurofac with a diet containing a major portion of dry feeds results in an improvement of the food conversion ratio of from 3 to 19 percent. Like results were not obtained when Aurofac was added to an all-meat diet.

Tropical Fishes

The controversy over fish foods fortified with antibiotics has not been limited to fishes of cold fresh water. Much has also been said about the effects of such foods on tropical fishes. Nigrelli and Atz (1952) have brought up pertinent arguments in their article, "Don't be a hypochondriac about your fishes." They report treating guppies with aureomycin by dissolving the antibiotic in the aquarium water at the concentration of 350.9 p.p.m. without causing any mortality or observing any distress. As a safe therapeutic measure, they recommend a concentration of 132 p.p.m. of aureomycin in the aquarium water. In discussing antibiotics as food supplements, they point out the possibility that continued use of antibiotics in food may cause a vitamin deficiency by destroying vitamin-producing microbes in the fish's gut. They also call attention to the possible danger of producing antibiotic-resistant strains of disease organisms.

The reaction of newborn guppies, *Lebistes reticulatus*, to aureomycin was observed by Berke, Silver, and Kupperman (1953). The drug was added to the food for a period of six months. We were unable to determine from the paper the concentration in which the drug was administered. Apparently it was given in massive doses in the food. The treated animals grew much less than did the control. The character and perhaps the quantity of microorganisms present in the aquaria was changed. This is shown by the overgrowth of *Candida albicans* that developed in the treated tank. The presence of *Candida albicans* is of theoretical importance because it is the cause of a most serious disease (moniliasis) that may appear as a complication of antibiotic therapy in man. The authors do not report whether or not this pathogenic organism invaded the tissues of the fish.

Dr. Aaron Wold of Hofstra College, Hempstead, New York, has tested the effects of aureomycin on tropical fishes. He reports (Wold, 1952) that fish kept four days in water containing 65.9 p.p.m. of aureomycin became hollow-bellied, refused to eat, swam at the surface, and finally died. Further work by Dr. Wold resulted in the development of a tropical fish food containing 59.5 to 79.3 p.p.m. of aureomycin. This food is now marketed on a large scale. Dr. Wold and others have attributed beneficial effects to the use of such products. We cannot fully accept such claims until the details of substantiating experiments have been published.

Salmon

In our experiments we used Aurofac, manufactured by the Lederle Laboratories Division of the American Cyanamid Company. Its ingredients are stated as follows: "dried extracted aureomycin meal and fermentation solubles, diatomaceous earth, and solvent extracted soybean oil meal." It is certified to contain not less than 1.8 grams of aureomycin hydrochloride per pound and not less than 1.8 milligrams of vitamin B_{12} activity per pound. Crude protein is not less than 10 percent, crude fat not less than 1 percent, and crude fibre not less than 7 percent. The manufacturer recommends that Aurofac be mixed with the food at a concentration not to exceed 1.4 percent. This is

equal to a concentration of 55.9 p.p.m. of aureomycin in the food. The considerable amount of testing which has been done has shown that the same relative results can be achieved by using either the purified B_{12} and aureomycin, or the less costly Aurofac.

There have been two salmon experiments other than ours using aureomycin-enriched foods. Robinson, Payne, Palmer, and Burrows (1951), working with fingerling red salmon (*Oncorhynchus nerka*) found no effect on the growth rate, but they thought that the fish may have been protected from an anemic tendency. The diet consisted of beef liver, hog spleen, canned salmon, and salmon viscera meal.

Earp, Ellis, and Ordal (1953) report that Klickitat Hatchery (Washington) tried to control an outbreak of Earp's kidney disease in king salmon fingerlings by adding Aurofac to the food at a level of 39.9 p.p.m of aureomycin. The weekly mortalities were 8.2 percent in the spring stock and 13.7 percent in the fall stock when treatment was begun August 20, 1951. The mortality rates in both stocks declined to about 1 percent by the last week in September. In another four weeks they began to rise and during the week ending December 29 they reached 13 percent in the fall stock and 11 percent in the spring stock. During January mortalities again fell to from 5.0 percent to 7.5 percent, after which time treatment with sulfa drugs was begun. Unfortunately there was no control and thus there is no way of knowing whether these changes in mortality resulted from the treatment with aureomycin.

In order to test the effectiveness of Aurofac on young salmonids at Steinhart Aquarium, two cold (49 to 51 degree F.) freshwater tanks of 1,000 gallons capacity each were prepared. Each tank was stocked with approximately 900 five-month-old fingerling king salmon (*Oncorhynchus tshawytscha*) with an average fork length measurement of 62 mm. Addition of Aurofac to the diet was initiated on May 3, 1951, using the maximum ratio recommended by the manufacturer: i.e., 1 pounds of Aurofac to 100 pounds of feed, or 55.9 p.p.m. of aureomycin in the food. The Aurofac in this proportion was mixed thoroughly with finely ground raw horse heart and fed to one group of the salmon fingerlings. The other group was held as a control, with the fish fed the same amount of heart without Aurofac. Both groups were fed once a day for six days of each week.

On July 31, 1951, Aurofac was discontinued and both tanks were fed only raw heart because of the obvious size difference between the fish in the Aurofac tank as compared with those in the control tank. When the results were tabulated, it was surprisingly found that Aurofac had actually retarded the fishes' growth (Table 1). At the end of 83 days on the Aurofac diet (July 25, 1951) the average growth increase was only 4.7 mm., in comparison with an average increase of 18.1 mm. in the control tank. The salmon in both tanks were infected with a bacterial disease. The symptoms were those of Earp's kidney disease as described by Earp, Ellis and Ordal (1953). Earp had identified this disease in another lot of young king salmon from Steinhart Aquarium

[3] To make comparisons easier, we have reduced all concentrations of aureomycin to parts per million, p.p.m. The p.p.m. as used here is the equivalent of the microgram per milliliter of the bacteriologist, and the milligram per liter or kilogram of the pharmacologist. The 50 milligrams per gallon of the aquarist equals 13.5 p.p.m. and the gram per ton of the feed man equals 1.11 p.p.m. The milligram per pound equals 2.22 p.p.m.

TABLE 1

Effects of Aurofac-enriched Diet Upon King Salmon Fingerlings

	Aurofac-enriched diet	Normal diet
Start of test—(May 3, 1951)		
Number of fish in each tank	900	900
Number of fish measured	17	17
Average fork length	62 mm.	62 mm.
83 days after start of test—(July 25, 1951)*		
Number of fish measured	18	18
Average fork length	67.0 mm.†	80.1 mm.†
Increase in average length in 83 days	4.7 mm.	18.1 mm.
Spread of measurements at end of 83 days	34 mm.	26 mm.
201 days after start of test—(November 20, 1951)		
Number of fish measured	12	12
Average fork length	87.9 mm.‡	106.5 mm.‡
Increase in average length in 201 days	25.9 mm.	44.3 mm.
Spread of measurements at end of 201 days	42 mm.	26 (44) mm.§
Mortality between July 26 and August 23, 1951	181	99

* Aurofac feeding stopped six days after this date, i.e., on July 31, 1951.
† t equals 4.84 and p equals less than .001.
‡ t equals 3.37 and p equals less than .001.
§ See text discussion.

early in 1951. The fish took food readily until the disease had advanced to the point that the fish were obviously very sick. Typical lesions of the disease could be found among the controls but they remained relatively healthy throughout the course of the experiment.

The mean fork lengths of the two groups were 67.0 mm. for those in the Aurofac tank and 80.1 mm. for those in the control tank. The "t" test of significance showed a value of 4.84, with a probability of occurrence of less than .001. Most significant was the difference in mortality rate. The controls had slightly more than one-half the mortality of the treated salmon. Three and three-quarters months later (i.e., 201 days or six and one-half months after start) another check was made of the growth rate in both tanks. The average increase in the control group was 18.4 mm. greater than that of the Aurofac group.

It has been reported that in addition to increased growth rate in pigs and chickens resulting from the use of Aurofac, this material has produced very uniform animals. By contrast, the exact opposite occurred after Aurofac had been fed to these salmon fingerlings. At the time of the 83-day check, the spread of length measurements of the Aurofac-fed fish covered 34 mm., whereas the controls covered only 26 mm. At the 201-day recheck the spread of measurements for the Aurofac-fed fish was 42 mm., and for 11 of the 12 controls, 26 mm. However, the twelfth control fish was much larger than the others and extended the spread of measurements another 18 mm. to 44 mm.[4]

From these data, it is apparent that Aurofac produced a detrimental effect upon king salmon fingerlings when fed at the maximum ratio recommended by the manufacturer. The effects of feeding Aurofac

[4] Samples taken on the 83d day (July 25) showed that the coefficient of variability, V, was 13.7 for the length measurements of the Aurofac-fed fish, whereas the V for the controls was 8.6. Samples taken on the 21st day (November 20) have a V of 16.2 for the Aurofac-fed fish and a V of 11.9 for the controls. (Coefficient of variability is the standard deviation expressed as a percentage of the mean.)

were: decreased growth rate, increased mortality, and increased runtiness. All of this happened in the presence of a disease that seemed to increase in severity.

Although there can be no doubt that the use of Aurofac in food has increased the growth rate in certain animals such as chickens and pigs, this has yet to be demonstrated in carefully controlled experiments with fish. There is evidence that aureomycin is effective in some fish diseases.

The careful assistance of Steinhart Aquarium staff members Walter Schmeebeli and Norval Green in carrying out this experiment is gratefully acknowledged. The Aurofac used in the test was furnished through the courtesy of William C. Loughlin and Company, San Francisco representatives of the Lederle Laboratories Division of the American Cyanamid Company.

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AGE AND LENGTH COMPOSITION OF THE SARDINE CATCH OFF THE PACIFIC COAST OF THE UNITED STATES AND MEXICO IN 1953-54[1]

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This report on age and length composition of the catch of sardines (*Sardinops caerulea*) off the Pacific Coast of North America is the eighth of a series which gives similar data from 1941-42 to the present season (Felin, et al.).

During the 1953-54 season, 2,856 tons were landed in the San Pedro region; this included fish landed at Santa Barbara, Port Hueneme, Santa Monica, Los Angeles-Long Beach Harbor, and Newport. During the same period, 316 tons were landed at San Diego; these fish were trucked to the Los Angeles area for processing, but are here referred to the San Diego region. Fish landings at Monterey and Santa Cruz amounted to only 113 pounds, and no samples were taken in this region. At Ensenada, Baja California, fishing is carried on throughout the year, but only data for the period August 2 through December 20, roughly approximating the California sardine season, were used in this report.

Sampling was carried on, in the manner described for the preceding season, at San Pedro, San Diego, and Ensenada.

Tables 1-5 show, by sex and region of catch, the length-frequency distributions of sardines of each year class as taken in the 1953-54 random scale samples.

Table 6 gives calendar dates for the lunar months included in Table 7.

Table 7 gives total tonnages and numbers of fish of each age caught in each region, estimated in the same manner as described for the preceding season.

Table 8 gives, by sex and region of catch, the mean length and standard error of the mean for each year class sampled in the 1953-54 season. These are based on the random scale samples.

Sampling and age determinations were continued by personnel of the California Department of Fish and Game and the U. S. Fish and Wildlife Service. A visiting fishery biologist, Miss Mary Samuel, from Central Marine Fisheries Research Station of the Ministry of Food and Agriculture, Government of India, assisted in processing of data.

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TABLE 1

Length Composition of the 1952 and 1951 Year Classes in 1953-54

Standard length mm.	1952 year class, age 1									1951 year class, age 2												
	San Pedro			San Diego			California total			San Pedro			San Diego			California total			Ensenada			Grand total		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
148	1		1				1		1															
150																								
152																								
154	1	2	3				1	2	3															
156	1	1	2				1	1	2															
158	1		1		1	1	1	1	2															
160	2		2				2		2															
162		1	1		1	1		2	2															
164	1		1	1	1	2	2	1	3															
166	2		2				2		2															
168	1	2	3	2		2	3	2	5				1		1	1		1						
170	1	1	2				1	1	2				1		1	1		1						
172	1		1		2	2	1	2	3															
174	1		1		1	1	1	1	2															
200										1		1				1		1						
202																								
204														1	1	1		1						
206													2	1	3	2	1	3						
208																								
210																								
212																								
214										1		1				1		1						
216				1		1	1		1	1	1	2				1	1	2						
218										1		1				1		1						
Totals	13	7	20	4	6	10	17	13	30	4	1	5	4	2	6	8	3	11						

TABLE 2

Length Composition of the 1950 Year Class in 1953-54

Standard length mm.	1950 year class, age 3														
	San Pedro			San Diego			California total			Ensenada			Grand total		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
196				1		1	1		1				1		1
198															
200				1		1	1		1	2		2	3		3
202											1	1		1	1
204					1	1		1	1	1	2	3	1	3	4
206	3	1	4	1	1	2	4	2	6	2	1	3	6	3	9
208	5		5	5	3	8	10	3	13		1	1	10	4	14
210	2		2	1	1	2	3	1	4		1	1	3	2	5
212	3	2	5	2	1	3	5	3	8	2	1	3	7	4	11
214	5	2	7		1	1	5	3	8	1		1	6	3	9
216	4	2	6	1	1	2	5	3	8				5	3	8
218	3	2	5		1	1	3	3	6				3	3	6
220	3		3		2	2	3	2	5				3	2	5
222		2	2					2	2					2	2
224	1	1	2	1		1	2	1	3				2	1	3
226		1	1	1		1	1	1	2				1	1	2
228		1	1					1	1					1	1
230		1	1					1	1					1	1
232		1	1					1	1					1	1
234															
236															
238		1	1					1	1					1	1
240		1	1					1	1					1	1
Totals	29	18	47	14	12	26	43	30	73	8	7	15	51	37	88

TABLE 3

Length Composition of the 1949 Year Class in 1953-54

Standard length mm.	San Pedro			San Diego			[illegible]			[illegible]			[illegible]		
	M	F	T	M	F	T	M	F	T	[illegible]			[illegible]		
198	1		1				1		1						
200	2		2				2		2						
202		1	1					1	1						
204					1	1		1	1	1					
206				2	1	3	2	1	3			2			
208	2		2	1	1	2	3	1	4						4
210	1	1	2	1	1	2	2	2	4						4
212	3	1	4	2	1	3	5	2	7						7
214	2	1	3		2	2	2	3	5						
216	4	3	7		1	1	4	4	8				4	4	8
218	1	1	2				1	1	2						
220		1	1		1	1		2	2						
222	3	2	5				3	2	5				3	2	5
224	1	1	2				1	1	2				1	1	2
226															
228	1	2	3				1	2	3				1	2	3
230	2		2				2		2				2		2
232		3	3					3	3						
234		3	3					3	3						
236	1	1	2				1	1	2						2
238															
240	2	2	4				2	2	4				2	2	4
242	1		1				1		1						
244	1		1				1		1				1		1
246		2	2					2	2					2	2
Totals	28	25	53	6	9	15	34	34	68	1	2	3	7	7	14

TABLE 4

Length Composition of the 1948 Year Class in 1953-54

Standard length mm.	1948 year class, age 5														
	San Pedro			San Diego			California total			Ensenada			Grand total		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
192										1		1	1		1
194															
196															
198				1		1	1		1				1		1
200				1		1	1		1	1		1	2		2
202										1		1	1		1
204					1	1		1	1	1	2	3	1	3	4
206	1	1	2	3		3	4	1	5		1	1	4	2	6
208	4	2	6	2	2	4	6	4	10	2		2	8	4	12
210	3	1	4	1	1	2	4	2	6	1	3	4	5	5	10
212	5	3	8	2	1	3	7	4	11		2	2	7	6	13
214	3	3	6	1	2	3	4	5	9		1	1	4	6	10
216	5	3	8		4	4	5	7	12		1	1	5	8	13
218	6	2	8	1	5	6	7	7	14				7	7	14
220	1	2	3	1	1	2	2	3	5				2	3	5
222	1		1		1	1	1	1	2				1	1	2
224	1	2	3				1	2	3		1	1	1	3	4
226	1	1	2				1	1	2				1	1	2
228		1	1					1	1					1	1
230	1	2	3				1	2	3				1	2	3
232	4		4				4		4				4		4
234	2	2	4				2	2	4				2	2	4
236	3		3	1		1	4		4				4		4
238	2	4	6				2	4	6				2	4	6
240	1		1				1		1				1		1
242		2	2					2	2					2	2
244	3	2	5				3	2	5				3	2	5
246		2	2					2	2					2	2
248		4	4					4	4					4	4
250	1	2	3				1	2	3				1	2	3
252		2	2					2	2					2	2
254		1	1					1	1					1	1
Totals	48	44	92	14	18	32	62	62	124	7	11	18	69	73	142

TABLE 5

Length Composition of 1947, 1946, and 1945 Year Classes in 1953-54

Standard length mm.	1947 year class, age 6									1946 year class, age 7									1945 year class, age 8					
	San Pedro			San Diego			California total			Ensenada			San Pedro			San Diego			California total					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
206				1	1	2	1	1	2					1	1	2		2						
208		2	2					2	2						2	2		2						
210																								
212	1	1	2				1	1	2					1	1	2		2						
214	2	1	3				2	1	3					2	1	3		3						
216	1		1				1		1					1		1		1						
218				2	1	3	2	1	3		1	1		2	2	4		4						
220		1	1					1	1						1	1		1						
222	1	2	3				1	2	3					1	2	3		3						
224	1		1		1	1	1	1	2					1	1	2		2						
226																								
228		1	1					1	1						1	1		1						
230	3		3				3		3					3		3		3						
232	1		1				1		1					1		1		1						
234	2		2				2		2					2		2	1	3						
236	1	1	2				1	1	2					1	1	2		2						
238	3	2	5				3	2	5					3	2	5	1	6						
240	2	1	3				2	1	3					2	1	3	2	5						
242	1	2	3				1	2	3					1	2	3		3	1		1			
244		6	6					6	6						6	6	1	7						
246		3	3		1	1		4	4					1	4	5	1	6	1	1	2			
248	2		2				2		2					2		2	1	3			1			
250		1	1					1	1						1	1		1		2	2			
252		2	2					2	2						2	2		2		2	2			
254																								
256		1	1					1	1						1	1		1		3	3			
258	1		1				1		1					1		1		1						
260	1		1				1		1					1		1		1		1	1			
262		1	1					1	1						1	1		1						
264	2		2				2		2					2		2		2						
Totals	25	28	53	3	4	7	28	32	60	0	1	1	28	33	61	10	10	20						

TABLE 6

Calendar Dates of Lunar Months for the 1953-54 Season

"August"	July 26-August 23
"September"	August 24-September 22
"October"	September 23-October 22
"November"	October 23-November 20
"December"	November 21-December 20
"January"	December 21-January 19
"February"	January 20-February 17

TABLE 7

Age (Year Class) Composition of the Sardine Catch in the 1953-54 Season (Numbers of fish are given in thousands, i.e., 000 omitted)

	Catch		Number of fish by age (year class)							
	Tons	Nos.	1	2	3	4	5	6	7	8
			1952	1951	1950	1949	1948	1947	1946	1945
San Pedro										
"October"	1,365	9,240	554	263	2,297	1,848	3,631	594	53	--
"November"	1,075	5,818	381	84	924	937	1,733	1,261	401	97
"December"	80	474	389	85	--	--	--	--	--	--
"January"	316	1,964	--	65	393	471	733	223	79	--
"February"[1]	20	124	--	4	25	30	46	14	5	--
Totals San Pedro	2,856	17,620	1,324	501	3,639	3,286	6,143	2,092	538	97
San Diego[2]										
"October"	289	1,908	114	54	474	382	750	123	11	--
"November"	21	298	19	4	47	48	89	65	21	5
"December"	6	99	81	18	--	--	--	--	--	--
Totals San Diego	316	2,305	214	76	521	430	839	188	32	5
Totals California	3,172	19,925	1,538	577	4,160	3,716	6,982	2,280	570	102
Ensenada										
"August"	1,241	6,552	--	524	2,097	524	3,407	--	--	--
"September"	1,275	[3]9,963	--	797	3,188	797	5,181	--	--	--
"October"	709	4,170	--	250	1,793	292	1,752	83	--	--
"November"	406	2,388	--	143	1,027	167	1,003	48	--	--
"December"	3,221	18,949	--	1,137	8,148	1,326	7,959	379	--	--
Totals Baja California	6,852	42,022	--	2,851	16,253	3,106	19,302	510	--	--
Grand totals	10,024	61,947	1,538	3,428	20,413	6,822	26,284	2,790	570	102

[1] Numbers of fish for this lunar period were prorated at the same ratio of age composition as the San Pedro catch for January.
[2] Numbers of fish in the San Diego catch were prorated at the same ratio as the San Pedro catch for the comparable months.
[3] Numbers of fish for this lunar period were prorated at the same ratio as the Ensenada catch for August.

TABLE 8

Number of Fish, Mean Length, and Standard Error of the Mean for Each Year Class in the 1953-54 Season, by Region of Catch

Year Class	San Pedro							
	No.	ML	SE	No.	ML	SE	No.	ML
1952								
Male	13	163	1.05	4	179	0.58		
Female	7	162	1.34	6	167	1.34		
Total	20	162	0.81	10	173	1.24		
1951								
Male	4	212	2.01	4	188	1.34	0	
Female	1			2				
Total	5	213	1.63	6	193	2.84	0	
1950								
Male	29	213	0.46	14	210	1.07	5	
Female	18	222	1.10	12	212	0.80	2	
Total	47	216	0.58	26	211	0.68	7	
1949								
Male	28	220	1.21	6	209	0.56		
Female	25	226	1.16	9	212	0.85	2	
Total	53	223	0.86	15	211	1.25	2	
1948								
Male	18	223	0.87	14	211	1.26	7	230
Female	41	228	1.15	18	215	0.56	14	228
Total	92	226	0.74	32	213	0.64	18	228
1947								
Male	25	236	1.50	3	211	2.00	0	
Female	28	237	1.39	1	224	1.19	1	
Total	53	237	1.01	7	219	2.55	1	
1946								
Male	10	237	1.51					
Female	10	252	0.84					
Total	20	245	1.20					
1945								
Male	0							
Female	1							
Total	1							

NOTES

A RECORD-SIZE THRESHER FROM SOUTHERN CALIFORNIA

On May 14, 1954, the Independent Fish Co., San Pedro, [illegible] an unusually large female common thresher, *Alopias vulpinus*, which contained four embryos approaching birth. The shark was brought into the market by Mr. Joe Stagnaro, owner of the boat Stroll II, after becoming entangled in his gill nets the previous night approximately five miles off Newport Beach. Statements from both the fisherman and the men in the market indicated that this was the largest thresher they had ever seen and was, moreover, the first from which the had taken pups. The pups were saved and presented to the California State Fisheries Laboratory, Terminal Island, but unfortunately the adult was neither measured nor weighed and had been reduced to an efficiently trimmed carcass 86 inches in length when first seen by our personnel.

The tail, esimated by Mr. Stagnaro to be between eight and nine feet in length, had been cut off in order to facilitate removal of the fish from the net. In the market, the head was removed from the body with a cut beginning approximately 16 inches behind the snout and running down and back over the gill slits. The caudal peduncle was severed just anterior to the caudal fin. If 16 inches (for the head) is added to our measured carcass length of 86 inches we arrive at a minimum figure of 102 inches exclusive of the tail. Proportional measurements for *Alopias vulpinus* on the Atlantic Coast (Bigelow and Schroeder, 1948), as well as those obtained from the embryos of the present specimen, indicate that the 102 inches represents but 46 to 48 percent of the total length. The total length, then, was presumably between 17.7 and 18.5 feet with the addition of the tail. Estimates of the fisherman and the men in the market, as well as figures given by Bigelow and Schroeder, indicate that 600 pounds would be a conservative weight for this animal.

In view of the remarks "Reaches no great size in California. Most specimens seen run from five to eight feet." (Roedel, 1953), it would appear that this individual, approximately 18 feet in length, was not only unusual but probably constitues a record size for threshers landed in California.

According to information given by Bigelow and Schroeder, *Alopias vulpinus* does not mature sexually before attaining a length of at least 14 feet. Since threshers of this size appear to be exceptionally rare off California, while the small immature fish are relatively common, we might speculate on the reasons for this apparent difference in distribution between young and adults. Probably either the adults live considerable distances offshore, where their chances of being captured

TABLE 1

Measurements of Four Term Embryos of the Thresher, Alopias vulpinus

Body measurement	Percentage of total length	
Total length in mm.: 1,228, 1,273, 1,280, 1,367	Range	Average
Snouth length:		
In front of eye	3.7– 4.0	3.9
In front of outer nostril	3.0– 3.4	3.2
Distance between inner ends of nostrils	1.3– 1.5	1.4
Eye diameter:		
Horizontal	1.1– 1.3	1.2
Vertical	1.7– 1.8	1.8
Interorbital width	4.0– 4.2	4.1
Mouth width	5.2– 5.5	5.4
Gill opening lengths:		
1st	2.0– 2.4	2.2
2d	2.3– 2.6	2.4
3d	2.6– 2.7	2.7
4th	2.5– 2.7	2.6
5th	2.3– 2.5	2.4
Distance from snout to:		
Insertion first dorsal	22.6–23.7	23.1
Insertion second dorsal	41.4–42.2	41.8
Insertion pectoral	15.4–16.2	15.8
Insertion pelvic	33.7–35.0	34.5
Insertion anal	42.4–44.0	43.3
Upper precaudal pit	46.9–48.1	47.5
Tip lower caudal lobe	50.8–55.0	52.8
First dorsal fin:		
Anterior margin	8.0– 8.5	8.2
Vertical height	5.3– 5.7	5.5
Length attached base	6.1– 6.4	6.3
Insertion to tip posterior lobe	6.7– 7.0	6.9
Second dorsal fin:		
Vertical height	0.6	0.6
Length attached base	0.7– 0.9	0.8
Insertion to tip posterior lobe	2.1– 2.2	2.2
Anal fin:		
Vertical height	0.8	0.8
Insertion to tip posterior lobe	2.0– 2.5	2.3
Pectoral fin:		
Anterior margin	14.3–14.8	14.6
Insertion to tip posterior lobe	8.2– 8.6	8.4
Pelvic fin:		
Anterior margin	5.4– 6.1	5.7
Insertion to tip posterior lobe	6.6– 7.2	6.9
Distance from:		
Posterior insertion 1st dorsal to anterior insertion 2d dorsal	13.1–13.7	13.4
Posterior insertion 2d dorsal to upper precaudal pit	4.8– 5.2	5.0
Anterior insertion anal to lower precaudal pit	3.6– 4.0	3.8
Caudal fin:		
Upper precaudal pit to tip of upper lobe	52.0–54.1	53.0
Lower precaudal pit to tip of lower lobe	6.6– 7.3	7.0

are consequently slight, or, since the species is primarily a temperate and warm temperate form, the majority of larger individuals of breeding size occur in warmer waters to the south of California. Reports from reliable observers tell of seeing enormous threshers in the Gulf of California, and certainly 18- to 20-foot individuals would not be considered unusual along the tropical American coasts.

The four pups taken from the female weighed a total of 50 pounds, ranging individually from 11.2 to 13.6 pounds. In total length they varied from 48.3 to 53.8 inches and the sexes were equally divided. Free-living threshers of a smaller size have been taken on the New England coast and there is no doubt that these present specimens were practically ready for birth. Their umbilical scars, though still visible, were very inconspicuous.

Because published data giving proportional measurements for the species are based on only a few individuals, and none of these are Pacific Coast threshers, the four young specimens were measured to add to the relatively meager record. Measurements were made to the nearest millimeter and are expressed in Table 1 as a percentage of the total length (snout to tip of upper caudal lobe).

All measurements were made with either calipers or dividers and hence are straight line measurements between points on the surface of the body. For example, the distance from the snout to the insertion of the first dorsal fin was determined by placing one caliper point at the tip of the snout and the other at the anterior insertion of the first dorsal, thus actually measuring a hypothetical straight line running diagonally between these two points. It should be noted that certain body measurements made by Bigelow and Schroeder on Atlantic Coast *Alopias vulpinus* were made in a significantly different way and are not directly comparable to ours. Their measurement of snout to first dorsal insertion, for example, is along a horizontal line between perpendiculars from the two points and gives a shorter measurement than that obtained by our method.

Although as yet the data are far too scanty to draw any conclusions, certain discrepancies in body proportions appear between this material and a like-sized individual from the Atlantic Coast. These discrepancies appear too great to be accounted for by differences in methods of measurement alone.

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—*David C. Joseph, Marine Fisheries Branch, California Department of Fish and Game, June, 1954.*

OCEAN RECOVERIES OF SACRAMENTO RIVER TAGGED STEELHEAD

Two tagged steelhead rainbow trout, *Salmo gairdneri gairdneri,* have recently been recovered by ocean fishermen off the California coast. Both fish had been tagged and released in the Sacramento River near Fremont Weir, 81 river miles above the confluence of the Sacramento and San Joaquin Rivers, by personnel of Federal Aid Project F7R. The fish were trapped for tagging while on their upstream spawning migration.

Mr. Don Hitchcock of San Francisco returned a tag taken from a 21-inch steelhead caught May 28, 1954, eight miles southeast of the Farallone Islands, 23 miles off San Francisco. It was caught on commercial salmon troll gear, with herring for bait. This fish was tagged January 8, 1954, with Petersen disks attached with stainless steel wire.

Mr. Arthur Smith of San Francisco returned a tag taken from a 25-inch female steelhead caught three miles off Point Reyes, Marin County, on June 13, 1954. It was taken on a 2½-inch gold-colored spoon trolled at a depth estimated to have been between 25 and 30 feet. This fish was tagged with a tantalum wire attached staple tag (Calhoun, *California Fish and Game,* 1953, vol. 39, no. 2, p. 209-218) on August 21, 1953. Three months later, on November 22, 1953, it was checked through the counting station at the fish ladder over the Clough Dam on Mill Creek, Tehama County. This station is 155 stream miles above where the fish was tagged.

While certainly not unexpected, these are the first reports of any Sacramento River tagged steelhead being recovered outside the Golden Gate. More than 2,600 adult steelhead have been tagged near Fremont Weir since July, 1950.—*Elton D. Bailey, Inland Fisheries Branch, California Department of Fish and Game, July, 1954.*

DELAYED DECOMPOSITION OF A TROUT CARCASS

Carcasses of trout are often seen early in the spring in lakes, especially near the shores, and their deaths are commonly attributed to "winter-kill." Dead fish, often showing little decomposition, are sometimes also found well into the summer; their deaths have generally been assigned to other factors, such as disease. The following observation of delayed decomposition of a fish carcass made in Castle Lake, Siskiyou County, California, is of interest in this connection and suggests that at least in some instances they may also have been caused by winter-kill.

On October 9, 1946, Castle Lake was treated with rotenone to eliminate all fish life (Wales, *California Fish and Game,* 1947, vol. 33, no. 4 p. 267-268). This lake has a surface area of 47 acres, a maximum depth of 120 feet, and lies at an elevation of 5,200 feet.

Six species of fishes were present in Castle Lake at the time: Lake Trout, *Salvelinus namaycush;* Rainbow Trout, *Salmo gairdneri;* Brown Trout, *Salmo trutta;* Eastern Brook Trout, *Salvelinus fontinalis;* Golden Shiner, *Notemigonus crysoleucus;* and Klamath Speckled Dace, *Rhinichthys osculus klamathensis.*

Cubé powder with a 5.4 percent rotenone content was applied at the general rate of 1.35 pounds per acre foot of water, and several hundred extra pounds were placed in the deeper water to ensure complete kill.

Numerous tests made with trout in live cages indicated the existence of lethal conditions in the lake until July, 1947. The explanation for this exceptionally long period for the dissipation of the rotenone is thought to lie in the fact that (1) the lake froze over soon after the treatment, reducing the circulation of water and delaying the oxidation of the rotenone and (2) an unusually large quantity of derris powder was placed in the deep water. Whatever the reason for the long period of toxicity, there seems little doubt that all fish were killed.

On May 31, 1951, the writer was in a skiff on the lake when he saw a white object bouncing on the waves against the rock cliffs at the south end of the lake. On rowing closer it was apparent that the object was a portion of a fish carcass. It was carefully lifted into the boat and found to be the mid-section of a fish that probably had weighed about eight pounds. Although some decomposition had taken place the flesh was still firm. The skin had disappeared, the bones were soft and each myotome stood out clearly. The odor was definitely that of decaying fish, but not nearly as strong as that of spent salmon carcasses.

At the time of chemical treatment the lake contained some lake trout weighing as much as 15 pounds and brown trout possibly as large as 10 pounds. Therefore, the carcass found 55 months later could have been of either species.

It is known that after chemical treatment many of the fish settled to the bottom, from which they could not be recovered. This was particularly true in the south end of the lake, where the maximum depth is 120 feet. Temperatures at a depth of 100 feet in Castle Lake have been known to reach 52 degrees F. in July, but probably do not rise above 40 degrees F. for more than four months of the year. At a depth of 100 feet the oxygen content is low, ranging from 1 to 5 p.p.m. There is considerable ooze on the bottom in this portion of the lake and fish may settle into it so that they are insulated from the warmer summer temperatures, and possibly cut off from oxygen. It is probable that this particular carcass decomposed at an extremely slow rate, until finally, in the spring of 1951, enough gasses had accumulated to bring it to the surface.—*E. R. Gorman, Inland Fisheries Branch, California Department of Fish and Game, July, 1951.*

A BLUE CRAYFISH FROM CALIFORNIA

Blue crayfish have been reported from the eastern United States a number of times. These reports concern either crayfish in which the normal color is blue (*Cambarus carolinus monongalensis*) or blue varieties or random blue individuals of otherwise normally colored animals. These blue crayfish seem to be restricted to the genera *Cambarus* and *Procambarus*. Dr. Horton H. Hobbs, Jr. (*in litt.*) reports that he has observed blue members of several species of *Procambarus* and occasional specimens of *Cambarus bartoni bartoni* and *C. longulus longulus*, as well as others. Published reports by Newcombe (1929a, 1929b) and Penn (1951) discuss the occurrence of blue crayfish in otherwise normal populations. It was of interest therefore to find an example of the "blue phase" in a California crayfish of the genus *Pacifastacus*. (Botts (1950) established *Pacifastacus* as a new genus for our native west American crayfishes and used *Astacus klamathensis* Stimpson as the genotype.)

Through the kindness of Mr. Dan Dean of Berkeley we received in September of 1953 a bright blue specimen which he had collected in Silver Lake, Amador County. The specimen was an immature male about three inches long. We have kept the specimen alive and it has moulted twice and now measures four inches from rostrum to telson. The first moult was sent to Dr. Hobbs, who considers it to be intermediate in character between *P. leniusculus* and *P. trowbridgi*.

The writer has submitted the above brief account for two purposes: first, to record the occurrence in the genus *Pacifastacus* of the "blue phase" and, secondly, in the hope that some of the readers of this journal may have information concerning the occurrence of other blue crayfish in California. Very little is known as to the causes of the random appearance of blue crayfish and, indeed, little more will be known until a careful study has been made of living specimens. If any reader of this note has information to contribute it is solicited and will be gratefully received. We are particularly anxious to obtain more living examples of blue crayfish in the hope that experimental studies can be made which will elucidate this rather unusual phenomenon.

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—Cadet Hand, Department of Zoology, University of California, Berkeley, March, 1954.

REVIEWS

Biological Conservation

By John D. Black; The Blakiston Company, Inc., New York, 1954, xiv + 446 p., 75 figs., 85.

This is a book written to serve at the college level as a text for [illegible] tion. The author himself states with reference to the subject matter: "I do not propose to exhaust the field of conservation but rather to build a foundation of information concerning renewable resources such as soil, water, [illegible] forests; to present an introductory study of the problem of wildlife conservation and then to consider wildlife conservation from the broader viewpoint."

Organization is excellent, with chapters and subheadings distinctly following each other in logical sequence. The text is divided into six major parts: Basic Considerations, The Environment, Fish and Other Aquatic Animals, Birds, Mammals, and Solving the Problem.

Although the space devoted to major individual wildlife species is necessarily limited, capable selection of material has been exhibited and the current status of important species on a national basis is clearly presented.

Most textbooks tend to be a rather dry assemblage of factual data, but here the author has demonstrated his ability to write interestingly and at the same time to maintain factual integrity. Well chosen illustrations dispersed throughout add to its attractiveness.

No attempt is made to introduce the subject of our marine fisheries resources. This is believed a rather serious omission, in view of the proclaimed objectives of the author. As the title indicates, emphasis has been placed upon wildlife, with somewhat limited supporting data on the conservation of water, soils, and forests. It is, therefore, not anticipated that this book will replace any of the standard general conservation textbooks now in use, which give a broader introduction to the subject. It should, however, serve as a supplemental reference for those seeking a well rounded picture of conservation of our inland fishes, birds, and mammals.

An annotated bibliography recommended as a core library for reference work in biological conservation should prove useful to those desiring to delve further into the subject. Also included as a separate appendix is a film guide designed to acquaint teachers with some of the better conservation films and how they may be obtained; a worthwhile feature, despite the fact that it may soon become out-dated.

Although this book is written for the beginner, rather than the professional wild life man, most workers in the various fields of conservation may profit by reading it. Most of us are prone to become so involved in our own specialty that the importance of such basic necessities as our soils, forests, or waters are given insufficient attention. We need periodically to read a book of this type to realign our perspective.—*Willis A. Evans, California Department of Fish and Game.*

Intertidal Invertebrates of the California Coast

By S. F. Light; revised by Ralph I. Smith, Frank A. Pitelka, Donald P. Abbott, and Frances M. Weesner; University of California Press, Berkeley, 1954, xiv + 446 p., 138 text figs. 85.

Based on S. F. Light's syllabus "Laboratory and Field Text in Invertebrate Zoology," the present book, extensively revised, is the work of 22 leading zoologists. A few of these contributors include such authorities as Cadet Hand (sea anemones), Libbie Hyman (flatworms), Olga Hartman (polychaetes), Robert J. Menzies and Milton A. Miller (isopods), Irwin M. Newell (marine mites), Joel W. Hedgpeth (pycnogonids), Joan C. Rattenbury and R. I. Smith (bryozoans), and Donald P. Abbott (ascidians). There are also sections by Rolf Bolin on intertidal fishes and Isabella A. Abbott on common conspicuous algae. For each group, there is a list by up-to-date scientific name of the species known from the region. The keys in

many instances represent original research and cover an assemblage of species for which keys do not exist elsewhere. The reviewer tested several of these and found them all workable.

A 52-page section giving general directions for field work and suggested field studies is well worth time spent in careful perusal. Especially important is the brief section labeled "Field Notes." There are many professional zoologists who would do well to read and then abide by the rules set forth here.

There is a fairly complete phylogenetically arranged bibliography, and the entire volume is well indexed.

While probably much too technical for the average citizen, this book should become a highly prized and (in time) well worn possession of every serious student and professional zoologist.—*John E. Fitch, California Department of Fish and Game.*

American Seashells

By R. Tucker Abbott; D. Van Nostrand Company, Inc., New York, 1954; xiv + 541 p.; 24 color and 16 black and white plates; 100 text figs. $12.50.

Recent, reliable, all-inclusive works on American seashells could, until this present volume, be considered as rare as some of the shells Mr. Abbott discusses on page six. The scope includes marine waters of the Atlantic Coast from Labrador to Florida, the Caribbean Islands, and the West Indies; of the Pacific Coast from Alaska to Lower California and Central America. Since it would be a physical impossibility to describe properly in one volume the more than 6,000 kinds of mollusks which are to be found within these geographical limits, the author is to be commended for having selected 1,500 species which in most instances include representative shells of the two ocean shores. The reviewer fully realizes there are those who will take exception to this statement and should like to add at this point that while he feels the Pacific fauna (considerably richer than that of the Atlantic) was somewhat slighted, the basic types, though often Atlantic forms, are definitely illustrated. A rather rough check of all groups shows Atlantic Coast gastropods, bivalves, tusk shells. and cephalopods ahead of Pacific Coast representatives by some 440 to 225, 260 to 145, 10 to 1, and 10 to 5, respectively. Only among the chitons (20 to 10) are more Pacific than Atlantic specimens described.

The several beginning chapters show excellent taste and make extremely interesting reading. These cover a diversity of subjects: "Man and Mollusks," lives of the various mollusks, collecting, and "How to Know American Seashells." A systematic account takes up 400 pages and includes scientific and common names, geographical ranges, descriptions, comparative remarks, and habitats of the 1,500 species. This is followed by an annotated bibliography, which is arranged by both area and subject matter. The entire volume is completely indexed.

The illustrations (by F. M. Bayer and J. C. McConnell) are clear and concise and the colors for the most part fairly true.

In general the volume is so well done that it almost makes the reviewer feel picayunish for criticism of the author's choice of common names for a very few Pacific Coast species. Prime among these is the use of "Californian tagelus" for a species which in 1952 alone realized over $15,000 to California bait diggers and is known to over 1,500,000 sport fishermen and bait dealers in California as the "jackknife clam." The few other common names to which the reviewer takes exception are again those used for species which are of economic importance on the Pacific Coast and which differ greatly from names printed in our fish and game laws or on our marketed products. Common names, regardless of the care with which they are selected, will always be a bone of contention with some individuals. Generally speaking, however, the names used in this work are exceptionally good and many lead one to wish that he had thought of them first.—*John E. Fitch, California Department of Fish and Game.*

The Book of Wild Pets

By Clifford B. Moore; Charles T. Branford Co., Boston, Mass., 1954; xii + 353 p., 128 drawings, 214 photographs. $5.95.

To quote from the author's prefatory remarks: "This volume is intended as a handy reference and source book on the care and feeding of our most common native (and in a few cases, 'naturalized') wild life forms in captivity, and should prove especially useful to teachers, laboratory and museum workers, boy and girl scouts, parents, and, in fact, to all whose backyard is the forest, desert, or merely subur-

ban foothills." After reviewing the content of [illegible] information contained therein could be used ad[illegible] state conservation departments, being especially [illegible] the general public and to workers in research laboratories. Most [illegible] to those $61 questions asked by the public are in the [illegible]. Various [illegible] presented have been well documented by the author [illegible] previous literature on the subject.

There is a surprising amount of information and reference [illegible] which are grouped into five major parts: The Aquarium, [illegible] Spiders as Pets, Mammals, and Birds. You can find out [illegible] boxes as floor size, entrance hole diameter, cavity depth, [illegible] for a variety of birds. Or, you can find out in detail the [illegible] intake for a mammal such as the skunk. The index, while [illegible] in its coverage of major subject divisions and featured animals.

Each of the five parts of the book has a list of "Other Helpful Materials." These listings are somewhat annoying, since they do not follow any [illegible] logic, or systematic order. Also, the pictures and charts, which [illegible] good in quality, are not necessarily closely related to the text.

One would gather from reading the book in detail that the taking of [illegible] for pets is a simple matter, with few problems attached, and with no [illegible] involved. However, the author is careful to give judicious warning [illegible] taking of game birds, as well as small native birds. He refers the reader to [illegible] conservation agencies and the Federal Government for permits and details.

The section on the care of deer, while giving good information about [illegible] nothing to discourage the reader from purposely obtaining a young deer. Since California law prohibits the taking of deer fawns, this section of the book is misleading to Californians and to residents of other states where similar laws are in effect.

Readers here in the West may find themselves somewhat at a disadvantage because the majority of the animals and plants discussed are eastern forms. Western forms such as the ring-tailed cat are omitted. However, the type of information presented for the eastern forms still should be applicable to a large degree in the West.

Workers in the field of fish and game management and natural history should find this book highly useful in their day to day contacts with the ever-questioning general public. It already has proved very useful in the work of the California Junior Museum. This book is written in a simple style which should be easily understood by the layman as well as the technician. *Fred G. Evenden, Director, California Junior Museum, Sacramento.*

Tricks That Take Fish

By Harold F. Blaisdell; Henry Holt and Company, New York, 1954; vi + 229 p., line drawings by Walter Hower. $3.95.

It is evident that the author of this book has spent considerable time and effort fishing inland waterways and in the study of feeding habits of game fishes. These studies have resulted in the development of various fishing methods that put fish in the creel. The title of the book could appropriately be changed to "How to Fish."

Ten chapters are devoted to the use of all types of sport fishing tackle, various natural baits and artificial lures, and specific methods of their use. Bait casting is particularly stressed.

Throughout the book Mr. Blaisdell points out that the method of presenting a lure is actually the "trick" that takes fish. To achieve this end he explains various methods, new and old, to put the lure where it presents a good imitation of natural food for the fish. Many methods are further explained by the use of sketches.

The "how-to-do-it" methods are adequately discussed, and spiced with stories of streamside experiences. The book is definitely written for the angler who has a working knowledge of fishing methods, and brings out the finer points of the art.

"Tricks That Take Fish" should be a welcome addition to a fisherman's library, and will enable him to make better catches as well as to enjoy fishing more fully. *—Chester Woodhull, California Department of Fish and Game.*

Traité de Pisciculture, Second Edition

By Marcel Huet; Éditions La Vie Rustique, Brussels, Belgium, 1953; xii + 371 p.; 280 figs. Boards 285 Belgian francs, cloth 345 Belgian francs; postpaid.

This second edition maintains the same high quality as did the first. Small changes occur throughout the text, but the major difference is noted primarily in Chapter V, Article IV, "Pisciculture des Tilipia." This emphasis is more appreciated when the great impetus in the use of *Tilipia* throughout Africa and the Far East is realized.

The illustrations are excellent and although the French text precludes its effective use by many American fish culturists it will certainly prove useful to those who are bilingual.—*J. B. Kimsey, California Department of Fish and Game.*

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