CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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Please direct correspondence to:

Mr. Phil M. Roedel, Editor
California State Fisheries Laboratory
Terminal Island Station
San Pedro, California

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AN OUTLINE OF CALIFORNIA FISHING GEAR[1]

By W. L. SCOFIELD
Bureau of Marine Fisheries
California Division of Fish and Game

This article succeeds "An Outline of Fishing Gear," which appeared in the April, 1938, issue of "California Fish and Game" (Vol. 24, No. 2, p. 185-190). Much of what follows is taken directly from the earlier publication, but the material has been revised and brought up to date. The outline here presented is limited to California and does not include a number of unusual kinds of gear used in foreign countries. It does include a few illegal fishing devices occasionally attempted by an optimist before court fines dampen his enthusiasm.

A visitor new to California is often confused by the many kinds of gear used in ocean fishing along our coast. Not only is there variety in the fishing devices themselves but there is such diversity in names that the newcomer is led to believe there is more complexity than actually exists. Later on he learns that some of the English, Sicilian, Dalmatian and Portuguese names are merely duplications of terms applied to the same type of fishing gear. The confusion is still further reduced when he realizes that many of the devices are similar in the method in which they are operated and that two or more appliances may differ only slightly in construction, depending on the manner in which they are to be fished. The different devices for catching ocean fish may be grouped into related types according to use and it is the purpose here to present such an orderly arrangement in the hope that it will aid somewhat in reducing the misleading complications in kinds and names of gear.

A few of the terms in the outline need a little explanation. "Fishing gear" obviously means all the apparatus and implements adapted to catching fish, except that as here used gear does not include the boat employed in the fishing operations. Incidentally fishing boats are commonly called by the name of the gear fished by them, as gill netter or purse seiner, for example, and likewise the men of the boat are designated by the gear they operate so the fishermen may be otter trawlers, hand liners or trammel netters.

The word net is a very general and inclusive term. Our words net and knot are related and a net is a fabric made by knotting cords leaving openings of uniform size. Such a fabric or net may therefore be used for confining fish, butterflies or straying locks of hair. The essentials of most (but not all) fishing nets are a wall of netting or webbing hanging vertically in the water with the upper edge buoyed by floats and the lower edge weighted. When such a wall of webbing is pulled through the water onto a beach or aboard a boat it is called a seine. Stationary nets are not called seines.

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[1] Submitted for publication March, 1951.

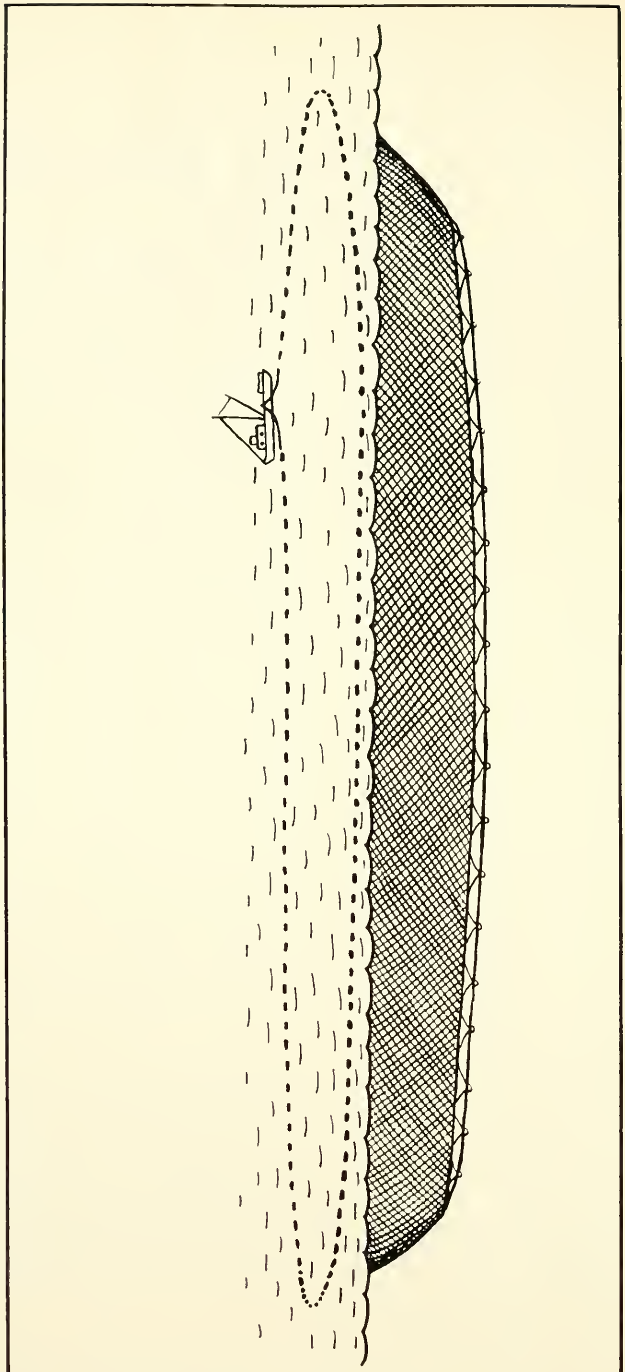

FIGURE 149. A purse seine laid out in a circle ready to be pursed, that is, closed on the bottom. Drawing by the author.

FIGURE 150. Pulling in a bait net over the stern of the fishing boat. *Photograph by R. D. Collyer.*

In this outline the frequently applied terms circle net and haul seine have been avoided because they are indefinite. It is convenient to use the general term ''round haul'' to include all the seines that are laid out in a circle (until the two ends meet) and then pulled aboard a boat. Round haul therefore includes the purse seine, lampara, ring net, and most bait nets but excludes beach seines and entangling gill nets layed out in a circle. The two basic types of round haul are the purse seine and lampara. The purse seine, after circling, is closed on the bottom by pulling a purse line (draw string) threaded through rings along the lead line. Like the early English money pouch, this purse also holds valuables. Typically, the purse seine is hauled aboard the fishing boat by pulling in from one end of the net. The lampara has no purse rings but is, at least partially, closed on the bottom by pulling the lead line in advance of the cork line. The two ends of the lampara are pulled aboard simultaneously. Years ago the lampara was modified by adding purse rings along part of the lead line, giving rise to the term ''half ring,'' but the practice of half ringing was of short duration because it was not long before the purse rings were extended all the way around the lampara lead line. We now call this hybrid gear ''ring net'' for want of a better name. The ring net is pursed like a purse seine but is pulled aboard from both ends at once like the lampara. The name ''half ring'' is still applied to ring nets by older fishermen but this term, if used at all, should be applied only to a seine that is ringed half way around the lead line. Such seines are now a rarity in California. Small and medium sized lamparas without rings persist on this coast as bait nets.

A net when laid out, cast, circled or shot is said to be ''set'' or ''in a set'' and the captain or the boat itself is said ''to set on'' a school of

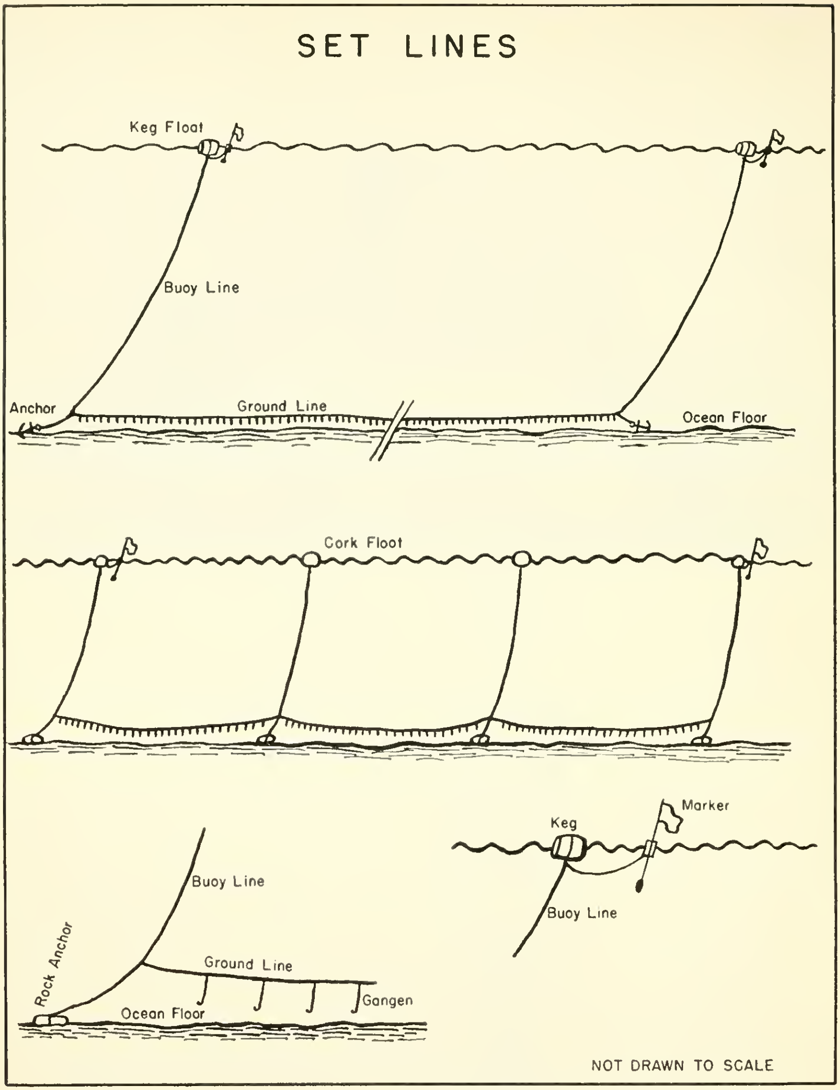

FIGURE 151. Illustrating two of the many forms of set lines. Drawing by the author.

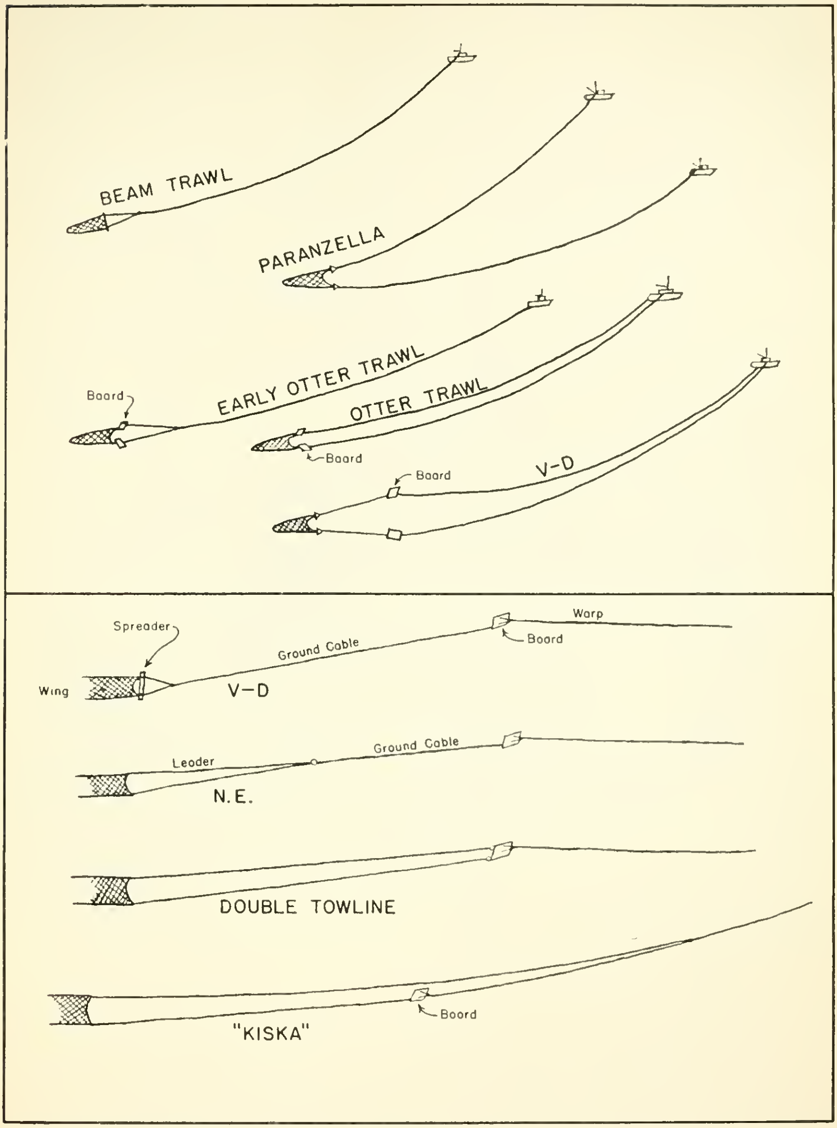

FIGURE 152. Sketch to show beam and paranzella trawls, two forms of early otter trawls, and the improved V-D type. Lower half of the figure illustrates four methods of placing the otter board in advance of the net wing. Drawing by the author.

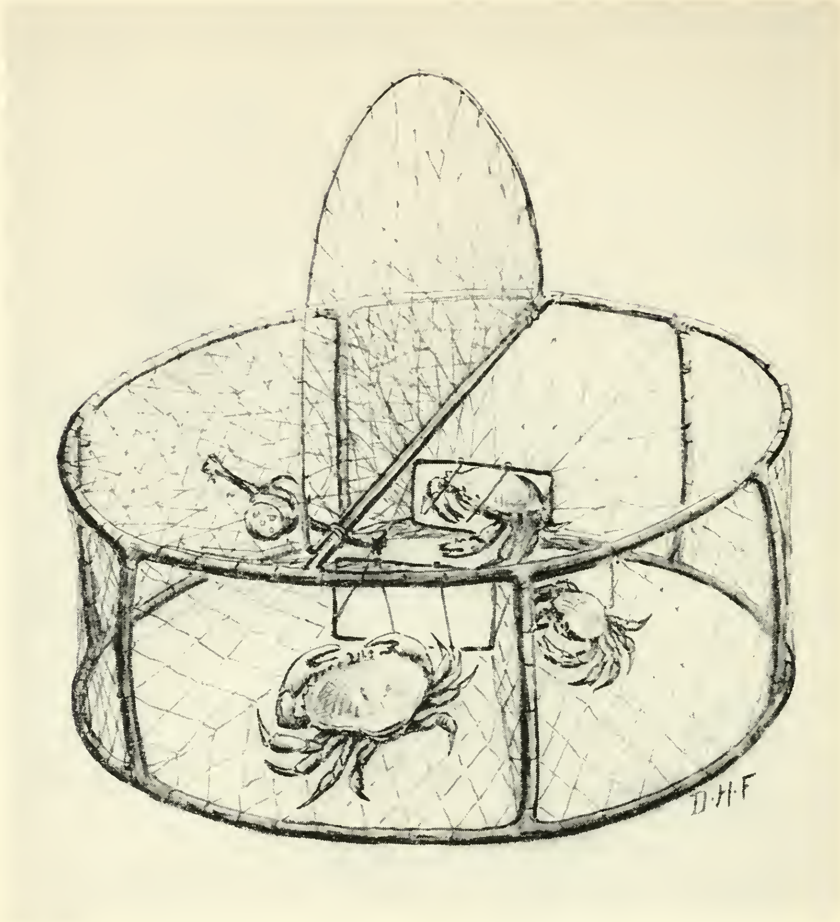

FIGURE 153. A crab trap of stainless steel wire woven about a welded iron frame. Note the rectangular opening to allow escape of undersized crabs. *Drawing by Donald H. Fry, Sr.*

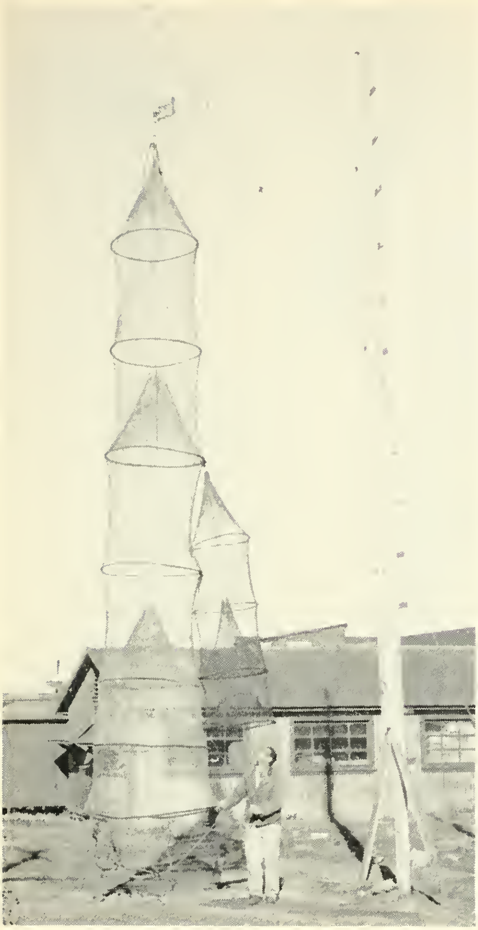

FIGURE 154. An old style river catfish net shown to the right of the modern fyke net. *Photograph by D. H. Fry, Jr.*

fish, but this is not the meaning of the word "set" as applied in the classification of gear. A net or line is considered set when it is anchored or in some way attached to the bottom or shore so that it is not free to move with water or air currents. By contrast a drift line or net has no such fixed attachment to the bottom or shore and is therefore free to drift with any current.

Two simple words of similar sound but very different meaning are often confused — troll and trawl. Trolling is pulling a line with one or more hooks through the water as from the stern of a boat while under way. A trawl is a bag net intended to be dragged along, on or near the bottom of the sea, so trawling is the dragging of such a net. Fortunately in this State we are spared the confusing application of the word trawl to a long stationary set line as is so frequent among fishermen in some of our eastern states.

A fish trap is some sort of an impounding device, drifting or set, and the term may be applied to a great variety of such structures. most of which are not permitted under California law. Small traps for fish, lobsters or crabs may legally be used in parts of this State under certain circumstances, and such traps may be built of wood slats or more commonly of wire netting over an iron frame. A small trap constructed of cord webbing over hoops is anchored in streams but this, as well as the wicker trap fished by our Indians, is given the special name "fyke." Strictly speaking a fyke is a funnel-shaped entrance leading to a small opening difficult to find as an exit which is the principle used in a common form of fly trap. The term fyke may be applied to any funnel entrance in fishing gear and the anchored impounding traps used in some of our California streams are locally called fyke nets.

Entangling devices capture fish by two methods called gill and trammel. In a gill net the fish pokes his head into a small mesh of the net and when he attempts to back out finds that his extended gill covers

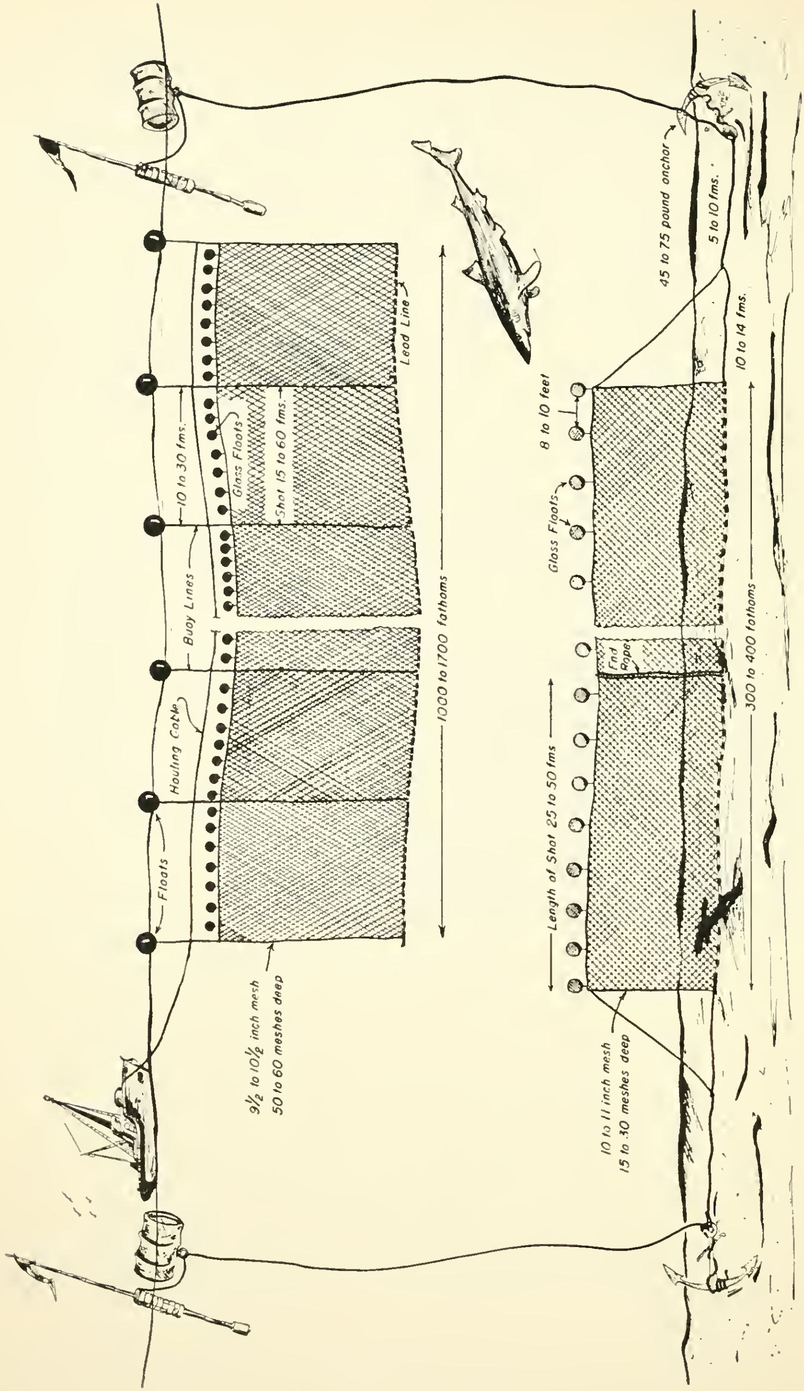

FIGURE 155. Drift and set gill nets used in the soupfin shark fishery. Drawing (not to scale) by Keith W. Cox.

are caught, thus the name gilling, but actually the fish is frequently found tightly wedged in the opening rather than caught by the gill cover. Trammel means to tie up or restrain in a confined space and a trammel net uses two or, more commonly, three walls of webbing, the inner curtain of small mesh hung slack with an outer wall of large mesh. The fish pokes the slack mesh webbing through a large mesh of the outer wall and finds himself in a pouch or pocket of the net and so entangled that he cannot execute a strategic retreat. An important difference between these two types of gear is that a gill net is obviously highly selective as to size of fish caught, whereas a trammel net entangles fish of a wide range of sizes.

There has been some confusion in the terminology applied to impounding nets that are lifted. To dip is to scoop or ladle and the word implies use of a tool with a handle. Therefore hoops or rings that are lifted by rope bridles, such as the old-fashioned crab rings, are not dip nets. Lifted hoop net does not include the river fyke net (built on hoops) because that net is a stationary trap, but does include such hoops or rings as depend upon sudden lifting to capture marine animals. Square or oblong lift nets supported by ropes or poles are classed as blanket nets. When the supports are poles over the side of a fishing boat the device is often called an outrigger. The popular cast net of the tropics has not been adopted in California.

It should be pointed out that no arbitrary classification of gear can accurately cover each type of apparatus, because slight changes in construction or, more important, a different method of operating may convert one device into another or into a hybrid that in appearance resembles one parent but behaves like the other. For example, a drift gill net in a stream is supposed to drift free with the current but an ingenious fisherman discovered that smooth rock weights attached by lines to the lead line of such a net would drag on the stream bed and retard the drift, yet these drags were not strictly anchors nor fixed attachments to the bottom. The courts ruled that the rocks prevented the net from drifting free with the current and the gill net was thereby converted from a drift to a set net. This same gill net if laid out in a semicircle around fish and pulled up onto the shore ceases to act as an entangling gill net and becomes an impounding beach seine. Again this gill net in a larger body of water may be circled about a school of fish and hauled aboard a boat. So used, it ceases to be a gill net and becomes an impounding round haul seine resembling the lampara. A drift gill net may be laid out across the mouth of an inlet on an ebbing tide. This trick is called "blocking off." The lead line soon is aground and at slack water the fish in the inlet are trapped, not gilled. The drift gill net has become an impounding set trap. This trapping action may be accomplished also by turning back the ends of the net (when laying it out on an ebbing tide) to form a "fish hook" at each end, thus trapping rather than gilling the fish. In each of the above-mentioned instances the manner of use rather than construction of the net determines the type of gear.

In spite of the variations in gear and the diversity in names the essential principles involved in capturing fish are simple. Man uses (1) a spear or related tool, (2) a hook, or (3) a net to confine in a small space or to entangle the victim.

OUTLINE OF FISHING GEAR

I. *Miscellaneous Devices*
   1. Spears—Gaff—Harpoon
   2. Shooting—Dynamite
   3. Poison
   4. Snares
   5. Diving suit—Face plate
   6. Rakes—Forks—Oyster dredge
   7. Bush weirs
   8. Traps (other than nets)

II. *Lines*
   1. Pole (including kite lines)
   2. Hand (drop line)
   3. Set
   4. Drift
   5. Troll (jig)

III. *Nets*
   1. Impounding nets
      a. Lifted
         (1) Dip nets
         (2) Hoop nets (including crab rings)
         (3) Blanket nets—Outriggers
         (4) Cast nets
      b. Pulled
         (1) Beach seines (chinchola)
         (2) Round hauls
            Purse seine
            Lampara
            Ring net
            Bait net
         (3) Trawl
            Beam
            Drag (paranzella)
            Otter
      c. Set
         (1) Trap
         (2) Fyke
         (3) Chinese shrimp net
   2. Entangling nets
      a. Gill nets
         (1) Drift
         (2) Sunken—Submerged—Diver
         (3) Set—Anchored—Staked
         (4) Circled
      b. Trammel nets
         (1) Drift
         (2) Set

THE SEA LIONS, SEALS AND SEA OTTER OF THE CALIFORNIA COAST[1]

By PAUL BONNOT
Bureau of Marine Fisheries
California Division af Fish and Game
Drawings by HESTER BONNOT

INTRODUCTION

To the average citizen a marine mammal is an occasional animal seen at the seashore, a trained seal in a zoo or aquarium, or a fur coat at the opera. The present paper endeavors to present some of the indigenous marine mammals, to describe pertinent details of their life histories, and to recount the vicissitudes they have experienced since their discovery and exploitation by man.

Aquatic mammals are descended from land animals that entered the sea in search of a more abundant food supply or for protection from enemies. There were several such migrations at different times which are indicated by the present degree of adaption to a marine existence.

The eared seals (fur seals and sea lions) are comparatively recent immigrants to salt water. Their young must be born on land. The rear flippers can be turned under and forward for moving about when ashore. The true seals (harbor and elephant seals) have evidently lived in the sea for a longer period than the eared seals. Seal pups can be born in the water. The rear flippers cannot be used on land. The whales, which are not included in the present account, are fully adapted to an aquatic existence and never come ashore.

The change from a terrestrial to an aquatic environment required some important anatomical changes. The legs and feet were modified into flippers. Hair and fur are satisfactory temperature controls on land, but water absorbs heat rapidly, and it was necessary to supplement this thermal apparatus. Between the skin and the body a layer of spongy tissue, impregnated with oil, has been developed which effectively retains the body temperature. This is known as blubber. It varies in thickness and oil content with the seasons, the food supply, and the physical condition of the animal.

In common with all organisms in a natural environment the marine mammals were controlled by biological checks that maintained the populations in balance with all associated species. The advent of man into this orderly design demoralized it completely. The human animal is the most persistent and rapacious predator that has so far appeared on the earth. Any organism that produces a commodity of value to man will usually be exploited by him until it is exterminated or reduced to an unprofitable remnant. The past and present pursuit of the marine

[1] Submitted for publication March, 1951.

mammals is a nice illustration of this apothegm. Exploitation has been in direct ratio to the financial return.

The California sea lions were killed for their oil and hides until comparatively few were left. This decimation, competition of whale oil, and increasing labor costs eventually made it unprofitable to hunt them. The sea otter was practically exterminated, and the fur seal herds were reduced to a low ebb. The sea otter and fur seal constitute a self-perpetuating fur resource that yields a relatively valuable product. Legal regulations have, therefore, saved them from extinction. The sea lion, on the other hand, cannot be profitably exploited at present; and there is seldom any protest against killing them.

SPECIES FOUND IN CALIFORNIA

Order Pinnipedia (Marine carnivores)
- Family Otariidae (Eared seals)
  - (External ears—hind flippers turned under and forward)
    - *Zalophus californianus* (California sea lion)
    - *Eumetopias jubata* (Steller sea lion)
    - *Callorhinus alascanus* (Northern fur seal)
    - *Arctocephalus townsendi* (Guadalupe fur seal)
- Family Phocidae (Hair seals)
  - (No external ears—hind flippers cannot be turned forward)
    - *Phoca vitulina* (Harbor seal)
    - *Mirounga angustirostris* (Northern sea elephant)

Order Carnivora (Meat eaters)
- Family Mustelidae (Weasels)
    - *Enhydra lutris* (Sea otter)

CALIFORNIA SEA LION (*ZALOPHUS CALIFORNIANUS*)

California sea lions are dark brown or black when wet and a light tan or brown when dry. An adult bull is seven feet long and will weigh from 800 to 1,000 pounds. The mature bulls have a bone keel on top of the skull which is covered with a roundish pad of tissue. It is a characteristic that will aid in identification. The cows are not as large as the bulls. They are slender and graceful by contrast. They weigh from 500 to 700 pounds. The bulls make a yelping bark. Cows have a quavering howl. The pups squawl and bleat when lost or in trouble.

This species was once abundant on the California coast as far north as the Farallon Islands. It has been reported from the Puget Sound area. The present range is from Point Reyes to central Mexico. The breeding range is from Point Piedras Blancas to an unknown point in Mexico.

Between 1860 and 1870, so many of these animals were killed for their oil and hides that Scammon, writing in 1874, says, "A few years ago great numbers of sea lions were taken along the cost of upper and Lower California, and thousands of barrels of oil were obtained. The number of seals slain exclusively for their oil would appear fabulous when we realize that it requires, on an average, throughout the season the blubber of three or four sea lions to produce a barrel of oil."

The first oil hunters pursued the California sea lion so persistently that only a few thousand were left to represent the once vast herds. A few years ago a Southern California company killed California sea lions on a necessarily limited scale in Baja California. The hides were used

FIGURE 156. California sea lions; cow above, pup below

for leather and the carcasses were canned for dog food. The late Clinton Abbott, then director of the San Diego Museum, was instrumental in having the Mexican Government forbid the practice. In the last few years several individuals have taken a number of California sea lions in an endeavor to produce oil and meal on a commercial scale. A small sea lion population is difficult to exploit commercially and the ventures

FIGURE 157. California sea lions; bull, cow and pup. Note the sacrittal crest of the bull.

were financial failures. Although the California sea lion population has increased somewhat in the last 20 years, the omnipotent natural checks are as impartial as they have always been. In addition fishermen kill sea lions in the vicinity of their nets or gear, and many people shoot them from shore or boats merely for the "fun" of the thing.

STELLER SEA LION (*EUMETOPIAS JUBATA*)

The Steller sea lion is a light grey when wet and a light brown when dry. A full grown bull is about 10 feet long and weighs between 1,500 and 2,000 pounds while the cows are between 600 and 1,000 pounds. Steller bulls snort and roar, and both sexes make a rasping growl. The cows and pups howl and bleat.

This is a northern species. The present range is from the Channel Islands of Southern California to the Bering Sea. The breeding range is from Santa Rosa Island to Alaska.

The Steller sea lions were not exploited in the early days to the same extent as the Californias. The hunters in the North Pacific were engrossed in obtaining more valuable species. The Stellers were granted

FIGURE 158. A group of Steller sea lion cows "arguing." Pup in foreground.

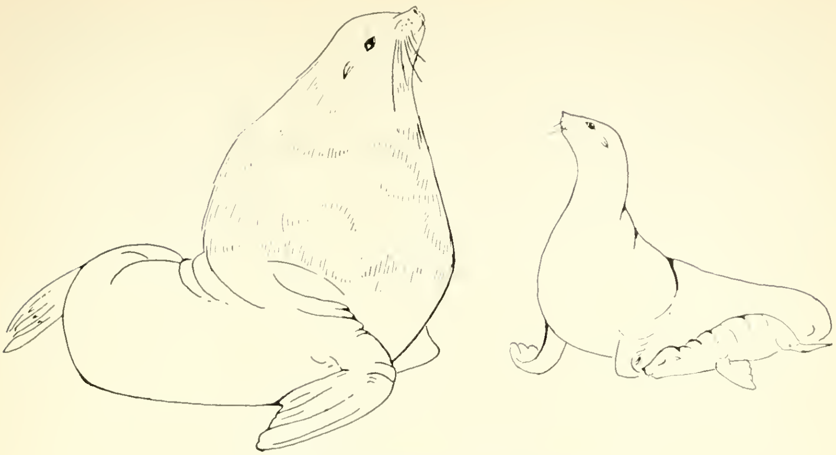

FIGURE 159. Steller sea lion family group

a reprieve while the sea otter was being virtually exterminated, and the great herds of fur seals reduced to a modicum of their original magnitude. Until very recently, the north coast Indians and Eskimos depended on the Steller sea lion for food, clothing, and boat building. However, they killed only what they required; and their activities, circumscribed by primitive weapons, produced little change in the population.

The only systematic killing of Steller sea lions in California occurred about 1900 when a considerable number were shot at the instigation of the fishing industry. Although there has been no organized hunting since that time the local population has remained static because of the same forces which inhibit any great increase of the California sea lion.

LIFE HISTORY NOTES ON SEA LIONS

The terrestrial ancestor of the eared seals was a primitive doglike animal which was also the progenitor of the bears. These two groups demonstrate their affinity by their anatomical similarity and by many of their habits and actions.

The terminology used to describe the eared seals is derived from early explorers and whalers. Although called sea lions a more appropriate name would be sea bears. Individuals are called bulls, cows, or pups. The areas that are used during the breeding season are known as rookeries. At other seasons the animals ''haul out'' on hauling grounds. The bulls collect a number of cows in a harem.

Although the sea lions have lived in the sea for thousands of years, they are not yet completely acclimated to their adopted environment. Sea lion pups must be born on land. They are not able to swim at birth but must acquire that very necessary accomplishment. Having become proficient in the water there are few aquatic animals that are faster or more at home. The front flippers are used in swimming; the rear ones trail behind and serve as a brake or a rudder. They swim on the back, sides, or belly, on occasion slowly rotating on the long axis as they move through the water. The young ones are very active and will sometimes "porpoise" several feet out of water. The adults are more sedate although they will also play, sometimes riding the surf in to the beach repeatedly, evidently merely for the fun of the thing. When landing on a steep bank or straight rock, they can shoot straight up out of water better than their own length. When moving on land, they appear clumsy but they can cover ground with a rolling, plunging gallop at surprising speed, and they can climb rocks and bluffs that would be difficult going for a human. They spring forward on the rear flippers, hitching the front ones ahead at each thrust. They will dive into the water from a considerable height and sometimes when frightened will leap 10 or 15 feet from a ledge to a rocky beach with apparently no harmful results.

Their eyesight does not seem to be very keen. They react promptly to a moving object, but a stationary one is accepted as merely part of the landscape. The sense of smell also seems to be poor. They identify each other by touching noses, and a cow is able to pick out her own pup by sniffing it. Hearing seems to be somewhat feeble. In the water sound vibrations can be received by the whole body, and ears would be of only limited use. When any number are congregated ashore, there is usually so much noise that individual sounds or calls are merely minor items in the collective uproar. Only a sudden loud noise like the report of a gun will attract any attention.

By human standards sea lions are not sanitary. The rookeries and hauling grounds are usually on rocky uneven ground which catches debris. Excreta and dead animals are simply trodden underfoot. A sea lion rookery disperses pungent and gamy odors.

FIGURE 160. Part of the Ano Nuevo Steller sea lion rookery. This is the largest rookery in California. *Photograph by P. Bonnot.*

During the last part of May the sea lions start to congregate on the rookeries. Pups are born through June and July. Each cow has one pup. A few days after the pup is born the cow comes in heat and is bred. A sea lion cow is pregnant practically all the time.

During the breeding season most of the animals are on the rookery during the day. The daylight hours seem to be spent in sleeping or wrangling with immediate neighbors. Most of the fishing is done at night. In the vicinity of a large rookery there will usually be found a number of animals hauled out by themselves. These are the young bulls, not yet sufficiently mature to qualify as herd bulls and cows that are too young or too old to have pups. There are not many of the latter class. Groups of these animals will sometimes lie on the surface of the water in a compact mass resting and sleeping. This is known as rafting. During the breeding season rafts will consist of nonbreeding animals. The rest of the year any of them are apt to form rafts.

Sea lions do not seem to maintain the formal harems so characteristic of the breeding habits of the fur seals. The bulls do a certain amount of fighting, but only occasionally is one seen that is cut and mauled, a common condition among the fur seal bulls.

Indications are that wild sea lions live, barring accidents, for 12 to 14 years. In zoos some live 18 or 20 years. It is the opinion of experts that the bulls are sufficiently mature to begin breeding when they are five or six years old. Cows will breed when they are two years old.

After the breeding season is over, about the middle of August, the animals scatter along the coast. Most of the Steller bulls go north and winter off the coast of British Columbia and Alaska. Very few Steller bulls can be found on the California coast during the winter. There is some evidence that the California sea lions also make a northern move-

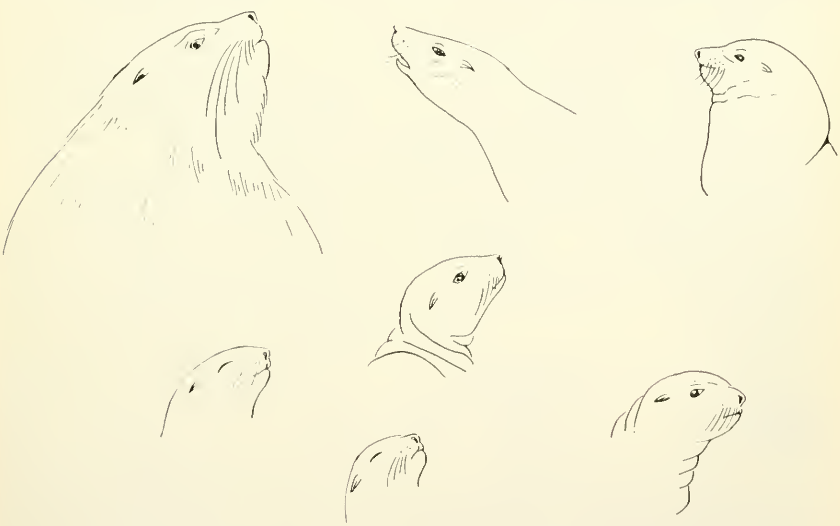

FIGURE 161. Steller sea lion heads. Bull, cow, and young bull at top, pups below.

ment during the winter, animals from Baja California moving into the area about the Channel Islands off Southern California (Fry, 1939).

For the first few days after it is born the sea lion pup eats, sleeps and grows very fast. After this preliminary chore has been attended to, he forgathers with his contemporaries and paddles and splashes about in tide pools and shallow water. It is a curious fact that until the pups learn to use their flippers and coordinate breathing they are more helpless in the water than the young of many terrestrial animals. If an accidental slip or a sudden swell takes a young pup into deep water, it is in a bad fix. A cow whose pup is strangling and squawling beyond its depth will stay with it and show considerable concern, but she appears to be at a loss about what to do. The pup usually drowns. A good many are drowned before they learn to swim.

Having finished a swimming lesson, the pup climbs up on higher ground and goes to sleep. Here he may also run into difficulties. The herd bulls do not deign to notice such small fry; and when several bellicose combatants are roaring and lunging at each other, a pup that has not gone to sleep in a protected place must be spry in removing himself from that vicinity. If he is too slow and is stepped on, his frantic squawling is submerged in the uproar occasioned by the disturbance and completely ignored by the pugnacious combatants. Some are killed in this manner although they appear to be able to absorb an astonishing amount of punishment without serious injury.

Each cow knows her own pup and hunts for it when she comes ashore. She will have nothing to do with another cow's pup. A starving

FIGURE 162. A young California sea lion trained by Homer Snow. The animals are clever and willing performers and demond applause like any prima donna. *Photograph by Homer Snow.*

pup, whose mother has perhaps been killed, that shoves in next to the rightful claimant in an endeavor to obtain some nourishment, is sometimes picked up and thrown 10 feet away with a side jerk of the head. If he happens to land on another cow, he may again be tossed aside.

Sea lions are gregarious but are not necessarily sociable. They travel and fish in small groups and collect in large numbers on the rookeries, but they remain rugged individualists. Among a group lying on shore there is usually a continuous moving about; and if one animal treads on another, there is a local row. These disturbances seldom amount to more than a baring of teeth and a noisy expression of outspoken opinion, but they do not convey an impression of amiability.

The most memorable characteristic of a sea lion rookery is the pulsing sound that is seldom absent. It ebbs and flows with here and there an individual voice breaking through with an inquiring call, an indignant protest or a belligerent defiance. When the rookery happens to be situated on a beach at the base of a cliff, the wailing calls of the cows and pups are echoed weirdly. Combined with the surge of the surf and the calls of sea birds, an impression is produced which is unforgettable.

Sea lions do well in captivity after becoming adjusted to a diet of dead fish, which they do not eat in the wild. They are very intelligent animals and are clever performers and jugglers. Stellers are too large for anything except a permanent exhibit, and bulls of both species are usually too large and pugnacious for ready handling. The "trained seals" seen in shows and circuses are practically always California sea lion cows.

The environment inhabited by the sea lions is intolerant of physical impotence. An individual weakened by disease or mechanical injury is eliminated promptly, with the ruthless and impassive efficiency by which nature maintains the vigor of species.

Practically all wild sea lions contain stomach worms (nematodes) which appear to constitute a normal condition. The worms may become lethal, however, under certain unfavorable conditions. Most sea lion stomachs contain a number of round stones. It has been suggested that the stones have been deliberately swallowed as a vermicide. A number of cases of conjunctivitis have been noted among wild sea lions. This disease is sometimes of epidemic proportions. The animals observed seemed to be totally blind but all appeared well fed. It is not known whether the disease persists and eventually causes death or whether the animals recover.

Killer whales and large sharks catch and eat sea lions though what proportion of the population is removed by these predators is not known.

The most consistent check on the increase of the sea lion population is the high death rate of the new-born pups. Observations on many rookeries indicate that at least half of the pups are eliminated before the end of the breeding season. They are mashed by the larger animals; many are drowned before they learn to swim; and some succumb to endemic diseases. Some of the rookeries are on rocky reefs only a few feet above the high tide. Occasionally an off-season storm will send huge seas boiling over such a rookery and will drown every pup on it.

For many years prior to 1930 the trimming hunters effectively curtailed the number of adult bulls of both species of sea lions. The trimmings consist of the genital organs, the gall bladder, and the whiskers. These were shipped to China. The hunters received from $3 to $5 a set. The gall bladder was made up into a medical preparation; the stiff bristle-like whiskers were used to clean opium pipes; and the sex organs were dried, powdered, and incorporated into a tonic alleged to rejuvenate the aged and encourage the production of sons. Although considered a superstition based on the observed potency of the herd bulls, recent medical research on the origin and efficacy of hormones indicates that perhaps there may be a valid basis to the claims of the Chinese medicine man. After the beginning of the Japanese-Chinese war, the Chinese market for sea lion trimming disappeared, and none of the big bulls have been killed in recent years for this purpose.

The sea lions are periodically condemned by both commercial and sport fishermen. A number of investigations have been made to determine the size of the population and the type and amount of food consumed.

Considerable information has been accumulated but the facts and the conclusions derived from them are usually regarded with more or less suspicion because they do not confirm many of the assertions of the fishermen.

During the last 20 years the amount of fishery products taken from California waters by commercial and sport fishermen has become so large that some species of fish are showing signs of depletion. As it becomes more difficult to catch fish, it is human nature to ascribe the condition to some agency not related to human activity.

A recent publicity release makes the following categorical statements: "There are 10,000 sea lions on the coast. They destroy 500,000 pounds of fish daily or 182,500,000 pounds annually. This fish, valued at 20 cents per pound, equals $36,500,000."

There are approximately 9,000 sea lions on the coast of California, so the 10,000 claimed is not too far off. No one knows accurately how much food a wild sea lion needs or consumes in a given time, but there is some information on which to base an estimate. Captive sea lions are maintained in good condition on a ration of from 2 to 30 pounds of fish per day, depending, of course, on size. In the wild herds the largest animals, the bulls, are relatively few in number. They do not eat during the breeding season and most of the Steller bulls migrate up the coast to British Columbia and Alaska during the winter. The food supply of a wild carnivorous animal is usually an irregular proposition. In this case when fish are plentiful many would be eaten; when they are scarce or absent, the sea lion might go for days without taking any.

A consideration of the known facts and indications leads to the conclusion that 10 pounds of fish per day per sea lion will be a generous average. At this rate 10,000 sea lions will consume 100,000 pounds per day or 36,000,000 pounds per year. Stomach examinations have shown that about 75 percent of the food eaten by sea lions are species not considered of much or any value by humans and some of them are active or potential predators on desirable species. To be conservative reduce this to 50 percent. On this basis the sea lions would take about 18,000,000 pounds of food fish annually.

In 1949, the latest year for which complete figures are available, the fish taken in California waters by commercial fishermen was 801,842,000 pounds valued at about $22,000,000. Some simple calculations will demonstrate that this represents 3 cents per pound. The 18,000,000 pounds of food fish taken by the sea lions would be worth, then, $540,000, presupposing their inclusion in the human catch. This may well be a very moderate price to pay for the suppression of a number of organisms whose destructive potentialities are an unknown quantity because the sea lions have so far kept them in check.

It is understandable that commercial fishermen, sportsmen, and seashore resort owners take a dim view of the activities of the sea lions. On occasion they rob and tear up nets and other types of commercial gear and thereby incur the wrath of the fishermen. They scare the fish away from favorite angling areas which does not endear them to sportsmen. The resort owners, of course, are affected financially by the exasperation of the sportsmen, and they sometimes use the sea lions as a palliative to explain a periodic absence of catchable fish or to console some of the tyros among the cash customers who have failed to make a catch.

Some of the arguments that have been advanced in defense of the sea lions have been based on insufficient data and erroneous conclusions. One biologist killed a number of sea lions in Monterey Bay some years ago and found that without exception they had been feeding on squid. He inferred from this that the California sea lion subsists on squid. A couple of months later when the squid were scarce and the sardine schools were plentiful in the bay, he would probably have revised his opinion.

On the other hand, it is never safe when dealing with any wild organism to make blanket indictments. Many years ago two half-grown Steller sea lions were shot from the cannery dock in the estuary of the Klamath River "because they were killing salmon." It was evening and salmon were rolling and jumping in considerable numbers so the conclusion seemed justified. The next morning the two dead sea lions were found on the opposite shore, stranded by the tide. As a matter of interest they were cut open "to see how many salmon they had eaten." No salmon were found. Both were full of lampreys. For those who do not appreciate the significance of this finding, it might be pointed out that the lamprey is one of the most persistent, voracious and destructive natural enemies of the salmon.

NORTHERN FUR SEAL (*CALLORHINUS ALASCANUS*)

When they are wet, the northern fur seals are a dark dappled grey to black; when dry, a light iron grey. They are smaller animals than the sea lions, and there is a greater difference in size between the sexes. A large bull is seven feet long and weighs about 300 pounds. An adult cow is about four feet long and will weigh about 100 pounds.

The northern fur seal breeds on the Pribilof Islands in the Bering Sea during the summer months. When the pups are able to swim, the herd starts its movement to the south. They pour through the passes in the Aleutian chain and fan out over the north Pacific. The migration extends to Central California and then the reverse movement begins, timed so that the herd will arrive at the rookeries at the proper season.

Fur seals are highly polygamous, and the herd bulls fight savagely to maintain their chosen territory and the cows they have collected. The bulls do not go into the water or eat during the two or three months that they are maintaining their harems. At the end of the season they are emaciated and many are battle scarred. An average harem, among the northern fur seals, is about 20 cows.

During the migration the herd seldom approaches the coast, remaining from one to 200 miles offshore. An occasional individual is found on a California beach. An examination usually demonstrates that the seal has been injured. Shark bites and gun shot wounds have been noted.

The northern fur seal is an outstanding example of what can be accomplished by a sane policy of managing a natural resource in contrast to unrestricted exploitation. The Pribilof Islands were discovered by the Russians in 1786. Although fur seals were taken continually after that year, the Russian Government maintained some control; and when the United States bought Alaska from Russia in 1867, it was estimated that there were between two and four million animals in the herd.

For 40 years after the purchase of Alaska the United States Government leased the sealing privilege to private companies. Under these leases some 2,320,028 skins were taken. When the last lease expired in 1910, the government took over the management of the herds.

The first pelagic sealers began operating between 1871 and 1878. The pelagic seal hunter followed the migrating herd in schooners and ships. They carried a number of white and Indian hunters who deployed from the mother ship in canoes and dories every morning, weather permitting, and shot ever seal they could find. Every cow that was killed meant the death of two seals; the cow, and the embryo she was carrying. After being shot only one in four seals floated long enough to be picked up. Pelagic sealing is an example of the ruthless despoliation that has depleted or extirpated many natural resources.

It was not until 1911 that a treaty between the United States, Great Britain, Russia, and Japan, enforced by United States and Canadian revenue cutters, put a stop to pelagic sealing. The 1910 census of the Pribilof fur seal herds shows a total of 132,000 individuals, a sufficient commentary on the effects of unrestricted exploitation.

The fur seal is a highly polygamous animal, and the killing of surplus bulls does not in any way curtail the population. By careful management the fur seal herd has increased phenomenally since 1911 and paid off handsomely. In 1948 the herd numbered 3,800,000, and 70,000 skins were taken from surplus three-year-old bulls. At an average price of $30 this represents $2,100,000.

By contrast to the well managed northern fur seal fishery, the herds of Antarctic fur seals (*Arctocephalus*) were persistently maltreated. Prior to 1800 the population of this species was estimated to be larger than that of the north Pacific. The southern fur seals were found on the islands which lie to the south of South America and Africa. There were no controls whatever on the taking of these animals. From 1800 to 1830 millions of southern fur seals were killed, and by 1850 most of the herds had been exterminated or reduced to such small numbers that it was not profitable to hunt them.

GUADALUPE FUR SEAL (*ARCTOCEPHALUS TOWNSENDI*)

The Guadalupe fur seal resembles superfically the California sea lion. It is smaller, and the bull lacks the sacrittal crest. The Guadalupe fur seal is an eared seal that can turn the rear flipper under and forward for progression on land. It is, therefore, not a true seal, but a near relation of the sea lion. Sea lions have only a more or less coarse hair. The fur seal also has the hair, but next to the skin and about half as long as the hair is the soft dense plush-like fur from which it gets its name.

Its former range was from the Farallon Islands to Central Baja California. The species was not numerous in comparison with the northern species and was unfortunate in inhabiting an area close to expanding centers of human population. The north Pacific whaling fleet went through this region on the way to the Arctic and when whales were scarce the whaling crews hunted for seals. The success of whaling and sealing voyages depended on acquiring the largest salable cargo in the shortest possible time. Every seal that could be found was killed, regardless of size or sex. By 1890 the species was considered to be extinct.

From 1890 to the present time, only a few of the animals have been seen. Several scientific expeditions to Guadalupe Island have recorded and collected what was supposed to be the sole survivors of the species. However, a few animals can still be found. A few years ago the San Diego

FIGURE 163. A Guadalupe fur seal bull, San Nicolas Island, July, 1949. *Photograph by G. A. Bartholomew, Jr.*

Zoo obtained two young individuals of this species, but they did not live very long in captivity. In 1938 three young bulls were seen at Point Piedras Blancas (Bonnot, Clark, and Hatton, 1938). During 1949 a fur seal bull was photographed on San Nicolas Island by G. A. Bartholomew, Jr., of the University of California at Los Angeles. With adequate protection this species may again become a part of the natural fauna.

It is assumed that the breeding habits of the Guadalupe fur seal are much the same as those of the northern fur seal.

Fur seals do not appear to be as intelligent as the sea lions. They follow blindly inherited instincts and habits. Many of the animals can be killed on a rookery every season, but the survivors will return to the same beach until none are left. This lack of perspicacity was undoubtedly a factor in the rapid disappearance of the Guadalupe fur seal.

NORTHERN ELEPHANT SEAL (*MIROUNGA ANGUSTIROSTRIS*)

The elephant seal is a true seal. They are light grey in color and are huge animals; an adult bull actually measured was 22 feet long. Such an individual is estimated to weigh four tons. The adults seem to be silent, merely blowing or snorting when alarmed or fighting. The pups and yearlings emit a "scream" which is unique among seals.

Originally the range of the species was from Point Reyes to Magdalena Bay.

The elephant seal was relatively abundant before 1840, but by 1870 was practically extinct. Whenever the gray whale, which occurs in the same region, was scarce the whale crews hunted seals. The elephant seals

FIGURE 164. Elephant seals at Guadalupe Island, Mexico. *Photograph by John E. Fitch, April, 1948.*

are sluggish, inoffensive animals, and it was only necessary to walk up to them as they lay on the beach and thrust a lance through the heart.

From 1870 to 1911 only a few of the animals were seen about Guadalupe Island and San Cristobal Bay in Baja California. The Mexican Government now protects them, and the herd about Guadalupe has increased to about 5,000. With the cessation of persecution and the consequent increase in numbers, the elephant seal is beginning to spread out over its former range. In 1938, four yearling elephant seals were observed at Adam's Cove, San Miguel Island (Bonnot, Clark, and Hatton, 1938) and three adults were found on Santa Barbara Island on June 30, 1948 (unpublished notes). One of the animals at Santa Barbara Island was dead, having been shot presumably by a fisherman. During the early part of 1949, 143 elephant seals of both sexes and all sizes were counted on San Nicolas Island by G. A. Bartholomew, Jr., of the University of California at Los Angeles. In May, 1950, Robert Collyer, of the Division of Fish and Game, reported 135 animals on San Nicolas.

Very little is known about the life history of the elephant seal. During this century only a few pups or young animals were seen until the late 1930's. The herd on the famous elephant seal beach on Guadalupe Island has been observed usually during the summer months. The animals are hauled out at that time to shed. Unlike most animals, the elephant seal does not shed the hair, but the outer layer of skin sloughs off in patches. While this is taking place, they flip the coarse volcanic sand over themselves to ease the itching and to drive away the flies. During the time they are shedding, they are reluctant to go into the water as the salt water probably burns the semiraw underskin.

Not much is known about the food of the elephant seal. The stomachs of those on the beach was usually empty. The eye is very large and luminous, which implies use in semidarkness, which in this case would suggest deep water. Huey (1930) examined the stomach contents of an elephant seal taken off San Diego and his findings endorse the supposition that the seal forages in deep water. The stomach contents of this specimen, killed by a fisherman, consisted almost entirely of sharks and skates and seven ratfish. Ratfish live on the bottom in from 50 to 100 fathoms of water. The large eye of the elephant seal would be necessary in this dim region.

HARBOR SEAL (*PHOCA VITULINA*)

The harbor seal is usually a light grey, irregularly mottled with dark brown. There is little to distinguish males from females. The males are usually slightly larger, up to about five feet in length and 250 pounds in weight. Females are about as long and will weigh about 200 pounds. Both sexes are cigar shaped. They make a number of sounds: a loud snort, a throaty bark, like a small dog; and the pups bleat.

The harbor seal has a more or less cosmopolitan distribution. It is found along the coast in small bands usually in sheltered locations or about the entrance or inside bays and estuaries. There are perhaps 500 in California waters.

The pups are usually born from the end of May through June and July. The pup has a prenatal coat of hair which is shed before birth, and the shed hair is expelled at the time of birth. Although most of the pups are born on shore, they can be born in the water and are able to swim at once. In any case, the ones born on shore are usually in a situation where the tide will cover them in an hour or two.

The rear flippers cannot be turned under and forward but always extend out behind. They are useless for progression on land where the seal moves by rhythmic movements of the belly muscles. In the water the animal swims with the rear flippers palm to palm, moving them

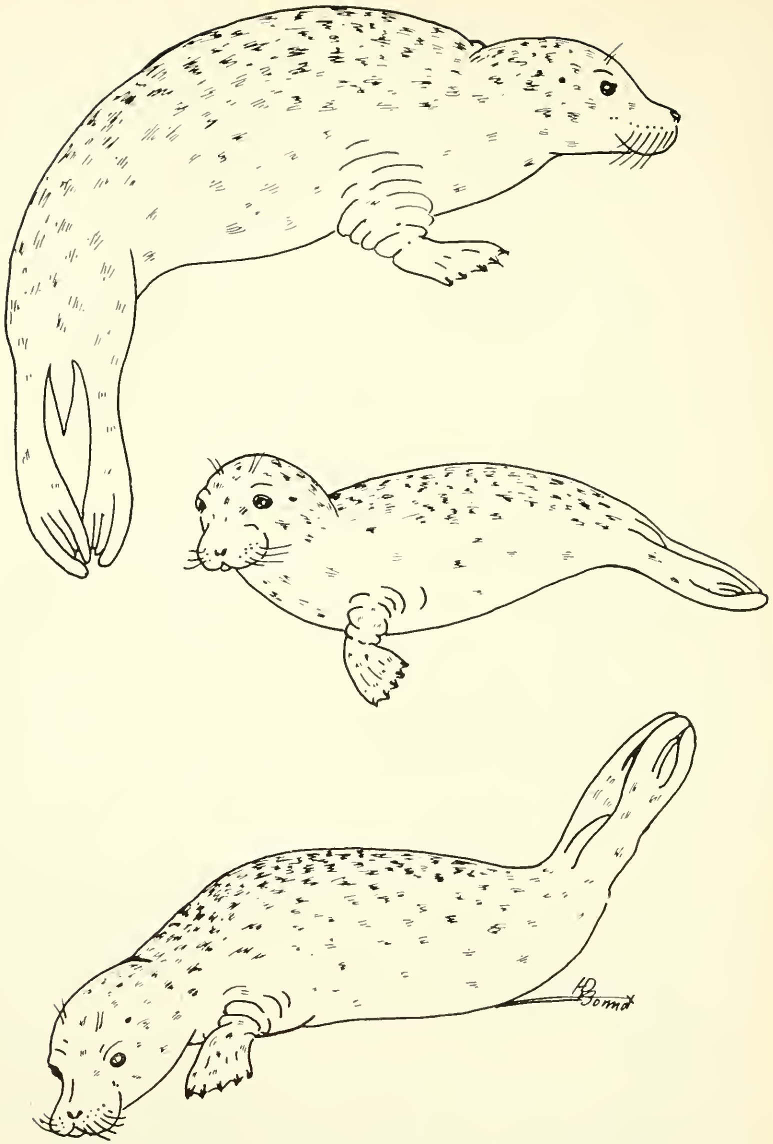

FIGURE 165. Characteristic poses of harbor seals

sideways with a sculling motion. They swim on the belly or back and are slow in comparison with some other pinnipeds.

The seals eat a variety of fish, molluscs and crustaceans, usually slow moving or sedentary forms. They are at times a definite nuisance to commercial fishermen but because of their lack of speed and comparatively small numbers do little real damage. Captive harbor seals have flourished for years on five pounds of fish a day.

SEA OTTER (*ENHYDRA LUTRIS*)

The sea otter is four or five feet long. It has a blunt rounded muzzle set with heavy bristles. The tail is about one-fourth the length of the body. The fore feet are small, but the hind ones are large and webbed to the end of the toes. The outer guard hairs are black with whitish tips. Old animals become grayish or white about the head and neck. The original range on the North American coast was from Bering Sea to Baja California.

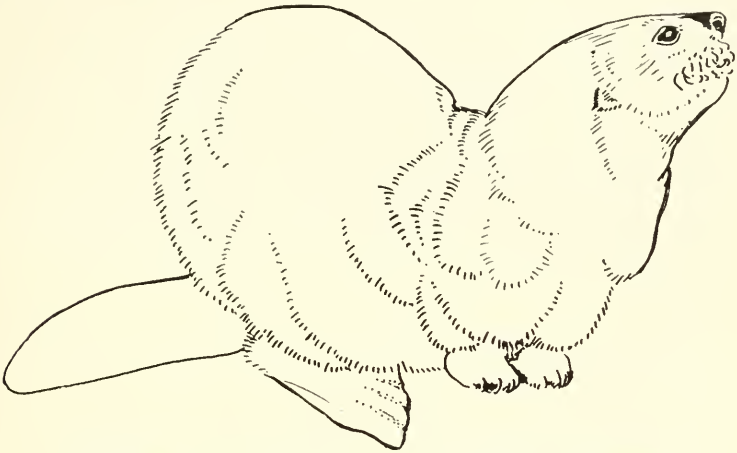

FIGURE 166. Sea otter. After a painting by L. A. Fuertes for the National Geographic Magazine, November, 1916.

The fur of the sea otter is the finest and most valuable of any fur-bearing animal. From the standpoint of the sea otter, this is a dubious distinction. It is responsible for the virtual extermination of the species. The sea otter was comparatively plentiful when first discovered by the Russians about the Pribilof Islands. They soon became scarce in the North Pacific, and the hunters pursued them down the West Coast as far as Central California. Hundreds of thousands were taken and by 1870 they were very rare or nonexistent in most of their former range. They were considered extinct in California although for many years there were persistent reports of sea otter by fishermen along the then inaccessible coast from Monterey to San Simeon. These reports were investigated by biologists who usually were shown photos of young California sea lion cows or listened to descriptions of animals only remotely resembling a sea otter. From 1928 to 1936 a number of sea lion surveys offered an opportunity to examine this stretch of coast, but no sea otter were seen.

In March, 1938, a routine check was made of reported sea otter off Bixby Creek, a few miles south of Monterey, and this time the report was authentic. Over a hundred of the animals were lying in a cove just north of the mouth of the creek. They remained in the vicinity for several weeks and were seen by many people. They have since scattered up and down the coast, and a few of the animals can usually be seen from favorable places along the coast road. Although it is a felony even to be in possession of a skin, a few have been killed in the last few years.

With continued protection the sea otter may again become an interesting and valuable item in the natural fauna.

In contrast to most carnivores that are inherently savage, sometimes even toward their own kind, the sea otters are gentle, inoffensive animals. They live and hunt in pairs or small groups in complete amity. In their spare time, after the serious business of making a living, they are lively and playful, exhibiting many impish tricks. The females demonstrate a marked solicitude for the well being of their young, and this trait was turned to account by the otter hunters. By killing the young otter they could be sure of taking the female as she would remain near by.

The otters live among the kelp in shallow water diving to the bottom for sea urchins, limpets, and abalones. Having obtained one of these organisms on the bottom, they come to the surface, roll over on their backs, and use the chest as a dining table. After eating, a thorough clean up and wash down is in order before another dive to the bottom. They rest and sleep among the kelp, floating on their backs, with one or more strands of the seaweed wound around them for anchorage. They occasionally come ashore to lie in the sun or in search of shelter during unusually heavy weather.

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AN ABNORMAL CARP, *CYPRINUS CARPIO*, FROM CALIFORNIA WATERS[1]

By J. L. McHUGH and W. E. BARRACLOUGH
Scripps Institution of Oceanography
La Jolla, California[2]

In early October, 1949, a peculiar fish was caught on hook and line in an irrigation canal east of El Centro, Imperial County, by Mr. Williams of Brawley, California. Captain Willard Greenwald, of the Bureau of Patrol and Law Enforcement, California Division of Fish and Game, who tentatively identified the specimen as a carp, brought it to the Scripps Institution of Oceanography for confirmation. In spite of its obvious deformity, the fish was found to agree in all essential respects with *Cyprinus carpio* Linnaeus.

The carp and some of its close relatives are notably variable in body form and structure. From a single species of this group (*Carassius auratus*) have been produced, by careful breeding, the widely divergent varieties of the common goldfish. Many of the peculiar domestic forms

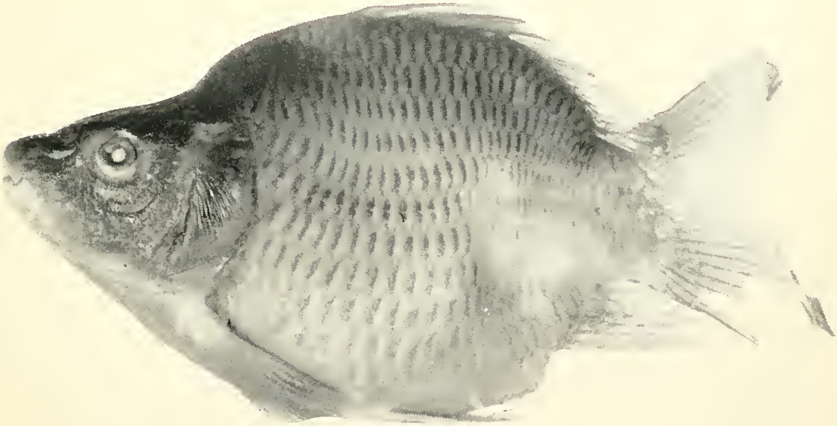

FIGURE 167

of the goldfish are paralleled by similar types of carp. The body form and rate of growth of the carp are known to be extremely sensitive to the effects of environment (Kirpichnikov, 1945) and the specimen here

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[2] Contributions from the Scripps Institution of Oceanography, New Series, No. 535. The senior author is now Director, Virginia Fisheries Laboratory, Gloucester Point, Virginia. The junior author has returned to the Pacific Biological Station, Nanaimo, B. C., from which laboratory he was on educational leave.

described (Figure 167) is similar in outward appearance to the "mast-form" described by Wunder (1939).

An X-ray photograph showed that the deformity is not confined to external features. The vertebral column is reduced in length by the fusion of adjacent centra in several regions, and at about its midlength at least 10 centra are fused in a solid segment. Malformations occur in at least nine regions of the backbone. Two striking features are apparent: (1) the identity of the individual centra is preserved in the neural and haemal processes, which are present in numbers normal for the species, and (2) the fused groups of vertebrae, separated by distinct articular spaces, are, with the exception of the major segment of 10 centra mentioned above, each approximately as long as a single vertebra.

Fusions and deformities involving a limited number of vertebrae are not uncommon in natural populations of fishes. In Atlantic (*Clupea harengus*) and Pacific herring (*Clupea pallasi*) such anomalies are found in as many as 14 percent of the individuals in a sample (Ford and Bull, 1926; McHugh, 1942). These occur most commonly at the posterior end of the vertebral column, and are characterized by a duplication of the neural or haemal spines or both, in association with a centrum that is typically single. Schmidt (1921) found that double vertebrae of this type were more common in trout (*Salmo trutta*) with low numbers of centra, and assigned the numerical value 1.5 to such vertebrae. As pointed out by McHugh (1942), fusions in other parts of the vertebral column differ in structure and probably in origin from those at the posterior end. It is obvious that in the carp described here the true number of vertebrae is indicated by the vertebral processes, and that a numerical adjustment such as proposed by Schmidt would result in a vertebral count that would be ridiculously low for the species.

The external meristic features also correspond with those of the normal carp, as indicated by the following fin-ray and scale counts: dorsal III, 20; anal III, 5; pectoral 16; pelvic 9; scales 6-37-6. The foreshortening of the body has its most marked effect externally in the region overlying the section of maximum coalescence of vertebral centra, at a point about midway between the insertions of the pelvic and anal fins. In the region of the lateral line, from this point backward, the scales are crowded together so that less of their area is exposed. Under the microscope these have the appearance of regenerated scales, their centers being granular in texture with no regular pattern of circuli. The scales in the anterior portion of the body appear normal, and an attempt was made to determine the age of the fish. Although the annuli are not clearly marked, the fish was approximately in its sixth year of life. In length (159 mm.) it was therefore much smaller than a normal carp of this age. Because the caudal peduncle is extremely short, the median fins, when depressed, overlap the caudal fin (Figure 167).

Malformations of this type are occasionally seen in many species of teleost fish. A somewhat similar abnormality in a carp from the upper Illinois River has been described by O'Donnell (1945). In his specimen the last eight precaudal and the 17 caudal centra were completely fused. He concludes that the condition resembles arthritis deformans as found in man and other mammals.

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PHEASANT COOPERATIVE HUNTING AREA RESULTS, 1950[1]

By CHESTER M. HART, FRED L. JONES, and DALE E. SHAFFER
Bureau of Game Conservation
California Division of Fish and Game

SUMMARY AND CONCLUSIONS

1. Ten cooperative areas totaling 138,634 acres were operated by the California Division of Fish and Game during the 10-day 1950 pheasant hunting season which opened November 18th.
2. A total of 104,213 acres was opened to the general public for controlled hunting, with a maximum of 8,770 hunters permitted at one time.
3. Hunting pressure and kill per unit area were somewhat less than in 1949, which was due partially to adverse weather and difficult hunting conditions.
4. A total of 47,889 man-days of hunting was expended on the areas, resulting in a checked kill of 17,523 birds.
5. The take averaged 158 cocks per 1,000 acres with a wild kill of 84 birds per 1,000 acres.
6. Approximately half of the total kill was made during the first three days of the season.
7. Game farm birds made up nearly half of the total kill. The area with the highest proportion of stocked birds in the kill was Firebaugh with 93 percent. Stocked areas having the greatest predominance of wild kill, 72 percent, were Natomas and Grimes.
8. Returns from 13,021 stocked birds were 62 percent. Birds released inseason gave a 70 percent return while those liberated during the week prior to the season yielded a return of 65 percent. Returns from earlier liberations were low, all less than 25 percent.
9. Nearly half of the hunter days were expended during the opening week end of the season. Hunting pressure lowered during the weekdays and increased slightly on Thanksgiving Day and the final week end. Staten Island had the greatest seasonal hunting pressure per unit area, and Sartain the least.
10. The average success of 0.39 bird per hunter was slightly greater than in 1949. Seasonal success was greatest on the unstocked Sartain area but was highest on opening day on the Firebaugh and Los Banos areas, where game farm birds were most predominant in the

[1] Submitted for publication April, 1951. Federal Aid in Wildlife Restoration Act, California Project 22-R. The authors wish to express their appreciation for important contributions made by Project 22-R Leader Harold T. Harper who has been recalled to active duty in the Air Force. Also, acknowledgments are due numerous members of the Bureau of Game Conservation and Bureau of Patrol whose efforts make the cooperative hunting areas a success.

kill. Over-all success was greatest on opening day, but in six areas the highest success fell on the fourth or fifth day. The total kill was made on 29 percent of the hunter days.

11. Hunters using dogs had uniformly higher success and lower crippling loss than hunters without dogs.
12. Local and San Francisco Bay region hunters predominated on all areas. Numbers of hunters in these two categories were approximately equal on Staten Island and Meridian. Local hunters were in the majority on other areas except Ryer Island, Sartain, and Sutter Basin, where Bay area hunters predominated.
13. Hunter reaction to the cooperative plan was highly favorable, with nearly 87 percent of all classifiable comments approving this system of controlled hunting. Slightly more than half of the comments on the Sartain area, the only one collecting a daily hunting fee, were unfavorable.
14. The hunting plan also met with the widespread approval of the cooperating landowners. More than 90 percent of the landowners contacted after the season were satisfied with operation of the areas in 1950, and only two stated that they would not continue with the agreement. Hunter damage to property of cooperating landowners was slight.
15. Two seasons of operation have shown that the cooperative hunting area plan is eminently successful in opening land to hunter access, and satisfactorily solves the most pressing problems of landowners and sportsmen in regard to pheasant hunting.

INTRODUCTION

The 1950 hunting season marked the second year that the cooperative hunting area plan of the California Division of Fish and Game has been in operation. This plan to open up land to the general public for upland game bird hunting by assisting landowners to regulate hunting on their property met with widespread approval by participating landowners and sportsmen. The success of the first season of operation led to enlargement of the program in 1950. During the 1950 pheasant hunting season 10 cooperative hunting areas totaling 138,634 acres were operated, compared to six areas totaling 72,100 acres in 1949. All of the areas except one made no charge for hunting. The single charge area collected the daily fee of $2 per hunter allowed by the cooperative hunting area law.

Rules and regulations for management and control of the areas were essentially the same as in 1949 (Harper, Metcalfe and Davis, 1950). A change in regulations gave the landowner the privilege of reserving up to 20 percent of the quota of open area permits for his land, in lieu of placing as much as 20 percent of his property in a restricted zone.

Signs were changed to eliminate some confusion caused in 1949 by having the Division of Fish and Game emblem on all types of signs. The new signs were larger with more distinctive colors: the background of the open zone sign was white with a green triangle superimposed upon it, corresponding to the green back tag issued to the open zone hunter; the background of the closed zone sign was red, and that for the restricted area was white. Closed and restricted zones were posted more heavily than in 1949, at approximately one-tenth mile intervals. Open zones were posted at least every one-fifth mile.

Weather conditions before and during the pheasant season were unusually bad. Access to many parts of the hunting areas was considerably limited by heavy rains that made secondary roads impassable and caused closure of most private roads. Rain, muddy ground, and wet cover made hunting unusually difficult and tiresome. The adverse conditions undoubtedly decreased the hunting pressure and kill, but it is difficult to evaluate the degree to which these hunting season factors were influenced by the weather.

Hunting season regulations for 1950 prescribed a 10-day season, starting Saturday, November 18th, with a daily bag limit of two cocks and a season limit of 10. Shooting hours were from 8 a.m. to sunset. Pheasant tags costing $1 per set of 10 were required.

CHECKING METHODS

Small portable checking stations were operated the full 10 days of the season on all areas. The types of applications and permits were changed from the book form used in 1949 to a system of individual cards. This change speeded the issuing of permits and facilitated tabulation of hunting season results. Landowners issued all permits on the single charge area and the restricted and reserved permits on the noncharge areas.

Back tags were used as identification markers instead of the arm band of the previous year. Restricted zone back tags were square with red printing on a white background. These contrasted sharply with the open zone tags which were triangular shaped with black printing on a green background. The back tags had a large number to indicate the hunting area. Separate series marked with "A" or "B" were used on alternate days. Permits and back tags were valid only for the area and date issued and were required to be returned when hunters left the area. Possession of the back tag off the area constituted a misdemeanor, which probably accounted for the small percentage of nonreturns.

Each hunter was given a sheet of instructions with a map which showed the boundaries of that particular area and the location of the various zones. Also, hunters were briefed on types of signs enclosing the open, closed, and restricted zones and were instructed to hunt only in fields posted with signs corresponding to the color of their back tags.

Figures 168 and 169 show the application and permit forms used in 1950. Table 1 gives the number of portable checking stations and personnel used on each of the 10 cooperative hunting areas in 1950. Total use of checking stations and checking personnel varied from day to day on some areas with the decrease or increase in hunting pressure. Local sportsmen assisted division personnel on Staten Island by directing traffic and giving information on the opening weekend of the season.

Division wardens patrolled all cooperative hunting areas to enforce trespass rules and game laws. Violations were few and consisted mainly of trespass on restricted and closed zones.

Area No. ______

COOPERATIVE HUNTING AREA

APPLICATION FOR PERMIT

Permit No. ______

The undersigned hereby agrees to abide by the Rules and Regulations printed below

COOPERATIVE HUNTING AREA RULES AND REGULATIONS

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

Name ______________________________ Nov., 1950

Address ______________________________
Street and Number City

FIGURE 168. Hunting Permit application form

COOPERATIVE HUNTING AREA

HUNTER PERMIT

........Nov. 1950 Nº 92505

The bearer is hereby granted permission to hunt in the open zone of Cooperative Hunting Area No.

Subject to the rules and regulations printed on the reverse hereof.

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

Good only on day issued **Not Transferable** **California Division of Fish and Game**

KILL RECORD

No. Bagged........................No. Crippled and Lost........................

Band Numbers..

(Look for leg and wing bands)

No. of hours hunted........................Did you use a dog? Yes........ No........
(Check one)

Remarks..

RETURN FILLED OUT PERMIT BEFORE LEAVING AREA

COOPERATIVE HUNTING AREA

RESTRICTED ZONE HUNTER PERMIT

.... Nov. 1950 Nº 329

The bearer is hereby granted permission to hunt in the restricted zone of Cooperative Hunting Area No.

Controlled by the undersigned subject to the rules and regulations printed on the reverse hereof.

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

Good only on day issued **Not Transferable** ....
(Landowner or Agent)

KILL RECORD

No. Bagged........................No. Crippled and Lost........................

Band Numbers..

(Look for leg and wing bands)

No. of hours hunted........................Did you use a dog? Yes........ No........
(Check one)

Remarks..

RETURN FILLED OUT PERMIT BEFORE LEAVING AREA [OVER]

FIGURE 169. Open and restricted zone hunter permit forms. The rules and regulations shown in Figure 168 appear on the back of each permit.

TABLE 1

Number of Checking Stations and Personnel on Cooperative Hunting Areas for the 1950 Hunting Season

	Day of season									
	1	2	3	4	5	6	7	8	9	10
Permit and checking stations										
Staten Island	2	2	2	2	2	2	2	2	2	2
Ryer Island	3	3	3	3	3	3	3	3	3	3
Sutter Basin	4	4	4	4	4	3	3	2	2	2
Natomas	6	6	6	6	6	6	6	6	6	6
Grimes	6	6	6	5	4	6	5	5	5	3
Sartain[1]	5	5	3	3	3	3	3	3	3	3
Butte Creek	4	4	4	4	4	4	4	4	4	4
Meridian	4	4	4	4	4	4	4	4	4	4
Los Banos	4	4	3	3	3	4	3	3	3	3
Firebaugh	3	3	3	2	2	2	2	2	2	2
Total	41	41	38	36	35	37	35	34	34	32
Checkers										
Staten Island[2]	6	6	6	6	6	6	6	6	6	6
Ryer Island	6	6	6	6	6	6	6	6	3	3
Sutter Basin	7	7	7	7	7	7	7	3	3	3
Natomas	12	12	12	12	12	12	12	12	12	6
Grimes	12	12	12	12	12	12	12	12	12	12
Sartain	9	9	7	7	7	7	7	7	7	7
Butte Creek	8	8	8	8	8	8	8	8	8	8
Meridian	8	8	8	8	8	8	8	8	8	8
Los Banos	7	7	7	7	7	7	7	7	7	7
Firebaugh	8	8	6	6	6	8	7	8	4	4
Total	83	83	79	79	79	81	80	77	70	64
Wardens										
Staten Island	6	6	3	3	3	3	3	3	3	3
Ryer Island	6	6	4	4	4	4	4	6	6	4
Sutter Basin	4	4	4	4	4	4	4	4	4	4
Natomas	8	8	8	8	8	8	8	8	8	8
Grimes	9	10	10	4	4	4	4	4	4	4
Sartain	5	5	5	5	5	5	5	5	5	5
Butte Creek	7	5	4	4	4	4	4	4	4	2
Meridian	3	3	3	3	3	3	3	3	3	3
Los Banos	5	5	3	3	3	1	2	3	3	3
Firebaugh	2	2	2	2	2	2	2	2	2	1
Total	55	54	46	40	40	38	39	42	42	37

[1] On Sartain only two stations issued permits each day. All stations checked hunters out.
[2] On Staten Island six sportsmen helped direct traffic on the opening weekend.

DESCRIPTION OF AREAS

Of the 10 areas operated in 1950, five had functioned in 1949. These were Staten Island, Sutter Basin, Natomas, Grimes and Sartain; the sixth of the original areas, Williams, was dropped in 1950. Areas were selected on the basis of capacity to support a maximum number of hunters, comparatively heavy pheasant populations for the region, avail-

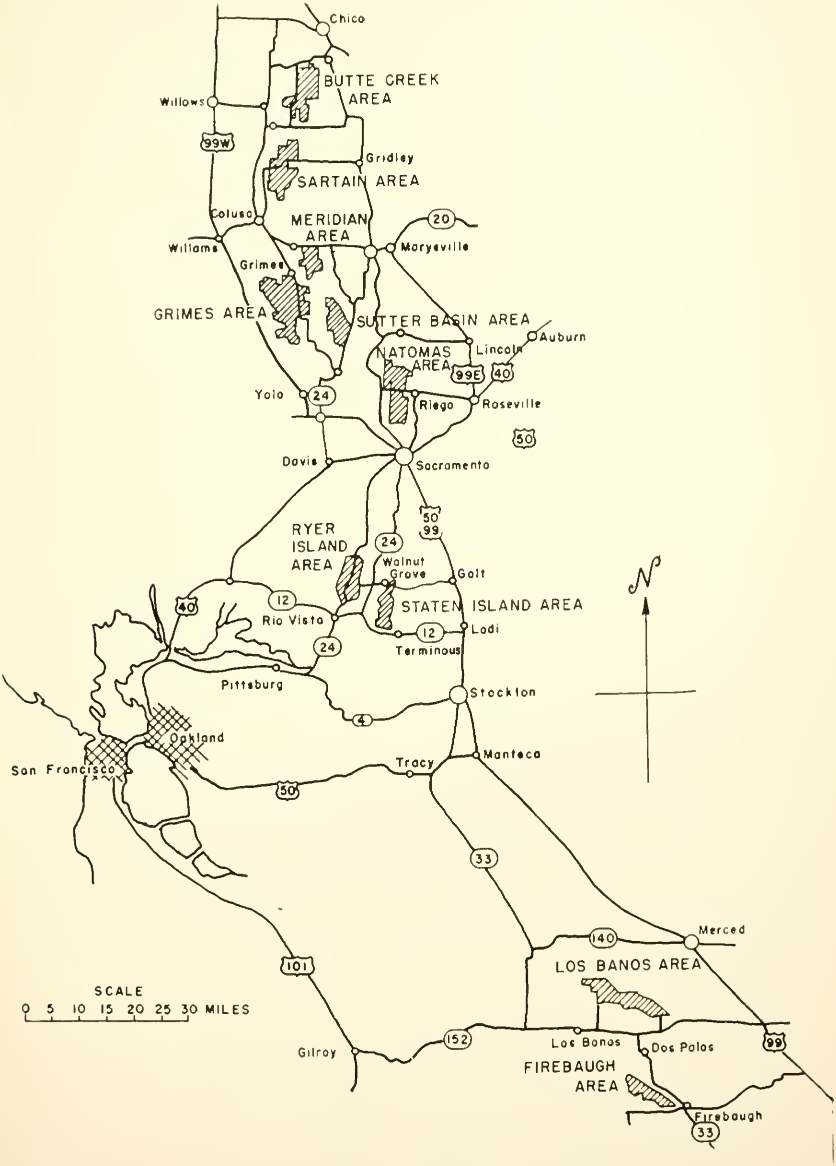

FIGURE 170. Location of cooperative pheasant hunting areas, 1950

ability to hunters, and willingness of landowners to open their land to controlled hunting.

As compared to five in the Sacramento Valley and one in the Delta region in 1949, in 1950 there were six areas in the Sacramento Valley, two in the Delta and two in the San Joaquin Valley (Figure 170). Addition of areas in the San Joaquin Valley was made in order to provide facilities over a larger portion of the State, thereby offering hunting to more of the State's pheasant hunters. The number of areas in the Sacramento Valley was increased because of heavy hunting pressures in that region and availability of good pheasant habitat.

Table 2 shows the total acreage in each type of zone for each area, and number of hunters allowed in open zones at any one time. Total acreage in open zones was increased from 58,450 in 1949 to 104,213 in 1950. The number of hunters allowed at one time was increased from 7,500 to 8,770. The increase in acreage was relatively greater because most of the areas added comprised poorer quality pheasant habitat. Further, some areas were enlarged more than was anticipated, due to the last minute acquiescence by many landowners, so that the number of hunters allowed at one time was limited ultimately by the number of back tags manufactured instead of by the acreage in open zones. This was not inopportune because the bad weather caused hunting to be concentrated near the hard-surfaced roads, and a reduction in the number of hunters allowed was desirable in the interest of safety.

Crops grown during the year and crop acreages are presented in Table 3. Rice, barley and wheat were the principal crops grown on Butte Creek, Sartain, Grimes and Natomas areas in the Sacramento Valley, and Firebaugh in the San Joaquin Valley. Beans and cereal grains were the major crops on Meridian and Sutter Basin areas, with the latter also having a large acreage of irrigated pasture. Field corn, barley and asparagus predominated on Staten Island. Grain sorghums, sugar beets and alfalfa were the important crops on Ryer Island. Cotton was the principal crop on the Los Banos area, with barley and alfalfa secondary in importance.

Over-all cover conditions during the season (Table 4) were better than those prevailing in years of normal fall weather. The rainy period preceding and during pheasant season prevented practically all of the burning and plowing of rice stubble usually done at that time. However, some areas were noticeably deficient in standing cover. Approximately 83 percent of the Meridian area was plowed or cultivated, and a fairly high percentage of the area open to hunting on the Sartain and Sutter Basin areas was worked up. On the whole, areas in the Delta and San Joaquin Valley regions had a higher percentage of the total acreage in standing cover than did those located in the Sacramento Valley.

TABLE 2

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

Area	Open zone		Restricted zone	Closed zone	Total
	Acres	Hunters allowed at one time	Acres	Acres	Acres
Staten Island	6,820	500	1,050	1,330	9,200
Ryer Island	10,207 [1]	665	1,325	1,425	12,597
Sutter Basin	7,674	800	381	3,414 653 acres opened on 4th day 303 acres restricted on 6th day	11,469
Natomas	16,994	1,360	2,590	2,600	22,184
Grimes	18,653	1,800	5,810	1,880	26,343
Sartain	10,700	1,150	860	1,960 540 acres restricted on 4th day 500 acres restricted on 10th day	13,520
Butte Creek	10,138	1,150	2,493 200 acres opened on 5th day	1,700 200 acres restricted on 5th day 600 acres opened on 8th day	14,331
Meridian	8,982	600	360	25	9,367
Los Banos	7,091	320	212	3,158	10,461
Firebaugh	6,954	425	708	1,140 40 acres opened on 5th day	8,802
Total	104,213	8,770	15,789	18,632 1,293 acres opened in season 1,543 acres restricted in season	138,634

[1] 2,400 acres flooded the second day of the season.

TABLE 3

Approximate Acreages of Crops

Crop	Area										
	Staten Island	Ryer Island	Sutter Basin	Natomas	Grimes	Sartain	Butte Creek	Meridian	Los Banos	Firebaugh	Totals
Alfalfa	80	1,683		782	300			353	1,015	160	4,373
Asparagus	1,500										1,500
Barley	2,700	330	465	515	7,640	2,225	1,701	178	1,082	3,000	19,836
Beans		438	3,504		455			6,691			11,088
Cotton									2,141	500	2,641
Dry pasture and wasteland	470	2,001	1,054	2,706	2,500	1,058	900		2,327	552	13,568
Fallow		3,419			4,208	531	956			520	9,634
Field Corn	2,800	123			30				52		3,005
Irrigated pasture		14	2,829	275		44	20				3,182
Miscellaneous	125	28	151		335	34		602	692	465	2,432
Oats or oats and vetch				1,044			316				1,360
Plowed	325		308	4,295		5,720	4,115		2,257		17,020
Rice			965	6,307	7,065	3,250	5,620	1,021		2,605	26,833
Sorghums		3,397		867	40		339		140		4,783
Sugar Beets	600	2,056			1,120	204			755		4,735
Tomatoes	600	27			380						1,007
Vetch				80	970			60			1,110
Wheat		191	2,482	5,313	1,300	454	364	1,219		1,000	12,323
Acres double cropped		750	289					757			1,796

TABLE 4

Approximate Acreages Under Different Cover Conditions During the 1950 Season

Area	Acres of standing crops	Acres of stubble	Acres fallow and miscellaneous	Acres plowed or cultivated
Staten Island	3,190	3,415	470	2,125
Ryer Island	2,292	3,818	4,618	2,229
Sutter Basin	3,875	1,059	1,054	5,481
Natomas	1,917	6,539	1,492	12,236
Grimes	868	8,722	8,200	8,553
Sartain	1,570	1,680	1,667	8,603
Butte Creek	286	5,694	1,854	6,497
Meridian	405	1,007	110	7,845
Los Banos	2,344	1,186	4,097	2,834
Firebaugh	670	1,985	5,072	1,075
Total	17,417	35,105	28,634	57,478

HUNTING SEASON RESULTS

Information obtained for each day of the season from the filled-out permits included the number of birds bagged, number crippled or lost, band numbers, number of hours hunted, and whether or not a dog was used. Space was provided for remarks, but comments regarding the hunter's approval or disapproval of cooperative hunting areas was the only information tabulated from this section.

Table 5 gives seasonal figures, for each area, of number of permits issued, number of permits returned, checked kill, calculated kill, and crippling loss. Table 6 presents a breakdown of these categories by day and area and shows in addition gun hours and acres hunted. The rest of this report is based upon these figures.

TABLE 5

Number of Permits Issued and Returned, Birds Killed, and Birds Crippled on Each Cooperative Hunting Area

Area	Permits issued	Permits returned		Checked kill	Crippling loss		Calculated kill
		Number	Percent		Number	Percent	
Staten Island	4,323	4,237	98.0	976	123	12.6	996
Ryer Island	4,069	3,965	97.4	1,412	188	13.3	1,449
Sutter Basin	4,590	4,261	92.8	1,568	239	15.2	1,689
Natomas	9,144	8,550	93.5	2,584	323	12.5	2,764
Grimes	8,612	7,998	92.8	4,063	467	11.5	4,375
Sartain	1,691	1,493	88.2	793	158	19.9	898
Butte Creek	6,413	6,197	96.6	2,024	288	14.2	2,095
Meridian	2,630	2,494	94.8	1,292	117	9.0	1,362
Los Banos	2,648	2,469	93.2	996	82	8.2	1,068
Firebaugh	3,769	3,692	97.9	1,815	157	8.7	1,853
Total	47,889	45,356	94.7	17,523	2,142	12.2	18,549

TABLE 6

Hunter Use, Kill, and Acreage Open to Hunting on Each Area

Area	Day of season										Unknown	Season totals
	1	2	3	4	5	6	7	8	9	10		
Staten Island												
Permits issued	769	748	134	254	382	706	393	456	382	99		4,323
Permits returned	730	728	133	250	378	696	390	456	377	99		4,237
Checked kill: Total	306	157	47	117	140	91	39	37	31	11		976
Kill: Wild birds	130	75	35	16	48	43	22	25	19	8		421
Kill: Game farm birds	176	82	12	101	92	48	17	12	12	3		555
Acres hunted (open and restricted)	7,870	7,870	7,870	7,870	7,870	7,870	7,870	7,870	7,870	7,870		7,870 [2]
Gun hours reported[1]	1,906	2,149	359	706	1,114	1,868	1,126	1,358	1,014	247		11,847
Ryer Island												
Permits issued	907	773	194	288	188	388	212	458	536	125		4,069
Permits returned	907	763	155	276	176	388	200	458	521	121		3,965
Checked kill: Total	469	315	50	102	131	119	63	72	74	17		1,412
Kill: Wild birds	219	136	15	42	28	50	43	54	60	13		660
Kill: Game farm birds	250	179	35	60	103	69	20	18	14	4		752
Acres hunted (open and restricted)	10,207	7,807	7,807	7,807	7,807	7,807	7,807	7,807	7,807	7,807		8,047 [2]
Gun hours reported[1]	2,476	2,257	412	911	566	1,139	649	1,587	1,566	358		11,921
Sutter Basin												
Permits issued	1,397	940	110	126	256	404	364	489	435	69		4,590
Permits returned	1,309	853	91	123	206	384	349	475	407	64		4,261
Checked kill: Total	711	211	38	68	144	135	113	78	55	15		1,568
Kill: Wild birds	470	156	28	47	81	35	38	50	35	8		948
Kill: Game farm birds	241	55	10	21	63	100	75	28	20	7		620
Acres hunted (open and restricted)	8,055	8,055	8,055	8,055	8,708	8,708	9,011	9,011	9,011	9,011		8,568 [2]
Gun hours reported[1]	4,443	2,413	230	357	592	1,234	1,050	1,685	1,268	200		13,472

Natomas												
Permits issued	2,303	2,031	327	441	685	1,025	487	887	766	192	----	9,144
Permits returned	2,159	1,842	327	368	636	964	479	844	757	174	----	8,550
Checked kill: Total	1,062	494	122	94	161	151	182	123	145	50	----	2,584
Kill: Wild birds	815	393	108	80	91	79	77	79	96	45	----	1,863
Kill: Game farm birds	247	101	14	14	70	72	105	44	49	5	----	721
Acres hunted (open and restricted)	19,584	19,584	19,584	19,584	19,584	19,584	19,584	19,584	19,584	19,584	----	19,584[2]
Gun hours reported[1]	6,188	5,510	872	1,063	1,831	2,355	1,439	2,458	2,147	465	----	24,328
Grimes												
Permits issued	2,886	1,549	258	276	406	803	493	1,012	814	115	----	8,612
Permits returned	2,462	1,469	253	261	390	713	476	954	777	112	131	7,998
Checked kill: Total	1,772	739	106	147	234	314	136	300	152	41	122	4,063
Kill: Wild birds	1,418	651	93	107	116	155	84	124	97	28	67	2,940
Kill: Game farm birds	354	88	13	40	118	159	52	176	55	13	55	1,123
Acres hunted (open and restricted)	24,463	24,463	24,463	24,463	24,463	24,463	24,463	24,463	24,463	24,463	----	24,463[2]
Gun hours reported[1]	9,418	5,548	832	879	1,437	2,490	1,748	3,535	2,924	365	119	29,295
Sartain												
Permits issued	823	227	60	28	47	77	79	114	156	80	----	1,691
Permits returned	696	174	57	28	47	75	79	103	154	80	----	1,493
Checked kill: Total	287	110	33	19	40	61	51	57	77	58	----	793
Kill: Wild birds	265	107	33	16	38	59	51	55	76	57	----	757
Kill: Game farm birds	22	3	----	3	2	2	----	2	1	1	----	36
Acres hunted (open and restricted)	11,560	11,560	11,560	12,100	12,100	12,100	12,100	12,100	12,100	12,600	----	11,988[2]
Gun hours reported[1]	2,963	742	198	124	193	305	322	450	650	217	----	6,164
Butte Creek												
Permits issued	1,673	1,320	304	426	488	736	338	575	439	114	----	6,413
Permits returned	1,636	1,254	294	416	466	716	331	559	422	103	----	6,197
Checked kill: Total	836	336	95	85	163	238	96	97	51	27	----	2,024
Kill: Wild birds	379	176	51	57	51	58	41	37	13	15	----	878
Kill: Game farm birds	457	160	44	28	112	180	55	60	38	12	----	1,146
Acres hunted (open and restricted)	12,631	12,631	12,631	12,631	12,831	12,831	12,831	13,431	13,431	13,431	----	12,931[2]
Gun hours reported[1]	4,476	3,686	795	1,132	1,405	1,947	1,024	1,567	1,218	340	----	17,590
Meridian												
Permits issued	895	614	125	105	154	134	165	231	174	33	----	2,630
Permits returned	826	566	122	101	153	127	155	216	165	29	34	2,494
Checked kill: Total	596	258	45	78	79	67	70	37	18	1	43	1,292
Kill: Wild birds	289	130	26	19	15	24	----	15	1	1	12	532
Kill: Game farm birds	307	128	19	59	64	43	70	22	17	----	31	760
Acres hunted (open and restricted)	9,342	9,342	9,342	9,342	9,342	9,342	9,342	9,342	9,342	9,342	----	9,342[2]
Gun hours reported[1]	2,394	1,663	355	299	399	376	418	678	409	75	----	7,066

TABLE 6—Continued

Hunter Use, Kill, and Acreage Open to Hunting on Each Area

Area	Day of season										Unknown	Season totals
	1	2	3	4	5	6	7	8	9	10		
Los Banos												
Permits issued	412	363	121	184	227	332	213	317	358	121		2,648
Permits returned	307	362	121	181	226	325	204	307	338	98		2,469
Checked kill: Total	288	129	70	100	128	121	73	44	30	13		996
Kill: Wild birds	56	29	24	8	25	8	7	18	4	5		180
Kill: Game farm birds	236	100	46	92	103	113	66	26	26	8		816
Acres hunted (open and restricted)	7,303	7,303	7,303	7,303	7,303	7,303	7,303	7,303	7,303	7,303		7,303[2]
Gun hours reported[1]	737	942	321	403	589	799	531	830	809	225		6,186
Firebaugh												
Permits issued	798	599	169	213	332	583	286	428	281	80		3,769
Permits returned	798	575	168	204	325	573	286	407	274	79	3	3,692
Checked kill: Total	710	231	66	191	181	143	110	107	43	30	3	1,815
Kill: Wild birds	48	21	8	3	7	20	5	1	6			119
Kill: Game farm birds	662	210	58	188	174	123	105	106	37	30	3	1,696
Acres hunted (open and restricted)	7,662	7,662	7,662	7,662	7,702	7,702	7,702	7,702	7,702	7,702		7,686[2]
Gun hours reported[1]	1,896	1,366	472	477	884	1,449	853	1,226	677	307		9,607
Totals—All areas												
Permits issued	12,863	9,164	1,802	2,341	3,165	5,188	3,030	4,967	4,341	1,028		47,889
Permits returned	11,830	8,586	1,721	2,208	3,003	4,961	2,949	4,779	4,192	959	168	45,356
Checked kill: Total	7,037	2,980	672	1,001	1,401	1,440	933	952	676	263	168	17,523
Kill: Wild birds	4,085	1,874	421	395	500	531	368	458	407	180	79	9,289
Kill: Game farm birds	2,952	1,106	251	606	901	909	565	494	269	83	89	8,285
Acres hunted (open and restricted)	118,677	116,277	116,277	116,817	117,710	117,710	118,013	118,613	118,613	119,113		117,782[2]
Gun hours reported[1]	36,897	26,276	4,846	6,351	9,010	13,962	9,160	15,374	12,682	2,799	119	137,476

[1] Some permits did not report the hours hunted.
[2] Acres hunted is an average not a season total.

Kill and Hunter Days

All areas except Sartain had the maximum allowable number of hunters on opening day. The fee of $2 per day on the Sartain area and its distance from centers of population undoubtedly caused many hunters to go elsewhere.

The 45,356 hunters checked killed 17,523 birds in 1950 as compared with 12,114 birds killed by 38,273 hunters in 1949. The increase of 18.5 percent in hunters closely paralleled the 17 percent increase in numbers of hunters allowed at one time. However, the total acreage hunted increased 82 percent, and 67 percent more cocks were stocked on the areas. This combination of factors resulted in a 44.5 percent increase in birds killed.

Birds Killed per 1,000 Acres

Table 7 presents the calculated total number of game farm and wild birds killed per 1,000 acres and the kill of wild birds alone. The areas which operated in both 1949 and 1950 had a lower kill of wild birds per 1,000 acres the second year, but all of them, except Staten Island, yielded a higher wild kill per unit area than did the areas added in 1950. Lower hunting pressure in 1950, unfavorable weather, and addition of areas having lower wild populations partially explain the over-all large drop in wild kill per 1,000 acres from 141 in 1949 to 84 in 1950.

TABLE 7

Calculated Kill [1]

Area	Total kill	Wild kill	Total kill per 1,000 acres	Wild kill per 1,000 acres
Staten Island	996	430	126	55
Ryer Island	1,449	677	180	84
Sutter Basin	1,689	1,021	197	119
Natomas	2,764	1,992	141	102
Grimes	4,375	3,166	179	129
Sartain	898	857	75	71
Butte Creek	2,095	852	162	66
Meridian	1,362	561	146	60
Los Banos	1,068	193	146	26
Firebaugh	1,853	121	241	16
Total	18,549	9,870	158	84

[1] Calculated by assuming nonreturning permittees had the same success as those returning permits.

Daily Percentage of Kill

Table 8 shows by areas the percentage of the checked seasonal kill taken each day. In 1949 more than two-thirds of the total checked kill was taken on the first three days of the season and in 1950 slightly more than one-half of the checked kill was harvested on the first three days. This change was caused in part by the opening day falling on a Saturday in 1950; hunting pressure dropped sharply on Monday, the third day of the season, and a work-day for most hunters. The Friday opening in 1949 resulted in heavy hunting pressure for the first three days.

TABLE 8

Daily Kill Expressed as a Percentage of the Known Seasonal Kill

Day	Staten Island	Ryer Island	Sutter Basin	Natomas	Grimes	Sartain	Butte Creek	Meridian	Los Banos	Firebaugh	Averages all areas
1	31.4	33.3	45.3	41.1	43.7	36.2	41.3	46.1	28.9	39.1	40.2
2	16.1	22.3	13.5	19.2	18.2	13.9	16.6	20.0	13.0	12.7	17.0
3	4.8	3.5	2.4	4.7	2.6	4.2	4.7	3.5	7.0	3.6	3.8
4	12.0	7.2	4.3	3.6	3.6	2.4	4.2	6.0	10.0	10.5	5.7
5	14.3	9.3	9.2	6.2	5.8	5.0	8.1	6.1	13.0	10.0	8.0
6	9.3	8.4	8.6	5.8	7.7	7.7	11.8	5.2	12.1	8.0	8.2
7	4.0	4.5	7.2	7.1	3.3	6.4	4.7	5.4	7.3	6.0	5.3
8	3.8	5.1	3.5	4.8	7.4	7.2	4.8	2.9	4.4	6.0	5.3
9	3.2	5.2	5.0	5.6	3.7	9.7	2.5	1.4	3.0	2.4	4.0
10	1.1	1.2	1.0	1.9	1.0	7.3	1.3	0.1	1.3	1.7	1.5
Date unknown					3.0			3.3		0.1	1.0

Considerably more game farm birds were stocked during the season in 1950, which increased the kill in the latter part of the season and correspondingly reduced the percentage of the kill made in the first three days.

Old-young Ratio of Kill

Samples of the kill were examined throughout the season to determine the ratio of adult to juvenile cocks in the wild pheasant populations on three of the areas. Information on bursa depths measured and recorded from birds killed on the Sartain and Firebaugh areas is presented in Figure 171. Standards used on these two areas to assign cocks to old, indeterminate age, or young classes according to bursa depth were those arrived at in the course of experimental work on the Sartain and McManus study areas (Ferrel, Harper and Hiehle, 1949). Birds examined on Staten Island were designated as young or adult after probing the bursa and noting other physical characteristics, but bursa depths were not recorded.

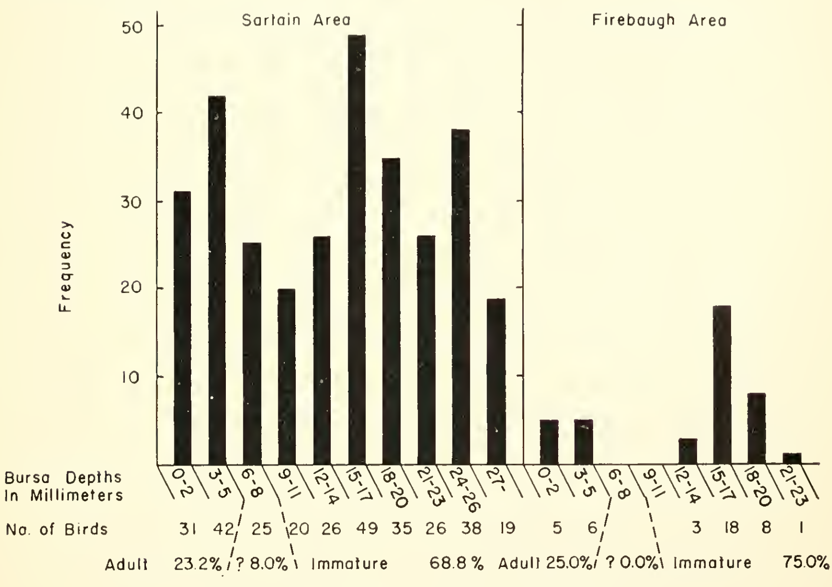

FIGURE 171. Frequency distribution of bursa depths

On Sartain the percentage of the kill made up of young birds was the lowest in the four years that old-young ratios have been taken there. This evidently reflected the combined effect of a rather poor nesting season in 1950 and comparatively light hunting pressure in 1949 which resulted in more cocks surviving and being taken as adults the following season.

Data obtained on Sartain in 1949 indicated that the method of using bursa depths alone may be of questionable accuracy in determining age ratios of wild pheasants in this region (Harper, Hart and Shaffer, 1951). However, the methods employed should show accurately the year to year trend of age ratios in the bag, since the same methods and standards have been used each year.

Bursa depths checked on the Firebaugh area fell into two widely separated groups indicating that 25 percent of the cocks were adult and 75 percent immature. The 147 birds examined on Staten Island were classified as approximately 39 percent adults and 61 percent juveniles.

Kill of Game Farm Birds

The 13,021 game farm cocks stocked on the areas during 1950 furnished 47 percent of the total checked kill (Table 9). Extremes were 4.5 percent on Sartain, representing birds from surrounding areas as no releases were made on this cooperative area, and 93.4 percent on Firebaugh where the wild population was low and large releases were made. On Los Banos, another area of low wild population, game farm birds made up approximately 82 percent of the kill. On Grimes and Natomas, areas of heavy wild populations, they made up approximately 28 percent.

Table 10 shows that proportionate takes of game farm birds were highest on the first day of the season and on days following inseason releases. Table 11 indicates the rate of kill following inseason releases. Approximately 63 percent of the total seasonal kill of these birds was made by the end of the first day following release and 95 percent by the end of the fourth day. In comparison, approximately 44 percent of the wild kill was taken on the first day, and 73 percent in the first four days. The rate of kill on the date of release is low compared to that on the following day because releases were generally made late in the afternoon, after hunters had left the field, in order to avoid the criticism that is generally leveled against releases before the gun.

TABLE 9

Percentage of Game Farm and Wild Birds in Each Day's Kill

Area	Type of bird	Day of season										Un-known	Seasonal average
		1	2	3	4	5	6	7	8	9	10		
Staten Island	Wild	42.5	45.8	74.5	13.7	34.3	47.2	56.4	67.5	61.2	72.7		43.1
	Game farm	57.5	54.2	25.5	86.3	65.7	52.8	43.6	32.5	38.8	27.3		56.9
Ryer Island	Wild	46.6	43.2	30.0	41.2	20.6	42.0	68.2	75.0	81.1	76.5		46.7
	Game farm	53.4	56.8	70.0	58.8	79.4	58.0	31.8	25.0	18.9	23.5	†	53.3
Sutter Basin	Wild	66.0	73.9	73.6	69.0	56.2	25.9	33.6	64.0	63.6	53.4		60.5
	Game farm	34.0	26.1	26.4	31.0	43.8	74.1	66.4	36.0	36.4	46.6		39.5
Natomas	Wild	76.6	79.6	88.5	85.0	56.5	52.3	42.3	64.3	66.2	90.0		72.0
	Game farm	23.4	20.4	11.5	15.0	43.5	47.7	57.7	35.7	33.8	10.0		28.0
Grimes	Wild	79.9	88.1	87.7	72.8	49.5	49.3	61.8	41.3	63.8	68.3	54.9	72.2
	Game farm	20.1	11.9	12.3	27.2	50.5	50.7	39.2	58.7	36.2	31.7	45.1	27.8
Sartain	Wild	92.3	97.2	100.0	84.2	95.0	96.6	100.0	96.5	98.6	98.1		95.5
	Game farm	7.7	2.8		15.8	5.0	3.4		3.5	1.4	1.9		4.5
Butte Creek	Wild[1]	45.3	52.3	53.6	67.0	31.3	24.4	42.7	38.1	25.4	55.5		43.3
	Game farm	54.7	47.7	46.4	33.0	68.7	75.6	57.3	61.9	74.6	44.5	†	56.7
Meridian	Wild	48.5	48.9	50.4	25.4	19.0	35.8		40.6	5.5	100.0	27.8	41.2
	Game farm	51.5	51.1	49.6	74.6	81.0	64.2	100.0	59.4	94.5		72.2	58.8
Los Banos	Wild	18.1	22.5	34.3	8.0	19.5	6.6	9.6	40.9	13.3	38.4		18.1
	Game farm	81.9	77.5	65.7	92.0	80.5	93.4	90.4	59.1	86.7	61.6	†	81.9
Firebaugh	Wild	6.8	9.1	12.1	1.5	3.9	14.0	4.5	0.9	14.0			6.6
	Game farm	93.2	90.9	87.9	98.5	96.1	86.0	95.5	99.1	86.0	100.0	100.0	93.4
Averages	Wild	58.1	62.8	62.6	39.5	35.6	38.0	39.4	48.1	60.0	68.4	47.0	53.0
	Game farm	41.9	37.2	37.4	60.5	64.4	62.0	60.6	51.9	40.0	31.6	53.0	47.0

[1] Includes 55 wild transplanted birds.
† Date unknown game farm returns prorated over season.

TABLE 10

Daily Kill of Wild and Game Farm Birds Expressed as a Percentage of the Season Kill

Area	Type of bird	Day of season										Un-known
		1	2	3	4	5	6	7	8	9	10	
Staten Island	Wild	30.9	17.8	8.3	3.8	11.4	10.2	5.2	5.9	4.6	1.9	
	Game farm	31.6	14.8	2.2	18.2	16.6	8.6	3.1	2.2	2.2	0.5	
Ryer Island	Wild	33.1	20.6	2.3	6.4	4.2	7.6	6.5	8.2	9.1	2.0	
	Game farm	33.2	23.8	4.6	8.0	13.7	9.2	2.7	2.4	1.9	0.5	†
Sutter Basin	Wild	49.5	16.5	3.0	5.0	8.5	3.7	4.0	5.3	3.7	0.8	
	Game farm	38.9	8.9	1.6	3.4	10.1	16.2	12.1	4.5	3.2	1.1	
Natomas	Wild	43.8	21.2	5.8	4.3	4.9	4.2	4.1	4.2	5.1	2.4	
	Game farm	34.3	14.0	1.9	1.9	9.7	10.0	14.6	6.1	6.8	0.7	
Grimes	Wild	48.2	22.2	3.2	3.6	3.9	5.3	2.9	4.2	3.3	0.9	2.3
	Game farm	31.5	7.8	1.2	3.6	10.5	14.1	4.6	15.7	4.9	1.2	4.9
Sartain	Wild	35.0	14.1	4.4	2.1	5.0	7.8	6.7	7.3	10.0	7.6	
	Game farm	61.2	8.4		8.3	5.5	5.5		5.5	2.8	2.8	
Butte Creek	Wild[1]	43.2	20.0	5.8	6.5	5.8	6.6	4.7	4.2	1.5	1.7	
	Game farm	40.0	14.0	3.8	2.4	9.8	15.7	4.8	5.2	3.3	1.0	†
Meridian	Wild	54.5	24.5	4.9	3.6	2.8	4.5		2.8	0.2	0.2	2.2
	Game farm	40.5	16.9	2.5	7.7	8.3	5.6	9.3	2.9	2.2		4.1
Los Banos	Wild	29.0	16.1	13.3	4.4	13.9	4.4	3.9	10.0	2.2	2.8	
	Game farm	29.0	12.2	5.6	11.3	12.6	13.8	8.1	3.2	3.2	1.0	†
Firebaugh	Wild	40.4	17.7	6.7	2.5	5.9	16.8	4.2	0.8	5.0		
	Game farm	38.9	12.3	3.4	11.1	10.3	7.3	6.2	6.3	2.2	1.8	0.2
Averages	Wild	43.9	20.2	4.6	4.2	5.4	5.7	4.0	4.9	4.4	1.9	0.8
	Game farm	36.0	13.4	3.0	7.4	10.9	11.0	6.9	6.0	3.3	1.0	1.1

[1] Includes 55 wild transplanted birds.
† Date unknown game farm returns prorated over season.

TABLE 11

Rate of Kill of Game Farm Birds Released in Season Expressed as a Percentage of Total Returns

	Days after release											
	0		1		2		3		4		Later or unknown	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Daily	204	6.7	1,723	56.2	612	20.0	251	8.2	122	4.0	150	4.9
Cumulative	204	6.7	1,927	62.8	2,539	82.9	2,790	91.1	2,912	95.0	3,062	100.0

Table 12 summarizes returns from all male birds stocked on the areas, and Table 13 gives the daily returns from each release on each area. Approximately 70 percent of the cocks released inseason were bagged. Preseason releases, which were made from January to the day before the season, gave returns which averaged about 59 percent, with the highest of these returns from birds freed in November. Figure 172

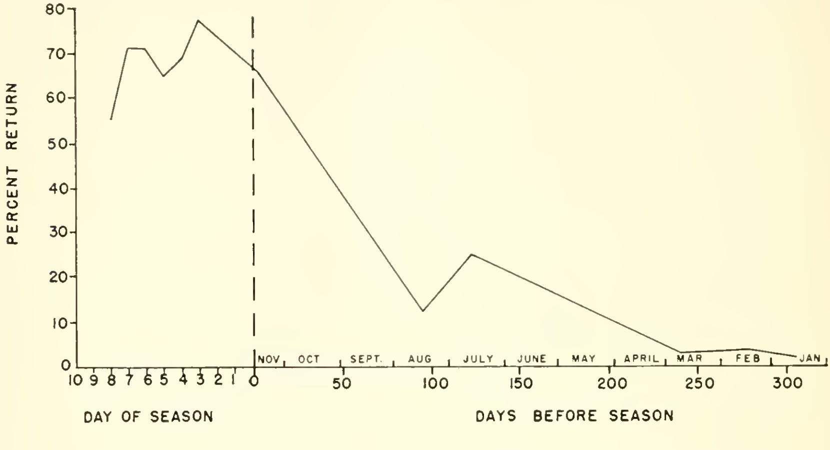

FIGURE 172. Band returns by date of release from all liberations of game farm birds on cooperative hunting areas, 1950

shows the return based on the length of time in the field. Early releases put comparatively few birds in the bag, due chiefly to a high rate of mortality over the intervening months. The percentage of birds bagged from August releases was lower than from July liberations, which paralleled results obtained from previous experimental stocking (Harper, Hart and Shaffer, 1951). This appears to be due to adverse weather or habitat conditions in midsummer. Except for this reversal there is a direct relation between length of time in field and degree of return, those releases made a few days prior to or in the first part of the season yielding the highest returns.

Table 14 shows seasonal composition of the kill on each area. Birds other than wild pheasants or pheasants stocked on the cooperative hunting areas in 1950 contributed very little to the bag. As noted in this table, 20 additional band returns received after the hunting season were added to the totals for Firebaugh, because they markedly changed some of the kill figures. Careful examination of the data showed that the considerable task of revising completed tabulations and repeating computations to include these few late band returns would result in insignificant changes for all areas other than Firebaugh. Therefore, additional late band returns received for other areas were not used.

TABLE 12

Summary of Releases and Kill of Game Farm Birds on All Areas, 1950

Date released	Cocks released		Returns by day of season											Total returns coop. areas	Off area returns	Total returns	
	Number	Age (mos.)	1	2	3	4	5	6	7	8	9	10	Unknown			Number	Percent
January	45	9	1											1		1	2.2
February	25	12	1											1		1	4.0
March	53	12–15	1		1									2		2	3.8
July	342	3	41	25	6	1	2	1	4	2			2	84	1	85	24.8
August	200	3	1	4	4	1		3		2	1	1		17	7	24	12.0
November 8–17	7,976	4–6	2,780	1,042	213	179	160	121	99	70	57	35	82	4,838	117	4,955	62.1
Subtotals	8,641	3–15	2,825	1,071	224	181	162	125	103	74	58	36	84	4,943	125	5,068	58.7
November 20	699	4–5			14	325	102	52	19	12	7	1	3	535	6	541	77.4
November 21	1,826	4–5				78	610	317	112	57	46	10	13	1,243	15	1,258	68.9
November 22	814	4–5					2	343	85	38	39	9	10	526	5	531	65.3
November 23	459	4–5						53	177	52	32	3	2	319	7	326	71.0
November 24	542	4–5							57	246	56	17	4	380	4	384	70.9
November 25	40	5									22			22		22	55.0
Subtotals	4,380	4–5			14	403	714	765	450	405	202	40	32	3,025	37	3,062	70.0
Grand totals	13,021	3–15	2,825	1,071	238	584	876	890	553	479	260	76	116	7,968	162	8,130	62.4

TABLE 13

Releases and Kill of Game Farm Birds by Area

Date released	Cocks released		Returns by day of season											Total returns coop. areas	Off area returns	Total returns	
	Number	Age (mos.)	1	2	3	4	5	6	7	8	9	10	Unknown			Number	Percent
Staten Island																	
Aug. 4	200	3	1	4	4	1		3		2	1	1		17	7	24	12.0
Nov. 13	500	4	169	77	8	18	11	11	8	5		2		309	8	317	63.4
Nov. 20	150	4				82	17	9	3					111	2	113	75.3
Nov. 21	150	4					64	25	6	4	9			108		108	72.0
Totals	1,000	3–4	170	81	12	101	92	48	17	11	10	3		545	17	562	56.2
1949	1,156	3–5	1	1						1	2			5		5	0.4
Ryer Island																	
Mar. 25	8	15			1									1		1	12.5
Nov. 14	400	5	113	82	11	13	9	13	4	9	7	3	3	270		270	67.5
Nov. 17	300	4	128	95	7	4	5	2		3			2	246		246	80.2
Nov. 20	100	4			13	37	7	8	3		1	1	2	72	1	73	73.0
Nov. 21	200	4				5	81	45	13	5	5		1	155		155	77.5
Totals	1,008	4-15	241	177	35	59	102	68	20	17	13	4	8	744	1	745	74.0
Sutter Basin																	
Nov. 14	450	5	130	36	5	12	12	11	5	6	5			222	23	245	54.5
Nov. 15	250	5	98	15	3		5	6	1		3	1		132	12	144	57.6
Nov. 21	200	5				9	44	33	14	4	8	3		115	1	116	58.0
Nov. 22	100	5						47	11	4	1	1		64	2	66	66.0
Nov. 23	99	4½							41	13	3	2		59	5	64	64.6
Totals	1,099	4½–5	228	51	8	21	61	97	72	27	20	7		592	43	635	57.8
1949	1,009	4	1		1				1					3		3	0.3

Natomas																
Jan. 15	45	9	1											1		1	2.2
Feb. 12	25	12	1											1		1	4.0
Mar. 19	45	12	1											1		1	2.2
Nov. 13	500	5	99	57	6	5	5	4	5	2	4	1		188	8	196	39.2
Nov. 14	400	5	128	39	7	4	5	1	4	2	1	1		192	6	198	49.5
Nov. 21	160	5					59	19	8	5	4			95	4	99	61.8
Nov. 22	160	5						45	5	9	7	1		67		67	41.9
Nov. 23	160	5							79	23	10			112	2	114	71.3
Nov. 25	40	5									22			22		22	55.0
Totals	1,535	5-12	230	96	13	9	69	69	101	41	48	3		679	20	699	45.6
1949	1,461	3-12	2	2					1	1		1		6		6	0.4
Grimes																	
Nov. 13	300	5	99	23	5	12	12	7	11	2	5	2	10	188	2	190	60.3
Nov. 14	300	5	100	29	3	5	1	7	1	1	2	2	2	153	11	164	54.7
Nov. 16	400	5	150	33	5	5	7	5	5	3	4		22	239	3	242	60.5
Nov. 21	300	4				18	89	50	21	17	6		6	207	3	210	70.0
Nov. 22	200	4½					2	89	14	5	9	4	9	132	3	135	67.5
Nov. 24	280	5								145	27	5	4	181	4	185	66.0
Totals	1,780	4-5	349	85	13	40	111	158	52	173	53	13	53	1,100	26	1,126	63.2
1949	1,498	4	3				1				1		2	7		7	0.5
Sartain																	
No releases																	
Butte Creek																	
July 18	342	3	41	25	6	1	2	1	4	2			2	84	1	85	24.8
Nov. 14	250	5	98	44	8	6	8	5	3	3	4		2	181	2	183	73.1
Nov. 15	250	5	82	17	7	9	1	7	4	5	1	2		135		135	54.0
Nov. 16	500	5	224	71	23	12	11	5	2	3	6	2	2	361	3	364	72.8
Nov. 21	266	4					86	65	14	8	8	3	1	185		185	69.5
Nov. 22	207	4						95	27	9	10	3	1	145		145	70.0
Nov. 24	62	4								29	9	1		39		39	62.9
Totals	1,877	3-5	445	157	44	28	108	178	54	59	38	11	8	1,130	6	1,136	60.6

TABLE 13—Continued

Releases and Kill of Game Farm Birds by Area

Date released	Cocks released		Returns by day of season											Total returns coop. areas	Off area returns	Total returns	
	Number	Age (mos.)	1	2	3	4	5	6	7	8	9	10	Unknown			Number	Per-cent
Meridian																	
Nov. 15	500	4	203	77	7	4	5	1	3		1		7	308	7	315	63.0
Nov. 16	300	5	96	49	9	6	4	4	3	3			14	188	8	196	65.3
Nov. 20	150	4			1	43	25	18	4	5	2		1	99	3	102	68.0
Nov. 21	150	4				6	29	20	21	7	1		5	89	5	94	62.6
Nov. 23	100	4½							38	7	13		2	57		57	57.0
Totals	1,200	4-5	299	126	17	59	64	43	69	22	17		29	741	23	764	63.6
Los Banos																	
Nov. 15	676	5	214	90	40	31	32	13	24	8	8	5	15	480	3	483	71.4
Nov. 20	99	5				52	17	8	4	1	2			84		84	84.8
Nov. 21	100	5					47	19	7	4	2			79		79	79.0
Nov. 22	147	4-5						67	28	11	12			118		118	80.2
Totals	1,022	4-5	214	90	40	83	96	107	63	24	24	5	15	761	3	764	74.7
Firebaugh																	
Nov. 8	250	6	32	8	11	4	9	3	4	4	1	7		83	7	90	36.0
Nov. 9	250	5½	47	33	7	4	1	5	3	1	1	4	1	107	5	112	44.8
Nov. 14	600	4	293	80	19	10	6	3	5	5	3		2	426	2	428	71.3
Nov. 15	300	4	141	30	5	7	4	3	2	1	1	1		195	6	201	67.0
Nov. 16	300	4	136	57	14	8	7	5	2	4		2		235	1	236	78.7
Nov. 20	200	4				111	36	9	5	6	2			169		169	84.5
Nov. 21	300	4				40	111	41	8	3	3	4		210	2	212	70.7
Nov. 23	100	4						53	19	9	6	1		88		88	88.0
Nov. 24	200	4							57	72	20	11		160		160	80.0
Totals	2,500	4-6	649	208	56	184	174	122	105	105	37	30	3	1,673	23	1,696	67.8

TABLE 14

Composition of Kill on Each Area

Area	State game farm releases prior to 1950	State coop. area releases 1950[2]	Other state releases	Game management area releases	Total game farm	Wild (resident)	Wild (transplanted)	Total kill
Staten Island	5	546	4	----------	555	421	----------	976
Ryer Island	1	744	5	2	752	660	----------	1,412
Sutter Basin	3	600	----------	17	620	948	----------	1,568
Natomas	7	679	22	13	721	1,863	----------	2,584
Grimes	7	1,105	9	2	1,123	2,940	----------	4,063
Sartain	4	28	----------	4	36	757	----------	793
Butte Creek	12	1,131	1	2	1,146	823	55	2,024
Meridian	3	746	7	4	760	532	----------	1,292
Los Banos	6	761	49	----------	816	180	----------	996
Firebaugh[1]	4	1,673	19	----------	1,696	119	----------	1,815
Total	52	8,013	116	44	8,225	9,243	55	17,523

[1] 20 postseason game farm returns added in to totals.
[2] Includes returns of releases made on cooperative areas other than that on which taken.

Hunting Pressure

Hunter days expended during the opening three days in 1949 amounted to 63 percent of the total as compared to 50 percent expended during the opening three days of 1950 (Figure 173). As explained

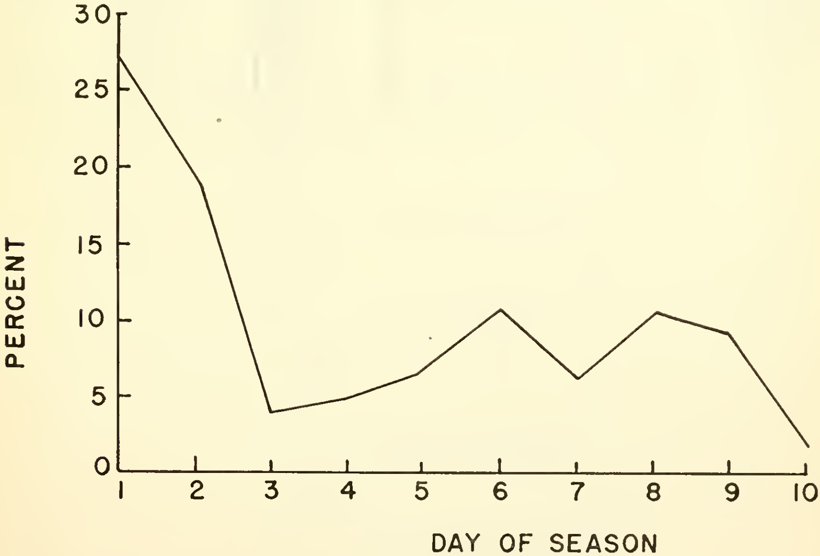

FIGURE 173. Hunters per day expressed as a percentage of the total number

previously, the fact that the third day in 1950 was a working day affected these figures. Hunting pressure was low on the week days, increasing slightly on Thanksgiving Day (the sixth day) and again on the final weekend.

The average of 3.3 hours spent in the field by each hunter (Table 15) was less than the 3.6 hours hunted in 1949, as would be expected from the adverse hunting conditions.

The number of gun hours per day closely parallels the number of hunters per day. Data for each expressed as percentages of the season totals are given in Table 16 and Figure 173. Daily and seasonal hunter days per 1,000 acres for each area in 1950 are given in Table 17. These figures varied from 143 hunters per 1,000 acres on Sartain to 551 on Staten Island. In 1949, Natomas was highest with 1,058 hunter days per 1,000 acres, due to its close proximity to Sacramento. The corresponding figure for 1950 was less than half that amount, because the size of open and restricted zones was nearly doubled while the total number of hunters decreased.

TABLE 15

Calculated Length of Hunter Day on Each Area

Area	Number of hunters reporting hours hunted	Total reported number of hours hunted	Average hours hunted
Staten Island	4,035	11,847	2.9
Ryer Island	3,656	11,921	3.3
Sutter Basin	3,946	13,472	3.4
Natomas	8,037	24,328	3.0
Grimes	7,396	29,295	4.0
Sartain	1,408	6,164	4.4
Butte Creek	5,774	17,590	3.0
Meridian	2,225	7,066	3.2
Los Banos	2,306	6,186	2.7
Firebaugh	3,431	9,607	2.8
Totals and average	42,214	137,476	3.3

TABLE 16

Gun Hours per Day Expressed as a Percentage of Total Gun Hours

Day	Staten Island	Ryer Island	Sutter Basin	Natomas	Grimes	Sartain	Butte Creek	Meridian	Los Banos	Firebaugh	Averages, all areas
1	16.0	20.8	33.0	25.5	32.1	48.1	25.4	33.9	11.9	19.8	26.8
2	18.1	19.0	17.9	22.6	18.9	12.0	21.0	23.6	15.2	14.2	19.1
3	3.0	3.5	1.7	3.6	2.8	3.2	4.5	5.0	5.2	4.9	3.5
4	6.0	7.6	2.6	4.4	3.0	2.0	6.5	4.2	6.5	5.0	4.6
5	9.4	4.7	4.4	7.5	4.9	3.2	8.0	5.6	9.5	9.2	6.6
6	15.8	9.6	9.2	9.7	8.5	5.0	11.1	5.3	13.0	15.1	10.2
7	9.5	5.4	7.8	5.9	6.0	5.2	5.8	5.9	8.6	8.9	6.7
8	11.5	13.3	12.5	10.1	12.1	7.3	8.9	9.6	13.4	12.7	11.2
9	8.6	13.1	9.4	8.8	10.0	10.5	6.9	5.8	13.1	7.0	9.2
10	2.1	3.0	1.5	1.9	1.3	3.5	1.9	1.1	3.6	3.2	2.0
Day unknown	----------	----------	----------	----------	0.4	----------	----------	----------	----------	----------	0.1

TABLE 17

Hunter Days per 1,000 Acres

Day	Staten Island	Ryer Island	Sutter Basin	Natomas	Grimes	Sartain	Butte Creek	Meridian	Los Banos	Firebaugh	Averages
1	98	89	173	118	118	71	132	96	56	104	106
2	95	99	117	104	63	20	105	66	50	78	80
3	17	25	14	17	10	5	24	13	17	22	16
4	32	37	16	28	11	2	34	11	25	28	22
5	49	24	29	35	17	4	38	16	31	43	29
6	90	50	46	52	33	6	57	14	45	76	47
7	50	27	40	25	20	7	26	18	29	37	28
8	58	59	54	45	41	9	43	25	43	56	43
9	49	69	48	39	33	13	33	19	49	36	39
10	13	16	8	10	5	6	8	4	17	10	10
Seasonal	551	495	545	473	351	143	500	282	362	490	420

Hunter Success

Hunter success seasonally and by day for all areas is given in Figure 174 and Table 18. Over-all success per hunter day was 0.39 birds per hunter as compared to 0.32 birds per hunter in 1949.

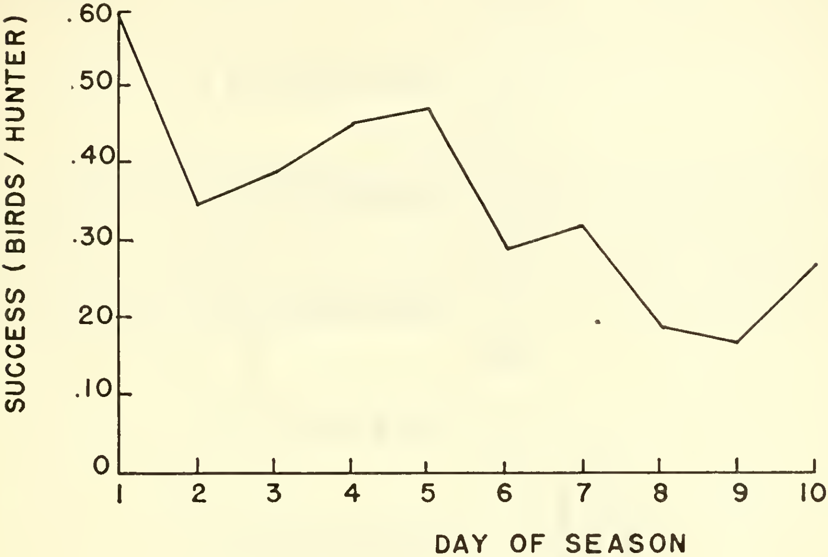

FIGURE 174. Hunter success (birds per hunter), all areas

Increased success was due to a combination of fewer hunters per unit area with heavier game farm bird stocking just prior to and during the season. Hunters on the Sartain area again, as in 1949, had the highest success. This probably was caused more by low hunting pressure than by the somewhat greater length of time these hunters spent in the field. The Meridian, Grimes and Firebaugh areas followed Sartain closely in that order. Success on Sartain, where no game farm birds were stocked, was highest in midseason. The time during the season when success was highest on other areas varied considerably and was greatly influenced by inseason stocking. Twenty-nine percent of the hunter days accounted for all birds taken on the areas, approximately the same as in 1949 (Table 19). Expressed in another way, successful hunters averaged 1.35 birds per day, but no birds were bagged on more than 70 percent of the hunter days.

TABLE 18

Hunter Success by Day
(Birds per Man)

Day	Staten Island	Ryer Island	Sutter Basin	Natomas	Grimes	Sartain	Butte Creek	Meridian	Los Banos	Firebaugh	Averages
1	.42	.52	.54	.49	.72	.41	.51	.72	.94	.89	.59
2	.22	.41	.25	.27	.50	.63	.27	.46	.36	.40	.35
3	.35	.32	.42	.37	.42	.58	.32	.37	.58	.38	.39
4	.47	.37	.55	.26	.56	.68	.20	.77	.55	.94	.45
5	.37	.74	.70	.25	.60	.85	.35	.52	.57	.56	.47
6	.13	.31	.35	.16	.44	.81	.33	.53	.37	.25	.29
7	.10	.32	.32	.38	.29	.65	.29	.45	.36	.38	.32
8	.08	.16	.16	.15	.31	.55	.17	.17	.14	.26	.19
9	.08	.14	.14	.19	.20	.50	.12	.11	.09	.16	.17
10	.11	.14	.23	.29	.37	.73	.26	.03	.13	.38	.27
Seasonal	.23	.36	.37	.30	.51	.53	.33	.52	.40	.49	.39

TABLE 19

Hunter Days by Level of Success

	Two birds	One bird	No birds
Hunter days	4,534	8,455	32,367
	29%		71%

Use of Dogs

A comparison of hunter success and crippling loss with and without dogs, (Tables 20 and 21) showed results in general parallel to those obtained for the 1949 hunting season. Hunters using dogs were more successful in bagging birds, averaging 0.47 birds per day compared to 0.30 bagged by those without dogs. Hunters with dogs reported an average crippling loss of 10.3 percent, compared to a 15.8 percent loss by hunters without dogs.

TABLE 20

Use and Effect of Dogs on Kill

Area	Hunter days		Total bag		Reported crippling loss	
	Number	Percent	Number	Percent	Number	Percent[1]
Staten Island						
With dog	1,811	42.7	540	55.3	57	46.3
Without dog	2,317	54.7	409	41.9	64	52.0
Not specified	109	2.6	27	2.8	2	1.7
Ryer Island						
With dog	1,841	46.4	816	57.8	96	51.1
Without dog	1,944	49.0	579	41.0	89	47.3
Not specified	180	4.6	17	1.2	3	1.6
Sutter Basin						
With dog	2,174	51.0	927	59.1	115	48.1
Without dog	1,870	43.9	610	38.9	120	50.2
Not specified	217	5.1	31	2.0	4	1.7
Natomas						
With dog	5,244	61.3	1,999	77.4	220	68.2
Without dog	3,011	35.2	532	20.6	88	27.2
Not specified	295	3.5	53	2.0	15	4.6
Grimes						
With dog	4,147	51.9	2,670	65.7	212	45.3
Without dog	3,383	42.2	1,234	30.4	232	49.7
Not specified	468	5.9	159	3.9	23	5.0
Sartain						
With dog	846	56.7	541	68.2	104	65.8
Without dog	578	38.7	223	28.1	53	33.6
Not specified	69	4.6	29	3.7	1	0.6
Butte Creek						
With dog	3,676	59.3	1,463	72.3	185	64.3
Without dog	2,211	35.7	489	24.2	95	32.9
Not specified	310	5.0	72	3.5	8	2.8
Meridian						
With dog	1,420	56.9	906	70.1	75	64.1
Without dog	863	34.6	315	24.4	39	33.3
Not specified	211	8.5	71	5.5	3	2.6
Los Banos						
With dog	911	36.9	428	43.0	26	31.7
Without dog	1,442	58.4	550	55.2	53	64.7
Not specified	116	4.7	18	1.8	3	3.6
Firebaugh						
With dog	1,385	37.5	816	45.0	59	37.5
Without dog	2,159	58.5	937	51.6	97	61.8
Not specified	148	4.0	62	3.4	1	0.7
Total						
With dog	23,455	51.7	11,106	63.4	1,149	53.6
Without dog	19,778	43.6	5,878	33.5	930	43.4
Not specified	2,123	4.7	539	3.1	63	3.0

[1] Given as percent each group made of total reported crippling loss.

TABLE 21

Effect of Dogs on Success and Crippling Loss

Area	Hunters with two birds		Hunters with one bird		Hunters with no birds		Reported crippling loss	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent[1]
Staten Island								
With dog	104	5.7	332	18.3	1,375	75.9	57	10.6
Without dog	70	3.0	269	11.6	1,978	85.4	64	15.6
Ryer Island								
With dog	214	11.6	388	21.1	1,239	67.3	96	11.8
Without dog	143	7.4	293	15.1	1,508	77.5	89	15.4
Sutter Basin								
With dog	248	11.4	431	19.8	1,495	68.8	115	12.4
Without dog	144	7.7	322	17.2	1,404	75.1	120	19.6
Natomas								
With dog	477	9.1	1,045	19.9	3,722	71.0	220	11.0
Without dog	106	3.5	320	10.6	2,585	85.9	88	16.5
Grimes								
With dog	767	18.5	1,136	27.4	2,244	54.1	212	7.9
Without dog	312	9.2	610	18.0	2,461	72.8	232	18.8
Sartain								
With dog	164	19.4	213	25.2	469	55.4	104	19.2
Without dog	46	8.0	131	22.7	401	69.3	53	23.8
Butte Creek								
With dog	340	9.2	783	21.3	2,553	69.5	185	12.6
Without dog	99	4.5	291	13.2	1,821	82.3	95	19.4
Meridian								
With dog	273	19.2	360	25.4	787	55.4	75	8.3
Without dog	77	8.9	161	18.7	625	72.4	39	12.4
Los Banos								
With dog	124	13.6	180	19.8	607	66.6	26	6.1
Without dog	135	9.4	280	19.4	1,027	71.2	53	9.6
Firebaugh								
With dog	241	17.4	334	24.1	810	58.5	59	7.2
Without dog	275	12.7	387	18.0	1,497	69.3	97	10.4
Total								
With dog	2,952	12.6	5,202	22.2	15,301	65.2	1,149	10.3
Without dog	1,407	7.1	3,064	15.5	15,307	77.4	930	15.8

[1] Given as a percentage of the total kill for each group.

Home Region of Hunters

Tables 22 through 31 show where the hunting pressure for each area originated. Local and San Francisco Bay region hunters predominated on all areas. Natomas, Butte Creek, Los Banos, Grimes and Firebaugh supported the greatest number of local hunters, while Ryer Island, Sartain and Sutter Basin attracted more Bay area hunters. Staten Island and Meridian had approximately equal numbers of local and Bay area hunters. During the 1949 season, only Natomas had predominantly local hunters and the five other areas supported large numbers of Bay area hunters. The fewer areas on which San Francisco Bay region hunters predominated in 1950 (3 out of 10) as compared to 1949 (5 out of 6) is explained by the dispersion of approximately the same number of hunters from this region over a larger number of cooperative hunting areas.

Local and Bay area hunters composed more than 80 percent of the hunters on all areas except Meridian, Los Banos, Firebaugh and Sartain. These two categories included nearly 60 percent of the hunters on Sartain and 70 to 80 percent of the total on the three other areas.

TABLE 22

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

Region of residence	Opening 2 days		Weekdays		Final weekend	
	Number	Percent	Number	Percent	Number	Percent
Local	796	52.6	1,207	51.9	218	45.3
San Francisco Bay Region	552	36.3	902	38.8	220	45.8
Southern California	29	1.9	17	0.7	2	0.4
San Joaquin Valley	36	2.4	44	1.9	4	0.8
Upper Sacramento Valley	12	0.8	6	0.3	10	2.1
Others	40	2.6	41	1.8	2	0.4
Unknown	52	3.4	108	4.6	25	5.2

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

TABLE 23

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

Region of residence	Opening 2 days		Weekdays		Final weekend	
	Number	Percent	Number	Percent	Number	Percent
Local	324	19.3	460	26.6	154	23.3
San Francisco Bay Region	1,191	70.8	934	54.1	461	69.8
Southern California	21	1.3	16	0.9	4	0.6
San Joaquin Valley	12	0.7	29	1.7	2	0.3
Upper Sacramento Valley	3	0.2	10	0.6	5	0.8
Others	21	1.3	22	1.3	5	0.8
Unknown	108	6.4	257	14.8	30	4.4

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

TABLE 24

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

Region of residence	Opening 2 days		Weekdays		Final weekend	
	Number	Percent	Number	Percent	Number	Percent
Local	441	18.9	444	25.4	94	18.6
San Francisco Bay Region	1,565	66.9	1,124	64.3	358	71.0
Southern California	29	1.3	37	2.1	0	0.0
San Joaquin Valley	40	1.7	9	0.5	3	0.6
Upper Sacramento Valley	143	6.1	39	2.2	7	1.4
Others	60	2.6	53	3.0	15	3.0
Unknown	59	2.5	43	2.5	27	5.4

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

TABLE 25

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

Region of residence	Opening 2 days		Weekdays		Final weekend	
	Number	Percent	Number	Percent	Number	Percent
Local	3,353	77.3	3,279	85.2	796	83.1
San Francisco Bay Region	437	10.1	156	4.0	61	6.4
Southern California	94	2.2	51	1.3	1	0.1
San Joaquin Valley	78	1.8	36	0.9	11	1.2
Upper Sacramento Valley	90	2.1	87	2.3	29	3.0
Others	67	1.5	25	0.6	5	0.5
Unknown	215	5.0	218	5.7	55	5.7

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

TABLE 26

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

Region of residence	Season total[1]	
	Number	Percent
Local	704	8.9
San Francisco Bay Region	5,808	73.0
Southern California	254	3.2
San Joaquin Valley	108	1.4
Other Sacramento Valley	580	7.3
Others	260	3.3
Unknown	227	2.9

Local: Glenn, Colusa, Lake, Yolo, Sutter, Yuba, Butte Counties.
San Francisco Bay Region: Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Sonoma, Napa Counties.
Southern California: Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
San Joaquin Valley: San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Kern, Tulare, Mariposa, Tuolumne Counties.
Other Sacramento Valley: Sacramento, Placer, El Dorado, Amador, Nevada, Tehama Counties.
Others: All other counties.
Unknown: Residence not stated on permit.
[1] Breakdown into three periods not possible because many applications were neither dated nor kept separate by days issued.

TABLE 27

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

Region of residence	Opening 2 days		Weekdays		Final weekend	
	Number	Percent	Number	Percent	Number	Percent
Local	116	11.0	57	14.1	30	12.7
San Francisco Bay Region	535	51.0	166	41.0	118	50.0
Southern California	90	8.6	70	17.3	10	4.2
San Joaquin Valley	34	3.3	3	0.7	1	0.4
Other Sacramento Valley	67	6.4	21	5.2	6	2.6
Others	123	11.7	26	6.4	13	5.5
Unknown	85	8.0	62	15.3	58	24.6

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

TABLE 28

Residence by Region of Hunters on Butte Creek Cooperative Hunting Area No. 7

Region of residence	Opening 2 days		Weekdays		Final weekend	
	Number	Percent	Number	Percent	Number	Percent
Local	1,665	55.6	2,038	71.1	371	67.1
San Francisco Bay Region	671	22.4	333	11.6	81	14.6
Southern California	153	5.1	93	3.2	5	1.0
San Joaquin Valley	67	2.2	42	1.5	2	0.4
Other Sacramento Valley	139	4.7	87	3.1	9	1.6
Others	205	6.9	167	5.8	64	11.5
Unknown	93	3.1	107	3.7	21	3.8

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

TABLE 29

Residence by Region of Hunters on Meridian Cooperative Hunting Area No. 8

Region of residence	Opening 2 days		Weekdays		Final weekend	
	Number	Percent	Number	Percent	Number	Percent
Local	482	31.9	334	36.6	84	40.6
San Francisco Bay Region	576	38.2	287	31.4	76	36.7
Southern California	59	3.9	57	6.2	4	1.9
San Joaquin Valley	54	3.6	22	2.4	1	0.5
Other Sacramento Valley	121	8.0	69	7.5	10	4.8
Others	93	6.2	65	7.1	12	5.8
Unknown	124	8.2	80	8.8	20	9.7

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

TABLE 30

Residence by Region of Hunters on Los Banos Cooperative Hunting Area No. 9

Region of residence	Opening 2 days		Weekdays		Final weekend	
	Number	Percent	Number	Percent	Number	Percent
Local	403	52.0	921	66.0	247	51.6
San Francisco Bay Region	176	22.7	203	14.6	126	26.3
Southern California	50	6.5	45	3.2	12	2.5
Other San Joaquin	35	4.5	36	2.6	10	2.1
Northern California	----------	----------	11	0.8	----------	----------
Others	99	12.8	142	10.2	68	14.2
Unknown	12	1.5	36	2.6	16	3.3

Local: Merced, Stanislaus, Madera, San Benito, Fresno Counties.
San Francisco Bay Region: Contra Costa, San Mateo, Santa Clara, San Francisco, Alameda Counties.
Southern California: Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
Other San Joaquin: San Joaquin, Kings, Tulare, Kern Counties.
Northern California: All counties north of San Francisco Bay.
Others: Santa Cruz, Monterey, San Luis Obispo, Mono, Tuolumne, Calaveras, Mariposa, Inyo, Alpine Counties.
Unknown: Residence not stated on permit.

TABLE 31

Residence by Region of Hunters on Firebaugh Cooperative Hunting Area No. 10

Region of residence	Opening 2 days		Weekdays		Final weekend	
	Number	Percent	Number	Percent	Number	Percent
Local	889	63.7	1,480	73.6	258	71.5
San Francisco Bay Region	73	5.2	68	3.4	27	7.5
Southern California	150	10.7	95	4.7	10	2.8
Other San Joaquin	132	9.4	139	6.9	25	6.9
Northern California	4	0.3	34	1.7	3	0.8
Others	71	5.1	99	4.9	27	7.5
Unknown	78	5.6	96	4.8	11	3.0

Local: Fresno, Merced, San Benito, Madera Counties.
San Francisco Bay Region: San Francisco, San Mateo, Alameda, Contra Costa, Santa Clara Counties.
Southern California: Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
Other San Joaquin: Stanislaus, San Joaquin, Kings, Tulare, Kern Counties.
Northern California: All counties north of San Francisco Bay.
Others: Inyo, Calaveras, Tuolumne, Mariposa, Alpine, Santa Cruz, Monterey, San Luis Obispo, Mono Counties.
Unknown: Residence not stated on permit.

Cock-hen Ratios

Sex ratio counts were taken with hiking censuses before and after the season on five of the areas in the Sacramento Valley. Preseason counts indicated that ratios varied from approximately 43 to 61 cocks per 100 hens, with an average of 51.8 cocks per 100 hens. Postseason counts revealed that ratios then were fairly comparable on all areas, with an average of 16.5 cocks per 100 hens remaining after the hunting season. Table 32 gives the sex ratio data for each of the five areas. The number of birds counted indicates only the size of the sample taken to obtain the sex ratio, and does not necessarily reflect the number of birds on the area.

TABLE 32

Sex Ratios on Cooperative Hunting Areas in the Sacramento Valley

Area	Preseason		Postseason	
	Birds counted	Cock-hen ratio	Birds counted	Cock-hen ratio
Natomas	533	43.3:100	564	15.1:100
Sutter Basin	597	61.4:100	928	18.8:100
Grimes	739	48.4:100	786	15.8:100
Butte Creek	486	54.8:100	760	14.3:100
Sartain	855	52.4:100	1,236	17.5:100
Totals and averages	3,210	51.8:100	4,274	16.5:100

REACTION OF HUNTERS TO COOPERATIVE HUNTING AREAS

Comments of hunters on cooperative areas were recorded on returned permit forms. The number of permits having comments that could be interpreted as either favorable or unfavorable was approximately 2 percent of the total number returned. As in 1949, the reaction of hunters was predominantly favorable. More than 90 percent of the comments were favorable on 7 of the 10 areas, and unfavorable comments exceeded 18 percent on the charge area only. As could be expected, people paying a fee to hunt were more critical, and slightly more than half of their comments were unfavorable. Table 33 presents data in regard to comments made by hunters on each area.

TABLE 33

Reaction of Hunters to Cooperative Hunting Areas

Area	Comments[1]			
	Favorable		Unfavorable	
	Number	Percent	Number	Percent
Staten Island	56	87.5	8	12.5
Ryer Island	100	95.2	5	4.8
Sutter Basin	105	92.9	8	7.1
Natomas	78	96.3	3	3.7
Grimes	203	94.0	13	6.0
Sartain[2]	53	46.1	62	53.9
Butte Creek	135	82.3	29	17.7
Meridian	48	100.0	0	0.0
Los Banos	21	100.0	0	0.0
Firebaugh	35	97.1	1	2.9
Totals	834	86.7	129	13.3

[1] The majority of the hunters made no comments or made comments that could not be interpreted as either favorable or unfavorable.

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

REACTION OF LANDOWNERS COOPERATING

Questionnaires were sent to each of the 142 cooperating landowners or agents soon after the close of the hunting season. Of a total of 70 landowners that returned questionnaires or were contacted in person, 64 were satisfied with the operation of the areas in 1950. Fifty-nine landowners stated, some conditionally, that they would continue with the program; two replied that they would not continue, and nine were undecided.

Hunter damage to cooperating landowners' property was negligible when weather and ground conditions, number of hunters involved, and total acreage are considered. Eleven landowners reported some type of damage, mainly trampling of standing crops or cutting up of wet, secondary roads.

The majority of the landowners opposed a longer pheasant season; only 7 of the 66 persons that answered this question favored a longer season.

Constructive suggestions were received from a number of landowners for various methods of improving operation of cooperative hunting areas.

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THE FISHERY OF CLEAR LAKE, LAKE COUNTY, CALIFORNIA[1]

By GARTH I. MURPHY[2]
Bureau of Fish Conservation
California Division of Fish and Game

TABLE OF CONTENTS

INTRODUCTION

A study of Clear Lake was initiated in May of 1946. The general objectives of the investigation were to ascertain the condition of the sport fishery, and, if possible, to prescribe a management program to improve it.

This report is organized into three general sections. The first is concerned with descriptive material on Clear Lake and its drainage basin. The second section includes all the available data on the catch. The third section deals with specialized information, such as growth rate, that can be grouped around individual species or groups of species. These sections are followed by a discussion of the problems at Clear Lake.

[1] Submitted for publication February, 1951.

[2] Now with the U. S. Fish and Wildlife Service, P. O. F. I., Honolulu, T. H. The following persons assisted with the field work: Mr. William Donaldson, Mr. R. D. Beland, and Mr. Robert Hoffman. A particular debt of gratitude is owed the Lake County Board of Supervisors, who, at the instigation of the Lake County Sportsmen's Association, made county funds available for some of the field work and for certain capital expenditures. A number of employees of the Division of Fish and Game rendered invaluable aid. In particular, Warden Jack Sawyer of Lakeport was most helpful through advice and criticism based on his years of intimate acquaintance with Clear Lake.

Some of the information derived from this study has been published in other papers. These include data on the life histories of the Sacramento perch (Murphy, 1948a), the Sacramento hitch (Murphy, 1948b), the greaser blackfish (Murphy, 1950a), and the Sacramento squawfish (Taft and Murphy, 1950). The midsummer feeding habits of largemouth black bass of the year were described by Murphy (1949). A closed season on largemouth bass at Clear Lake was considered in detail, and was found to be undesirable and unnecessary (Murphy, 1950b).

A complete list of the fishes of Clear Lake is given in Table 1.

TABLE 1

The Fishes of Clear Lake

Common name	Scientific name
Rainbow trout	Salmo gairdnerii
Western sucker	Catostomus occidentalis
Carp[1]	Cyprinus carpio
Greaser blackfish	Orthodon microlepidotus
Hitch	Lavinia exilicauda
Sacramento squawfish	Ptychocheilus grandis
Thicktail chub	Gila crassicauda
Splittail	Pogonichthys macrolepidotus
Western roach	Hesperoleucus symmetricus
White catfish[1]	Ictalurus catus
Brown bullhead[1]	Ameiurus nebulosus
Mosquitofish[1]	Gambusia affinis
Largemouth black bass[1]	Micropterus salmoides
Green sunfish[1]	Lepomis cyanellus
Bluegill[1]	Lepomis macrochirus
Sacramento perch	Archoplites interruptus
Black crappie[1]	Pomoxis nigro-maculatus
Fresh-water viviparous perch	Hysterocarpus traskii
Riffle sculpin	Cottus gulosus
Three-spined stickleback	Gasterosteus aculeatus

[1] Introduced form.

CLEAR LAKE AND ITS DRAINAGE BASIN

General Description

Clear Lake (Figures 175 and 176) lies in the central portion of Lake County in Northern California at an elevation of 1,325 feet. It is in the Upper Sonoran Life Zone, with the Transition Zone appearing on the higher mountains that surround it. Its surface area varies with its level, as shown in Table 2, but for computational purposes the area of the lake will be regarded as 40,000 acres. Several small islands exist in the lake, as indicated in Figures 175 and 176. It is worth noting that Clear Lake, because of its relative shallowness, is potentially capable of producing sport fish over its entire area.

TABLE 2

Area of Clear Lake at Various Water Levels

Rumsey Gage reading in feet	Area in acres	Rumsey Gage reading in feet	Area in acres
—3.00	38,206	6.00	42,658
—2.00	38,641	7.00	43,365
0.00	39,607	7.56	43,748
1.00	40,119	8.00	44,050
2.00	40,640	9.00	44,566
3.00	41,018	10.00	44,990
4.00	41,319	10.30	45,118
5.00	41,910		

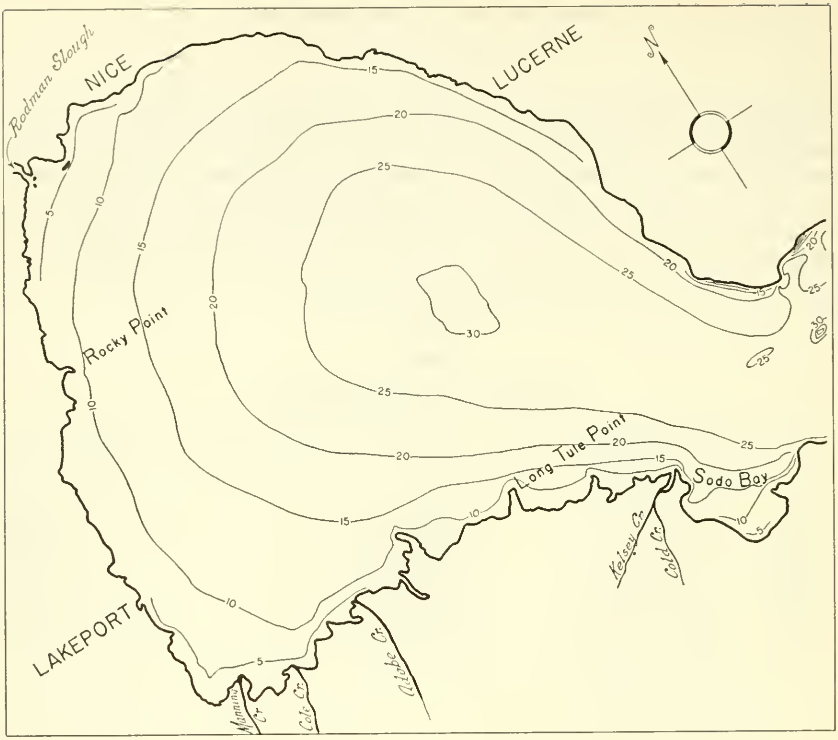

FIGURE 175. Clear Lake, west portion

The length of the shore line varies with the lake level, but is approximately 100 meander miles. The character of the shore line varies considerably. From Lakeport to west of Nice there are low mud flats lined with tule (*Scirpus*). From Nice to Clearlake Oaks the hills rise above the lake and the shore line is gravelly with occasional patches of tule. Between Clearlake Oaks and Clearlake Highlands the shore is also gravel and sand, with patches of tule, and the hills for the most part rise steeply from the lake. The extreme lower end of the lake is characterized by low-lying marshy areas with considerable stands of tule. The shore line between Lower Lake and Soda Bay is characterized by steep volcanic hills rising above beaches covered with boulders, gravel, and patches of tule. From Soda Bay to Lakeport it is characterized by sandy beaches, mud flats, and dense stands of tule.

Cache Creek, the outlet of Clear Lake, originally flowed directly into the Sacramento River. It is now intercepted by the Yolo By-pass and reaches the Sacramento River only at times of flood. As it leaves Clear Lake it is also partially controlled by a dam constructed in 1915 in order to store water for irrigation. By court decree the maximum storage in the

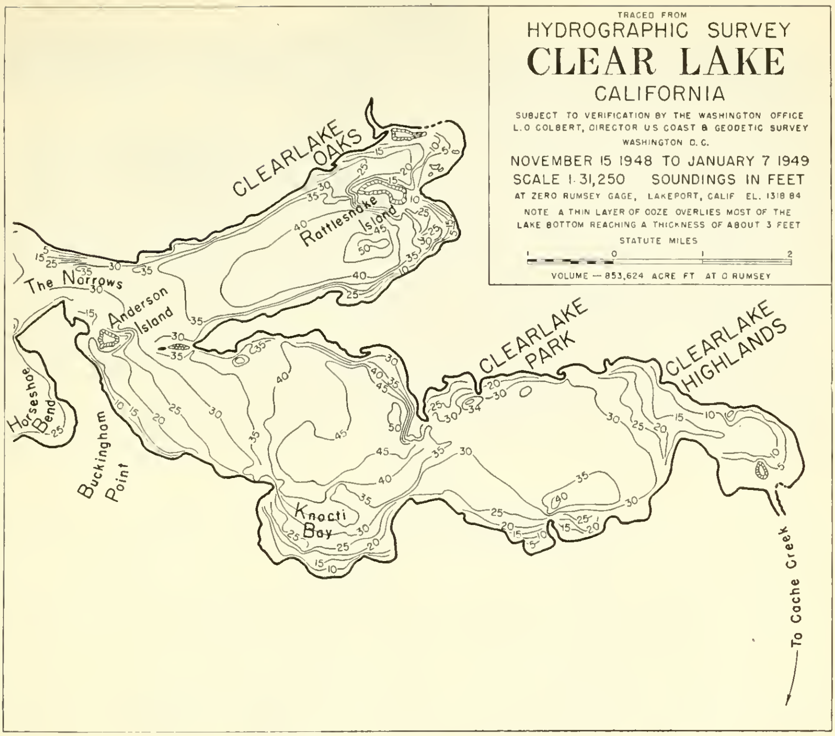

FIGURE 176. Clear Lake, east portion

lake is 7.56 feet above an arbitrary level referred to as 0.0 on the Rumsey Gage. The reference point for this gage is a concrete star in the courthouse lawn at Lakeport. Another reference point was later constructed because it was feared that agents of the water company might tamper with the level of the star. Under the court decree limiting the lake level to 7.56 feet, the maximum storage is 319,000 acre-feet. This storage capacity is not realized during dry years, and during wet years the level occasionally rises to 10 feet or so, due to the inability of the outlet to accommodate the runoff.

Clear Lake has three main tributaries, Middle Creek, Scott Creek, and Kelsey Creek, and several minor tributaries. Most important of these are Manning Creek, Cole Creek, and Adobe Creek on the south shore of "Upper Lake," Morrison Creek and Schindler Creek on the northeast shore of "Upper Lake," and Seigler Creek flowing into the lake near the town of Lower Lake. All of these streams go dry in their lower reaches during most years. Kelsey, Middle, Scott, and Seigler Creeks have permanent water in the higher reaches and support limited trout fisheries. The mouths of these streams are indicated in Figures 175 and 176.

Limnology

A minimum description of the chemical, physical, and biological characteristics of a body of water is needed in order to understand the character of the fish population and the fishery.

One of the most important characteristics of the water, directly affecting fish life, is temperature. Temperature is significant from several viewpoints. One is that if the water is too cold, fish do not grow, and consequently there is no production. Taking 50 degrees F. as the arbitrary critical point for growth, it can be seen from Table 3 that the fish in Clear Lake enjoy a growing season of approximately 10 months per year. This long growing season prevailed in 1949 despite the fact that the winters of 1948-49 and 1949-50 were among the coldest in local history.

No true thermocline is formed in Clear Lake. This is apparently due to its large size and shallowness, coupled with extensive wave action. Occasionally after a series of seven or eight unusually calm days oxygen depletion will develop near the bottom in the deeper parts of the lake.

TABLE 3

Temperature Records for Clear Lake [1]

Date	January [2]			February [2]			March		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
1	40	43.5	41.8	38	41	39.5	45	47	46.0
2	40	42.5	41.3	37.5	42.5	40.0	44.5	47	45.8
3	--------	40	--------	39	40	39.5	45.5	50	47.3
4	37	41	39.0	39	41	40.0	47	51	49.0
5	37	41	39.0	41	45	43.0	47	52	49.5
6	37	41.5	39.3	43	44.5	43.8	46	50	48.0
7	37.5	39.5	38.5	42	47.5	44.8	46	47	46.5
8	38	40.5	39.3	44	47.5	45.8	45	46	45.5
9	38	41	39.5	44.5	46.5	45.5	45	49	47.0
10	38	40.5	39.3	41	49.5	45.3	46.5	50	48.3
11	37.5	40	38.8	42	49.5	45.8	48	49	48.5
12	37.5	40	38.8	41.5	50	45.8	48	49	48.5
13	37.5	38.5	38.0	45	48	46.5	48	50	49.0
14	36.5	39.5	38.0	45	46	45.5	49	50	49.5
15	37	39	38.0	45	47.5	46.3	50	51.5	50.8
16	37	39.5	38.3	45	50	47.5	49	51.5	50.3
17	39.5	41	40.3	48	52	50.0	48	53	50.5
18	41.5	46.5	44.0	46	53.5	49.8	49.5	53	51.3
19	41	44.5	42.8	48	50.5	49.2	49	50	49.5
20	42	43.5	42.8	47	55	51.0	48	50	49.0
21	42.5	46.5	44.5	49	52	50.5	49	53	51.0
22	45	46.5	45.8	47.5	49	48.3	51	55	53.0
23	43	46	44.5	47	48	47.5	50	52.5	51.3
24	40.5	42.5	41.5	46.5	--------	--------	51	53	52.0
25	38.5	41	39.8	--------	--------	--------	50	53	51.5
26	38	42	40.0	--------	--------	--------	51	56.5	53.8
27	38.5	41	39.8	--------	--------	--------	50.5	53	51.8
28	38.5	42.5	40.5	--------	--------	--------	51	54	52.5
29	40	43	41.5	--------	--------	--------	--------	--------	--------
30	39.5	41	40.3	--------	--------	--------	--------	--------	--------
31	38	40.5	39.3	--------	--------	--------	--------	--------	--------

[1] These records were obtained from a thermograph located on a pier about four miles north of Lakeport. The bulb was located at a depth of four feet, 100 feet from shore.

[2] Records for January 1st to February 9th are for 1950. The remainder are for 1949.

TABLE 3—Continued

Temperature Records for Clear Lake [1]

Date	April			May			June		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
1	50	54.5	52.3	59	63.5	61.3	63.5	70.5	67.0
2	50.5	55	52.8	60.5	61.5	61.0	64	73	68.5
3	51	59	55.0	59	63.5	61.3	68	72.5	70.3
4	55.5	61	58.3	59.5	65.5	62.5	68.5	74.5	71.5
5	54.5	59	56.8	60	66.5	63.3	70	75	72.5
6	55	62	58.5	63	68	65.5	68	74.5	71.3
7	55	60	57.5	62	69	65.5	67	76	71.5
8	54	59	56.5	62	64.5	63.3	71	78.5	74.3
9	53	60	56.5	61	69	65.0	70	76	73.0
10	54.5	62	58.3	63.5	73	68.3	68.5	76	72.3
11	55.5	64.5	60.0	64	68.5	66.3	68.5	79	73.8
12	55	64	59.5	63	68.5	65.8	71.5	83	77.3
13	56	63.5	59.8	64	74	69.0	74	79.5	76.8
14	57	66	61.5	67	70.5	68.8	73	81	77.0
15	60	68	61.5	--------	--------	--------	75.5	83	79.3
16	61	65	63.0	--------	71	--------	76.5	80	78.0
17	60	67	63.5	65	66.5	65.8	75	79.5	77.8
18	57.5	64	60.8	63	65	64.0	72	74.5	73.3
19	54.5	58	56.3	62.5	65.5	64.0	70	76.5	73.3
20	54.5	58	56.3	62	63.5	62.8	70	--------	--------
21	57	63	60.0	61	69	65.0	--------	--------	--------
22	57.5	67	62.3	62	68	65.0	--------	--------	--------
23	60	62	61.0	62	67.5	64.8	--------	--------	--------
24	59	63.5	61.3	62	75.5	68.8	--------	--------	--------
25	59	66	62.5	64	78	71.0	--------	--------	--------
26	60	68	64.0	64	72	68.0	--------	--------	--------
27	60	65	62.5	63	69	66.0	--------	--------	--------
28	60.5	62.5	61.5	62	69	65.5	--------	73	--------
29	59	61	60.0	63	65	64.0	69	80	74.5
30	59	62	60.5	63	70	66.5	69.5	80	74.8
31	--------	--------	--------	64.5	67	65.8	--------	--------	--------

[1] These records were obtained from a thermograph located on a pier about four miles north of Lakeport. The bulb was located at a depth of four feet, 100 feet from shore.

TABLE 3—Continued

Temperature Records for Clear Lake [1]

Date	July			August			September		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
1	70	81	75.5	78.5	87	82.8	72	80	76.0
2	70	82	76.0	76.5	85	80.8	73	80	76.5
3	71	79.5	75.3	76.5	83.5	80.0	74	83.5	78.8
4	72	79	75.5	75	81	78.0	76	82	79.0
5	74	78	76.0	75	80	77.5	76	81	78.5
6	71	78	74.5	74	77	75.5	73	82	77.5
7	71	79.5	75.3	71.5	81	76.3	75	78.5	76.8
8	--------	--------	--------	73	81	77.0	74	79	76.5
9	--------	--------	--------	73	80	76.5	72	76	74.0
10	71	--------	--------	73.5	79.5	76.5	71	78	74.5
11	86.5	--------	--------	74	81	77.5	72.5	79	75.8
12	--------	84	--------	72	80	76.0	73	--------	--------
13	78	87	82.5	72.5	82	77.3	72.5	78.5	75.5
14	80	86	83.0	72	82.5	77.3	72	78.5	75.3
15	75	86	80.5	72	81	76.5	71.5	74.5	73.0
16	78.5	88	83.3	73	81	77.0	69	73	71.0
17	77	87	82.0	71	81	76.0	67.5	81	74.3
18	76	77	76.5	72.5	81	76.8	68	79.5	73.8
19	73	81	77.0	70.5	83	76.8	68.5	80	74.3
20	74	82	78.0	70	82	76.0	70	80	75.0
21	73	83	78.0	73	84	78.5	70	78.5	74.3
22	73	82	77.5	71	80	75.5	69.5	80.5	75.0
23	76	77	76.5	71	79	75.0	68.5	75.5	72.0
24	72.5	81	76.8	70	79	74.5	67	71	69.0
25	73.5	86.5	80.0	72	82	77.0	65	74	69.5
26	73	82.5	77.8	70.5	81	75.8	67	75	71.0
27	74	84	79.0	73.5	79	76.3	68	72.5	70.3
28	75	84	79.5	74	82	78.0	66.5	75	70.8
29	72.5	84.5	78.5	74	81	77.5	69	73	71.0
30	72	86	79.0	74.5	82	78.3	65.5	76	70.8
31	78.5	81.5	80.0	73	84.5	78.8	--------	--------	--------

[1] These records were obtained from a thermograph located on a pier about four miles north of Lakeport. The bulb was located at a depth of four feet, 100 feet from shore.

TABLE 3—Continued

Temperature Records for Clear Lake [1]

Date	October			November			December		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
1	67.5	77	72.3	56	65	60.5	51.5	57.5	54.5
2	67	77.5	72.3	55.5	64	59.8	52	55.5	53.8
3	67	77	72.0	55	63	59.0	49.5	55	52.3
4	67	71	69.0	55.5	63.5	59.5	49	54.5	51.8
5	64	69	66.5	54	60.5	57.3	51	53.5	52.3
6	62	65.5	63.8	54	59	56.5	49	51	50.0
7	59.5	63.5	61.5	55	58	56.5	47	48	47.5
8	56.5	66	61.3	55	65	60.0	46.5	53.5	50.0
9	59	66.5	62.8	54	--------	--------	47	50.5	48.8
10	62	68	65.0	--------	--------	--------	44.5	48	46.3
11	--------	--------	--------	51	58	54.5	41.5	47.5	44.5
12	--------	--------	--------	52	57.5	54.8	43	47.5	45.3
13	--------	--------	--------	50	59	54.5	43	48	45.5
14	--------	70	--------	51	57.5	54.3	43.5	44.5	44.0
15	60.5	72.5	66.5	52	59	55.5	42.5	47.5	45.0
16	59.5	73.5	66.5	52	59	55.5	45	47	46.0
17	58.5	63	60.8	51	56.5	53.8	45	47	46.0
18	55	58.5	56.8	49.5	59.5	54.5	45	47	46.0
19	52	57.5	54.8	53.5	57.5	55.5	42.5	45.5	44.0
20	52.5	61	56.8	55	60	57.5	40.5	44	42.3
21	54	64.5	59.3	52	57.5	54.8	40	44.5	42.3
22	55.5	65.5	60.5	52.5	57	54.8	40.5	45	42.8
23	55.5	65	60.3	54	60	57.0	42	45.5	43.8
24	56	64.5	60.3	54	59.5	56.8	42.5	45.5	44.0
25	57	65.5	61.3	53.5	59	56.3	41	45	43.0
26	56	59	57.5	49.5	55	52.3	40	44	42.0
27	54	64.5	59.3	51	55	53.0	40	44	42.0
28	55	65.5	60.3	--------	--------	--------	40	44	42.0
29	55	66.5	60.8	--------	--------	--------	40	43.5	41.8
30	55	63.5	59.3	--------	58.5	--------	41	43.5	42.3
31	56	65.5	60.8	--------	--------	--------	41	44	42.5

[1] These records were obtained from a thermograph located on a pier about four miles north of Lakeport. The bulb was located at a depth of four feet, 100 feet from shore.

Table 4 gives a typical vertical series of thermal and chemical observations in Clear Lake during the summer. Table 5 gives a typical temperature-oxygen series after several consecutive days of hot calm weather.

Much of Clear Lake is bordered by volcanic formations which introduce alkaline materials into the lake. Two small borax lakes lie nearby and many "soda" springs empty into the lake. It is entirely possible that some of the sudden mortalities of large numbers of fishes which occur in some sections of the lake from time to time are caused by sudden localized excesses in alkalinity, caused by an eruptive discharge of large quantities of alkaline material into the lake.

Generally the clarity of the water of Clear Lake is low. At times the waters of the entire lake are laden with silt borne in by heavy discharges from the tributary streams, particularly in winter and early spring. During the summer the upper shallow end of the lake often becomes turbid, when bottom deposits are disturbed during periods of high winds. There are large quantities of phyto- and zooplankton in the water, so that at best visibility usually is limited to a foot or two, even when inorganic turbidity is low.

TABLE 4

Chemical and Physical Series for Clear Lake, July 18, 1947
(Station Off Rattle Snake Island)

Depth in feet	Temperature in degrees F.	Oxygen in p.p.m.	pH[1]
Surface	73	8.4	8.5
5	73		
10	73		
15	73		
20	73		
25	72		
30	72		8.5
35	72		
40	71		
45	71	7.2	8.1

[1] Total alkalinity (methyl orange) varies around 150 p.p m.

TABLE 5

Typical Physical and Chemical Data for Clear Lake After 10 Days of Calm Weather, July 24, 1946
(Station Off Soda Bay)

Depth in feet	Temperature in degrees F.	Oxygen in p.p.m.
Surface	82	8.4
3	80	9.6
6	78	
10	78	7.4
13	77	
16	77	7.0
20	77	
23	77	6.0
26	75	4.0
29	73	0.7
33	73	0.5
36	73	0.5

Early settlers were impressed by the clarity of the waters of Clear Lake. It is unbelievable that they were viewing the lake as it is today. Assuming that Clear Lake aboriginally was clear, a highly plausible explanation is available to account for its present condition. Instead of a handful of Indians residing in the Clear Lake drainage, there are now approximately 10,000 permanent residents and many more summer visitors. Effluents from settlements must eventually reach the lake, considerably augmenting the supply of essential nutrients. In addition, agriculture is carried out on the surrounding lands. This allows the nutrient salts to be leached more rapidly, and, in addition, adds more nutrient salts to the drainage in the form of fertilizers. These nutrients stimulate the growth of plankton, and could well account for the present abundance of these microscopic organisms.

General erosion in the drainage during the last 30 years, caused by overgrazing, fire, and agriculture, apparently has caused considerable silting in the lake and a greater tendency toward inorganic turbidity. There is evidence suggesting that the upper end of Clear Lake has silted in two or three feet from depths recorded in 1893. Detailed engineering studies are needed, however, to verify this statement.

THE FISHERY OF CLEAR LAKE

History of the Fishery

The recent history of the Clear Lake fishery is a fascinating example of the tremendous changes in the fish faunas of western waters brought about by the hand of man.

The present fishery of Clear Lake is based on a typical California warm-water assemblage. Largemouth black bass, black crappie, bluegill, Sacramento perch, white catfish, and brown bullhead dominate the catch. An occasional trout is taken (the writer knows of four during 1947) and an occasional squawfish is captured. A limited commercial fishery for carp exists on a permit basis.

When the waters of the lake were clear, the sport fishery was chiefly rainbow trout and Sacramento perch, both of which apparently existed in enormous numbers. Steelhead ascended Cache Creek, passed through the lake, and spawned in the tributaries. In these tributaries they were taken in large numbers by the residents. Squawfish were also enormously abundant and, judging from accounts, enjoyed considerable popularity as a food and sport fish (Taft and Murphy, 1950). Squawfish are practically extinct in the lake today. Sacramento perch are now scarce, trout almost nonexistent, and steelhead precluded by the dam and by alterations in the lower reaches of Cache Creek.

One of the first major changes in the fauna of the lake resulted from the introduction of carp. The most authentic story yet uncovered by the writer is as follows. Captain Floyd, who owned an estate known as Ko-no-tay on the north shore of "The Narrows," installed a carp pond on the grounds in 1880. During the following winter the pond flooded and about two dozen carp escaped into the lake. This story appeared in the May 4, 1926, issue of the Lake County Bee. The same story was told the writer by Eathan Anderson, a well-educated Pomo Indian whose father worked for Captain Floyd at the time.

Previous to the successful introduction of carp, an attempt was made by the California Fish Commission to introduce the Great Lakes whitefish (*Coregonus c. clupeaformis*). According to the Report of Commissioners of Fisheries for 1872-73, 25,000 whitefish fry were hatched in a temporary hatchery on Kelsey Creek and released in Clear Lake. It was hoped that these fish would thrive there and could then be distributed over the rest of the State. Nothing authentic has been heard of them since then.

White catfish were introduced very early, but the exact date is not known. The Report of the Commissioners of Fisheries for 1880, page 9, states: "The seventy-four catfish imported from the Raritan River, in 1874, have increased and multiplied, and this increase distributed until now, we believe, there is no county in the state from Del Norte to San Diego, that has not been supplied with a greater or less number of these fish." We can assume that plants were made in Clear Lake during this period. Apparently this planting was not entirely successful. Jordan and Gilbert (1894) reported them in Clear Lake, but a letter received by the Lake County Sportsmen's Club from the Fish and Game Commission and reported in the August 17, 1922, edition of the Lake County Bee stated that according to the report of Mr. McGregor (an employee of the Division of Fish and Game) the only catfish in Clear Lake was the brown bullhead. It further stated that the white catfish was introduced during the early introductions into California but evidently did not thrive.

White catfish were successfully reintroduced into Clear Lake in 1923, according to an account in the Lake County Bee, October 27, 1926. In addition, 5,000 mature fish were planted in the lake in 1926. This species has thrived and is now the basis for the bulk of the sport fishery. Just why the earlier introduction failed is not known. Presuming that the record of Jordan and Gilbert (1894) was based on specimens at hand, and not on the record of introductions, the species must have become extinct shortly thereafter. In 1940 (Shapovalov, 1940) white catfish died in large numbers in Clear Lake. Shapovalov estimated 43,000 had died within a few days. Possibly some similar previous epidemic completely exterminated the progeny of the first planting.

The introduction of the brown bullhead is even more obscure, but evidently took place during the same period, i.e., around 1880.

Largemouth black bass were introduced in 1888. In this year two shipments were sent to Clear Lake by Mr. James A. Richardson, as reported in the Biennial Report of the State Board of Fish Commissioners for 1889-1890. Each shipment consisted of 160 fish. A later plant was made in 1896 (Biennial Report, State Board of Fish Commissioners, 1895-96). By 1910, bass fishing was excellent in Clear Lake. Page 36 of the 1909-10 Biennial Report of the Board of Fish and Game Commissioners states: "In the past two years experienced anglers who have fished in every state of the Union report to our office that the black bass fishing in Clear Lake exceeded anything in their experience."

Black crappie and bluegill were introduced during the period 1909-10 (Biennial Report, Board of Fish and Game Commissioners, 1909-1910). The plant was made by deputies Ernest Schaeffle and Frank McCrea and the fish originated at the U. S. Bureau of Fisheries station at Meredosia, Illinois. Green sunfish are not accounted for but could have been introduced at the same time.

Mosquitofish were introduced in 1925. The Lake County Bee for September 27, 1925, gives an account of this introduction, which was made by Professor Freeborn of the University of California in order to effect mosquito control. Four thousand fish were placed in the lake.

Table 6 summarizes available data on the introduction of fish into Clear Lake.

TABLE 6

Record of Introductions of Fishes Into Clear Lake

Species	Date	Success	Authority
Whitefish	1873	Unsuccessful	Calif. Comm. of Fish., Rept., 1872–73
Carp	1880	Successful	Informant, and Lake Co. Bee, May 4, 1926
White catfish	1880	Unsuccessful	Calif. Comm. of Fish., Rept., 1880
	1923	Successful	Lake Co. Bee, Oct. 27, 1926
Brown bullhead	1880?	Successful	
Largemouth black bass	1888	Successful	Calif. Fish. Comm., Biennial Rept., 1889–90
Smallmouth black bass	1895	Unsuccessful	Calif. Fish. Comm., Biennial Rept., 1895–96
Golden shiner[1]	1896	Unsuccessful	Calif. Fish. Comm., Biennial Rept., 1895–96
Mud pickerel[2]	1896	Unsuccessful	Calif. Fish. Comm., Biennial Rept., 1895–96
Black crappie	1910	Successful	Calif. Fish and Game Comm., Biennial Rept., 1909–10
Green sunfish	1910?	Successful	
Bluegill	1910	Successful	Calif. Fish and Game Comm., Biennial Rept., 1909–10
Yellow perch	1910	Unsuccessful	Calif. Fish and Game Comm., Biennial Rept., 1909–10
Brown trout	1924	Unsuccessful	Lake Co. Bee, June 18, 1924
Lake trout	1924	Unsuccessful	Lake Co. Bee, June 18, 1924
Mosquitofish	1925	Successful	Lake Co. Bee, Sept. 27, 1925

[1] Notemigonus crysoleucus.
[2] Esox vermiculatus.

Regulation of the Clear Lake fishery has been the usual picture of constantly decreasing bag limits, but in contrast with most waters in the State, a closed season has not been imposed since 1910. Commercial fishing and the lack of a closed season have been the most controversial subjects in the history of legislation affecting the lake. The result to date is that there is no commercial fishery with the exception of a limited permit fishery for carp. The commercial fishery for catfish was ended in 1941 by legislative action. At present a sport fishing license is required for taking of all fish in Clear Lake. The bag limits are as follows: largemouth black bass, 5; black crappie, sunfish, and Sacramento perch, 25 in the aggregate; catfish, 15 pounds in the round or 8 pounds dressed, length limit 9 inches. Night fishing is permitted for catfish.

Historical Data on the Catch

Before proceeding with an analysis of the modern catch records for Clear Lake it is of interest to review some historical material. This was obtained by surveying back issues of the Lake County Bee, a weekly newspaper published in Lakeport. This material is interesting, in particular because it shows that the "good old days" were not as consistently good as "old timers" imply. Some of it indicates a wavering policy towards rough fish by local authorities. The material is presented chronologically, in the form of brief excerpts and abstracts.

(1) January 9, 1907—"Fishing for bass, Sacramento perch, chappaul [Sacramento squawfish] and catfish is good in the lake."

(2) June 12, 1907—"Clear Lake does not belie its name."

(3) February 6, 1913—Supervisors passed a resolution to open Clear Lake to all-year fishing as there are millions of bass and trout in the lake. Sport fishing could not make a dent in the population, and trout bite only in the winter.

(4) October 30, 1913—Bass and trout now biting well. A party of six caught 39 fish, one-half of them trout.

(5) March 7, 1917—Commercial catfishermen caught 2,500 pounds in the last week.

(6) February 20, 1918—A 30-pound carp was caught in Clear Lake.

(7) July 7, 1921—The winners of a black bass derby for the period January 1st to July 1st were announced: First prize, 7¾ pounds; second prize, 6 pounds, 13 ounces; third prize, 5 pounds, 13 ounces. (It is of interest to note the size of the fish that won third prize, as this indicates that seven- to eight-pound bass were not as abundant as old timers say.)

(8) October 27, 1921—"Rain has improved catfish and bass fishing."

(9) November 10, 1921—There is a plan to bring the Mississippi channel catfish to Clear Lake.

(10) August 17, 1922—Excerpts from a letter written by W. H. Shebley, in charge of the Bureau of Fish Culture, California Division of Fish and Game, to the local sportsmen's club: "Absolutely against introducing pike and pickerel to Clear Lake." "Thinks brown trout would do well in the lake." "Writer quite familiar with conditions in Clear Lake 30 years ago. At that time trout were quite plentiful in the lake."

(11) January 4, 1923—A permit to seine carp was requested of the Fish and Game Commission by Al Hemming.

(12) April 23, 1924—Sportsmen's club to discuss closing of Clear Lake to angling during May and June.

(13) May 7, 1924—Bass, crappie, and Sacramento perch are biting well in the lake.

(14) June 19, 1924—Four hundred twenty-five thousand trout to be planted in Clear Lake tomorrow. Three hundred fifty thousand planted in the lake one week ago.

(15) January 7, 1925—A move to reconsider commercial catfishing. Captain Dave Dondero of the California Division of Fish and Game states that fish are in no danger of extermination and that the catch this winter is better than three years ago. Objectors claim that tourists cannot catch the fish in the summer season, arguing that this indicates depletion of the supply. (At that time brown bullheads were the chief catfish in the lake, and they are notoriously poor summer biters. However, this item refutes claims of "old timers" that "you used to be able to catch a gunny sack full any time.")

(16) October 21, 1925—A proposal to close Clear Lake to bass fishing during May and June defeated at the game club meeting.

(17) January 27, 1926—The fish and game club placed an order for 200,000 white catfish. The original plant of 1,400 was made in 1922. A few of these up to five pounds have been caught.

(18) April 7, 1926—Coleman states that the trout planted will rid the lake of gnats and rough fish. (Coleman was the first fresh-water ''biologist'' employed by the Division of Fish and Game.)

(19) April 21, 1926—Dondero, Ora, and two other fishermen tried to catch a mess of bass to feed Mr. I. Zellerbach (California Fish and Game Commissioner), but failed. (Old timers say bass fishing was always good. But, although these two men were expert fishermen, and April is one of the best months for bass, they failed.)

(20) October 27, 1926—Five thousand mature white catfish shipped here from the San Joaquin by the Fish and Game Commission to the sportsmen in a Meredith Fish Company truck.

(21) December 8, 1926—Game club requested Fish and Game Commission to close bass fishing on the lake for the first time in a decade.

(22) April 13, 1927—Huffman fished all winter averaging five bass per week. Another big run of pike (Sacramento squawfish) is on, up to 10 pounds. Bay area sportsmen are fishing for them.

(23) April 20, 1927—State to remove carp and blackfish from Clear Lake.

(24) May 4, 1927—Bass fishing is at its best.

(25) May 25, 1927—Bass were placed in Clear Lake 30 years ago. The lake was not fished much by outsiders until five years ago.

(26) July 13, 1927—Bass fishing has let up.

(27) July 20, 1927—Catfish are out in deep water and may be taken with worms and minnows.

(28) August 3, 1927—Bass are harder to take now than in the spring.

(29) April 4, 1928—''Clear Lake is to be rid of rough fish by new state plan.''

(30) April 13, 1932—Last Sunday there were 550 automobiles containing 1,600 visitors in the Clear Lake region.

(31) September 21, 1932—There was a sudden death of large numbers of fish off Clear Lake Oaks, and in Cache Creek. Dondero remembers a similar occurrence about 25 years ago.

(32) January 4, 1933—There was a meeting on ridding the lake of rough fish. State aid was sought.

(33) March 15, 1933—''County chamber seeks more game fish in lake. Also, protests loss of fish over dam.''

(34) March 28, 1933—There was an appeal for funds to handle the problem created by dead fish along the shore.

(35) August 29, 1934—Gases in the lake killed tons of fish Sunday. The great majority of the fish killed were said to be bullheads.

(36) July 25, 1935—Not for years have so few dead fish been seen along the shore.

(37) November 19, 1936—''Supervisors are not in favor of removal of rough fish from the lake. Just what the reason is has never been made known.''

(38) July 19, 1940—Bass fishing around the lake is not so good, and not too many are having luck with white catfish.

(39) October 25, 1940—''Bass are biting at the lower end of the lake again and quite a few have been caught.''

(40) March 12, 1943—At a hearing, the Lake County Sportsmen's Association was against seining rough fish as minnows are scarce in the lake.

These interesting excerpts indicate that angling was better in earlier years. A tendency can be noted, however, to describe the fishing as better in former years during what are now regarded as former years.

Angling, however, was apparently better in earlier years than now. The reasons for poorer fishing at the present time will be brought out later. However, in all years fishing has not been consistently good, and a period of poorer fishing has usually occurred in midsummer. Further, it is impossible to ascribe poor angling during the summer in early years to overfishing, for as late as 1941 there were only about 3,600 anglers fishing in this 40,000-acre lake.

Modern Catch Records

In a practical study of the catch the first question the fisheries worker should answer is, "How good is the fishing?" If fishing is good he need go no further. If fishing is poorer than one would expect in that type of water, the worker has a problem. If the lake is not producing the proper quantities of fish, and the catch per unit of effort is low, either the population of catchable fish is low, or the angler cannot harvest them. The worker must find out why and prescribe a remedy.

The measurement of the *quality* of the fishing (catch per unit of effort) should be quite accurate and unbiased. The measurement of the *total catch* should be accurate if the lake is producing as much as its inherent capacity permits. On the other hand, if a rich lake is producing only an estimated 10 pounds of fish per acre and the quality of fishing is poor, it does not matter if the figure 10 pounds per acre is 100, 200, or 300 percent in error. We know something is wrong and must try to find out what the trouble is and correct it. The measure of the success of our management will be the catch per unit of effort. This will be a reliable measure until the total catch begins to approach the estimated maximum production of the lake. Then total catch becomes the most important measure, and should be estimated with the greatest possible accuracy.

A corollary type of catch information is implied in the question: "What percentage of the population is removed each year?" This can be answered by tagging experiments and by a study of the catch curve. The catch curve is simply an estimate of the number of individuals in each year class. If a large percentage of the catch is composed of older individuals that have been vulnerable to angling for a number of years, we can conclude that the angler has little effect on the population.

A third type of desirable information is growth rate. If fish are growing rapidly we can assume that they are adapted to the environment, and that the water is not overpopulated. Rapid growth also indicates that perhaps the population can be increased numerically.

Before launching into the details of these indices, it will be helpful to consider in brief form the picture that they reveal for Clear Lake.

1. Total catch. Low. Estimates are rough, but the sport catch is around 20 pounds per acre, or about 20 fish per acre.
2. Catch per unit of effort. Low. About two fish per angler day. Indicates that the density of the fish population is low.

3. Rate of harvest. Low. Examinations of catch reveal that most individuals have been vulnerable for one to five years. Data on this point are rough.
5. Growth rate. High. Indicating, in combination with measures one to three, that recruitment of young fish to the population is low. This is probably due to poor survival between the egg and the time the individual fish enters the fishery.

Modern records of the Clear Lake catch are available from five sources:

1. The Division of Fish and Game keeps records of all commercial landings.

2. Records of the catch of operators taking carp and blackfish from the lake under special permit are kept by the Bureau of Patrol.

3. The Bureau of Fish Conservation estimates the sport catch of the State by county in certain years. Briefly, this is accomplished by mailing a questionnaire to a random sample of the licensees. The total catch is estimated from the returns. Curtis (1940) and Calhoun (1950) give a full description of this method.

Since the returns are by county they are not, in most cases, directly applicable to any particular water. However, Clear Lake supports over 95 percent of the fishing for warm-water species in Lake County and it is felt that the county returns can be applied directly to the lake. The accuracy of these figures is difficult to estimate. Since they have been taken each year in approximately the same manner, it is believed that even though the estimated total catch may not be accurate the figures may be used as an index for comparison from year to year.

4. A fourth source of data is a survey of the 1948 catch conducted by the Opinion Research Center of the University of Denver. This "Gallup-type poll" was designed to furnish estimates of the catch in California, and was carried out simultaneously with the usual mailed questionnaire in 1948. A detailed discussion of this survey, and estimates of its validity, are given by Calhoun (1950).

Both of these estimates for the year 1948 are highly unreliable at the county level, as the number of anglers sampled was relatively small. For instance, the number of Lake County anglers as estimated by the survey was 39,000. The standard error of this estimate is 5,360.

Proportionally large standard errors exist for the estimates of the number of fish caught. The standard errors of the results of the post card survey are about half the magnitude of those applying to the personal interview survey. Thus, the "quality index" obtained from these two recent surveys is of no value, except to indicate changes of abundance of two or three times.

5. The fifth source of catch data is field studies at Clear Lake.

In 1947 an attempt was made to secure a field estimate. This was done by establishing record books at three boat liveries, one at Soda Bay, one at Clearlake Oaks, and one at Clearlake Highlands. These records were kept by the liverymen six days a week and by an employee of the Division of Fish and Game on the seventh day, either a Saturday or a Sunday. A high degree of cooperation was obtained, partly because the operators were continually checked, reminded of the importance of accurate records, and remunerated with modest sums of money. The one-day-a-week census by a Division employee afforded a check on the records of the other six, since the records taken on that day could be compared with the others for consistency. From these data a monthly estimate of the total boat catch was obtained as follows: A monthly count was made of all craft, both public and private, available to fishermen. The total boat catch was then estimated by the formula

$$\frac{\text{Total boats available} \times \text{total catch at the 3 liveries}}{\text{Boats available at the 3 liveries}} = \text{Total boat catch}$$

Throughout the season the three liveries from which records were obtained had approximately 10 percent of the total boats available, and theoretically 10 percent of the total effort emanated from them. Throughout the summer months approximately 750 boats were available on the lake. At times the liverymen did not fill out the record blanks completely. Occasionally entries for the number of hours fished and/or the number of people in a boat were omitted, but since this information was not needed in estimating the total catch, the records were used. During the months of October, November, and December, when fishing effort was extremely light, records were kept at the Clearlake Oaks livery only.

The shore catch was estimated from a weekly (Sunday) count of shore fishermen. During this survey all areas of the lake shore that could be reached by car, and consequently all areas that could be reached by shore fishermen, were inspected, the number of fishermen counted, and whenever possible, their catch examined. It is estimated that one-half the fishermen for the day of the survey were counted, since the average fishing day was about five hours. That is, only the morning fishermen were counted on one-half of the lake and only the afternoon fishermen on the other half. The total shore catch was estimated on a weekly basis by the formula

$$\frac{\text{Number fishermen counted on day of survey} \times 2 \times \text{Total skiffs recorded for week}^{1}}{\text{Number recorded skiffs on day of survey}} \times \text{Catch per hour by}$$

shore fishermen $\times$ 5 hours in fishing day = Total shore catch for the week. This estimate is admittedly rough, but since the shore catch is small in relation to the boat catch, the estimated total catch is not greatly affected.

The greatest possible source of error in the field estimate is in the assumption that privately owned skiffs are used for angling with the same intensity as rental skiffs. This assumption is probably false, since a man probably does not buy a skiff until his use intensity makes it uneconomical to rent. He certainly does not go to the trouble to bring it to a resort area unless he intends to use it intensively. This causes underestimation of the catch. Another source of systematic error is the skiff count. Some boats were undoubtedly missed, thereby producing a lower estimate. Taking these factors into consideration, it appears that the 1947 field estimate may represent only half the true catch. It does not, however, seem possible that the error is more than 100 percent.

[1] This fraction is designed to estimate the total number of shore fishermen for the week. It is based on the assumption that amounts of shore and boat angling have a constant relationship during each weekly period.

TABLE 7

Estimated Clear Lake Catch, in Pounds—Sport and Commercial Landings Combined

Type	1936	1937	1938	1941	1942	1943	1946	1947	1948
Commercial	146,000	245,000	36,000	145,000	240,000	165,000	315,000	415,000	324,000
Sport	152,000	180,000	236,000	496,000	816,000	804,000	424,000	178,000	844,000
Total	298,000	425,000	272,000	641,000	1,056,000	969,000	739,000	593,000	1,168,000
Pounds per acre	7	11	7	16	26	24	18	15	29

In addition to the attempted estimate of the total catch made in 1947, qualitative studies of the catch have been made in subsequent years. These will be referred to as they become pertinent to the discussion.

The estimated total harvest from Clear Lake is shown in Table 7. These figures were obtained from the known commercial catch and the estimated sport catch. The sport catch for 1947 was estimated from field studies previously described. Other estimates of the sport catch are from the post card surveys. Table 8 details the records available for the commercial and permit fisheries.

TABLE 8

Known Commercial Catch, Clear Lake, in Pounds

Species	1932	1933	1934	1935	1936
Carp	35,000	50,000	135,000	75,000	60,000
Blackfish	270,000	130,000	90,000	70,000	80,000
Catfish[1]	----------	----------	25,000	24,000	6,000
Total	305,000	180,000	250,000	169,000	146,000
Species	**1937**	**1938**	**1939**	**1940**	**1941**
Carp	120,000	?	?	?	55,000
Blackfish	100,000	8,000	?	?	80,000
Catfish[1]	25,000	28,000	29,000	16,000	10,000
Total	245,000	36,000	29,000	16,000	145,000
Species	**1942**	**1943**	**1944**	**1945**	**1946**
Carp	80,000	125,000	165,000	290,000	295,000
Blackfish	160,000	40,000	40,000	40,000	20,000
Catfish[1]	0	0	0	0	0
Total	240,000	165,000	205,000	330,000	315,000
Species	**1947**	**1948**	**1949[2]**		
Carp	394,000	321,000	385,000		
Blackfish	21,000	3,000	0		
Catfish[1]	0	0	0		
Total	415,000	324,000	385,000		

[1] Catfish are sold both in the round and dressed. A dressed fish weighs approximately one-half of a round fish. An unknown percentage of these fish was dressed, so that the poundage is a minimum figure.
[2] 1949 records incomplete.

Table 9 gives a breakdown of the sport catch by year and by species for the years 1936-1948. Since no attempt was made to separate the two species of catfishes in the questionnaire survey, we can assume that catfish returns include both white catfish and brown bullhead. Sacramento perch were not singled out in the questionnaire and are probably listed as crappie by the anglers, because very few distinguish the two.

TABLE 9

Sport Catch, Clear Lake, in Numbers—Except Where Noted the Data Are From the Questionnaire Surveys

Species	1936	1937	1938	1941	1942
Largemouth black bass	20,200	15,800	20,000	56,700	98,200
Crappie	11,900	11,900	14,900	38,700	51,000
Sunfish	12,600	14,300	16,900	53,700	85,000
Catfish	103,800	140,400	188,900	347,600	580,000
Total	148,500	182,400	240,700	496,700	814,200
Anglers	3,572	4,524	6,395	12,510	16,065
Species	**1943**	**1946**	**1947[1]**	**1948**	**1948[2]**
Largemouth black bass	70,500	54,000	15,290	101,000	58,200
Crappie	290,000	34,000	11,340	75,000	----------
Sunfish	71,000	59,000	19,890	197,000	160,800
Catfish	408,000	341,000	133,910	528,000	778,600
Total	839,500	488,000	180,430	901,000	997,600
Anglers	13,000	17,800	?	26,420	39,000

[1] Based on an estimate made in the field during 1947.
[2] Personal interview survey.

Table 10 gives a breakdown of the sport catch in terms of weight per surface acre. By way of comparison, Eschmeyer (1942) and Eschmeyer and Manges (1945) reported a catch of 5.6 pounds per acre for Norris Reservoir, Tennessee, in 1940 and 13 pounds in 1944. The highest estimated sport catch for Clear Lake of 21.1 pounds per acre in 1948 does not seem excessive in view of the richness of Clear Lake.

TABLE 10

Sport Catch, Clear Lake, in Pounds per Acre [1]

Species	1936	1937	1938	1941	1942
Largemouth black bass	0.75	0.56	0.75	2.21	3.68
Crappie	0.25	0.25	0.31	0.87	1.12
Sunfish	0.19	0.19	0.19	0.69	1.06
Catfish	2.56	3.50	4.68	8.69	14.50
Total	3.75	4.50	5.93	12.46	20.36
Species	**1943**	**1946**	**1947[2]**	**1948**	
Largemouth black bass	2.62	2.00	0.56	3.75	
Crappie	6.44	0.75	0.25	1.65	
Sunfish	0.88	0.75	0.25	2.46	
Catfish	10.20	7.21	3.38	13.16	
Total	20.14	10.71	4.44	21.02	

[1] Mean weight of each fish in angler's catch computed for 1947 was used in preparing this table. Largemouth black bass—24 ounces; crappie—14 ounces; bluegill—8 ounces; catfish—16 ounces.
[2] From field estimate made in 1947. Rest of figures from mailed questionnaire survey.

Table 11 shows the composition of the catch as percentages of the numbers of each species in the total catch. In general, the numbers of the various species in relation to the total catch have held remarkably constant through the period 1936-1948 with the exception of 1943. In that year crappie were extremely abundant, indicating very high survival of the 1940 and/or 1941 year class. It is gratifying to note that the figures for 1947, which are based on field studies of the catch, are in close alignment with the questionnaire estimates of 1936-1948.

TABLE 11

Percentage Composition of the Sport Catch, Clear Lake

Species	1936	1937	1938	1941	1942	1943	1944	1946	1947[1]	1948
Largemouth black bass	14	9	9	11	12	8	10	11	9	11
Crappie	8	6	6	8	6	35	10	7	6	8
Sunfish	9	8	7	11	12	8	11	12	11	22
Catfish	69	77	78	70	70	49	69	70	74	59

[1] Based on an estimate made in the field during 1947.

Table 12 gives data on the quality of the fishing during the period 1936 to 1948. The figure "quality index" is the number of fish caught in Clear Lake per angler reporting successful fishing in Lake County. For example, if 10 anglers reported catching 400 fish during 1946, the index would be 40. Though the index is a measure of catch per unit of effort, it is impossible to orient this figure to any of the accepted units of effort, such as angler hour and angler day. This table indicates that the quality of the fishing has remained fairly constant during the years 1936-1944. The one exception is 1943, when abnormally large numbers of crappie were reported caught. The quality index dropped in 1946, indicating that fishing during that year was only 60 percent as good as the 1936-1944 average. This is a 40 percent drop and indicates some basic maladjustment in the fishery. It is of interest to note that this apparent drop in the quality of the fishing after 1944 coincides with the quality drop reported by long-term residents of the Clear Lake area.

TABLE 12

Quality of Fishing for All Species in Clear Lake

	1936	1937	1938	1941	1942
Quality index	41.2	40.6	37.6	40.7	50.6
Estimated anglers	3,572	4,524	6,395	12,510	16,065
Anglers sampled	893	1,223	627	450	459

	1943	1944	1946	1948
Quality index	65.0	43.5	27.4	34.2
Estimated anglers	13,000	?	17,800	26,420
Anglers sampled	367	206	339	159

As stated earlier, the 1948 catch statistics are highly unreliable on the county level, due to the small number of anglers sampled. The standard error for the estimate of the number of Lake County anglers is in the neighborhood of 14 percent. The standard error of the catch is of the same magnitude. About all that can be said of the 1948 figures is that they are an unbiased estimate. Earlier figures, based on samples from three to forty times as large, are considerably more reliable. The trend of the catch for the years subsequent to 1946 must be obtained from data gathered at Clear Lake.

Actually, the estimate of 26,000 Lake County anglers in 1948 is probably not far from reality. The estimated number of anglers in 1943 was 13,000. Since then license sales in California have doubled, so it is not surprising that the pressure on Lake County has also doubled. Details on the trend of California angling license sales and Lake County anglers are given in Table 13.

TABLE 13

Comparative Data on Angling Pressure in Clear Lake and in All California

Year	California anglers[1]	Lake County anglers[2]	Index of California anglers	Index of Lake County anglers	Index of California anglers	Index of Lake County anglers
1936	299	3,572	1.00	1.00		
1937	313	4,524	1.05	1.26		
1938	347	6,395	1.16	1.79		
1939	366		1.26			
1940	388		1.30			
1941	453	12,510	1.52	3.50		
1942	433	16,065	1.45	4.50		
1943	445	13,000	1.49	3.64	1.00	1.00
1944	437		1.47		0.98	
1945	554		1.81		1.25	
1946	767	17,800	2.56	4.98	1.74	1.37
1947	885		2.96		1.98	
1948	957	26,420	3.24	7.30	2.15	2.00

[1] In thousands.

[2] Lake County anglers are estimated from mailed questionnaire. Figures given are for successful anglers only. About 88 percent of all Lake County anglers are successful. About 78 percent of all Lake County anglers fish in Clear Lake.

Even though the 1948 survey appears to have produced a reasonable estimate of the angling pressure, the catch data appear to be in error. The small sample, 159, appears to have included a disproportionate number of the sort of angler who "camps all summer on the lake," and therefore has a high catch. This causes the "quality index" (Table 12) to be high. Further indication of random error in the 1948 estimates is found in Table 11. The relative numbers of each species are at variance with previous experience, and are at variance with actual field data (Table 16). For instance, there is no field indication that the relative strength of catfish in the catch was lower in 1948. In fact, indications are that they formed a greater percentage of the total catch in 1948.

Table 14 gives a monthly breakdown of the 1947 Clear Lake catch, estimated in the field by the method described in the first part of this section. Black bass show two peaks of abundance, a major peak during the spring and early summer and a minor peak during the fall. The fall fishery is just as productive as the spring fishery, but the catch is much

TABLE 14

Monthly Sport Catch in Clear Lake, 1947

Month	Number of trips	Largemouth black bass	Black crappie	Bluegill	Sacramento perch	White catfish	Brown bullhead	Total fish
January	5,200	1,600	60	0	0	0	130	1,790
February	5,200	1,600	60	0	0	0	130	1,790
March	7,200	2,080	1,440	160	0	7,520	1,150	12,350
April	14,400	2,580	4,210	1,250	630	23,120	1,330	33,120
May	12,300	2,400	2,430	10,790	870	24,120	40	40,650
June	13,900	710	360	3,400	300	36,140	340	41,250
July	13,800	640	530	3,320	0	23,000	80	27,570
August	10,380	530	100	860	0	7,270	50	8,810
September	8,300	1,640	350	110	0	5,880	0	7,980
October	2,100	510	0	0	0	1,210	0	1,720
November	2,100	1,632	0	0	0	544	0	2,176
December	700	672	0	0	0	70	0	742
Totals	95,580	16,594	9,540	19,890	1,800	128,874	3,250	179,948
Percentage	----------	9.2	5.3	11.1	1.0	71.6	1.8	----------

smaller in the fall since local residents constitute the bulk of the fishermen, whereas during the spring large numbers of anglers from centers of population, such as San Francisco, visit the lake. Crappie and bluegill enter the catch in large numbers during the spring and early summer only. Sacramento perch appear in small numbers during April, May, and June and then disappear from the catch entirely. Brown bullhead are taken mainly in late winter and early spring. The bulk of the Clear Lake catch is made up of white catfish. In 1947 they entered the catch in large numbers in March, reached a peak in June, and fell off considerably in late summer. With the exception of black bass, the peak of the catch for each species, quantitatively and qualitatively, is reached just before and during the spawning period.

Table 15 is a summary of the 1947 boat catch records that were complete. As mentioned earlier, many of them were incomplete with respect to number of hours fished and other items. All such records were eliminated in preparing this table. Table 15 serves as a bridge between Tables 14 and 16. Table 14 represents the field estimated total catch for 1947. As described earlier, the estimate was evidently too low. The data gathered to form it, however, are without bias as to the relative weight given boat and shore anglers. Table 15 represents boat angling for the entire lake. Table 16 represents angling from one particular livery located on Clear Lake. Nearly complete records are available from this livery for 1947, 1948, and 1949, and it is planned to maintain these records for an indefinite period in the future. Tables 14 and 15 establish the relation of fishing at this livery to all fishing in the lake, on the basis of the 1947 studies. Comparison between the tables shows that in 1947 all anglers caught 1.9 fish per trip, all boat anglers caught 2.1 fish per trip, and anglers at "The Oaks" livery caught 2.5 fish per trip. In other words, anglers fishing from boats at "The Oaks" livery in 1947 were 32 percent more successful than anglers in general. Small differences in the relative numbers of the different species caught can be noted, but all of these are believed to be systematic and not sampling errors. For instance, the relative number of crappie caught from the livery is less than the relative number caught from the lake as a whole. This is due to very successful pier fishing for crappie, classed as shore angling, and not recorded at the livery.

Table 16 indicates that angling in 1948 was better than in either 1947 or 1949. This was due mainly to larger catches of bluegill and white catfish. The increased catfish catch will be taken up in detail in the section entitled "The Fishes."

TABLE 15

Qualitative Sample of Clear Lake 1947 Boat Catch

Month	Anglers	Angler hours	Large-mouth black bass	Crappie	Bluegill	Sacramento perch	White catfish	Brown bullhead	Total	Catch per hour	Catch per angler day
February	83	351	25	1	0	0	0	2	28	.080	
March	225	999	65	45	5	0	235	36	386	.387	
April	785	3,549	94	123	26	2	1,324	60	1,629	.458	
May	904	4,496	187	140	638	62	1,949	2	2,978	.661	
June	996	5,000	65	17	256	18	2,724	22	3,102	.620	
July	856	4,025	46	10	157	0	1,536	1	1,750	.426	
August	829	3,597	47	0	27	0	575	5	654	.165	
September	427	1,902	94	17	7	0	245	6	369	.191	
October	65	271	16	0	0	0	0	38	54	.214	
November	48	118	51	0	0	0	17	0	68	.491	
December	34	100	21	0	0	0	2	0	23	.220	
Totals	5,252	24,408	711	353	1,116	82	8,607	172	11,041		2.1
Percentage			6.4	3.2	10.1	0.7	78.0	1.6			

TABLE 16

Sport Boat Catch, Clear Lake Oaks, 1947, 1948, and 1949

	Year	January	February	March	April	May	June	July	August	September	October	November	December	Total	Percentage of total	Catch per angler day
Anglers	1947	0	87	225	472	782	584	462	464	224	65	45	34	3,444	----------	--------
	1948	17	62	109	313	664	606	873	609	479	99	43	5	3,879	----------	--------
	1949	1	56	80	680	906	758	1,005	440	254	133	97	19	4,429	----------	--------
Angler hours	1947	0	371	980	2,253	4,411	3,301	2,308	2,386	1,044	271	235	154	17,714	----------	--------
	1948	72	193	417	1,573	3,727	3,005	5,113	3,414	2,550	532	220	28	20,844	----------	--------
	1949	2	270	356	3,853	5,121	4,411	5,465	2,086	1,259	651	415	64	23,953	----------	--------
Largemouth black bass	1947	0	26	65	56	169	43	14	41	79	16	51	21	581	6.8	0.169
	1948	3	7	42	36	30	52	18	4	54	38	22	1	307	2.4	0.079
	1949	0	53	7	21	52	108	29	0	120	121	65	9	585	5.2	0.134
Crappie	1947	0	1	46	108	47	9	2	0	17	0	0	0	230	2.7	0.067
	1948	0	0	4	36	99	27	15	21	15	1	0	0	218	1.6	0.056
	1949	0	4	2	131	21	19	13	0	0	0	0	0	190	1.7	0.043
Bluegill	1947	0	0	5	17	799	286	151	23	0	0	0	0	1,281	15.2	0.3720
	1948	0	3	4	3	255	802	718	46	25	0	0	0	1,856	14.7	0.4780
	1949	0	0	5	190	373	610	279	9	121	1	0	0	1,588	14.1	0.3585
Sacramento perch	1947	0	0	0	0	64	15	0	0	0	0	0	0	79	0.9	0.023
	1948	0	0	0	2	86	35	0	0	0	0	0	0	123	1.0	0.032
	1949	0	0	0	18	16	11	0	1	0	0	0	0	46	0.4	0.010
White catfish	1947	0	0	235	879	1,677	1,950	794	406	164	38	17	2	6,162	73.2	1.790
	1948	0	19	1	553	1,364	712	2,754	2,288	1,747	157	155	5	9,755	78.2	2.518
	1949	0	0	19	2,137	1,550	1,429	2,298	569	391	144	67	50	8,654	77.0	1.954
Brown bullhead	1947	0	2	36	33	4	22	1	0	0	0	0	0	99	1.2	0.029
	1948	0	0	43	116	4	17	0	62	0	0	11	0	253	2.1	0.065
	1949	0	0	62	60	39	11	0	2	1	0	0	0	175	1.6	0.040
Total number of fish	1947	0	29	387	1,093	2,760	2,326	962	470	260	54	68	23	8,432	----------	2.450
	1948	3	29	90	746	1,838	1,645	3,505	2,422	1,841	196	188	6	12,509	----------	3.228
	1949	0	57	95	2,557	2,051	2,188	2,619	581	633	266	132	59	11,238	----------	2.537
Fish per angler day	1947	0.00	0.33	1.72	2.33	3.54	3.90	2.08	1.01	1.16	0.79	1.51	0.68	2.44	----------	--------
	1948	0.18	0.47	0.84	2.38	2.77	2.78	4.06	3.98	3.84	1.98	4.37	1.20	3.22	----------	--------
	1949	0.00	1.02	1.19	3.76	2.26	2.89	2.61	1.34	2.49	2.02	1.35	3.12	2.54	----------	--------
Fish per hour	1947	0.000	0.078	0.369	0.49	0.63	0.70	0.42	0.20	0.25	0.19	0.29	0.15	0.48	----------	--------
	1948	0.041	0.155	0.216	0.47	0.49	0.55	0.67	0.71	0.72	0.37	0.88	0.21	0.60	----------	--------
	1949	0.000	0.211	0.267	0.66	0.40	0.50	0.48	0.28	0.50	0.41	0.32	0.92	0.47	----------	--------
Percentage of total fish	1947	0.000	0.346	4.590	12.97	32.79	27.61	11.34	5.58	3.085	0.641	0.806	0.249	100.007	----------	--------
	1948	0.024	0.232	0.720	5.96	14.69	13.17	28.03	19.40	14.717	1.568	1.503	0.048	100.055	----------	--------
	1949	0.000	0.507	0.845	22.75	18.25	19.47	23.30	5.17	5.633	2.367	1.175	0.525	99.992	----------	--------

TABLE 17

Catch Records for Warm-water Lakes From Various Areas

Lake	Area in acres	Black bass	Crappie	Sunfish	Catfish	Others[1]	Total	Pounds per acre	Catch per hour
Eagle Mt. Lake, Texas, 1947[2]	9,600	7,540	236,670	----------	----------	----------	244,210	17.69	0.76
Spirit Lake, Iowa, 1947[3]	5,800	3,155	13,094	3,277	108,310	58,777	186,613	21.00	1.65
East Okoboji, Iowa, 1947[3]	1,950	360	14,002	531	7,072	7,734	29,699	12.80	0.93
West Okoboji, Iowa, 1947[3]	3,950	1,657	6,190	4,556	7,761	44,251	64,415	13.30	1.40
Lost Island, Iowa, 1947[3]	1,330	----------	----------	----------	322,152	913	323,065	64.60	4.39
Center Lake, Iowa, 1947[3]	264	156	----------	17	42,308	----------	42,481	96.5	1.50
Black Hawk Lake, Iowa, 1947[3]	955	148	15,572	146	7,284	19	25,626	17.6	0.72
Lake St. Marys, Ohio, 1946[4]	11,000	5,573	305,352	12,705	131,013	13,036	468,680	12.58	0.99
Lake Laramie, Ohio, 1946[4]	1,500	1,388	17,007	10,971	9,772	----------	41,136	6.92	0.65
Norris Reservoir, Tennessee, 1944[5]	34,200	45,700	226,000	15,300	----------	18,300	305,300	13.00	0.48[6]
San Diego City Reservoirs, California, 1944[7]	4,111	64,600	82,000	37,600	8,300	----------	192,500	----------	1.14[6]
Clear Lake, California, 1946	40,000	54,000	34,000	59,000	341,000	----------	488,000	10.71	----------

[1] Northern pike, walleye, yellow perch, white bass, carp, sauger, rock bass, redhorse, catfish, etc.
[2] Lamb and Buck (1948).
[3] Rose (1948).
[4] Clark, Now, and Flynn (1948).
[5] Eschmeyer and Manges (1945).
[6] Catch per trip divided by 5.
[7] From records kept by City of San Diego.

Table 17 summarizes catch data from waters in other areas. It is presented to give the reader some conception of the part that such fish as bass play in warm-water fisheries. In addition, examination of the data affords an opportunity to judge the angling quality at Clear Lake against a background of other waters. The 1947 catch per hour at Clear Lake was about 0.38 fish for all anglers and 0.48 for boat anglers from "The Oaks" livery. For "The Oaks" livery, the 1948 catch was 0.60 fish per hour and 0.47 for 1949. This does not compare unfavorably with the catch for some of the other waters listed in Table 17, but it should be borne in mind that fishing from "The Oaks" livery is one-third better than fishing over the entire lake. The only water in Table 17 that compares with Clear Lake in size is Norris Reservoir in Tennessee. The fishing in that lake is apparently of about the same quality as in Clear Lake, and Norris is known as a "good fishing lake." Actually, Clear Lake is considerably richer than Norris and does not fluctuate much. It should, then, support a denser fish population and consequently have better fishing than Norris Reservoir. In the opinion of the writer, Clear Lake, properly managed, should afford angling equal to that of the San Diego city reservoirs (Table 17).

Summary

The studies of the Clear Lake catch have brought to light several important facts.

1. There was a decided drop in the quality of the fishing after 1944 (Table 12).
2. The total catch is far below the maximum to be expected from a lake as shallow and fertile as Clear Lake, and the quality of the angling is poorer than expected.
3. In the years 1947, 1948, and 1949 there have been minor fluctuations in the quality of the fishing, but there has been no definite upward or downward trend.

THE FISHES

This section presents the data that can best be grouped around the individual species, or groups of species.

In the paragraphs to follow, length refers to "fork length," unless otherwise noted. Specimens for the growth studies were gathered in 1947. Scales for age studies were removed from the region between the dorsal fin and the lateral line. The scales were dry mounted, and the samples from each fish were read twice. Whenever disagreement between the two readings occurred, the sample was discarded. The fish in Age Group 0 are those which had not formed an annulus and were therefore zero to one year old. This in part explains the range about the mean for each year class, since an Age Group 1 fish taken just after annulus formation would be smaller than one taken just before the next annulus formed.

Growth and length-weight data are given in the form of tables. In order to compare the growth rate of Clear Lake fish with the same species in other areas the mean lengths of each year class for at least one other area are included.

White Catfish

The white catfish is the most important sport fish in Clear Lake, forming about 70 percent of the total catch. It is caught by using cut bait, live minnows, and plugs.

Examination of the gonads of individuals in the catch indicates that this species spawns in June and early July. The smallest individual examined, 8.3 inches in fork length, was maturing.

An attempt was made to interpret the age of specimens of white catfish by studying growth rings on the preopercular bones. The method seems promising but, of course, needs the verification of experimental evidence. The results of the study are given in Figure 177. The technique used was to measure the fork length of the specimen, and remove the two preopercular bones. In the laboratory these were cleaned by boiling and then dried. A code number was placed on each pair of bones, and the data taken at the time of capture recorded elsewhere. The bones were placed in a box, mixed and withdrawn one at a time without regard to pairing. After the first reading, the figures were paired. Any specimen on which the two readings (left and right) were not identical was rejected and the whole process repeated and the resultant four readings compared and inconsistencies again rejected. If the data secured in this manner are reasonably accurate, the bulk of the Clear Lake Catch is composed of 3-, 4-, and 5-year-old fish.

TABLE 18

Length in Inches of Sport-caught White Catfish, Clear Lake

Year	Number	Mean	Standard deviation	Standard error	Minimum	Maximum
1946	160	11.3	1.5	0.12	8.3	15.4
1947	375	11.7	1.7	0.09	8.3	20.5
1948	320	10.6	1.4	0.08	6.5	15.5
1949	881	10.7	1.7	0.06	7.0	18.5

The lengths of sport-caught white catfish in four years are given in Table 18. Figure 178 illustrates the length frequencies for 1947 and 1948. The differences in mean length between the catch of 1947 on the one hand and those of 1948 on the other are highly significant statistically and biologically.

In addition to a downward shift in mean length in 1948 and 1949, small fish (of a size virtually absent in 1946 and 1947) appeared in the catch. These small fish (six to eight inches) are probably in their second and third summers. Their appearance in the catch in 1948 and 1949 indicates better survival of the 1947 and 1948 hatches. The catch per unit of effort was better in 1948 than in 1947 (Table 15) indicating that these small fish were superimposed on a population of larger fish slightly fewer in number than the 1947 population of large fish. In 1949 the catch per unit of effort was nearly identical to 1947 but the average size was identical to that in 1948. This indicates that larger fish were less abundant in 1949 than in 1947. It should be borne in mind that two factors operate to prevent the small fish from appearing in the catch in proportion to their strength in the population: (1) it is illegal to take fish under nine inches in total length and (2) small catfish are undesirable to anglers. That they were abundant in 1948 and very abundant in 1949 is indicated by frequent complaints from anglers of "bait stealers" and undersized fish.

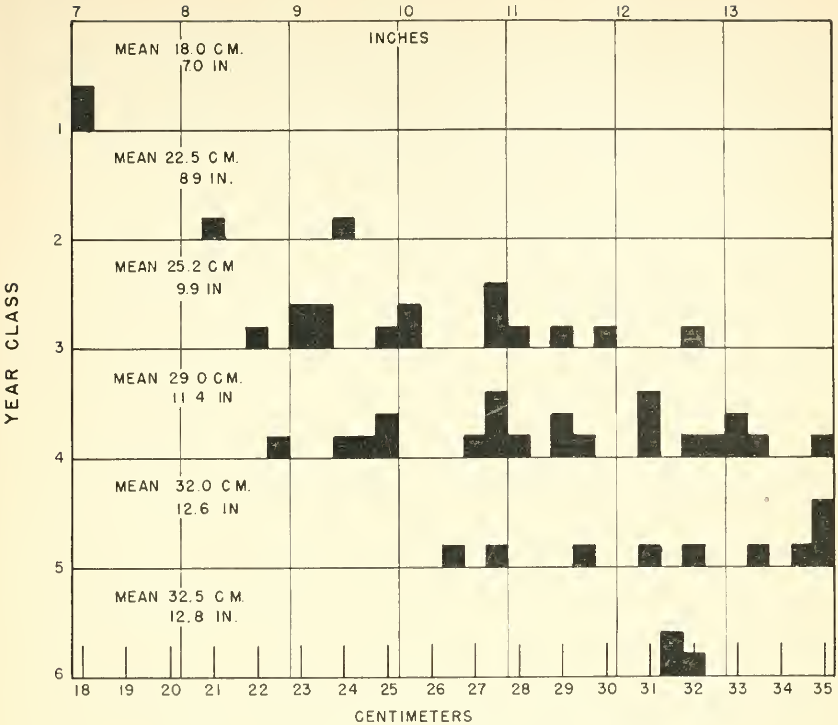

FIGURE 177. Growth rate of white catfish, Clear Lake, 1946-47

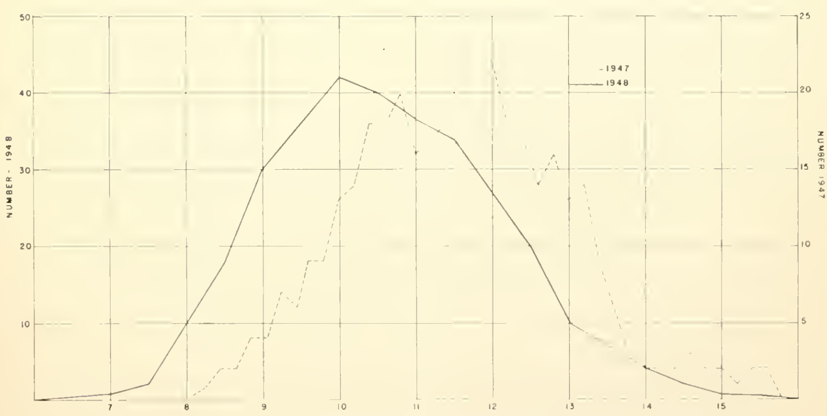

FIGURE 178. Length of white catfish in the sport catch, Clear Lake, 1947-48

Summarizing, the available data indicate that for an unknown period up to 1949 the fishery was preying on a decreasing population of older fish, with low recruitment to the population. Survival of the hatch apparently increased after 1946, resulting in increased recruitment to the catchable stock in 1948 and 1949. Recruitment in 1948 and 1949 appeared adequate to maintain the population, and may have been large enough to produce better fishing in 1950 and 1951.

Table 19 summarizes the length-weight data obtained.

TABLE 19

Length-weight Relationship of White Catfish, Clear Lake, 1946-1947

Length, inches	Number	Mean weight, ounces	Weight range, ounces
7.1	1	2.7	
7.5			
7.9			
8.3	1	5.4	
8.7	2	5.7	5.4- 6.2
9.1	7	7.0	4.4- 7.9
9.4	10	7.7	6.2- 8.9
9.8	14	9.0	7.9- 9.7
10.2	15	9.2	7.0-10.6
10.6	21	10.7	8.9-13.2
11.0	13	11.9	9.7-13.2
11.4	16	9.4	11.5-15.9
11.8	35	14.3	10.6-17.7
12.2	21	15.4	12.4-18.6
12.6	22	17.5	12.4-24.8
13.0	16	20.5	18.6-24.8
13.4	11	20.9	16.8-23.9
13.8	5	21.7	19.4-23.9
14.2	4	23.6	21.2-25.7
14.6	1	22.1	
15.0	1	28.3	
15.4			
15.7			
16.1	1	42.4	
16.5	1	38.9	
17.0			
17.3			
17.7			
18.1			
18.5			
18.9			
19.3	2	80.0	71.4-88.2

Brown Bullhead

The brown bullhead taken by sportsmen in 1947, 1948, and 1949 were large for this species, indicating that the population is not heavily exploited. Their population is relatively small, and they comprise about 2 percent of the total catch. Apparently the bullhead was much more important before the introduction of the white catfish.

TABLE 20

Length in Inches of Sport-caught Brown Bullhead, Clear Lake

Year	Number	Mean	Standard deviation	Standard error
1947	75	11.6	1.5	0.18
1948	171	12.0	0.9	0.08
1949	103	11.5	1.4	0.13

The brown bullhead is the first species to be taken in numbers after the cold period of midwinter, when the catch of all species is near to zero. Bullhead fishing generally follows the first rain that is coincidental with lake water temperatures close to 45 degrees F. Bullhead fishing usually remains fairly good until the end of April. Then they seem to cease biting, though netting reveals them to be as abundant as ever in the littoral zone.

The average size of brown bullhead taken in Clear Lake is large (Table 20).

Largemouth Black Bass

As can be seen from the data in Table 21, the growth rate of bass in Clear Lake is greater than in any other area except the deep South,

TABLE 21

Length in Inches of the Various Age Groups of Largemouth Black Bass in Clear Lake and Other Areas

Age group	Clear Lake[1]				Michigan[2]	Lake Mead[3]	Norris reservoir[4]	Wisconsin[5]	Louisiana[5]
	Number of specimens	Minimum length	Maximum length	Mean length	Mean length	Mean length	Mean length	Mean length	Mean length
0	16	3.0	5.3	4.0	3.3				
							6.9	3.5	7.7
1	17	3.2	9.2	6.7	6.1	10.3			
							12.2	7.4	11.3
2	26	10.4	15.1	12.2	8.7	12.6			
							14.6	10.9	14.6
3	11	13.8	16.3	14.8	10.0	13.4			
							16.2	12.6	19.0
4	7	14.8	17.8	16.7	12.1	14.6			
							17.5	14.0	21.0
5	9	18.1	20.3	19.8	13.7	15.2			
							19.3	15.3	23.6
6	1	21.4	21.4	21.4	15.1	16.4			
							20.8	16.5	25.0

[1] Fork length at capture.
[2] Beckman (1949). Total length at capture.
[3] Moffett (1943). Total length at capture.
[4] Stroud (1948). Total length. This study used calculated lengths; Stroud's age 1 fish are at an age between age group 0 and age group 1, etc.
[5] Bennett (1945). Total length. See footnote 4 for explanation of age.

represented by Louisiana. The sample of Age 0 fish is somewhat misleading. It is drawn in July. As will be pointed out, many Age 1 fish reach a length of over eight inches by September and enter the sport catch, but these were not sampled in 1947.

Table 22 gives statistics on samples of the sport catch. It is difficult to assign biological significance to the variations in mean length. The 1948 and 1949 measurements were made by a layman. He was definitely biased to even inches. The cumulative effect of this bias is to exaggerate the mean size, probably by one-half inch.

TABLE 22

Length in Inches of Sport-caught Largemouth Black Bass, Clear Lake [1]

Year	Number	Mean	Standard deviation	Standard error
1946	19	14.5	4.3	0.97
1947	70	13.5	2.6	0.31
1948	100	14.4	2.4	0.24
1949a	84	16.6	2.2	0.24
1949b	22	7.8	----	----

[1] In 1949 the size limit was removed. 1949a are all bass over 9 inches. 1949b are all bass under 9 inches.

The 1949 series is divided into two sections, "a" and "b." Section "a" represents fish of the 1947 and older year classes. Section "b" represents fish of the 1949 year class. These were taken in September and represent the largest individuals of the 1949 hatch. Concentrations of fish of the year build up during the summer. By September these are large enough to be taken on flies and other small lures. These concentrations break up in October. Fish in their second summer (Age Class 1) do not enter the catch to any great extent. This may be due to the methods of angling used at Clear Lake. In their third summer they again enter the catch, becoming reduced in numbers in subsequent years.

The data on the catch show that bass in their third, fourth, and fifth summers (Age Groups 2, 3, and 4) make up the bulk of the sport catch, with considerable numbers of older fish represented. Since bass spawn at the end of their second year, all Age Group 2 and older fish have spawned at least once.

Though bass constitute only 10 percent of the sport catch in Clear Lake, the population does not appear to be overfished. Individual year classes do not disappear for several years after entering the fishery. The fact that bass over five or six years of age do not appear more frequently is probably due to the short life span evidenced by rapidly growing fishes. This has been found to be true in other waters.

Length-weight data for bass from Clear Lake are shown in Table 23.

TABLE 23

Length-weight Relationship of Largemouth Black Bass, Clear Lake, 1946-1947

Length, inches	Number	Mean weight, ounces	Weight range, ounces
5.1	2	0.9	
5.5	1	1.8	
5.9	2	1.8	
6.3	1	1.8	
6.7	4	2.2	1.8–2.7
7.1			
7.5	5	3.5	
7.9	1	3.5	
8.3	2	4.4	3.5–5.4
8.7	2	6.2	5.4–7.0
9.1			
9.4			
9.8			
10.2	1	8.9	
10.6	1	10.6	
11.0	5	12.4	10.6–14.1
11.4	1		
11.8	4	14.3	12.4–15.9
12.2	1	16.8	
12.6	1	16.8	
13.0	2	21.2	
13.4	1	23.0	
13.8	2	24.3	23.9–24.8
14.2	3	28.5	24.8–33.6
14.6	3	27.1	22.1–31.8
15.0	3	35.4	32.7–38.9
15.4			
15.7			
16.1	1	37.1	
16.5	4	38.9	34.5–42.7
17.0			
17.3	1	38.9	
17.7	1	24.8	
18.1	3	48.9	26.5–63.6
18 5			
18.9	1	60.9	
19.3			
19.7			
20.1	1	80.1	
20.5	1	100.0	
20.9			
21.3	1	70.7	

Bluegill

The growth of bluegill in Clear Lake is very satisfactory (Table 24), comparing favorably with that in other areas. The average length of bluegill taken in Clear Lake is eight inches (Table 25), and this is also the modal class. These fish are in their fourth summer (Age Group 3). Very few older fish are taken, indicating that these fast-growing individuals die soon after their fourth or fifth summer. Supporting this contention is the fact that many of the large bluegill taken by seining, but not by angling, are in very poor condition and appear to be wasting away.

Bluegill in Age Group 1 are probably the most numerous of the year classes vulnerable to angling. They are not taken in large numbers, because anglers do not use flies or very small baited hooks to any great extent. They have their sight set on larger quarry. In fact, a large portion of the bluegill catch is made by anglers fishing for bass or crappie, using small minnows for bait. Frequently, too, small bluegill, if captured, are released unless the angler is a young boy.

Bluegill appear to spawn in Clear Lake invariably at the end of their first year. There is even a suggestion that some of the earlier spawned, faster growing individuals spawn at the end of their first summer of life.

The evidence available for the bluegill population indicates that the angler does nothing more than harvest a small portion of them shortly before they would die a natural death. In other words, the angler's influence on the population is close to zero. Large quantities of bluegill of the year can be seined along the shore in midsummer. The query naturally rises as to why there are not more big bluegill in the lake when anglers don't hurt them, there is plenty of food, and large numbers of young are hatched. Heavy predation by carnivorous species is the most logical answer. This and related questions will be dealt with in the discussion section.

Length-weight data for bluegill are shown in Table 26.

TABLE 24

Length in Inches of Various Age Groups of Bluegill in Clear Lake and Other Areas

Age group	Clear Lake[1]				Michigan[2]	Ohio[3]	Illinois[4]
	Number of specimens	Minimum length	Maximum length	Mean length	Mean length	Mean length	Mean length
0	22	1.3	4.8	2.3	1.7		
						1.7	1.2
1	20	2.6	5.9	4.1	3.1		
						3.6	3.5
2	23	4.7	8.1	6.5	4.3		
						5.1	4.8
3	46	6.2	9.3	8.1	5.4		
						5.9	6.0
4	12	8.2	9.8	8.9	6.6		
						6.8	6.7
5	1	9.1	9.1	9.1	7.3		
						7.4	

[1] Fork length at capture.
[2] Beckman (1949). Total length at capture.
[3] Roach and Evans (1947). Total length. Lengths calculated at end of year of life.
[4] Bennett (1945). Total length. Lengths calculated at end of year of life.

TABLE 25

Length in Inches of Sport-caught Bluegill, Clear Lake

Year	Number	Mean	Standard deviation	Standard error
1946	21	8.1	0.6	0.13
1947	93	8.0	1.1	0.11
1948	100	8.3	1.1	0.11
1949	225	8.1	1.2	0.08

TABLE 26

Length-weight Relationship of Bluegill, Clear Lake, 1946-1947

Length, inches	Number	Mean weight, ounces	Weight range, ounces
3.5	1	0.5	
3.9	2	0.9	0.9- 0.9
4.3	3	0.9	0.9- 0.9
4.7	1	1.8	
5.1	3	1.7	1.6- 1.8
5.5	4	2.2	1.8- 3.5
5.9	4	2.4	1.8- 2.7
6.3	3	3.2	2.7- 3.5
6.7	4	4.4	3.5- 5.4
7.1	3	5.0	4.4- 5.4
7.5	1	6.2	
7.9	10	7.4	7.0- 7.9
8.3	15	8.4	4.4- 9.7
8.7	27	10.0	7.9-12.4
9.1	7	11.0	9.2-12.4
9.5	1	12.4	
9.8	1	17.7	

Sacramento Perch

The Sacramento perch, the only member of the sunfish family native to California, forms less than 1 percent of the sport take of Clear Lake. Formerly, before the introduction of alien species, it was enormously abundant. Competition with introduced species probably accounts for the reduction. The perch does not guard its eggs as do other sunfish (Murphy, 1948a). This is the most vulnerable point in its life cycle, and it is probable that the introduced bluegill and catfish consume large quantities of the eggs.

Though the population is small, it appears healthy. The largest specimen encountered in 1949 was 14 inches in length. The average size of the 1949 catch (Table 27) represents fish in their fourth summer. Murphy (1948a) gives the growth rate of the Sacramento perch. Since the perch spawns at the end of its first summer, and is vulnerable to angling during its second summer, it does not appear to be overfished. Though it is not overfished it will probably never become abundant in

Clear Lake because of severe competition. It is very doubtful if even complete protection from angling would increase its numbers, since its decline took place during a period when there was very little angling in Clear Lake.

TABLE 27

Length in Inches of Sport-caught Sacramento Perch, Clear Lake

Year	Number	Mean	Standard deviation	Standard error
1948	103	9.0	1.4	0.14
1949	46	9.3	1.2	0.18

Black Crappie

The black crappie in Clear Lake grow very rapidly, comparing favorably in growth with those in Norris Reservoir (Table 28). Growth in the first year is slow. During the second year, when presumably they become carnivorous, growth spurts ahead. As is the case in Norris Reservoir, these rapidly growing fish disappear after their fifth summer. Probably the older fish that are not caught die. Indicative of this, a few large dead and dying crappie have been found nearly every spring in Clear Lake.

As can be seen by a comparison of Tables 28 and 29, the bulk of the sport catch in 1946, 1947, and 1948 was composed of fish in their third, fourth, and fifth summers (Age Groups 2, 3, 4). In the 1949 sample, fish in their second summer (Age Group 1) were strongly represented. Whether this is due to nonrandom sampling or a stronger 1948 year class is not known. That the latter possibility was the case is indicated by the capture of more crappie of the year by seining in the summer of 1948 than were captured in 1946 or 1947. (See Table 30 for length-weight data.)

The estimated relative strength of crappie in the catch has remained rather constant at Clear Lake except for 1943 (Table 11). In other areas crappie are subject to great fluctuations in abundance.

Crappie do not appear to be over-exploited at Clear Lake.

TABLE 28

Length in Inches of Various Age Groups of Black Crappie in Clear Lake and Other Areas

Age group	Clear Lake[1]				Michigan[2]	Reelfoot Lake[3]	Norris reservoir[4]	Ohio[5]
	Number of specimens	Minimum length	Maximum length	Mean length	Mean length	Mean length	Mean length	Mean length
0	1	1.5	1.5	1.5				
							2.5	2.3
1	10	5.7	9.3	8.2				
							9.2	4.6
2	12	9.3	11.6	10.9	5.9			
						7.6	11.5	6.3
3	27	11.5	15.7	12.9	8.0			
						9.0	12.7	7.7
4	7	12.4	13.6	13.1	9.0			
						9.7	13.7	9.1
5	1	13.8	13.8	13.8	9.9			
						10.4		9.9

[1] Fork length at capture.
[2] Beckman (1949). Total length at capture.
[3] Bennett (1945). Total length. Lengths calculated at end of year of life.
[4] Stroud (1948). Total length. Lengths calculated at end of year of life.
[5] Roach and Evans (1948). Lengths calculated at end of year of life.

TABLE 29

Length in Inches of Sport-caught Black Crappie, Clear Lake

Year	Number	Mean	Standard deviation	Standard error
1946	20	12.6	0.7	0.14
1947	33	11.4	1.7	0.29
1948	104	12.2	2.2	0.22
1949	102	9.9	1.6	0.16

TABLE 30

Length-weight Relationship of Black Crappie, Clear Lake, 1946-1947

Length, inches	Number	Mean weight, ounces	Weight range, ounces
7.5	1	3.5	3.5
7.9	3	3.8	3.5- 4.4
8.3	3	5.4	4.4- 6.2
8.7	3	6.5	5.4- 7.0
9.1	1	7.0	------
9.5	1	8.9	------
9.8	1	8.9	------
10.2	1	9.7	------
10.6	2	10.9	10.6-11.5
11.0	5	13.1	12.4-14.3
11.4	1	16.8	------
11.8	4	16.4	15.5-17.7
12.2	9	17.7	15.0-21.2
12.6	5	19.9	17.7-23.0
13.0	4	21.6	17.7-24.8
13.4	2	25.7	24.8-26.5
13.8	3	24.4	22.1-26.5
14.2	------	------	------
14.6	------	------	------
15.0	------	------	------
15.4	------	------	------
15.7	1	47.6	------

Rough Fish

The term rough fish as herein used includes all nongame species. They are for the most part members of the family Cyprinidae, but the term also includes such fish as sculpins. Consideration of these species is an integral part of a survey of a sport fishery, since rough fish play an important role in the production of game fish. For instance, an overabundance of rough fish may be detrimental to the game fish population through competition for food and space. On the other hand, these nongame species may be of considerable value through the forage their young provide for sport fishes.

Until 1942 or 1943 rough fish were exceedingly abundant in Clear Lake, but since that time they have declined precipitously. In earlier years hitch, splittail, greaser blackfish, suckers, squawfish, and carp abounded in Clear Lake. At the present time (1946-50) blackfish, carp, and suckers are present in fair numbers. Hitch are present but relatively scarce, squawfish are rare, and only a few splittail fingerlings have been found in three summers of intensive seining. The disappearance of these three species (hitch, splittail, and squawfish) and the reduction of the other species has greatly reduced the supply of forage fish which change the basic foods (plankton, etc.) into a form available to the piscivorous fishes, such as bass and white catfish. (The exception to this is the squawfish, which, as an adult, is in competition with game fish through its carnivorous habits.)

Some of the evidence that points to this recent decline of rough fish is as follows:

1. The enormous runs of squawfish, hitch, and splittail that once entered the streams no longer occur. According to residents in the area,

these runs once "choked" the streams. Occasionally the flows in the streams dropped rapidly, stranding great masses of fish in the stream channels. Figure 179 illustrates this phenomenon with respect to a run of squawfish in Kelsey Creek.

FIGURE 179. A run of squawfish stranded in Kelsey Creek near Kelseyville, Lake County, April 29, 1899. *Photograph by O. E. Meddaugh.*

2. Lakeshore residents formerly obtained bait minnows with ease by netting around piers. At present, virtually all of the young fish netted are young bluegill.

3. Table 31 gives a comparison of gill netting during 1938 and 1946-1947. The 1938 netting was carried out by A. W. Lindquist of the U. S. Bureau of Entomology and Plant Quarantine in connection with

TABLE 31

Gill Net Catches, Clear Lake

Year	Hours fished	White catfish	Sacramento perch	Bluegill	Splittail	Carp	Greaser blackfish	Sacramento squawfish
1938	125	15	11	3	156	23	1	43
1946–7	344	46	3	21	0	40	7	0

studies on the Clear Lake gnat. The 1938 netting was done in August and September and the 1946-47 netting in June, July, and August.

The netting in both years was done with a 125-foot net with graduated mesh.

Most of the differences noted are insignificant because of vagaries in sampling technique, but the complete absence of squawfish and splittail in 1946-47 is highly significant.

4. In the spring and early summer enormous numbers of carp and greaser blackfish died annually until the early 1940's. At present these fish die in fair numbers during the same period, but by comparison with the windrows of dead fish that formerly occurred, their number is minute. Apparently the cause of death was (and is) spawning exhaustion, and the greatly reduced numbers of dead fish in recent years indicate a much reduced population.

The species that have disappeared or have been seriously reduced (hitch, splittail, squawfish, and sucker) are stream spawners. Consideration of the life histories of these fishes and of the changes brought about in the tributary streams indicates that reduction of their populations was due to deterioration of their spawning and nursery streams.

The spawning streams utilized by these species arise in the hills surrounding Clear Lake. Many of them are trout streams in their headwater areas. All of the important streams flow through several miles of intensively cultivated valley land before emptying into Clear Lake. In aboriginal days these streams probably did not dry up near their mouths until September at the earliest. It is in these low-gradient, gravel-bottomed, valley stream sections that the rough fish of Clear Lake spawned, and it is these sections that have deteriorated in recent years as regards spawning and nursery grounds, because of their going dry in early summer or late spring.

Fires and lumbering in the headwater areas of these streams have contributed to more rapid runoff in the winter and lower stream flows in summer. However, the greatest single factor causing deterioration of the lower reaches of these streams is irrigation demand. This factor increased greatly during the 1940's, as more land was intensively irrigated in response to high prices for agricultural products. The highly developed agriculture of the valleys is dependent upon the ground water and the uncertain summer runoff for irrigation water, and at least some of these streams have an intimate relation with the ground water. For instance, pumping 10 cubic feet per second from the Big Valley ground water draws eight cubic feet per second from Kelsey Creek.

In attempting to evaluate the effects of these changes on the stream-spawning fish, it is helpful to consider the specific example of a hitch run in Kelsey Creek. In 1949 hitch were able to ascend Kelsey Creek and spawn. Their eggs were deposited on gravel bars. In the lowland agricultural sections of the stream rapidly falling flows stranded a large percentage of the eggs. Many hatched, however, but the bulk of the young hitch would not have migrated out of the stream until the third week in June. As that spring was dry, farmers began irrigating in the third week of May. This almost immediately cut off the tenuous surface flow Kelsey Creek was maintaining to the lake. The bulk of the hitch crop was then stranded in the stream and ultimately perished. (A more detailed discussion of the dependence of hitch on stream flows is given in a recent publication [Murphy, 1948b].) The flow regime in Kelsey Creek in 1949 was typical of the pattern in other Clear Lake tributaries that year, and this was reflected in the extreme scarcity of hitch of the year in Clear Lake.

In contrast to 1949, unusually heavy late spring rains in 1948 maintained flows in most streams until midsummer. This was reflected in a large crop of hitch of the year in Clear Lake. In 1946 and 1947, as in 1949, the hitch crop was a failure, and this can be laid directly to unfavorable runoff patterns in those years.

The exact relation of squawfish and splittail to the runoff pattern is not known, as it is in the case of the hitch. They spawn at about the same time as the latter species, but if their young normally remain in the streams for even a few weeks longer than the young of hitch they probably were decimated by the now usual adverse runoff pattern that causes only severe reduction of the hitch. Suckers spawn earlier, usually in February, and most of their young migrate to the lake before June 1st. Consequently, they have not been as severely affected as the other species.

Decline of the lake-spawning blackfish cannot be laid to adverse stream flows. Their decline, which has not been as drastic as that of the stream spawners, can probably be laid to increased predation by game fish in the absence of other forage fish.

DISCUSSION AND SUMMARY

The study of Clear Lake indicates that two principal changes in the fish population have taken place. The first change was brought about by the introduction of exotic species, chiefly carnivores, and taking place for the most part between 1870 and 1900. The second change came during the early 1940's and was caused by a combination of poor rainfall years and war-intensified irrigation. This latter change first affected several species of stream-spawning cyprinid forage fishes. It operated by reducing their spawning and nursery areas. Reduction of the forage fish supply lowered the carrying capacity of the lake. This lowered carrying capacity of the lake was reflected in a drop in the quality of angling after 1944.

It might be argued that any drop in the supply of cyprinid forage would be compensated by bluegill sunfish, or to paraphrase, why do bluegill not furnish all of the forage needed? The answer appears to lie in rather vaguely defined limitations on bluegill reproduction, and in the morphology of the lake. Certainly, if growth rate is indicative, food is not a limiting factor on bluegill. Bluegill spawning areas exist in the littoral areas of the lake only, and their young are more or less confined to that same area. If bluegill are the only forage fish in the lake, production of forage takes place only in a relatively narrow band of shore area, making the effective area of the lake much smaller than the total area. This restriction on food production must result in a lower game fish population. On the other hand, forage fish that tend to range over a wider area of the lake increase the actual productive area, which should result in a larger population of game fish.

Apparently the cyprinid forage fishes, formerly very abundant in the lake, were to a considerable extent offshore inhabitants, at least after the first few months of life. Their reduction lowered the productive area of the lake, resulting in a smaller population of game fishes. It might be argued that a reduction of forage fish should have acted to reduce the growth rate of the population. While it is impossible to ascertain whether or not a drop in growth rate occurred, it is apparent that this could not have been severe. Stunting, such as occurs in farm ponds, would not be expected in a large lake populated with several carnivores. Rather, reduction in forage fish would result in increased predation on young game fish, the end product being a numerically weaker population of game fish. This appears to have been the case at Clear Lake.

Briefly stated, the study of Clear Lake showed that the production of game fish on a per acre basis is low; the catch per unit of effort is low; and growth of the game fish is good. There is good indication that before the mid-1940's the catch per unit of effort was higher than at present. There is excellent indication that the population of cyprinid forage fish was considerably larger in earlier years. And, field studies showed that the survival of the young of one of the game fish, the largemouth black bass, was closely correlated with the numerical strength of the year's crop of forage fish (Murphy, 1950b). These several lines of evidence point rather strongly to the conclusion that the game fish in Clear Lake can be increased numerically by augmenting the supply of forage fish.

In order to increase the supply of forage fish, commercial fishing on the greaser blackfish was stopped in 1948. It was recognized that this was only a partial solution, because the take of blackfish was not large, and the most important forage fish were the stream-spawning cyprinids that had been severely reduced. Since there was little hope of rehabilitating the streams, it was decided to introduce a new forage fish to the lake. The golden shiner (*Notemigonus crysoleucus*), a lake-spawning, slow-growing cyprinid, was selected and introduced in 1950. This species is an important source of forage in eastern waters, and is abundant in the San Diego city reservoirs, waters that are providing excellent fishing.

A possible detriment to the future of the fishery was the treatment of the lake in 1949 with an emulsion of TDE at the rate of 1 part TDE to 70,000,000 parts of water. This work was done by the Lake County Mosquito Abatement District in order to eradicate the phantom midge (*Chaoborus asticopus*). This, and possibly other insect species, was completely eliminated from the lake. The midge constituted a sizable segment of the insect diet of the fish (Lindquist, Deonier, and Hancey, 1943). Whether other insects are, or will, become sufficiently abundant to satisfy the demands of the fish population for insect food, only the future will reveal.

It is of interest to note that, though there have been several changes in the fish populations of Clear Lake, the angler has had no important noticeable effect on these fish populations. In fact, it appears very certain that the only effect of angling has been a reduction in the number of "lunkers." This is not surprising, since it is easy to demonstrate mathematically that even moderate angling mortality will greatly reduce the chances of a fish reaching a large size (or great age). This reduction in the number of older fish is compensated by increased survival of the young, making for larger numbers of small and medium sized fish.

Since angling has little effect on the fish population, it follows that only a few basic regulations are needed. Restriction of the method of harvest to angling with hook and line is the most important regulation. Secondarily, moderate bag and possession limits are needed. These have a twofold purpose. Relatively low limits insure that angling will not adversely affect the fish population. In addition, they discourage illegal methods of catching fish, such as fishing with set lines and nets. For, if a large possession limit were allowed, the individual might be tempted to use any means at his disposal to fill his limit. Limits should be set high enough to encourage the angler to fish, and high enough to enable the individual to bring home a good "mess" if he is "lucky."

"Lucky" is a term worthy of consideration. Many anglers and hunters feel that they are entitled to a limit each time they venture afield. This is particularly characteristic of hunters who frequent commercial and private duck clubs. This "limit" is not something which the sportsman should expect or even aim for each time he goes out; *it represents a point beyond which he must not go!*

With respect to Clear Lake, the writer believes that the regulations in force in 1950 are close to ideal. The one possible exception is the minimum size limit of nine inches on catfish, which appears to be unnecessary. The important restrictions on harvesting the fish of Clear Lake are the provision that they be taken by angling only, and the moderate bag limits. These should be observed by every sportsman, and vigorously enforced by the Division of Fish and Game.

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THE FRESH-WATER MUSSELS OF CALIFORNIA[1]

By PAUL BONNOT
Bureau of Marine Fisheries
California Division of Fish and Game

There are more than 500 species of fresh-water mussels in the United States. About 40 species grow shells that are thick and dense, and these supplied the material for a button industry that flourished in the Middle West for many years. Mussels are able producers of pearls and these at one time brought a good price. They have comparatively little value at present. The famous ''pearl oysters'' of the South Pacific are not oysters but near relatives of the mussels.

Fresh-water mussels are edible if they can be obtained in sufficient quantity. They are steamed in the same manner as the sea mussels.

Although these bivalves can and sometimes do move about, they are usually found partly embedded in the bottom. The anterior end is under the surface, and the animal sets obliquely with the posterior, the siphon end, facing usually upstream, against the current.

The life history of the fresh-water mussels is of interest as it differs in some respects from that of most of the other bivalves. The eggs develop in the ovaries and then pass into the gill chamber. After growing a tiny shell, they are discharged into the water and fall to the bottom. At this stage they are called glochidia. A long thread from the tiny animal floats in the water, and when this touches a passing fish, it adheres and the glochidium pulls itself rapidly up and snaps its valves on gills or scales. If unable to procure a host, the larval mussel dies in a few days. The irritation engendered by the glochidium causes a growth of tissue by the fish which encloses it.The cyst is air and water tight. After 70 or 80 days of internal development, but with no increase in size, the young mussel works its way out of the encystment and drops to the bottom, ready to take up its adult life. The encysted stage may be the means by which mussels are distributed in many fresh-water streams that flow into the ocean. Although they cannot live in salt water, they could be transported from one stream to another while protected in their waterproof envelope.

The semiparasitic stage is a curious adaption which ensures the distribution of the reproductive products. Very little, if any, nourishment seems to be extracted from the host, and even a heavy infestation does not seem to be injurious. Murphy (1942) found that under more or less artificial conditions an infestation of 1,200 glochidia was fatal to trout. In a natural environment, however, most species of fish seem to be able to support 2,000 or more without harmful results (Coker et al., 1922).

Enormous numbers of glochidia are produced in order to maintain the species. Comparatively few are able to obtain a host while in the parasitic stage, and the adults are exposed to many environmental

[1] Submitted for publication February, 1951.

hazards. Floods, droughts, and freezing take a heavy toll, and many animals, in addition to man, gather mussels. Fish eat the young after they have passed the encysted stage, and raccoons and muskrats take large numbers. In recent years, increasing pollution has been responsible for the disappearance of fresh-water mussels from many areas.

The shells or valves of the species that inhabit running water are usually eroded by the mechanical action of sand and chemicals in solution in the water. Whole beds of mussels are sometimes destroyed by excessive erosion.

The species that inhabit sluggish or standing water are acclimated to stagnant water and can resist drying for extended periods.

The streams and lakes of California are inhabited by three species of fresh-water mussels. One of these lives in slow-moving streams and lakes, the other two in swift running water. Permanent fresh-water areas are not extensive in California, and in consequence, limnetic species, although sometimes widely dispersed, seldom find the necessary environmental components conducive to long life or large populations.

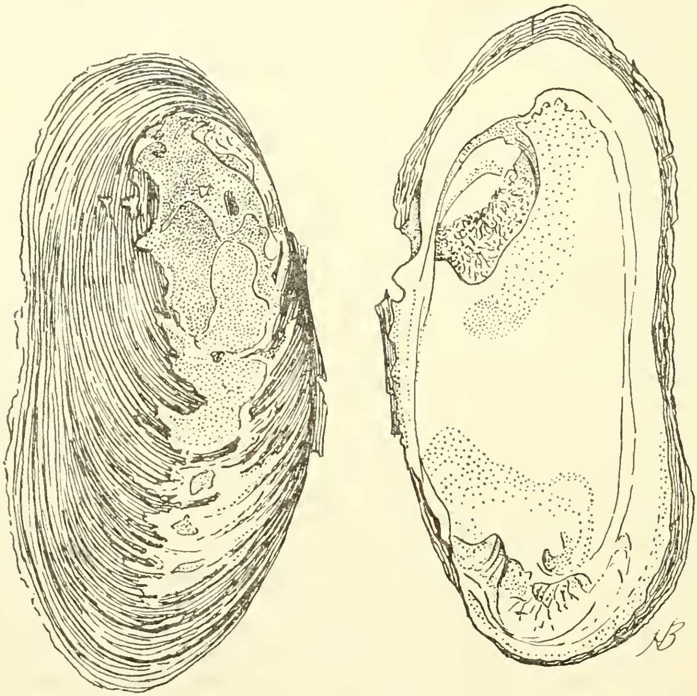

FIGURE 180

PEARLY NAIAD (*MARGARITIANA MARGARITIFERA*)

Description. Shell elliptical, elongate, one central tooth at the umbo of right valve, two teeth on left valve. Periostracum (the covering of the outside of the shell) glossy mahogany, usually worn off at hinge end. Inside color brilliant orange, purple, blue, green or pink. Color fades soon after death. To four inches.

Habitat and Range. Found in gravel and sand in clear running streams from the Columbia River south to Southern California.

Notes. Most of the shells of these mussels are scoured and worn near the umbo by sand and chemicals dissolved in the water.

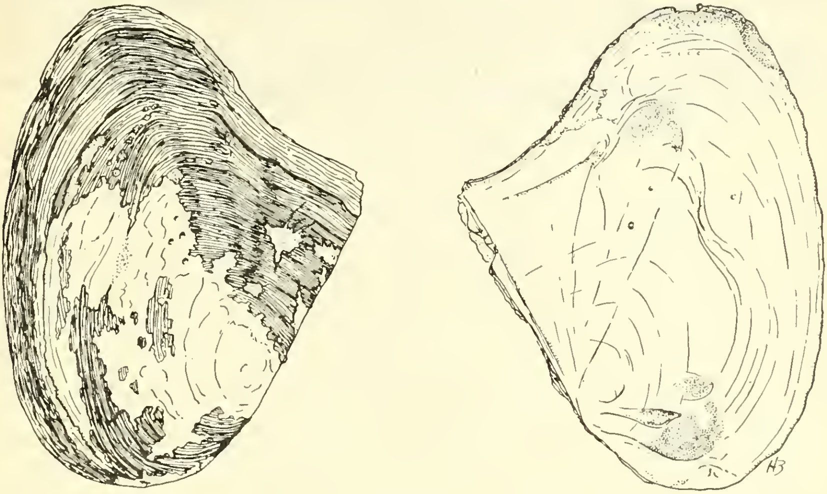

FIGURE 181

NUTTALL'S ANODON (*ANODONTA NUTTALIANA*)

Description. Shell thin, no hinge teeth. Periostracum greenish brown. Inside of shell bluish. The hinge line extends upward to form a right triangle above the oval part of the shell. To three inches.

Habitat. Slow-moving streams or lakes and ponds from Canada to Mexico.

Notes. There are a number of species of this genus listed, but they are based on such minute differences that some authorities consider them merely geographical forms of one species.

ANGULAR ANODON (*GONIDEA ANGULATA*)

Description. Shell thin, one rudimentary tooth on each valve. A ridge divides the shell into two unequal parts, indistinct in some specimens. Periostracum dark brown; inside of shell nacreous, flesh colored. Three to four inches.

Habitat. Fresh-water streams and lakes from Canada to Mexico.

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A REMARKABLE SEA JOURNEY BY A RAINBOW TROUT (*SALMO GAIRDNERII*) OF "INTERIOR STOCK"[1]

By LEO SHAPOVALOV
Bureau of Fish Conservation
California Division of Fish and Game

On January 27, 1951, Lieutenant F. R. Colman, MSC, U. S. Navy, caught a 14½-inch trout bearing a metal strap jaw tag marked A 1632 OGC 1¼ miles upstream from the mouth of the Garcia River, Mendocino County, California. Lieutenant Colman wrote a letter requesting information concerning the history of the fish to the California Division of Fish and Game. Subsequent inquiry by the writer to Dr. H. J. Rayner, Chief of Operations of the Division of Fisheries of the Oregon State Game Commission, revealed that this tag had been placed on a rainbow trout released at Winchester Dam on the North Umpqua River, Oregon, on April 7, 1950, at which time the fish in the lot averaged four to the pound (approximately eight inches in length). Thus, within the space of 296 days this trout had made the 100-mile river trip to the mouth of the Umpqua River, had traveled some 300 miles at sea, and then had ascended the Garcia River about 1¼ miles, averaging in all a minimum of 1⅓ miles a day.

Of particular interest is Dr. Rayner's statement that the tagged fish were fall-spawning rainbow trout of stock derived directly from the U. S. Fish Commission's operations on the McCloud River, California, in the 1880's. The possibility does exist that this stock was contaminated at one time or another during its many years of hatchery existence by the inadvertent admixture of outside stock. This is a possibility that can be neither proved nor disproved, but should not be ignored.

However, in this instance having no specific evidence to the contrary, let us assume that no contamination took place. In such case, this remarkable sea journey by an "interior stock" rainbow trout has some interesting implications. The question, "What is the difference between a rainbow and a steelhead?" has been the source of much discussion among sportsmen and scientists alike. Whatever may be the systematic status of the various species and subspecies described as members of the "rainbow series," the behavior of rainbow of interior stock (i.e., supposedly nonmigratory) when planted in coastal streams is a problem of paramount interest from the fisheries management standpoint, which remains largely unresolved. A single record like the present one certainly does not provide a complete answer to this problem, but it does demonstrate that even small rainbow of what has been considered the purest "interior stock" in fish culture *are capable of* and *may* make prolonged journeys at sea. Studies on both naturally spawned and artificially propagated marked steelhead, *Salmo gairdnerii*, (Taft and Shapovalov, 1938), have shown that at least in some instances migrants return to the

[1] Submitted for publication March, 1951.

''home stream'' with extreme fidelity. The present record, coupled with some apparent examples of low survival to the creel of rainbows of interior stock planted in coastal streams, leads to the interesting speculation that such rainbows possess a tendency to migrate to sea, but lack a strong homing instinct.

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AN ANNOTATED LIST OF THE CLUPEOID FISHES OF THE PACIFIC COAST, FROM ALASKA TO CAPE SAN LUCAS, BAJA CALIFORNIA[1]

By J. L. McHUGH
Scripps Institution of Oceanography
La Jolla, California[2]

and JOHN E. FITCH
Bureau of Marine Fisheries
California Division of Fish and Game

The Cooperative Sardine Research Program, in which vessels and personnel of the California Division of Fish and Game, the U. S. Fish and Wildlife Service and the Scripps Institution of Oceanography are participating, is conducting surveys of spawning of sardines and studies of the distribution of larval, young and adult sardines along the Pacific coast from Oregon south to the tip of Baja California. Within this range a number of more or less closely related clupeoids are found, some in considerable abundance. The larvae of these species are so extremely similar in general appearance that their identification is not always easy. The characters by which these early stages may be recognized are now under investigation.

During the past few years many samples of clupeoids have been taken on a number of cruises, particularly along the Pacific coast of Baja California. Insofar as we can determine, the ranges of six species have been extended northward. In view of the rapidly increasing interest in the fishes of this section of the coast, and of the inadequate ichthyological knowledge of the southern waters, it seems appropriate that the available records be reviewed.

Only those families commonly encountered in bays or within a few miles of shore are treated here. For this reason the Alepocephalidae are not included.

For distributional records, reference has been made to several publications of a general nature, namely, Barnhart (1936), Clemens and Wilby (1946), Fowler (1944), Hildebrand (1943), Jordan and Evermann (1896), Meek and Hildebrand (1923) and Walford (1937). Where the range quoted in the present paper does not agree with that of the authors mentioned above, the appropriate literature reference or data bearing on recent collections are given. Unless otherwise indicated, the collections listed have been made on cruises of vessels of the Scripps Institution of Oceanography or of the California Division of Fish and Game.

[1] Submitted for publication February, 1951.
[2] Contributions from the Scripps Institution of Oceanography, New Series, No. 536. Dr. McHugh is now Director, Virginia Fisheries Laboratory, Gloucester Point, Virginia.

FAMILY ALBULIDAE—THE BONEFISHES

Albula vulpes (Linnaeus)—bonefish

Range. San Francisco Bay, California (Myers, 1936), to Panama.

Recent Collections. California: Oceanside, May 5, 1948; Newport Bay, October 9, 1949. Baja California: Turtle Bay, February 9, 1948; Santa Maria Bay and Magdalena Bay, April 15 and 16, 1950, respectively.

FAMILY CHANIDAE—THE MILKFISHES

Chanos chanos (Forskal)—milkfish

Range. Baja California to Panama. Although there have been no definite California records since a small planting of fish from Hawaii was made in the San Francisco region in 1877, the species has been taken off the west coast of Baja California (Clark, 1929) and is abundant in the Gulf of California.

FAMILY DUSSUMIERIIDAE—THE ROUND HERRINGS

Etrumeus othonops (Eigenmann)—California round herring

Range. Central California (Phillips, 1951) to the Gulf of California.

Recent Collections. California: off San Diego, June, 1947; Santa Cruz Island, November, 1949; Los Angeles Harbor and Santa Monica Bay, March, 1950. Baja California: San Roque Bay, February 8, 1948; Magdalena Bay, February 15 and August 15, 1949; Sebastian Viscaino Bay, September 29, 1949; Ballenas Bay, April 11, 1950.

FAMILY CLUPEIDAE—THE HERRINGS

Clupea pallasi Cuvier and Valenciennes—Pacific herring

Range. North coast of Eurasia, and from Bering Sea to northern Japan and to San Diego, California. This species is of great commercial importance in the waters of Alaska and British Columbia, where it reaches its greatest abundance. A number of local populations appear to represent distinct races. A single record from Tenacatita, Mexico (Seale, 1940), was almost certainly based on a mistaken identification.

Recent Collections. California: many taken in bait hauls, Los Angeles Harbor, winter of 1949-50; other schools hit during seismic operations, Santa Barbara region, 1948 and 1949; San Diego Bay and off Point Loma, 1946 to 1950.

Sardinops caerulea (Girard)—Pacific sardine

Range. Southeastern Alaska to the Gulf of California. Probably the most abundant clupeoid on the Pacific coast, its distribution centers off Southern California and northern Baja California. At least two distinct populations exist.

Recent Collections. Many recent collections have been made within this range.

Alosa sapidissima (Wilson)—shad

Range. Introduced in California waters in 1871, the species now ranges from Kodiak Island, Alaska, to San Diego, California (Welander, 1940).

Recent Collections. California: Santa Barbara region, 1948 and 1949; Huntington Beach, October 28, 1949.

Harengula thrissina (Jordan and Gilbert)

Range. San Juanico Bay, Baja California, and the Gulf of California, to Panama. This semitropical species probably does not range much farther up the outer coast of the peninsula. The known range is extended northward more than 200 miles.

Recent Collections. Baja California: San Lucas Bay, October 7, 1949; Santa Maria Bay, April 14, 1950; San Juanico Bay, April 12, 1950.

Lile stolifera (Jordan and Gilbert)

Range. Ballenas Bay, Baja California, to Peru. The known range is extended northward some 300 miles.

Recent Collections. Baja California: San Juanico Bay, September 26, 1948, and April 12, 1950; Coyote Lagoon, Ballenas Bay, September 25, 1948.

Opisthonema libertate (Gunther)—thread herring

Range. San Pedro, California, to Peru.

Recent Collections. California: San Pedro, April, 1950. Baja California: Ballenas Bay, April 11, 1950; San Juanico Bay, September 30, 1948, April 12 and 13, 1950; Santa Maria Bay, April 15, 1950; Magdalena Bay, September 28, 1948, and February and April, 1950.

FAMILY ENGRAULIDAE—THE ANCHOVIES

Engraulis mordax Girard—northern anchovy

Range. The ocean subspecies, *Engraulis mordax mordax*, ranges from northern British Columbia to Cape San Lucas, Baja California. The bay form, *Engraulis mordax nanus*, has been recorded only from the San Francisco Bay region, California (Hubbs, 1925).

Recent Collections. Numerous samples from southern British Columbia to southern Baja California examined in a study of local populations (McHugh, in press).

Anchovia magdalenae Hildebrand

Range. Known only from Magdalena Bay, Baja California. Described from two specimens and not since recorded.

Anchoa compressa (Girard)—deep-bodied anchovy

Range. Morro Bay, California, to Todos Santos Bay, Baja California. The known range is extended northward from Point Conception.

Recent Collections. California: Morro Bay, July 19, 1950 (collected by Boyd W. Walker); many samples from Mission Bay and San Diego Bay. Baja California: Todos Santos Bay, December 20, 1945, Estero de Punta Banda, July 12, 1946.

Anchoa mundeoloides (Breder)

Range. Almejas Bay, Baja California, and Gulf of California to Panama. A single specimen was collected in Almejas Bay from the Division of Fish and Game research vessel "N. B. Scofield" March 3, 1939, and deposited in the Stanford Natural History Museum collection. Not taken on the outer coast since that date.

Anchoa helleri (Hubbs)

Range. Gulf of California. A single specimen recorded by Hildebrand (1943) from Cape San Lucas, Baja California, is the only record from the southwestern limit of the Gulf. Hildebrand suggested that the collection may have been incorrectly labelled.

Anchoa ischana (Jordan and Gilbert)

Range. Gulf of California (Boyd W. Walker, ms.) to Acapulco, and to Magdalena Bay, Baja California. We have not taken this species from the outer coast of the peninsula.

Anchoa cultrata (Gilbert)

Range. Santa Margarita Island, off Magdalena Bay, Baja California. According to Hildebrand (1943) this species is known only from the original description, based on a single specimen which cannot be found. It resembles both *Anchoa ischana* and *Anchoa naso.*

Anchoa exigua (Jordan and Gilbert)

Range. San Juanico Bay, Baja California, to Panama. The known range is extended northward and westward from Mazatlan, Mexico.

Recent Collections. Baja California: San Juanico Bay, September 30, 1948; Magdalena Bay, February 15, 1949, and April 15, 1950.

Anchoa curta (Jordan and Gilbert)

Range. San Juanico Bay, Baja California, to Ecuador. The known range is extended westward from the mouth of Rio Yaqui, on the east side of the Gulf of California.

Recent Collections. Baja California: a small sample from San Juanico Bay, April 12, 1950, the first record from the Pacific coast of the peninsula.

Anchoa delicatissima (Girard)—slough anchovy

Range. Los Angeles Harbor, California, to Todos Santos Bay, Baja California.

Recent Collections. California: Brighton Beach, Terminal Island (Clothier, 1950); Santa Catalina Island, August 20, 1948. Baja California: Estero de Punta Banda, September 1, 1949.

Anchoa naso (Gilbert and Pierson)

Range. San Juanico Bay, Baja California, and Gulf of California (Walker, ms.) to Peru. The known range is extended northward 18 degrees of latitude from the Pacific coast of Panama, a distance of almost 2,000 miles in a northwesterly direction.

Recent Collections. Baja California: San Juanico Bay, September 30, 1948; Santa Maria Bay and Magdalena Bay, April 14 and 15, 1950.

Anchoviella scitula (Fowler)

This nominal species was described from a single specimen taken in San Diego Bay, California. According to Hildebrand (1943) who examined the type, it differs very slightly from *Anchoa exigua,* a species which might migrate northward during warm periods. The possibility also exists that the original description may have been based on an aberrant specimen of *Engraulis mordax,* for anal fin-ray counts as low as 12 (normally 20 to 25) have been encountered in this anchovy. Gill-raker counts in *Engraulis* also vary considerably, and the number increases throughout life (McHugh, in press). In spite of the numerous collections that have been made in the San Diego area in recent years not a single specimen referable to *Anchoviella scitula* has been taken. It seems highly unlikely that the species is valid.

Cetengraulis mysticetus **(Gunther)—anchoveta**

Range. San Pedro, California, to Peru.

Recent Collections. California: San Diego Bay, December, 1947, to January, 1948. Baja California: Magdalena Bay, February, 1949.

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A PRELIMINARY ANALYSIS OF NORTHERN CALIFORNIA SALMON AND STEELHEAD RUNS[1]

By GARTH I. MURPHY[2] and LEO SHAPOVALOV
Bureau of Fish Conservation
California Division of Fish and Game

INTRODUCTION

Considerable effort is spent each year in finding out how many salmon and steelhead there are in various populations along the Pacific Coast. These data are generally derived from two sources: counts over fishways

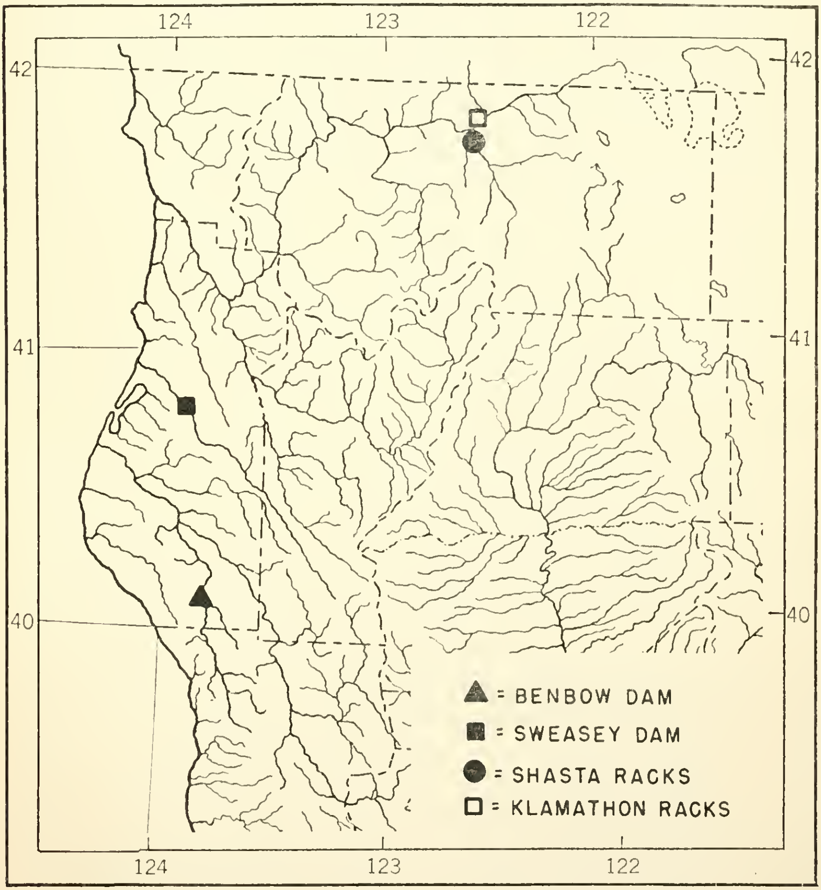

FIGURE 182. Map of northwestern California, showing locations of the four counting stations

[1] Submitted for publication May, 1950.
[2] Now with the U. S. Fish and Wildlife Service, P. O. F. I., Honolulu, T. H.

and measurements of the catch. Both furnish measures of the abundance of these valuable sport and commercial fishes. Counts over fishways are exact measures of abundance. The commercial catch generally also affords a reasonably good measure of abundance, as the demand for salmon is usually heavy, inducing fishermen to take all they can (Fry, 1949).

This report has two purposes. The first is to present the data gathered at four counting stations: Benbow Dam on the South Fork of the Eel River; Sweasey Dam on the Mad River; Klamathon Racks on the Klamath River; Shasta Racks on the Shasta River. These stations are shown in Figure 182. The second is to relate these counts to catch statistics from the commercial fishery on the Pacific Coast, particularly that of California. A discussion of certain phases of the biology of the salmons and steelhead is included.

NORTHERN CALIFORNIA FISH COUNTS

As a result of the growing realization of the need for exact data on the sizes of the runs of anadromous fishes, counts were initiated on the South Fork of the Eel and Mad rivers in 1938. These counts, as well as those from the Klamath and Shasta rivers, are given in Table 1. Weekly totals for the South Fork of the Eel and Mad rivers for the 1948-1949 season are shown in Table 2, as an example of the pattern of the runs in one year. The first run at the counting stations on these streams invariably follows the first heavy rains, since summer flows are too low to permit the fish to ascend the riffles to reach them.

TABLE 1

Northern California Fish Counts

Year	South Fork of the Eel River (Benbow Dam)			Mad River (Sweasey Dam)			Klamath River (Klamathon Racks)	Shasta River (Shasta Racks)
	King salmon	Silver salmon	Steel-head	King salmon	Silver salmon	Steel-head	King salmon	King salmon
1925[1]	----------	----------	----------	----------	----------	----------	10,420	----------
1926	----------	----------	----------	----------	----------	----------	9,387	----------
1927	----------	----------	----------	----------	----------	----------	----------	----------
1928	----------	----------	----------	----------	----------	----------	----------	----------
1929	----------	----------	----------	----------	----------	----------	4,031	----------
1930	----------	----------	----------	----------	----------	----------	2,392	19,338
1931	----------	----------	----------	----------	----------	----------	12,611	81,844
1932	----------	----------	----------	----------	----------	----------	13,740	34,689
1933	----------	----------	----------	----------	----------	----------	----------	11,570
1934	----------	----------	----------	----------	----------	----------	10,340	48,668
1935	----------	----------	----------	----------	----------	----------	14,051	74,537
1936	----------	----------	----------	----------	----------	----------	10,398	46,115
1937	----------	----------	----------	----------	----------	----------	33,144	33,255
1938	6,051	7,370	12,995	1,273	498	3,110	16,340	9,090[3]
1939	3,424	8,629	14,476	1,257	725	3,118	----------	28,169
1940	14,691	11,073	18,308	1,293	73	5,706	14,965	55,155
1941	21,011	13,694	17,356	3,139	308	4,583	11,204	13,252
1942	10,612	15,037	25,032	1,676	378	6,650	13,038	11,425
1943	7,264	13,030	23,445	1,236	259	4,921	----------	10,022
1944	13,966	18,309	20,172	----------	----------	----------	----------	11,498
1945	12,488	16,731	13,626	----------	----------	----------	----------	18,191
1946	16,024	14,109	19,005	1,181	415	5,106	----------	7,590
1947	13,160	25,289	18,225	717[2]	510	3,582	----------	341
1948	16,312	12,872	13,963	672	515	3,139	5,821	37
1949	3,803	7,495	13,715	484	512	4,074	11,504	139

[1] 1925 refers to counting year 1925-26, etc.
[2] Does not include an estimated 250 fish that passed the dam before counting started.
[3] Counting station moved seven miles upstream from the original location. This may account for some of the decrease in the counts.

TABLE 2

Weekly Counts, South Fork of the Eel River and Mad River, 1948-1949

Week beginning	South Fork of the Eel River (Benbow Dam)			Mad River (Sweasey Dam)		
	King salmon	Silver salmon	Steelhead	King salmon	Silver salmon	Steelhead
October 3	291	0	0	0	0	0
October 10	194	0	0	0	0	0
October 17	0	0	0	0	0	0
October 24	0	0	0	0	0	0
October 31	5,150	0	0	171	12	3
November 7	237	0	0	36	9	3
November 14	2,337	1,419	27	313	42	19
November 21	58	376	92	103	56	11
November 28	189	403	103	31	68	2
December 5	1,942	3,945	1,233	4	159	6
December 12	3,525	4,003	1,571	0	15	3
December 19	372	246	345	6	67	125
December 26	1,814	1,214	1,684	6	39	29
January 2	157	430	698	0	9	2
January 9	0	0	5,753	0	0	0
January 16	12	10	10	0	9	0
January 23	0	0	0	0	5	1
January 30	0	19	35	0	8	1
February 6	2	742	1,758	2	17	297
February 13	20	65	3,752	0	0	61
February 20	12	0	1,518	0	0	423
February 27	0	0	361	0	0	307
March 6	0	0	294	0	0	211
March 13	0	0	190	0	0	597
March 20	0	0	170	0	0	114
March 27	0	0	110	0	0	406
April 3	0	0	12	0	0	404
April 10	0	0	0	0	0	86
April 17	0	0	0	0	0	25
April 24	0	0	0	0	0	3

The data presented in Table 1 evoke three interesting questions: (1) Do they indicate any general upward or downward trends in these salmon and steelhead populations? (2) Do they indicate any relationship between the size of any particular year's run and the number of progeny from that run? (3) Are there any significant relationships between the sizes of the runs in these four streams; and do the sizes of these runs bear any relationship to the commercial catch?

The first question can be readily answered by simple inspection of the data. There have been definite upward and downward fluctuations at all stations, but, with two possible exceptions, no long-range trends are apparent. The first of the exceptions concerns the king salmon run in the Mad River. The counts in recent years in the Mad River are low enough to warrant careful inquiry, but may well be within the range of normal variation. The lowest count on record (1949) bears about the same relation to the highest count as does the lowest count for the South Fork of the Eel River to the highest. On the other hand, the recent king salmon counts for the Shasta River appear to be disastrously small. Referring again to the Mad River counts, some observers, viewing the low counts for the period 1947-49, are prone to blame the fishway for the poor runs. (Sweasey Dam was constructed in 1938.) This is in part refuted by the counters stationed at the dam. They report that fish have trouble entering the fishway at certain water stages, but that the block is far from complete and that the unfavorable water stages are of short duration. Further refutation of this claim is contained in the counts themselves. If the fishway is to blame for the low counts, why the lag of five successive cycles after the first return cycle of 1941-42 before the decline?

The question, does a big run in one year produce a big run in another, is best approached by the use of the correlation coefficient. This is a measure of the degree of relationship between any two sets of numerical data. A coefficient of 0 indicates no relationship, while coefficients of +1 and —1 indicate perfect positive and negative correlations, respectively. The significance of other coefficients depends upon the number of pairs of values and is determined from published tables. (See Snedecor, 1948, page 149.)

With this brief introduction to the correlation coefficient, we may return to the data in Table 1. Adopting a four-year cycle for king salmon and steelhead and a three-year cycle for silver salmon, it is apparent from visual examination that the relationship between size of a parental run and size of the offspring run is not very close. A big run does not necessarily produce a big run. The three "parent-offspring" correlations listed in Table 3 give some suggestion of a positive relationship for king and silver salmon, but none of the three is statistically significant.

It is easy to suggest reasons for this lack of correlation. Conditions for survival in the streams and ocean vary independently of the number of adults in a spawning run. A small run of adults may meet good

TABLE 3

Correlation Between Sets of Salmon and Steelhead Data

Species	Data		Period included	Number of years	Coefficient of correlation	Probability of significance
KS	Sacramento River[1]	Eureka[1]	20–49	30	.493	<.01
KS	Columbia River[1]	Eureka[1]	35–49	15	.239	>.05
KS	Eureka[1]	San Francisco[1]	20–49	30	.162	>.05
KS	Sacramento River[1]	San Francisco[1]	20–49	30	.555	<.01
KS	Columbia River[1]	San Francisco[1]	35–49	15	—.265	>.05
KS	Columbia River[1]	Sacramento River[1]	35–49	15	.054	>.05
KS	Columbia River[1]	South Fork Eel River	38–49	12	.766	<.01
KS	South Fork Eel River	Eureka[1]	38–49	12	.498	>.05
KS	South Fork Eel River	Mad River	38–49	10	.493	>.05
SH	South Fork Eel River	Mad River	38–49	10	.820	<.01
SS	South Fork Eel River	Mad River	38–49	10	—.084	>.05
KS	South Fork Eel River 4-year cycle	Parent-offspring	38–49	8	.295	>.05
SH	South Fork Eel River 4-year cycle	Parent-offspring	38–49	8	—.248	>.05
SS	South Fork Eel River 3-year cycle	Parent-offspring	38–49	9	.419	>.05
KS	Klamath River	Eureka[1]	25–49	16	.297	>.05
KS	Shasta River	Eureka[1]	30–49	20	—.005	>.05
KS	South Fork Eel River	Shasta River	38–49	12	.044	>.05
KS	Shasta River	Klamath River	30–49	13	.160	>.05
KS	Mad River	Shasta River	38–49	10	.238	>.05

KS—King salmon (*Oncorhynchus tshawytscha*).
SS—Silver salmon (*Oncorhynchus kisutch*).
SH—Steelhead trout (*Salmo gairdnerii*).
[1] Commercial catch. Data taken from publications of the California Division of Fish and Game and the Washington Fish Commission.

spawning conditions, good survival of young in the stream, and good survival in the ocean and so produce a good run of fish four years later. On the other hand, an exceptionally large run may find unfavorable conditions throughout and produce a small return run. A further complicating factor is that not all individuals in a spawning run are of the same age, and the percentage returning at each age may vary from year to year.

The third question evoked by the data, i.e., is a large run in one stream accompanied by large runs in other streams, can also be approached through a study of correlation.

Referring again to the data in Table 3, a significant correlation between the runs in any two rivers would indicate that the two populations had been subjected to common factors affecting their survival. A significant relationship between the commercial catch in a given area of the ocean and the run in some particular stream would indicate that the ocean catch was made up, at least in part, of fish from that particular river, or that the runs in all rivers are closely correlated.

The only significant correlations shown in Table 3 are:

1. *King Salmon:* Sacramento River commercial landings, San Francisco commercial landings.
2. *King Salmon:* Sacramento River commercial landings, Eureka commercial landings.
3. *King Salmon:* Columbia River commercial landings, South Fork Eel River counts.
4. *Steelhead:* South Fork Eel River counts, Mad River counts.

The significant correlations between the commercial catch of the Sacramento River and the San Francisco and Eureka troll fisheries indicate that a high percentage of the salmon caught in the troll fisheries are Sacramento River fish.

The high correlation between the South Fork of the Eel River king salmon counts and the Columbia River catch either indicates unexplained common factors, or is a "nonsense correlation," a meaningless correlation that is frequently found in time series (Snedecor, 1948, p. 164). The latter appears to be the more likely explanation, in the light of the low correlations between the various rivers and the lack of any evidence of common factors.

The significant correlation between the steelhead counts for the South Fork of the Eel River and the Mad River is not surprising. Both streams lie in the same climatic zone. Good stream survival conditions in one river are probably accompanied by good conditions in the other; both are subject to about the same intensity of sport fishing.

It is easy to offer plausible explanations for some of the poor correlations, but for others it is more difficult. The lack of correlation between the South Fork of the Eel River and Mad River runs of king salmon and silver salmon must be due to some factor or factors greatly affecting the survival in one but not the other. The lack of correlation between the other stream counts is superficially surprising, considering that the Klamath River (at Klamathon) and Shasta River fish are in the same area and presumably conditions for survival would vary together; however, the two streams are quite different in character. The lack of correlation between the Sacramento River runs and the Columbia River runs is not surprising, since the two streams lie in very different climatic zones. Whatever the reasons, it is evident that there is little or no correlation between the sizes of the runs of anadromous fishes in the various streams for which data are available. This may explain lack of correlation between the size of the commercial catch of king salmon in the two areas of the California coast. The troll fishery appears to prey on fish from the various rivers indiscriminately.

In the absence of more complete information, the following appears to be the most reasonable explanation of the data at hand. The Sacramento-San Joaquin system, being at the southern end of the spawning range of the king salmon, and in addition presently supporting runs of the same magnitude as the Columbia River, probably supplies most or a large part of the salmon in the San Francisco troll catch. This is consistent with the good correlation between the San Francisco ocean catch and the Sacramento River gill net catch. The Eureka troll fishery, lying geographically between the Columbia River and the Sacramento River, and "astride" several lesser salmon streams, probably draws more heavily on the latter. This explanation is consistent with the correlations given in Table 3. None of these streams, with the exception of the South Fork of the Eel and Columbia rivers, is correlated with another. A fishery drawing from all of them in addition to the Sacramento River would tend not to be correlated with the San Francisco troll fishery (which probably draws mainly on the fish from one stream). And, such a fishery would tend to be more stable, as is the Eureka fishery, than one such as the San Francisco troll fishery, that is probably largely dependent upon the fish from a single stream system (the Sacramento).

THE FACTORS GOVERNING THE SIZES OF THE RUNS

Mortality of salmon and steelhead may be divided sharply into two segments: ocean and stream. In this connection, the question arises: to what extent do the fresh-water and the ocean habitats, respectively, impose the upper limit on salmon populations within their present range of abundance? This is a problem of particular importance to management. It may be roughly paraphrased as follows. Is stream mortality density dependent or independent, and is ocean mortality density dependent or independent? (Density-dependent mortality is caused by factors that operate more severely as the population level rises and density-independent mortality is caused by factors that cause a constant death rate, regardless of the population level.)

It may be that stream mortality is largely density dependent. Such factors as overcrowding of spawning areas, disease, and predation frequently may operate in a density-dependent manner, particularly when the salmon and steelhead form the dominant element or one of the dominant elements of the fauna.

We do not have available much critical information on the ecology of salmon and steelhead, particularly of the younger fish, in the ocean. However, some observations on king salmon in the lower Eel River, Humboldt County, made in 1950 are of interest. The young king salmon appeared to move downstream in fairly compact schools. These schools remained compact in the upper sections of tidewater, but observations at the mouth of the river indicated that the schools were breaking up, since the fingerlings seen there were not in compact groups. Bait fishermen seining in Humboldt Bay frequently catch one or two or three king salmon of the year along with herring and other fishes. This capture of scattered individuals is a further indication that the schools of fingerlings do break up. It is well known that the larger king salmon range widely in the ocean and appear to be concentrated in either schools or feeding aggregations.

It is possible to set up certain criteria which will help to decide if it is the density-dependent or independent factors which are of primary importance in the ocean, and if these factors operate in a coastwise manner or localized.

If the ocean is presently imposing the upper limit on the salmon and steelhead populations, it follows that there must be strong density-dependent mortality factors operating in it. If the factors operate in a coastwise manner and if they are strong enough to place an upper limit on the salmon and steelhead populations (at present levels), they should also cause a strong correlation between the sizes of the various runs. The hypothetical situation presented in Table 4 illustrates this point. The relative numbers of downstream migrants for each of the two hypothetical streams for each of the years were selected at random, from one to four. Since they were taken at random, no correlation is to be expected (correlation coefficient = 0.00). Now, if the chief factors limiting the

TABLE 4

Hypothetical Situation Illustrating the Effect of Varying Random Factors on the Correlation Coefficient of a Random Set of Paired Items [1]

Downstream migrants		Ocean factors	Returning adults	
A	B		A_1	B_1
2	2	2	4	4
1	1	1	1	1
3	3	2	6	6
4	1	1	4	1
3	2	3	9	6
1	3	1	1	3
4	3	3	12	9
2	4	1	2	4
3	2	4	12	8
2	3	4	8	12

Correlation coefficient A — B = 0.00.
Correlation coefficient A_1 — B_1 = 0.784.

[1] The Pearsonian coefficient of correlation is customarily used only when the association is linear and the distribution around this line is homoskedastic (the spread, or dispersion, around this line is the same at all points). The model gives a linear regression but the dispersion around the regression line is heteroskedastic. This does not invalidate the table as an example of the action of a common factor on two unrelated populations.

number of salmon are density-dependent factors in the ocean, then the carrying capacity of the ocean must fluctuate widely, since the numbers of returning adults fluctuate widely (Table 1). This changing mortality is represented in Table 4 by the column labeled ocean factors. These factors were also taken at random, but restricted to the range of one to four, so that the maximum possible variation between the resultant runs (16 X) would approximate the observed variation (see Table 1). The numbers of adults returning to the streams after going through the varying ocean mortality is represented in the last two columns. The correlation coefficient for these is 0.784 (highly significant). This is in direct opposition to the lack of correlation noted in the actual data (Tables 1 and 3) on the sizes of the salmon runs in the various streams, with the minor exceptions already noted. In other words, the lack of correlation revealed in Table 3 between the sizes of various individual salmon runs suggests the absence of any general, widespread density-dependent factors operating upon these fish in the ocean along the Pacific Coast at the present levels of population abundance. It may also be inferred that variation in density-*independent* coastwise factors in the ocean is slight from year to year (for variation in density-independent factors in the ocean sufficient to produce the observed wide fluctuations in the numbers of adults returning to streams would also produce significant positive correlations, as illustrated in Table 4).

It might be hypothesized that density-dependent factors are operating in localized areas along the coast in such a manner that they affect the salmonids from the various streams independently. However, it seems unlikely that any such localized factors would operate on the larger king salmon (over 20 inches in length), for example, since these fish are known to range freely along the coast. Fishing mortality might operate in a localized manner if the migrants for one stream were schooled together and were caught in exceptionally large numbers. This does not appear to be the usual pattern.

Small salmon and steelhead in their first season of ocean life remain as possible victims of strong density-dependent mortality factors. The most important of these is probably predation.

Predation probably operates at almost all population levels in a density-dependent manner. If the species under consideration is the major element of the population of that class of fish (forage fish in the case of young salmon), predation will be strongly population dependent. If the species under consideration forms a minor element in the total population of that class of fish, predation will be only weakly population dependent (with respect to that species), the increase in predation rate increasing only slightly with increase of the species, and in effect resembling density-independent mortality.

One of the writers (G. I. M.) on studying the largemouth black bass population of Clear Lake, California, was able to point out a portion of the life history of the bass during which they were frequently simultaneously the chief forage fish and the chief predator (Murphy, 1949, 1950). It is obvious that in such a situation both competition for food and predation are density dependent.

Observations on the estuary of the Eel River in 1950 indicated that young salmon were a relatively minor element in the total population of small forage fish. In the ocean young salmon obviously constitute a small segment of the total forage fish population. Until special situations such as were found in the case of young bass in Clear Lake are determined to exist, we must conclude that ocean and estuarine mortality of small salmon is nearly density independent. A density-dependent situation might, however, exist in the estuaries of small coastal streams not frequented by large numbers of other small marine fishes. (On the other hand, the estuary might be regarded as an extension of the fresh-water environment.)

The considerations in the preceding paragraph do not preclude the existence of wide variations in density-independent mortality on a localized basis. (However, coastwise factors appear precluded by the lack of correlation between the runs.) In this connection it is of interest to note the differences between the amounts of fluctuation for the three species counted in the South Fork of the Eel River (Table 1). Fluctuations in the king salmon are on the order of seven times; in the silver salmon of three times; and in the steelhead of two times. Perhaps these differences may be laid to the size at which the various species go to sea: king salmon in their first year; silver salmon as yearlings; and steelhead as yearlings and older fish.

Silver salmon runs in several streams along the Oregon coast exhibit a high degree of correlation, judging from commercial catch statistics (McKernan, Johnson, and Hodges, 1950). However, these writers were able to correlate variation in some of the streams with environmental factors affecting the stream phase of the life of the silver salmon. They were unable to relate the fluctuations in the runs to any known changes in the ocean. Without ruling out this latter possibility, the writers concluded that the correlation between the runs (they did not evaluate this correlation numerically) was due to common factors affecting these streams. The presence of common factors would not be surprising, since the streams under consideration all lie in the same geographic belt.

Another line of evidence tending to dispute the contention that mortality in the ocean is density dependent lies in the consideration of the present abundance of salmon in relation to past abundance. It is reasonably well established that salmon are less abundant now than in the early days of exploitation, at a time when streams were relatively unspoiled. Many examples of once-existent runs that today are either gone or severely reduced can be cited. Runs that are healthy today are not producing at their former levels. Even if we assume that the factors affecting ocean mortality are density dependent, and that the former high level of abundance represented the maximum possible density, it follows that the populations of today are below the maximum and could be increased by increasing the number of seaward migrants.

DISCUSSION

The data and arguments presented above indicate, insofar as our present knowledge of the species under discussion extends, that most fluctuations in abundance may be laid to factors operating in the freshwater phase of their life cycles or to density-dependent factors in the ocean operating on a local basis. Assuming that this is true, we could increase the populations by increasing the numbers of seaward migrants.

Briefly, this might be accomplished by the following means:

1. Regulation and vigilant law enforcement, to insure that enough adults reach the spawning beds to fully utilize them.

2. Stream improvement, to enlarge the available spawning and nursery areas. This is obvious; since larger stream systems support larger runs of fish, it follows that enlargement of existing stream systems will be followed by larger runs of fish.

3. Maintaining natural conditions in existing stream systems.

4. Screening diversions, rescuing stranded young fish, and other similar measures.

These four are sound measures already well based in fact. Further management of anadromous fish runs awaits developments along two lines.

The first of these, artificial propagation, was at one time the only management tool available, and it was expected that hatcheries would maintain the runs. We know today that there are major flaws in this belief. Operation of hatcheries was originally based on the assumption that natural spawning was inefficient and that the eggs of a few females sheltered in a hatchery would produce as many fry as the eggs of many females spawning naturally. Today we know that the percentage of hatch under normal stream conditions is about as high as it is in the hatchery. Since in the case of the anadromous salmonids we have to take eggs that would have hatched naturally in order to stock our hatchery, it follows that the expense involved in operating the hatchery is wasted, insofar as production and planting of fry are concerned.

As indicated in this paper, there are a number of factors that cause mortality in the stream phase of the life of the salmons and steelhead. The thought has been advanced that better results than from natural propagation could be obtained by taking eggs from natural runs, hatching the fry, and, instead of planting them soon after, rearing the offspring until their normal downstream migration period. Theoretically, at least, this procedure should circumvent a considerable amount of stream mortality and result in an increase in the number of returning adults over the number that would have been produced if all fish had been allowed to spawn naturally. This, of course, assumes that survival of hatchery fish from egg to adult is considerably greater than that of wild fish Before such a program can be put on a production basis, we must know if the cost of running the hatchery will be fully repaid by the increase in the runs. In other words, we must get at least a dollar's worth of fish back for each dollar expended. Possible exceptions to this yardstick might be in the case of the rehabilitation of a badly depleted run of fish, in the event a dam precludes any natural spawning, or in the case of new environment opened up by stream clearance. An experimental program designed to test the economic feasibility of a hatchery program as outlined above is being initiated on the Mad River in Northern California.

The second line of endeavor looking towards expansion of our anadromous fish resources must start with an answer to the question, "Why do streams produce small runs one year and large runs another?" Obviously, if we could maintain production at peak levels in all streams each year, we would greatly increase these resources. There is little hope of accomplishing this until we know why the runs fluctuate. This is a difficult thing to determine, as evidenced by the uncertain results obtained by Silliman (1950) and McKernan, Johnson, and Hodges (1950), but in view of its importance, it justifies the expenditure of considerable effort.

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NOTEWORTHY SOUTHERN CALIFORNIA RECORDS OF FOUR SPECIES OF MARINE FISHES[1]

By PHIL M. ROEDEL
Bureau of Marine Fisheries
California Division of Fish and Game

Parmaturus xaniurus (Gilbert). Filetail Shark.

This small shark, known in deep water from Southern California to San Roque Bay, Baja California, has seldom been reported (Roedel and Ripley, 1950), so the recent capture of 15 specimens in two beam trawl drags made by the division's research vessel N. B. SCOFIELD is of interest. Both drags were made on February 19, 1951, in the Santa Barbara channel, between Santa Cruz Island and the mainland. (Station 51-B12, 14 mi. 175° true from Santa Barbara; Station 51-B14, 10 mi. 42° true from the west end of Santa Cruz Island). At Station 51-B12, 14 specimens were obtained in 128 to 140 fathoms over a green mud bottom. The fifteenth was collected at Station 51-B14 in 220 to 236 fathoms, again over a mud bottom. All have been deposited at the California Academy of Sciences, San Francisco.

Nezumia stelgidolepis (Gilbert). California Rat-tail.

A single representative of this little-known species was caught by an unknown commercial fisherman on April 20, 1951. The specimen was taken on a set line in 200 to 300 feet of water "off Point Vicente" and was 445 mm. (17½ inches) long (Figure 183). Dr. C. L. Hubbs, Scripps Institution of Oceanography, identified the fish.

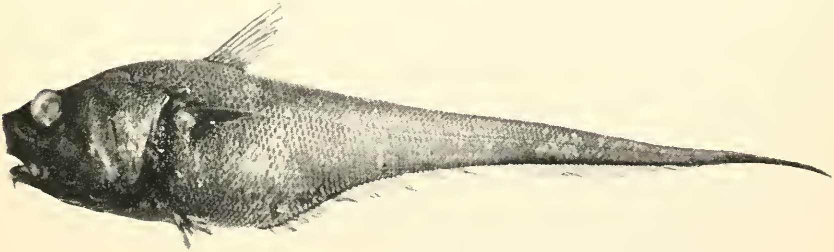

FIGURE 183. *Nezumia stelgidolepis*, 445 mm. total length. *Photograph by Vernon M. Haden, San Pedro.*

Mr. W. E. Ripley, Division of Fish and Game, reports that 15 specimens ranging from 25 to 37 cm. in length were obtained at N. B. SCOFIELD Station 51-B14 near Santa Cruz Island, together with the single filetail shark. Eleven of these specimens were deposited at the California Academy of Sciences.

[1] Submitted for publication June, 1951.

Scomberomorus concolor (Lockington). Monterey Spanish Mackerel.

Three specimens were taken in a bait haul made inside the Long Beach breakwater by the vessel JACKIE BOY on May 16, 1951. These represent the eighth, ninth and tenth *S. concolor* recorded from California since the 1880's, and the first since Fitch (1950) reported a specimen from Newport Harbor caught in July, 1949. This species was once the object of a fishery in Monterey Bay and its disappearance was the subject of considerable speculation for many years. It is now known that a population exists in the northern portion of the Gulf of California (Fitch and Flechsig, 1949).

The Long Beach specimens, 500, 553 and 557 mm. standard length, were all females. Two contained well-developed eggs and the third appeared to be recently spent. Gill raker counts were 8 + 19, 7 + 17 and 9 + 16; scales in the lateral line ranged from about 150 to about 165. These characters separate this species from *S. sierra*, which has fewer rakers and more scales. In addition, *S. sierra* is heavily spotted with gold on the sides. Presence or absence of these spots was once considered diagnostic, but it is now known that *S. concolor* may be moderately spotted. The largest of the Long Beach specimens had about 30 spots arranged in three irregular rows on each side, the smallest had a single row of faint spots with a few scattered below, while the third showed no trace of spotting.

Verrunculus polylepis (Steindachner). Triggerfish.

A single specimen was obtained by the sportfishing boat ANNA A in late May, 1951. The catch was made about a quarter of a mile off Seal Rock, Laguna Beach, in shallow water among kelp. Two triggerfish were caught by sportsfishermen on the Redondo Beach pier during the second week of June, 1951. One was identified as *V. polylepis*. The other was not saved but in all likelihood belonged to this species, which is a not infrequent visitor to Southern California.

Fitch (1951) reported a specimen from eight miles east of Anacapa Island, the northernmost record of which he had knowledge. However, Margaret C. Erwin, Santa Barbara Museum of Natural History, informs us that two specimens are known from farther north. One was caught January 14, 1946, in kelp near Goleta (seven miles west of Santa Barbara) and the other November 16, 1950, one-half mile offshore south of Point Conception.

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NOTES

OBSERVATIONS ON PINNIPEDS OF SAN MIGUEL ISLAND

A count was made of pinnipeds on a portion of San Miguel Island (the westernmost of the channel islands off the Southern California coast) on May 26, 1951. Observations were confined to a small area around Point Bennett, which contains the island's principal rookery and hauling grounds.

Three species were found: the California sea lion, *Zalophus californianus*, the Steller sea lion, *Eumetopias jubata*, and the northern elephant seal, *Mirounga angustirostris*. The animals counted included:

1,117	California sea lions
830	Steller sea lions
252	northern elephant seals
	34 bulls
	194 cows
	24 sex undetermined (animals in the water)

Counting the sea lions was difficult. Vantage points were scarce, and it was often necessary to use binoculars at considerable distances in order to avoid frightening the animals into the water. Many were concealed among the rocks and could not be seen unless closely approached, and at such times they had to be counted during a wild rush toward the sea. No attempt was made to obtain the number of sea lions that were already in the water because identifying them specifically was almost impossible. In view of these difficulties, the totals can only be regarded as indicating the minimum number of individuals present. No attempt was made to determine sex. Several newborn Steller sea lions were observed but no young of the other species were seen.

The elephant seals were found on sandy beaches and seemed to be organized into harems with about six cows to one bull. They could be easily approached and even touched without causing them to move. Several counts were made of both bulls and cows, and the numbers given are considered to be exact with the possible exception of those seen in the water. Only one of the bulls had a well developed proboscis; the other males were probably young.—*Robert D. Collyer and John L. Baxter, Bureau of Marine Fisheries, California Division of Fish and Game, June, 1951.*

RECOVERY OF A TAGGED SOUPFIN SHARK

On January 20, 1949, Mr. Lloyd Lindwall of Santa Barbara cooperating with the California Division of Fish and Game tagged 10 soupfin sharks (*Galeorhinus zyopterus*), northwest of San Martin Island, Baja California. One of these, a female 60 inches long, was tagged with disk No. 8730. On May 28, 1951, this shark was recovered by Mr. Don R. Mervin of Venice, California, on Sycamore Bank, 10 miles west-southwest of Point Dume. It was 63 inches long when recovered. Thus, it grew only three inches during the 28 months of liberation. This shark, released near the southern portion of the known range of the species, migrated northward some 240 miles before its recapture.—*Wm. Ellis Ripley, Bureau of Marine Fisheries, California Division of Fish and Game, June, 1951.*

ROUND HERRING OFF CENTRAL CALIFORNIA

A round herring, *Etrumeus othonops*, was caught by the purse seiner "Pearl Harbor" on December 16, 1950, about one mile offshore between Piedras Blancas and Cape San Martin, some 65 miles south of Monterey Bay. The specimen, 253 mm. total length (10 inches), was picked out of a load of sardines by Mr. John Aiello who turned it over to the Division of Fish and Game. This species has not previously been reported north of the Los Angeles area.—*J. B. Phillips, Bureau of Marine Fisheries, California Division of Fish and Game, June, 1951.*

IN MEMORIAM

PEDER STOCKLAND

It is with great regret that we must report the passing of Peder Stockland on May 22, 1951. Mr. Stockland held the responsible position of senior Netman and Boatswain of the Bureau of Marine Fisheries from April 19, 1938. Pete, as he was known to all of us who worked with him, was responsible for the success of our many and varied fishing activities. He supervised the construction and operation of numerous complex nets and lines, and also acted as mate of the research vessels.

Pete was noted for his unfailing good nature and willingness to do the work of three men. His one fault—if fault it was—was to do the hardest jobs himself instead of directing his subordinates to do them.

During the time Pete was assigned to Marine Fisheries, he had numerous occasions to work with all the other bureaus of the Division of Fish and Game. Although his headquarters were at Terminal Island, his work took him to all parts of the State. In so doing, he made many friends throughout the division, men who came to cherish and take pride in his friendship. All of these join his fellow crew members aboard the M.V. N. B. SCOFIELD and M.V. YELLOWFIN in paying their respects to the memory of Peder Stockland, and in expressing their sympathy to Mrs. Stockland.—*Richard S. Croker, Chief, Bureau of Marine Fisheries, California Division of Fish and Game.*

HERBERT F. JORDAN

When the fishing boat JOANNE foundered off San Francisco on February 18, 1951, another name was added to the long list of Fish and Game employees who have lost their lives in the line of duty. Herbert F. Jordan was returning from a salmon tagging trip when heavy seas capsized the JOANNE, and he and five others of the party were drowned. To date Mr. Jordan's body has not been recovered.

Mr. Jordan first commenced work for the Division of Fish and Game on December 11, 1947, at which time he was assigned to the Bureau of Licenses. On February 1, 1950, he transferred to the Bureau of Marine Fisheries as Senior Account Clerk in the San Francisco office. His many friends in the Division of Fish and Game join in extending their sympathy to his family.—*Richard S. Croker, Chief, Bureau of Marine Fisheries, California Division of Fish and Game.*

DONALD D. WHITE

Donald D. White, Fish Hatchery Assistant, Mt. Whitney Hatchery, died Sunday, June 17, 1951, at the Northern Inyo Hospital, Bishop. He had been confined to the hospital following a major operation and appeared to be convalescing satisfactorily. His sudden passing came as a great shock to all. He was employed at the Mt. Whitney Hatchery since January 1, 1948, and is survived by his wife Virginia, a daughter Dawna and a son David.—*Earl Leitritz, Supervisor of Fish Hatcheries, California Division of Fish and Game.*

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REVIEWS

American Resources

By J. Russell Whitaker and Richard Ackerman; Harcourt, Brace and Co., New York, 1951; xi + 497 p., 76 figs. $6.75.

This dispassionate survey of our resources is most thoughtful and thoroughgoing. The authors are under no illusions as to what has happened to this country's natural heritage or as to what yet can happen if we choose to disregard the warnings of the past and the present. But their attitude is not that of the bemoaner; it is always constructive and they are at pains to point out the courses, good and bad, which are open and the consequences of following one or the other of them. Without espousing any "isms," they recognize the need for intelligent control of both renewable and nonrenewable resources if the best use is to be got from them, and the corrollary needs for an educated public and a corps of well-trained specialists in the several fields involved.

Although the theme of the work is the United States, the authors are not unmindful of the rest of the world and of the international nature of many of the problems of today. The introductory chapters emphasize that, though man has so far managed to live off the capital stock of resources, the story of depletion is as old as history; that despite the scientific progress of recent years we remain, and no doubt will remain, dependent on the earth. Migration, the historic answer to depletion, does not solve the basic problems and in any event is no longer possible on a large scale. Conservation—wise use and reuse—offers a logical and hopeful alternative, which, in terms of present-day American society, means that we must learn to husband wisely what we have. The authors by no means imply that nothing has been done, but they do bring out the need for doing more and thinking through more clearly on the long-term results of projects proposed in the name of conservation.

The largest portion of the book is devoted to the problems of cultivable land. Water, grasslands and forests, minerals, and recreational resources are the topics of the remaining major divisions. Though the chapters on wildlife and fisheries are relatively short, the presentation covers the salient points and the conclusions are sound. The problems of fisheries, though rather far removed from the authors' own fields, are well set forth (certain recent developments on the Pacific Coast could have been mentioned with profit) and they emphasize the vital need for research and international cooperation if marine resources are to be properly utilized. The concept of wildlife problems is broad and again the needs for research, cooperation and education are emphasized. The biologist will nod sadly on reading the paragraph which recognizes and deplores the fact that so often the public (or vocal portions thereof) refuses to accept scientific findings when these run contrary to established prejudice.

The final chapter summarizes the problems and issues which face us and suggests what our course can be. It is designed as a guide to conservation for every citizen. Though not pessimistic in tone, it does not underestimate the magnitude of the task ahead or ignore the need for intelligent action on the part of the people if our resource potential is to be used for the greatest good. The book is highly recommended as text and reference. It is thoroughly annotated and indexed and the publishers have done an excellent job in making it an attractive volume.—*Phil M. Roedel, California Division of Fish and Game.*

The Elk of North America

By Olaus J. Murie; The Stackpole Co., Harrisburg, Pennsylvania, 1951, 376 p., 29 black and white plates + 32 figs. $6.50.

This book is a valuable contribution to the big game literature of North America. It is comprehensive in that it has attempted to cover all phases dealing with elk. The study was based primarily on the elk in the Jackson Hole area and these findings were then augmented by field studies in other localities. The author has spent the last 15 years in the center of the elk domain, at Moose, Wyoming, compiling and doing research on elk. In addition to his own exhaustive study of the subject, he has frequent references to other work done and has a very fine bibliography.

The book is divided into 19 chapters which include the following subjects: The Name, Origin of the American Wapiti, The American Forms of Elk, Early Elk Distribution in America, Elk Habitat, Life Zones, Migration, Physical Characters, Reproduction, Natural Enemies, Accidental Deaths, Parasites, Disease, Varied Opinions of the "Elk Problem," Food Habits, Elk Habits, The Elk Population, Elk Hunting, and Elk Management.

The chapter on elk hunting is rather incomplete and would not be a good source of information for a person going on an elk hunt. Some of the recent problems and solutions in management were not included in the chapter of that name. Although transplanting was mentioned, no descriptions of the trapping methods and procedures were brought forth. One other criticism is that the author completely left out descriptions or maps showing or describing the locations of the present-day populations of elk in North America.

In general, the chapters adequately covered the subject matter named by the titles. The chapter on physical characters was exceptionally good and represented a vast amount of field observations. The book is very well written and is certainly a must for the big game technician or any person interested in wild life.—*Jack L. Hiehle, California Division of Fish and Game.*

Australian Shells

By Joyce Allan; Georgian House, Melbourne, 1950. xix + 470 p., 112 text figures, 12 color plates, 32 halftone plates. $7.50.

A book such as this could only result from many years of hard work and could have been prepared only by one so ably qualified as the author, who is Curator of Shells in the Australian Museum, Sydney. Much of the material which she has presented was unquestionably taken from her own observations. Her aim in writing the book was to enable the many people interested in Australian shells to become acquainted with their names, habits, and life histories.

Most of the natural history notes on the various species are accurately and fully detailed and make extremely interesting reading. No attempt has been made to report on all of the 10,000-odd species known from the Australian area; however, the 1,240 species illustrated, plus the many others discussed but not illustrated, more than do justice to representative groups.

The introductory part of the book includes sections entitled "The Molluscan Animal and Its Shell"; "On the Distribution, Provinces, Zones, Environment and Other Factors Affecting a Mollusc's Life"; "Habits and Uses of Molluscs" and "Some Collecting and Preserving Hints." All are loaded with a wealth of interesting general as well as specific information.

The remainder of the book is divided into these major categories:

Sea-living univalves (Gastropoda)
Sea-slugs: Shell-bearing and shell-less (Opisthobranchia)
Chitons (Amphineura). Multivalve sea shells.
Tooth shells (Scaphododa)
Sea-living bivalves (Pelecypoda)
Air-breathing brackish water shells and slugs: Land snails and slugs: Fresh-water shells
Cephalopods—the many-armed molluscs (Cephalopoda)

Each of the sections is prefaced by a detailed description and a line drawing of a representative of the group under discussion. Of especial interest are the natural history sketches and notes on many of the species. These include an account of the history of the fishery for a large gastropod (*Trochus*) from whose shell buttons are manufactured; details of the poison apparatus of a cone shell, several species of which by their "bite" have caused the death of persons who have unwittingly picked them up and handled them; and a description of pearl culture and the pearl shell fishery in Australian waters.

The color plates, which are works of art, are unfortunately not numbered. Throughout the text reference is made to these plates by number, but the only way to identify them is to find the page reference under "List of Plates" in the front of the book.

The book could have been further improved by naming the species illustrated in each text figure instead of asking the reader to "see text for species." Too, the authority for the current scientific name for each species and a general bibliography or list of references would have been of considerable assistance to many of us who were not previously too familiar with Australian shells.

The index and the glossary of technical terms are of considerable assistance, and the drawbacks mentioned above should not detract from the value of this book for the amateur collector, student, or scientist. All will, I am sure, find many hours of pleasurable and enlightening reading within the covers of this highly recommended volume.—*John E. Fitch, California Division of Fish and Game.*

Fresh-water Fishes of the Pacific Coast—Identification

By Charles Everett; Binford & Morts, Portland, Oregon, 1949, 3 + 45 p. $0.50.

In this booklet 45 species or groups of fresh-water and anadromous fishes of the Pacific Coast are illustrated by diagrammatic outline drawings which feature their main distinguishing characters. Both native and introduced forms are included, with emphasis on game species. Scientific and common names, size, color, and range are given for each species or group. The material which has been included is generally accurate and probably sufficiently adequate to fulfill what the foreword states to be the booklet's only purpose, "to provide a handy tacklebox guide to the basic types."—*Leo Shapovalov, California Division of Fish and Game.*

Audubon Water Bird Guide

By Richard H. Pough; Doubleday and Co., Garden City, N. Y., 1951; xxviii + 352 p., 48 color plates, 138 text figures. $3.50.

This book, sponsored by the National Audubon Society, is simultaneously both broader and narrower in scope than the title leads one to believe. In terms of species, it covers the first half of the A. O. U. check list through the pigeon family, and thus actually considers, to quote part of the subtitle, "water, game and large land birds." Geographically, it is limited to "Eastern and Central North America from Southern Texas to Central Greenland." It forms a companion volume to the "Audubon Bird Guide" which treats the remaining land species of eastern North America.

In all, 258 species (subspecies are not considered) are described and illustrated in color. The 458 figures by Don Eckelberry represent every distinctive plumage save the downy and, as a rule, the juvenile. Line drawings by Earl L. Poole depict 138 of the species in flight. The text is excellent. For each species, sections concerned with identification, habits, voice, nest and range follow in that order; the extensive natural history notes are particularly interesting.

While the book will be of little field use to residents of the Pacific Slope, it will prove extremely valuable to those who live in or visit the area covered. Further, it provides an excellent reference for anyone, regardless of his locale, who is interested in this group of birds.—*Phil M. Roedel, California Division of Fish and Game.*

Fishing Flies and Fly Tying

By William F. Blades; Stackpole and Heck, Inc., Harrisburg, Pa., 1951; 234 p., illustrated. $7.50.

Subtitled "American Insects and Their Imitations," the most useful feature of this book is its presentation of specialized methods of tying realistic imitations. The author has a well-earned reputation among other fly tyers for his masterpieces of "exact" imitation. Some of the photographs show both the naturals and artificials; the resemblance is startling.

Like most general books on the subject it includes chapters on materials and tools, and discusses the tying of wet and dry flies, streamers, nymphs, and bugs.

There are 203 line drawings by the author. Descriptions of about 500 flies are included, and approximately 775 have been photographed—almost 200 in color. The inclusion of so many photos has increased the price of the book, and one questions the usefulness of illustrating every fly by a black and white photo. There are also a few snapshots of fishing scenes dear to the heart of the author. They have almost no scenic value and should have been omitted. The color plates are attractive although a bit muddy.

I believe that a beginner will find it easier to learn to tie flies by using some other book. I would recommend this one only to the advanced tyer who is interested in the painstaking job of making replicas of nymphs and adults.—*William A. Dill, California Division of Fish and Game.*

Marine Products of Commerce

By Donald K. Tressler and James McW. Lemon; Reinhold Publishing Co., New York, revised edition 1951; xiii + 782 p. $18.

The second edition of "Marine Products of Commerce," as the first, describes methods of harvesting and processing the resources of the oceans and its related waters. This edition is almost completely revised to take into account the technological developments in the various fisheries and is enlarged to include the new industries that have sprung up in the 27 years between publications. The two authors and their 14 collaborators, all experts in their specialized fields, have succeeded in compiling the most complete treatise on world fisheries to be written to date. Every known commercial fishery of importance, from abalone diving off California to whaling in Antarctica, is described with exactness and clarity. The preservation of fish for human use is the dominant feature of the entire book.

The organization of the material in the book is such that related subjects follow each other in logical sequence. Each fishery or industry is described by a brief history, a biological sketch of the plant or animal, old and new methods of harvesting, handling, and processing the raw materials, and the utilization of the final marketable products.

Chapters 1 to 4 discuss the extraction of chemical substances directly from sea water. Primarily, these are salt, magnesium, and bromine. The chapter on magnesium and bromine is one of the new sections in this edition.

The next two chapters describe the picturesque alga fishery and industry and the production of alginates with their multitude of uses. The discussion of algae and other seaweeds as food is of particular interest.

Pearl, mother of pearl, and the coral industries are each allotted a chapter. Included in this section are details of pearl culture as is practiced in Japan, at one time a closely guarded secret.

Chapters 10 through 24 delineate every phase of catching, handling, and preserving marine fish. The composition and use of commercial fishing gear is adequately covered in the chapter on "American Fish Gear." Included in this section are some of the fishing practices of other lands. Details are given on drying, smoking, pickling, and canning of fish as carried on in the different parts of the world. Processing machinery is described and illustrated. Of particular interest are some of the new developments in the preserving of fish, such as the quick freezing of fillets and a product known as "pressfish" from Norway. The methods of recovering and utilizing fishery by-products are outlined. Besides the usual items of fish oils and meals, we are told of many new developments, for example the recovery of protein solubles from stickwater and a semiliquid protein made from scrap and trash fish known as "liquid fish." Also, in this section, a separate chapter is devoted to the discussion of the composition and relative nutritive values of most of the fishes of commerce.

The various invertebrate animals on which there are distinct fisheries are each allocated a chapter. The discussion centers primarily about fisheries located in the United States, especially clams, shrimp, and lobsters. Oysters are dealt with on a world-wide basis.

The whaling industry, seal fishery, and marine turtle industry are each described in separate chapters.

The biological aspects of the various fisheries are presented with surprising completeness and detail, lending balance to the text which is predominantly concerned with processing. On the other hand the viewpoints on management and proper utilization of marine resources were not given adequate treatment. This is illustrated in the following statement which appears on page 10: ". . . dogfish and sharks and such fish should be eliminated because they destroy food fishes." It has been the experience of fishermen that a predatory or nuisance animal is almost impossible to eliminate. All such attempts have been very costly, and relatively unsuccessful. Why not adopt a constructive attitude and develop uses for such fish, thus creating new fisheries and industries which would benefit mankind?

Throughout the book the authors show the interrelationships of the various world fisheries. This is in keeping with the increasing realization that marine resources are of a global nature and of international concern. In the chapter on "Economic Importance of World Fisheries," numerous tables are presented which show, with the best available data, the relative importance of each country's fisheries and the extent of their trade in fishery products. About one-third of the chapter is allocated to details of the fisheries of the United States. No other country is given like treatment. This emphasis seems disproportionate in a section devoted to world fisheries. The above situation arises, no doubt, from the inherent difficulties in gathering world-wide fishery statistics. It is hoped that future editions, with the aid of recently created data-collecting organizations, will give proportional space to at least the principal fishing nations of the world.

Other chapters emphasizing the universalness of the resources of the oceans are, "The Ocean, Its potentialities and Products," "Characteristics of Marine Fishes," "Fluctuations in Abundance of Marine Fishes: Their Measurement, Causes and Prediction," and "Some Problems of the Fisheries."

"Marine Products of Commerce" is an invaluable book to all who are engaged in exploiting the sea and its resources for their livelihood. Its encyclopedic coverage will aid the curious in answering their questions, and will serve as a handy reference for the industrial executive, the fishery manager, and those engaged in fishery research. The bibliographic material at the end of each chapter will enhance the book's value as a text for students of fishery production, marine biology, oceanography, and foreign trade.—*Leo Pinkas, California Division of Fish and Game.*

The Sea Around Us

By Rachel L. Carson; Oxford University Press, New York, 1951; vii + 230 p. $3.50.

This review is written a month after publication of Miss Carson's book. The copy before me is from the fourth printing—sufficient evidence of popularity. Critics have been most generous in their praise, the public has trooped to the booksellers in numbers unusual and gratifying—it remains but to say that if somehow you have missed "The Sea Around Us," you have missed a treat, for the book is as good as its advance notices, an example of "popular" scientific writing at its best. It is crammed full of the lore of the sea and is as up to date scientifically as security regulations will allow. While other books have told much of the story, here it is expressed with that unusual clarity, style and accuracy which has brought Miss Carson well-earned awards for her writing as well as success in terms of copies sold.—*Phil M. Roedel, California Division of Fish and Game.*

Water, Land, and People

By Bernard Frank and Anthony Netboy; Alfred A. Knopf, New York, 1950; xviii + 331 + xi p. $4.

This book is definitely recommended to all wildlife "managers," both the professional biologist and the amateur sportsman. The authors have compiled an inventory of the problems that have resulted from past misuse and present as well possible solutions based on proper recognition of all the factors involved plus public education. In contrast to many similar books, the authors have been careful to document their findings with factual material rather than opinions. This is probably due to the authors' backgrounds; Frank as Assistant Chief of the Division of Forest Influences, U. S. Forest Service, and Netboy as a writer with various governmental agencies.

The first portion of the book deals with the problems, the second with the cost and the concluding portion with solutions. The arrangement is sound although the section on water economics is much too short in relation to its importance. Part III dealing with the solutions is, surprisingly, the longest. This is in direct contrast to so many books on "Conservation" that have been written in the past. The authors feel that "Unified Basin Development" provides the key to the future, such development to embrace both the biological and engineering answers to all conservation questions. As is pointed out, however, it will first be necessary to erase our previous mistakes of failing to assess the social consequences of the biological or land-use solutions to our watershed problems.

The authors call for the creation of an agency with the planning and coordinating functions of the defunct National Resources Planning Board and with the authority to veto programs submitted by the various federal bureaus. The case that is presented makes this proposal one that can be seconded by all persons interested in sound conservation of our renewable resources.—*R. M. Paul, California Division of Fish and Game.*

Going Light With Backpack or Burro

David R. Brower, Editor; The Sierra Club, San Francisco, 1951; xiv + 152 p. $2.

This is the definitive manual on western wilderness travel. The contributors are experienced, and their combined efforts have resulted in both a useful "how to do it" book and a charmingly written one. Woodsmanship, or perhaps better, "mountainship," camping, food, cooking, equipment, and first aid are adequately covered. There are also chapters on the use of maps and compass, and the care and treatment of women, children, and burros. A bibliography and an appendix with detailed food lists and a check list of equipment complete the volume. High mountain travel in the western United States is a specialized activity, and the usual books on camping seem to be designed primarily for eastern conditions. Here, you will find no long discussions on the choice of wood for fires (in the high Sierra you use whatever is available). Nor are there the usual comparisons of every known type of tent, or knot, or similar text-paddings which are merely confusing to the beginner. With a surprising economy of words the authors have given you the meat of a long experience, and at the same time have avoided the sterile tone of a manual. The book is as modern as today. Poor Nessmuk would shudder at the mention of polyvinyl chloride foodbags, nylon air mattresses, and a kit containing aureomycin capsules, and some may think that this smacks too much of gadgetry. But let me hasten to add—as the authors imply—that if the inventions of today will give you more freedom of action, then adopt them gladly. The spirit of wilderness travel merely demands that they be kept subservient. There is good humor in the text, and the line drawings by Milton Hildebrand have the freshness of mountain air. I have nothing but praise for this book which is written ". . . for a special sort of person, one not completely civilized, a throwback to an early age when man lived close to nature—his enemy if he were ignorant or slothful, his friend if he were observant, ingenious, self-reliant, and tough."—*Wm. A. Dill, California Division of Fish and Game.*

The Emigrations of Animals From the Sea

By A. S. Pearse; The Sherwood Press, Dryden, New York, 1950; xii + 210 p., 23 figs. $5.

This extremely thoughtful book presents, reviews and evaluates most dispassionately the available evidence on a topic about which many men have postulated: How and why did living things migrate from the sea? The discussion is divided into three major phases—routes from the sea, causes of emigration, and how the animals have changed as a result of emigration. There is a very extensive bibliography which adds much to the value of the book. Dr. Pearse has tried with marked success to present all sides to the many questions raised. Naturally he has his own opinions—for example, that not many animals have used estuaries as a gateway—but the proponents of every school will find their arguments recognized.

One criticism is that the text is broken by what seems an unnecessary amount of documentation which at times distracts from the thought. Another is that the language is extremely technical which effectively limits readership to the scientist. (Some of the terms are sure to give pause to zoologists who work in fields not closely associated with ecology.) This is too bad, for the subject matter is of general interest and, given a vocabulary less erudite, the book could have been made useful to a much wider audience. However, Dr. Pearse was patently writing for his fellow workers, and he has given them a comprehensive essay which they will read with profit.—*Phil M. Roedel, California Division of Fish and Game.*

REPORTS

FISH CASES

April, May, and June, 1951

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalone: Overlimit; undersize; closed season; no license; selling on sport license; out of shell; illegal possession	166	$4,982 50	
Angling: No license; failure to show license; 2 poles, 4 poles; closed season; night fishing; operating set line, fish trap; nonresident using resident license; predated license; postdated license; illegal gill net; fishing in closed stream; transfer of license; using another's license; falsify application for license; fishing too near lower side of dam; attempting to shoot fish; possession of spear; injuring and obstructing fish ladder; fishing from dam; taking fish by hand	509	7,849 00	85
Bass, Black: Overlimit; closed season	8	280 00	
Kelp: Overlimit	4	100 00	
Striped: Overlimit; undersized, possession in restaurant; offering for sale; buying and selling; 2 poles; 2 lines; unattended poles; no license	63	1,912 00	2
Catfish: 2 poles; overlimit, disturbing nets; undersize; night fishing; no license; taking other than by angling	21	420 00	
Clam: Closed season; overlimit; failure to show; no license; undersize; no noncitizen license	91	3,197 50	2½
Commercial: Failure to return party boat records; using round haul net, closed area; no commercial license; operating gill net District 19A; undersized catfish for sale; possessing unmarked lobsters; taking striped bass with trawl net; operating trawl net, closed waters; failure to tag domesticated trout; possessing undersized crabs for sale; wholesale fish dealer possessing lobster in closed season; transporting fish without license; no commercial fishing license; using dragnet in less than 25 fathoms, District 17; illegal use round haul net, District 118.5; no party boat permit; selling untagged packaged trout; failure to make fish receipts for halibut; wastage of fish (shad); overlimit cockles; taking and delivering undersized sardines	93	6,025 00	
Crab: Undersize; no license; no noncitizen license	9	420 00	
Frog: Closed season; undersize; taking with spear; spear within 300 feet of stream	20	475 00	
Grunion: Closed season; failure to show fish	5	95 00	
Lobster: Taking and possession, closed season	4	65 00	
Pike: No license	1	10 00	
Pollution: Oil; cattle spray	2	100 00	
Salmon: Spearing; no license; serving salmon taken on sport license in restaurant	3	110 00	
Sturgeon: Taking fully protected fish	1	100 00	
Sunfish: Closed season; no license; overlimit; at night; using another's license; failure to show fish on demand; selling young; taking with wire net	51	1,385 00	
Trout: Closed season; no license; false statement on license; alien using citizen's license; snagging; overlimit; 2 lines; closed stream; set lines; line with 5 attractor blades; possessing treble hooks; taking within 150 feet of lower side of dam	128	3,783 00	
Totals	1,179	$31,309 00	89½

GAME CASES

April, May, and June, 1951

Offense	Number arrests	Fines imposed	Jail sentences (days)
Deer: Taking doe; taking buck, closed season; spotlighting; night hunting; shooting from auto; allowing dogs to chase deer, closed season; possession of gun and light; taking without license in closed season; possessing fawn; taking spike buck	38	$5,115 00	82
Deer meat: Possessing unstamped meat; possessing parts of buck, spike buck, doe, closed season	21	2,350 00	----------
Dove: Closed season; overlimit	6	195 00	----------
Duck: Closed season; after hours; shooting from powerboat; use of live duck decoys; overlimit	15	600 00	----------
Elk: Bringing illegal elk into California	2	200 00	----------
Goose: Closed season; shooting from auto	2	75 00	----------
Hunting: Spotlighting; gun in refuge; taking sage hen eggs and destroying nest; discharging gun in refuge; hunting without license; possessing light and gun; hunting on restricted area; hunting on closed zone; failure to show license on demand; unplugged gun; night hunting; late shooting; bringing illegal game into California	30	936 00	2
Nongame birds: Taking sparrowhawk, lark sparrow, golden eagle, robin, titmouse, towhee, junco, seagull, robin	6	110 00	----------
Pheasant: Closed season; possession of hen; offering for shipment without permits; trapping; no license	15	1,180 00	125
Pigeon: Closed season	1	--------------	----------
Quail: Closed season; no license; trapping	5	305 00	15
Rabbit: Closed season; no license; night hunting; spotlighting; possessing Sierra hare, closed season	81	2,583 00	10
Sage hen: Closed season	1	100 00	----------
Squirrel: Closed season	1	50 00	----------
Totals	224	$13,799 00	234

SEIZURES OF FISH AND GAME

April, May, and June, 1951

	Number	Pounds
Fish:		
Abalone	1,285	-------------
Bass	274	-------------
Carp	300	-------------
Catfish	96	20½
Clam	10,854	-------------
Crab	393	-------------
Croaker, yellowfin	-------------	24
Frog	204	-------------
Grunion	205	-------------
Halibut	-------------	405
Lobster	45	2,899
Pike	3	-------------
Salmon	3	8
Sardine	-------------	147,000
Shad	-------------	1,350
Sturgeon	1	-------------
Sunfish	891	-------------
Trout	987	70
Game:		
Deer	12	482
Dove	25	-------------
Duck	37	-------------
Elk	-------------	30
Goose	2	-------------
Nongame birds	15	-------------
Pheasant	21	-------------
Pigeon	7	-------------
Quail	11	-------------
Rabbit	117	-------------
Sage hen	1	-------------

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