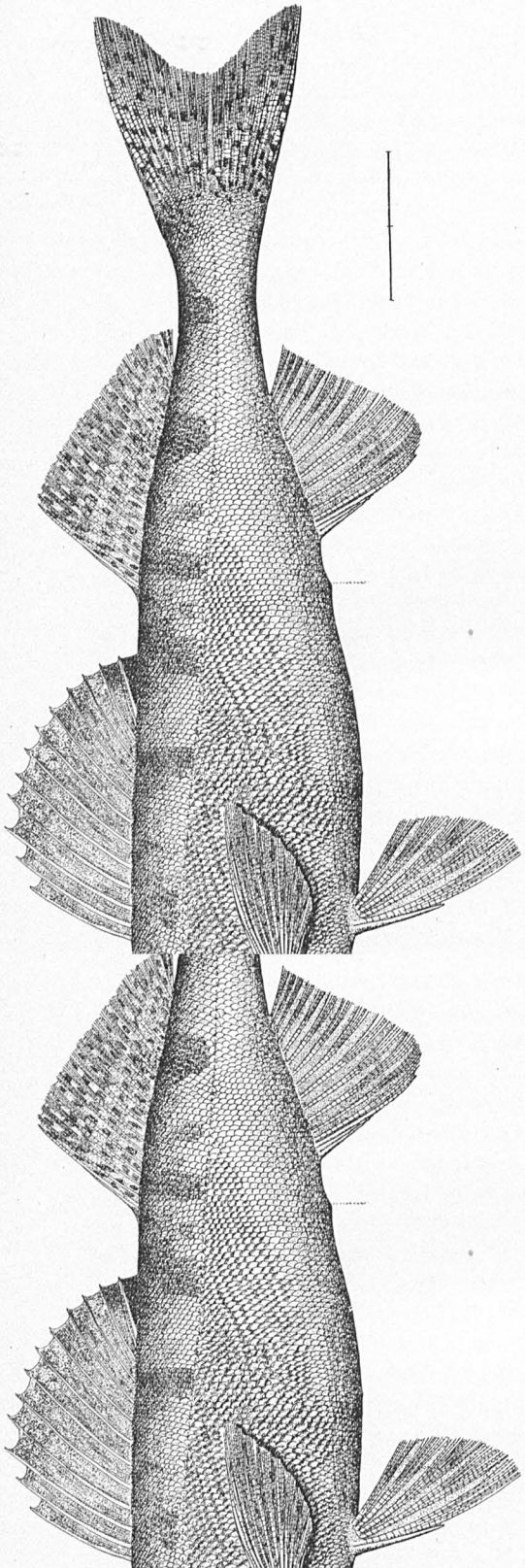
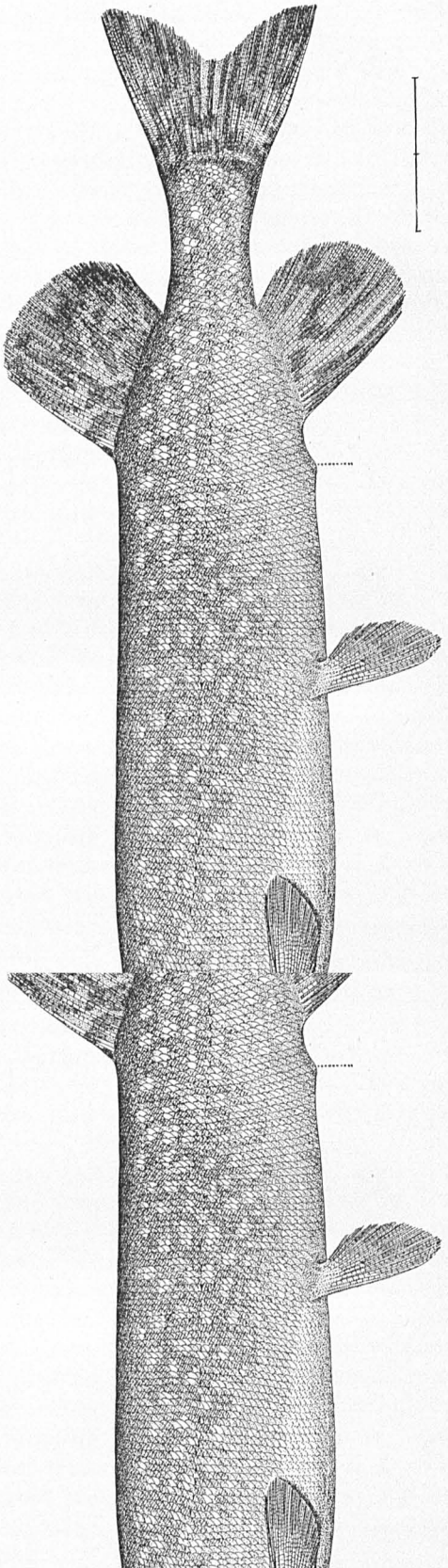


PIKE PERCH OR WALL-EYED PIKE (*Stizostedion vitreum*).

PIKE PERCH OR WALL-EYED PIKE (*Stizostedion vitreum*).



PIKE OR PICKEREL (*Lucius lucius*).

PIKE OR PICKEREL (*Lucius lucius*).

10.—A REVIEW OF THE HISTORY AND RESULTS OF THE ATTEMPTS TO ACCLIMATIZE FISH AND OTHER WATER ANIMALS IN THE PACIFIC STATES.

By HUGH M. SMITH, M. D.

PREFATORY REMARKS.

Few subjects connected with the utilization of our natural resources present greater interest than the possibilities for the successful transfer of useful animals from one section of the country to another and their acclimatization in new regions. The benefits that may accrue to a community or section through the introduction of new resources are various, and there are few parts of the country in which valuable non-indigenous animals are not now found.

In the case of water animals, the benefits of successful acclimatization are doubtless proportionally greater than with any other class, owing to the little attention they require after introduction, their extraordinary fertility as compared with land animals, and the slight labor and expense incident to their utilization. At the same time, it is apparent that the difficulties in the way of introduction of fish, mollusks, etc., are greater than with other animals; the drawbacks in the mere transportation are often very serious, especially when long journeys are to be made; while the uncertainties attending the deposition of the animals, the determination of the general results, and the gauging of the economic effects are much greater.

Among other influences militating against the successful introduction of fishes and other aquatic animals into new areas, in addition to those incident to their transportation, are the following: (1) Unsuitable water temperature; (2) unsuitable food; (3) unfavorable topographical condition of the bottom; (4) absence of suitable rivers for anadromous fish; (5) enemies and fatalities acting on a relatively small number of individuals.

The results attending the experimental introduction of aquatic food animals into the waters of the Pacific States must be regarded among the foremost achievements in fish-culture. The striking illustrations here presented of the influence of man over the supply of free swimming anadromous fishes, to say nothing of his ability to affect the abundance of non-migratory species, are of great economic and scientific interest.

Aside from the direct economic results which have followed the introduction of east-coast fishes into the waters of the Pacific States, a very important basis has been furnished for judging of the general effects of artificial methods in regions where the object of fish-cultural operations has been to maintain and increase the abundance of native species. Attention was first drawn to this phase of the subject in an article

contributed by the writer to the issue of *Science* for August 18, 1893, in which the following paragraph appears:

> Of scarcely less consequence than the actual results of shad introduction on the west coast is the important bearing which the success of the experiment must have in determining the outcome of artificial propagation in regions in which it is not possible to distinguish with satisfactory accuracy the natural from the artificial conditions. If these far-reaching, and no doubt permanent, results attend the planting, on few occasions, of small numbers of fry in waters to which the fish are not indigenous, is it not permissible to assume that much more striking consequences must follow the planting of enormous quantities of fry, year after year, in native waters? There is no reasonable doubt that the perpetuation of the extensive shad fisheries in most of the rivers of the Atlantic Coast has been accomplished entirely by artificial propagation. On no other supposition can the maintenance and increase of the supply be accounted for.

The zealous efforts of the fish commissioners of California to increase the quantity and variety of food and game fishes of the State deserve special recognition. For more than twenty-five years the energies of the commission have been almost constantly directed to the acclimatization of desirable fishes inhabiting the waters of the Eastern States. Their remarkable success when acting on their own behalf and in conjunction with the New York Fish Commission and the United States Fish Commission entitles them to the great credit and praise which they have received both from the inhabitants of California and from the people of other States and foreign countries. The other States of this section have also exhibited great interest in the improvement of their fish supply through the acclimatization of eastern species.

Mention should be made of the efficient services rendered to fish-culture by Mr. Livingston Stone in successfully taking fishes across the continent at a time when fish transportation was an undeveloped art and when the difficulties encountered would have discouraged one less enthusiastically interested and less competently informed on the general subject. To Mr. Stone more than to any other person is the direct credit due for the introduction of most of those fishes which have since attained economic prominence.

In this report I have considered all those species not already indigenous which have been introduced, or the introduction of which has been attempted, in California, Oregon, Washington, Idaho, and Nevada. Idaho has been included in the discussions because all its water-courses are practically tributaries of the Columbia River, and fish planted in that stream might find their way into the State, while plants in the open waters of Idaho might produce results in Oregon and Washington. The proximity to California of the Nevada lakes and rivers in which new fishes have been planted, and the similarity of the fishery interests of the contiguous parts of the two States, have appeared to warrant the inclusion of Nevada in the list. In the case of a few species having special interest, reference to their acclimatization in Utah has been made.

An interesting chapter might be prepared treating of the experimental introduction of native western fishes into new waters of the region—as, for instance, the acclimatization of the chinook salmon and rainbow trout in landlocked Nevada waters and the successful transplanting of the Sacramento perch (*Archoplites interruptus*) in Nevada—but this subject is foreign to the scope of the present paper.

It is intended in this paper to recount the history of the introduction of each aquatic species; to record the general results of the experiments; to state what is known of the habits of the animals in their new environment; and to give an account

of the economic importance attained and of the fisheries prosecuted. To facilitate the identification of the fish, especially on their appearance in new localities, illustrations of the principal species are included. The reports of State fish commissioners have been freely quoted, either as general information or to bear out the writer's statements regarding the different species.

The importance of this subject and the absence of any special paper dealing with its various aspects make it proper to give to the matter the detailed notice which it receives in the following pages. While the printed references to the subject have been numerous, there are many prominent phases which have not been mentioned, and the full extent of the industry which has been established as a consequence of the acclimatization experiments is unknown even to the people of the States most concerned.

The following fish and other aquatic animals receive special mention and will be considered in the order given:

(1) The Bullhead or Horned Pout (*Ameiurus nebulosus*).
(2) The White Catfish (*Ameiurus catus*).
(3) The Spotted Catfish (*Ictalurus punctatus*).
(4) The Carp (*Cyprinus carpio*).
(5) The Tench (*Tinca tinca*).
(6) The Goldfish (*Carassius auratus*).
(7) The Hawaiian Awa (*Chanos cyprinella*).
(8) The Shad (*Clupea sapidissima*).
(9) The Common Whitefish (*Coregonus clupeiformis*).
(10) The Atlantic Salmon (*Salmo salar*).
(11) The Landlocked Salmon (*Salmo salar sebago*).
(12) The Von Behr or European Brown Trout (*Salmo fario*).
(13) The Loch Leven Trout (*Salmo trutta levenensis*).
(14) The Lake Trout or Mackinaw Trout (*Salvelinus namaycush*).
(15) The Brook Trout (*Salvelinus fontinalis*).
(16) The Muskellunge (*Lucius masquinongy*).
(17) The Pike or Pickerel (*Lucius lucius*).
(18) The Eel (*Anguilla chrysypa*).
(19) The Crappy or Bachelor (*Pomoxis annularis*).
(20) The Strawberry Bass or Calico Bass (*Pomoxis sparoides*).
(21) The Rock Bass (*Ambloplites rupestris*).
(22) The Warmouth Bass (*Chænobrytlus gulosus*).
(23) The Blue-gill or Blue Bream (*Lepomis pallidus*).
(24) The Green Sunfish (*Lepomis cyanellus*).
(25) The Large-mouth Black Bass (*Micropterus salmoides*).
(26) The Small-mouth Black Bass (*Micropterus dolomieu*).
(27) The Yellow Perch or Ringed Perch (*Perca flavescens*).
(28) The Wall-eyed Pike or Pike Perch (*Stizostedion vitreum*).
(29) The Striped Bass or Rockfish (*Roccus lineatus*).
(30) The White Bass (*Roccus chrysops*).
(31) The Tautog (*Tautoga onitis*).
(32) The American Lobster (*Homarus americanus*).
(33) The Eastern Oyster (*Ostrea virginica*).
(34) The Soft Clam (*Mya arenaria*).

This paper is based chiefly on inquiries made by the writer in May and June, 1894, in the course of an inspection of the economic fisheries of the Pacific States. Acting under instructions from Hon. Marshall McDonald, the United States Commissioner of Fish and Fisheries, special attention was given to those fishes and other aquatic animals which had been artificially introduced into the waters of this region.

Much valuable information has also been obtained from Mr. A. B. Alexander, fishery expert on the steamer *Albatross*, who was detailed in 1893 for an investigation of this subject, and submitted a report embodying his observations on shad, striped bass, and catfish in the vicinity of San Francisco and in the Columbia River. In the following chapters Mr. Alexander's report has been freely quoted.

Use has also been made of the information on the foregoing fishes contained in the reports of Mr. W. A. Wilcox, field agent of the United States Fish Commission,

who has twice made a canvass of the fisheries of the entire Pacific Coast under very favorable circumstances.

In 1895, Mr. William Barnum, of the United States Fish Commission, visited parts of Idaho, Utah, Oregon, and Washington, and obtained information regarding non-indigenous fishes of those States that has been incorporated in this article.

The writer desires to express special obligations to Mr. John P. Babcock, chief deputy of the California Fish Commission, for numerous courtesies which have contributed to the completeness and accuracy of this paper. Mr. Arthur G. Fletcher, of the same commission, has also furnished a number of interesting notes.

Messrs. Babcock and Fletcher, cooperating with the writer, were able to secure accurate figures showing the monthly receipts of shad, striped bass, carp, and catfish in 1893 and 1894, which information is given elsewhere.

To the following fish-dealers of San Francisco acknowledgment is due for their kindness in according free access to their books, from which an accurate statement of the extent of the trade in the species under discussion could alone be obtained: American Union Fish Company, J. H. Kessing, A. Paladini, Pioneer Fish Company, G. Camilloni, S. Tarantino, B. Caito, and P. Gusmani.

The following-named gentlemen have courteously responded to inquiries and supplied useful data: Hon. George T. Myers, Portland, Oreg.; Mr. James Crawford, fish commissioner, Vancouver, Wash.; Mr. F. C. Reed, ex-fish commissioner, Astoria, Oreg.; Mr. Charles F. Lauer, The Dalles, Oreg.; Mr. George T. Mills, fish commissioner, Carson City, Nev.; Mr. W. H. Ridenbaugh, Boise, Idaho.

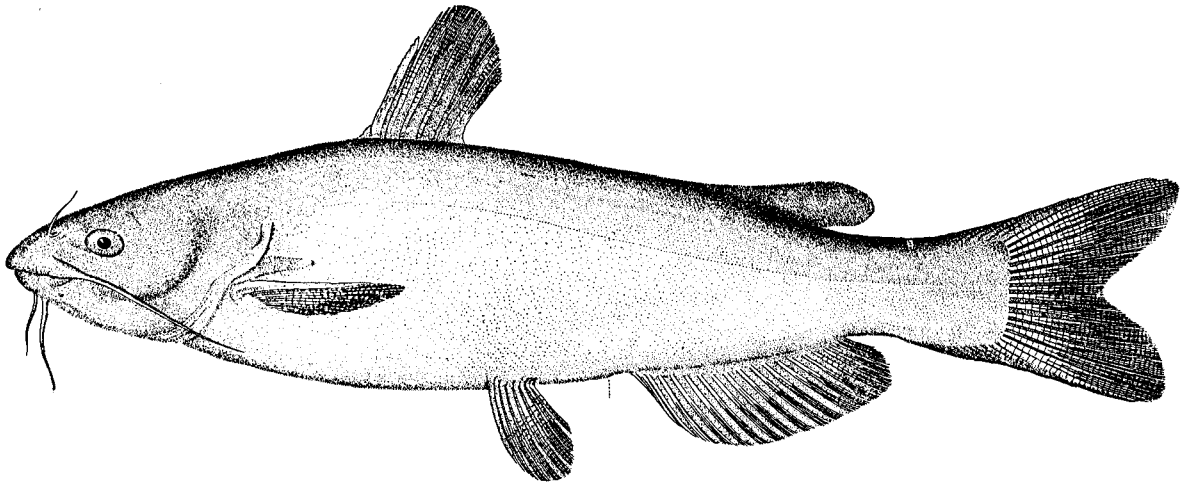
THE CATFISH.

INTRODUCTION TO PACIFIC STATES, AND RESULTS.

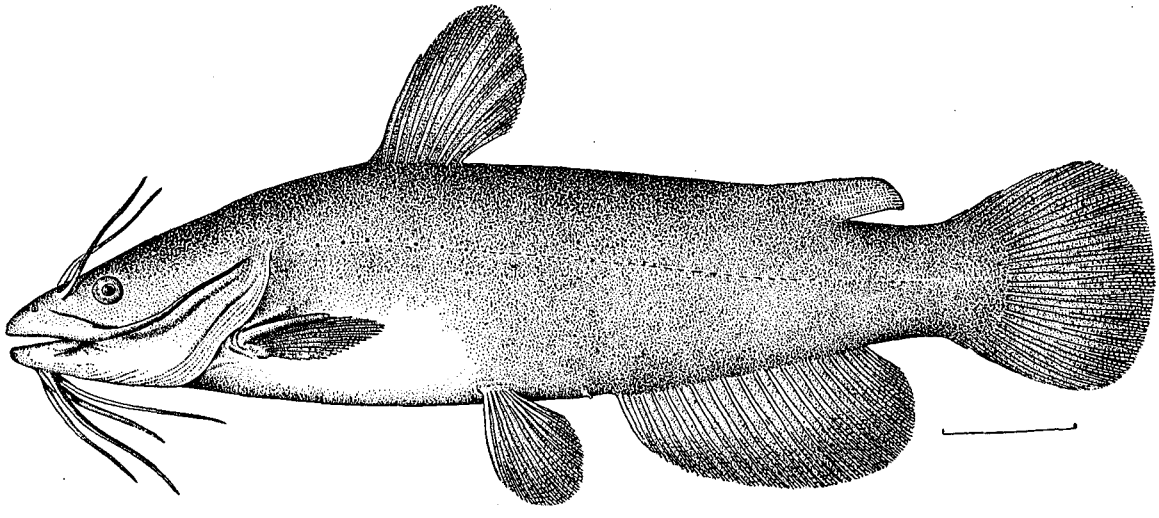
At least three species of catfish—the white catfish (*Ameiurus catus*), the yellow catfish or bullhead (*Ameiurus nebulosus*), and the spotted catfish (*Ictalurus punctatus*)—inhabiting parts of the United States east of the Rocky Mountains have been transferred to the Pacific States. Catfish were taken to California in 1874 by Mr. Livingston Stone,* of the United States Fish Commission, and subsequently one or two species were introduced into Oregon and Washington. Mr. Stone's assortment of eastern catfish consisted of 56 large Schuylkill catfish (*Ameiurus catus*) from the Raritan River, New Jersey, and 70 hornpouts or bullheads (*A. nebulosus*) from Lake Champlain, Vermont. The large white catfish were deposited in the San Joaquin River, near Stockton, Cal., and the bullheads were placed in ponds and sloughs near Sutterville, Sacramento County, Cal.; both plants were made on June 12, 1874.

It appears from Mr. Stone's account of his trip across the continent in 1874 that at Fremont, Nebr., on the Elkhorn River, he took on board some catfish from that stream, and that 18 of these were placed in the San Joaquin River, near Stockton, in conjunction with the other large catfish from New Jersey. Mr. Stone refers to these as "Mississippi catfish," but this designation is not definite enough to conclusively fix their identity; and as no specimens have recently been observed, and as no examples are preserved in collections, the ichthyological status of this fish must be considered unsettled. Recent collections in the Elkhorn River and neighboring waters by the

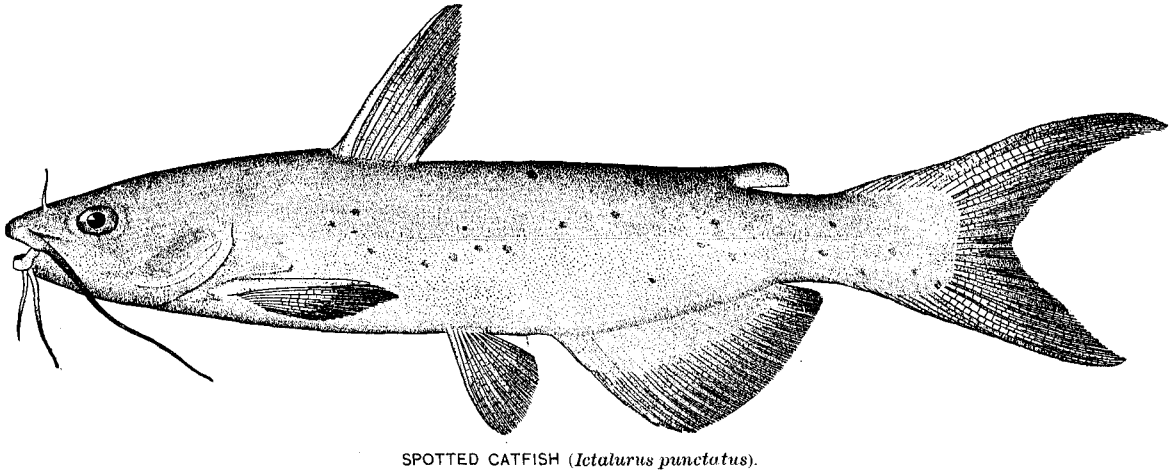
* See Report California Fish Commission, 1875-75, pp. 5, 6, 22, 30, 32.



WHITE CATFISH OR SCHUYLKILL CATFISH (*Ameiurus catus*).



YELLOW CATFISH OR BULLHEAD (*Ameiurus nebulosus*).



SPOTTED CATFISH (*Ictalurus punctatus*).

United States Fish Commission have disclosed the presence of a number of species of catfish, any or several of which might have been obtained by Mr. Stone. Among these are the spotted catfish, blue catfish, or channel catfish (*Ictalurus punctatus*); the fork-tailed catfish (*Ictalurus furcatus*); the mud catfish or yellow catfish (*Leptops olivaris*); the great fork-tailed catfish or Mississippi catfish (*Ameiurus lacustris*), and the black catfish or bullhead (*Ameiurus melas*). The first, third, and fifth named species are known to be common in the river in question, and only these are recorded from Fremont. It is therefore probable that specimens of one of these were secured by Mr. Stone.

The spotted catfish is probably the best of the tribe, and is the principal one distributed by the United States Fish Commission. In food value it is regarded by Jordan and Evermann as not inferior to the black bass. Several plants have in recent years been made in the Pacific States. In 1892 the following adult and yearling catfish were deposited in Washington waters, in response to requests: Seventy-five in Clear Lake, Skagit County; 125 in a private pond near Vancouver; 50 in Deer Lake, in Stevens County. In 1893, 100 were placed in the Boise River, Idaho, a tributary of the Snake River. Ten were put in the Balsa Chico River, California, in 1895. Plants of yearlings were made in Lake Cuyamaca and Feather River, California. in 1891, each water receiving 250 fish.

The results attending the introduction of catfish in California were immediate and marked. As early as 1875, the State commissioners reported on the matter as follows:

The Schuylkill catfish and the Mississippi catfish, placed in the San Joaquin River, have grown rapidly and spawned, but several of the large fish and many of the young ones have been caught by the fishermen near the San Joaquin bridge, and have been returned to the river. The fishermen at that point are much interested in their successful cultivation, and seem desirous that they should be preserved. By another year they will be so numerous that they may be caught with safety and shipped to market, as it would be impossible to exhaust the river by ordinary fishing. The hornpouts, a species of small catfish from Lake Champlain, which were placed in the lakes near Sacramento, have increased so abundantly that nearly one thousand have been caught and transported to the various lakes and sloughs in the Sacramento Valley. We caused several hundred of them to be placed in lakes containing brush and dead trees, in which it would be impossible to seine them. The acclimatization and perpetuation of these fish in the Sacramento Valley is assured, as they are now so situated that no amount of fishing will exhaust them.

In their report for 1876–77, the fish commissioners stated:

The 74 Schuylkill catfish imported in 1874, and placed in lakes near Sacramento, have increased to a vast extent. They already furnish an important addition to the fish food supply of the city of Sacramento and vicinity. From the increase we have distributed 8,400 to appropriate waters in the counties of Napa, Monterey, Los Angeles, Fresno, Tulare, Santa Cruz, Shasta, Solano, Alameda, San Diego, Yolo, Santa Barbara, and Siskiyou. These, should they thrive and increase as they have in Sacramento, will furnish an abundance of valuable food in the warm waters of the lakes and sloughs of the interior, and replace the bony and worthless chubs and suckers that now inhabit these places. It may be proper to call attention to the fact that these fish have become so numerous in the lakes near Sacramento that they can now be obtained in any quantity for stocking other appropriate waters in any part of the State.

In 1878–79 the California commissioners distributed 39,000 Schuylkill catfish to public waters in 22 counties, and reported as follows about the fish:

These have increased to millions and furnish an immense supply of food. They have become so numerous that they are as regularly on sale in the city markets as the most abundant native fish, and are sold at about the same prices. They thrive in our rivers and lakes, and in the still-water sloughs of our plains, as well as in the brackish sloughs in our tule lands. They appear to be equally at

home in lakes on the mountains and in artificial reservoirs in the valleys. Many farmers who have natural ponds on their farms, or who have surplus water from windmills and have made artificial ponds, have stocked them with this excellent fish. The produce of the few fish of this species, imported in 1874, now annually furnishes a large and valuable supply of fish food to people in the interior of the State. The value of all the fish of this species now caught annually and consumed as food would more than equal the annual appropriation made by the State and placed at the disposal of the fish commissioners. This variety of catfish has valuable characteristics which admirably fit it for wide distribution and for self-preservation in the struggle for existence.

The report of the California Fish Commission for 1880, from which the following extract is made, shows that over 24,000 catfish were distributed in the State waters, and that the fish had become so numerous and widely scattered that further attention from the commission was hardly demanded:

The 74 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. They are regularly sold in all the markets at the same prices as our most abundant fish. They are admirably adapted to the sloughs and warm waters of the great valley, and in them have so multiplied as to furnish a large supply of food. The aggregate value of this fish alone, sold in the markets of San Francisco and Sacramento annually, would more than equal the appropriation annually made by the State for fish-culture. How constant has been the demand made upon us for the wide distribution of this fish may be seen in our report of expenditures, which shows quite a large amount paid for their capture and in sending them by express to different parts of the State. These fish are now so numerous and widely distributed that probably the time has arrived when their further distribution should be left to private enterprise, and the money of the State heretofore used for this purpose be employed in importing some other equally valuable fish.

In considering the question of the economic value of the catfish and of the effects of its introduction on the native fishes, the fish commissioners make the following comment in their reports for 1883–84 and 1885–86:

It has been stated by fishermen that they would destroy all the native fish. It is our opinion that it was a timely act on the part of the former State commissioners to plant them just when they did, as our native fish were giving out. * * * They are coming more into favor with our citizens every year. The prejudice that existed at the time of their introduction is fast dying out, and the majority of our people claim that they are a better food-fish than the carp. Whether such be the fact is a matter of taste. The idea that they would destroy our native fish is a fallacy, as in the last two years statistics tend to show that such is not the fact.

Catfish are coming more into favor with citizens as food, and by a large class of consumers are preferred to carp. The planting of these fish was regretted by many and approved by more.

Catfish have been successfully introduced into the Columbia River and its tributary, the Willamette, but the full history of the planting is not recorded. Mr. F. C. Reed, of Astoria, contributes the following note on the origin of the catfish in the Columbia:

The extent of my knowledge of the history of this fish is as follows: About eight years ago [1888], when I was fish commissioner for Oregon, these fish were reported to be in Silver Lake, Washington. How they came there, I never was able to find out. When I heard they were in the lake, I was told they could not get out of the lake into the Columbia River; this was in reply to a request I made on the Washington authorities that I be allowed to go over to the lake and kill the catfish for fear they would get in the river and be another enemy to our salmon. It was only a year or two after this that during an unusual rise in the lake the fish were sent into the Cowlitz River, and from there to the Columbia. I thought at the time they were the real catfish, and would grow large enough to eat a 20-pound salmon, but now I do not think they will injure our salmon very much, as I have never seen them near the spawning-grounds, and think they prefer still and warmer water.

The history of the introduction of catfish into the waters of Nevada is very interesting. It appears that in 1877 Mr. H. G. Parker, the State fish commissioner, obtained from the Sacramento River, California, a large number of "Schuylkill" catfish (*Ameiurus catus*), which were deposited in Washoe Lake, the Truckee, Carson, and Humboldt rivers, and several sloughs, 25,000 yearlings being placed in the Humboldt alone. In all these waters the catfish rapidly became acclimatized, and in his report for 1879 and 1880 the commissioner states:

Nothing can be more satisfactory than the evidence I have of the increase and growth of the several lots of catfish I put in Washoe Lake and Carson, Truckee, and Humboldt rivers. Washoe Lake is so fully stocked and the fish of that size and vigor that further experiments would be useless. Over one hundred a day have been taken by one fisherman, none less than 14 inches long, and weighing from 1 to 1½ pounds. Of those planted in Carson River, at Schultz's ranch, several have been caught at Woodfords, 30 miles up the river from where deposited, and others 60 miles down the river from place of deposit, the latter having passed through all the poisonous substances flowing into the river from mining operations. Advices from the Truckee and Humboldt rivers warrant me in reporting equally as favorably as from those planted in Washoe Lake, and with another year's growth, or on the opening of the rivers in the coming spring, I have no hesitancy in stating that good and profitable fishing may be had. * * * In December, 1880, I distributed catfish in Washoe, Humboldt, Churchill, Lander, Eureka, Elko, Nye, and White Pine counties. * * * In all, I planted fish at 81 different places. Outside of the Truckee and Humboldt rivers, Pine Creek, and Newark Valley, the plants were in lakes, sloughs, streams, and larger springs, but in every place public waters.

In the report of the Nevada commissioner for 1881 and 1882 it is stated that 2,000 catfish were distributed in various waters in those years, and that the results had been marked in all the waters stocked, thousands of pounds of catfish being taken from Washoe Lake with hook and line in 1882. From the reports for 1883–84 and 1889–90 the following extracts are taken, which refer to the value of the catfish in waters where better fish can not flourish and to the economic importance which the fish have attained in Nevada.

From nearly every plant of catfish I have reports several times a year, and in every instance I have been complimented on the introduction of this very prolific and superior food-fish. Its hardy nature so well fits it for our saline and muddy waters, that in localities where the trout can not flourish this fish is sure to thrive and multiply far beyond any of our transplants. In Washoe Lake, Carson and Humboldt rivers, they are now found in such great numbers that anglers of all ages and sexes never abandon the pleasure until well-filled baskets and sacks mark the day's sport. For two years the Carson and Virginia markets have been to a great degree supplied with these fish from Washoe Lake. They find a ready sale at the highest prices. It has been my custom, and I now have on hand over 1,000 yearlings ready for distribution, in lots from 50 to 100 fish. The species of catfish herein mentioned were taken from the Schuylkill River, Pennsylvania, where it is unusual to find them to exceed 1 pound in weight, while in this State many are caught weighing over 2 pounds, thus showing the favorable results from transplanting fish.—(Report for 1883–84.)

The introduction and planting of the Schuylkill River blue catfish by our first fish commissioner, Mr. H. G. Parker, was commenced in August, 1877, the first deposits being made in Washoe Lake, Carson and Humboldt rivers. In two years these fish had increased to such numbers that the commission was enabled to stock other waters from the supply furnished in Washoe Lake. Thousands of pounds have been taken annually for the last eight or ten years, every family living near these waters supplying their table for about seven months of the year, while the markets of Carson and Virginia cities, although receiving large consignments, find such large sale that their stock is exhausted long before the most desirable salt-water fish find a purchaser. Add to this the fact of the number engaged in fishing for the market, and it will be seen that an industry has been developed, not only giving employment to quite a number of men and boys, but furnishing a food-fish of a most desirable and salable quality, and this through the workings of the Nevada fish commission.—(Report for 1889–90.)

Mr. W. H. Ridenbaugh, of Boise, Idaho, in 1895 took with a minnow net a few small, spotted catfish in Natatorium Lake, in Boise, thus indicating that the fish planted in 1893 have spawned.

DISTRIBUTION AND ABUNDANCE OF THE CATFISH.

It is not possible to assign to each species of catfish its present distribution in the Pacific States. There is nothing in the habits of the two kinds known to have become acclimatized that would prevent both inhabiting the same waters, although the yellow catfish or bullhead (*A. nebulosus*) is probably more likely to be found in warm, muddy ponds, sloughs, and ditches than is the other species, which, on the east coast, is commonly known as the channel catfish, in allusion to its habit of frequenting the deeper, colder, and clearer parts of the rivers.

In California the catfish have a more general distribution than any other fish. The State commissioners in 1880 asserted that there is no county in which these fish were not found; the wide distribution which the fish had given themselves had been supplemented by the efforts of the commissioners, who, from 1877 to 1879, planted them in 30 counties.

In California catfish are most numerous in the valleys of the Sacramento and San Joaquin rivers, where the conditions are very favorable for their multiplication. They are found in most of the tributaries of those streams and in the sloughs connected therewith. They have ascended the Sacramento River as far as Kenneth, a station 17 miles above Redding, and the San Joaquin to Tulare Lake. In 1886, Mr. William Utter, writing from Campo Seco, Calaveras County, reported that there were millions of catfish in the Mokelumne River, which joins the Sacramento River a short distance below Sacramento. Catfish are also found in several of the coast rivers of California.

In a "List of the fishes inhabiting Clear Lake, California," by Jordan and Gilbert, printed in the Fish Commission Bulletin for 1894, the bullhead (*A. nebulosus*) is recorded as very abundant, and the white catfish (*A. catus*) is reported as occasionally taken with the other species. In Lake Cuyamaca, near San Diego, catfish are reported as abundant, and some weighing 1½ pounds have been taken with lines.

Catfish are generally distributed in the Lower Columbia River and in the Willamette and other tributaries. The limits of their range in the Columbia basin have not been determined. They are very abundant in the sloughs connected with the Willamette River below Portland. Mr. F. C. Reed, of Astoria, states that the catfish of the Columbia basin is the bullhead, and that the catfish proper (that is, the fork-tailed form) does not occur. He recently obtained and forwarded to the Fish Commission a specimen of Oregon catfish; it was secured in Portland and was evidently caught in the Willamette River. It is 8 inches long, and Mr. Reed states that it is about the average size of those taken in the Columbia basin, although rather smaller than the usual run of those now saved for the markets, which are 10 to 12 inches long. An examination of this example shows that it is referable to the species known as the black catfish or bullhead (*Ameiurus melas*); it has the square tail and other features found in the common bullhead (*Ameiurus nebulosus*) and closely resembles the latter species, but differs from it in having a flatter head, a rather stouter body, and a shorter anal fin. In this specimen the length of the head is contained 3⅓ times in the body length, and the greatest depth 4¼ times in length; the anal fin has 17 rays, including rudiments, and its base is contained 5½ times in body length. In *A. nebulosus* the anal rays number

22. This specimen adds to the doubt existing as to the origin of the catfish in the Columbia basin. The supposition that the original stock in Oregon and Washington may have been obtained from California must be discarded, as the existence of *A. melas* in the latter State has not been determined, although this may have been the fish obtained by Mr. Stone in the Elkhorn River, Nebraska, in 1874, as previously suggested.

The quotations previously made from the reports of the Nevada fish commissioner are sufficient to show the wide distribution and great abundance of the catfish in that State.

SIZE AND WEIGHT.

The average weight of catfish taken for market in California is under 1½ pounds. There is a great abundance of very small fish in the Sacramento and San Joaquin rivers, and many seine hauls might be made in some places without yielding any over 10 inches long. Those weighing 5 pounds and upward are quite uncommon. Specimens of both species caught with a line by the writer at Collinsville, in June, 1894, were all 8 inches long or under. These were taken from the muddy waters of the Sacramento, and partook to a great extent of the color of the water; some were almost milk-white, others pale green or yellowish green.

Up to May 31, 1895, Mr. Babcock had observed no catfish in the San Francisco markets weighing over 3 pounds; on that day, however, he saw an 8-pound fish from the Sacramento River, in the American Union Fish Company's market, and heard of a 15-pound fish that had been received the same day.

Salmon gill-net fishermen of the Sacramento and San Joaquin rivers, using nets with a 7½ or 8 inch mesh, sometimes take large catfish. A salmon fisherman on Sherman Island, in the San Joaquin, informed the writer that he had caught several catfish weighing 10 pounds.

Mr. Charles Cuneo, of the American Union Fish Company, states that a few catfish weighing 6 to 8 pounds are received by San Francisco dealers, but that 15 or 16 inches is the usual length.

Mr. Alexander reports as follows on the size and weight of the catfish in California and the Columbia River:

> The average weight of the catfish sold in the markets of San Francisco is 1 pound. Occasionally fish weighing 7 and 8 pounds are brought in, but few fish of this size meet with a ready sale, and there is little inducement for fishermen to save them. The average length of catfish is about 12 inches. In the Columbia and its tributaries the fish run somewhat smaller, three-quarters of a pound being a fair average in weight and 10 inches in length.

FOOD OF CATFISH.

The catfish have the reputation among the California fishermen of being large consumers of fry and eggs of salmon, sturgeon, shad, and other fishes. This accords with their known habits in other waters. Mr. Alexander's examination, however, of the contents of several hundred stomachs of catfish in California and Oregon yielded only negative results as to the presence of young fish and ova.

Writing of the bullhead in Clear Lake, California, Jordan and Gilbert say that it is extremely abundant and is destructive to the spawn of other species. The scarcity of the valuable Sacramento perch in that lake, which they attribute to the carp, here as in the Sacramento River may be partly due to the more numerous catfish, which feed almost exclusively on animal matter.

By some persons the catfish are held responsible for the scarcity of Sacramento perch in the Sacramento and San Joaquin rivers. Mr. Babcock writes that he is informed by reliable men living above Colusa that up to 1880 perch were very common there and catfish were seldom taken, but since that time the catfish have increased beyond all belief and the perch have almost disappeared. The supposed influence of the catfish on the abundance of the perch arises from the spawn-eating propensities of the catfish.

Mr. A. Paladini, an extensive and long-established dealer of San Francisco, believes that catfish are especially injurious to salmon in the Sacramento River, where he thinks they destroy large quantities of ova and fry. This matter is sufficiently important to warrant careful attention. It would seem that the centers of abundance of catfish are probably remote from the spawning-grounds of salmon.

ASSOCIATION WITH OTHER FISH, ENEMIES, ETC.

In California and Oregon catfish inhabit to a great extent waters in which few other fish could or do exist. In the lagoons and sloughs connected with the San Joaquin, Sacramento, and Willamette rivers, but few fish besides catfish are taken with the fyke nets and set lines. When fishing is done in the main streams, a number of varieties are caught with catfish, among which are split-tails (*Pogonichthys macrolepidotus*), hardheads (*Ptychocheilus oregonensis*), and carp (*Cyprinus carpio*), and, in the Columbia basin, young sturgeon (*Acipenser transmontanus*).

Few enemies and no diseases disturb the catfish in Pacific waters, according to Mr. Alexander. No fish are known to prey on them except the striped bass, and even that species must do so very rarely. In some instances the ingestion of catfish by striped bass results in the death of the latter, the formidable spines piercing the stomach and entering the abdominal walls of the bass.

ORIGIN AND GENERAL EXTENT OF THE FISHERY.

From the extracts from the reports of the California fish commission previously quoted it may be seen that very soon after the introduction of the catfish a fishery was inaugurated. The practice of taking the fish for market from public waters has probably increased from year to year, although no statistics are available for any early years. At present it is probable that more catfish are caught for local and home consumption than for sale in the large marketing centers, but no accurate idea of the extent of the desultory and semiprofessional fishing can be formed.

The catfish fishery is not of large proportions in either California or Oregon. Only a small amount of capital is invested in it, but few persons are regularly engaged, and the catch is insignificant compared with the yield of many other fish taken in the same waters. The industry is more extensive in California than in Oregon.

The commercial fishery, in California at least, has probably reached its height, if it is not already on the decline. The receipts of catfish by the San Francisco dealers in 1894 were nearly 30 per cent less than in 1893; the decrease was due wholly to the lack of demand, the fish being more abundant. The large receipts of shad in the markets in recent years have doubtless put a check on the value of catfish and the expansion of the fishery.

FISHERMEN, APPARATUS, AND METHODS.

Fyke nets and set lines or trot lines are the apparatus chiefly employed for taking catfish. Both these appliances are used in California; but in Oregon Mr. Alexander reports that only fyke nets are set. Considerable quantities are in some localities incidentally taken in drag seines. In the semiprofessional fishing, hand lines and dip nets are also employed. The catfish fishery of California is carried on by a few persons who make a business of taking those fish throughout the year. It may be followed with some regularity for a time, but is seldom allowed to interfere with the capture of salmon, striped bass, and other more valuable species.

The number of persons who may be regarded as catfish fishermen in 1893 was about 100. These made their headquarters at Red Bluff, Fremont, Sacramento, Knight's Landing, Isleton, Bouldin Island, Jersey Landing, and other points on the two rivers. More than half the regular fishermen were Chinese.

The apparatus used in the catfish fishery of California in 1893, as determined by Mr. Alexander, consisted of 750 fyke nets, valued at $8,500; 100 trawl lines, valued at $150, and 15 drag seines, valued at $375. The number of boats used for lifting nets and trawls was about 60, with a value of $900. It should not be understood that all of the apparatus shown is used at one time. A few nets or trawls may be set for a few days or weeks, taken up, and not employed again for several months or possibly not until the next year.

The catfish fishery in Oregon is carried on by seven fishermen in the vicinity of Sauvies Island, situated in the Willamette River, a short distance below Portland. Mr. Alexander reports that a Mr. Mitchell is more extensively engaged in the business than anyone else, and that the Portland dealers look to him for their supply of catfish. He lives, with his family and hired men, in a small portable house on the bank of a slough where the fishing is done. The house is so constructed that it may easily be put on a float and moved from place to place, as occasion requires. Another structure, 15 by 30 feet, is built on a scow, in which the skinning, dressing, and boxing of the fish for market are done. The fish as caught are kept in three live-cars until needed for shipment. Four fyke nets are employed by this crew; they are set at the ends of two leaders and are valued at $160; small skiffs are used to tend the nets. The aggregate investment in the fishery at this place is $445. Six other persons were in 1892 more or less regularly engaged in taking catfish, but less extensively than Mr. Mitchell. They had 5 scows, 9 skiffs, 12 cars, and 8 nets, with leaders, which property was worth about $1,615, making $2,060 the total value of the apparatus, boats, etc., devoted to the fishery.

The following account of the fyke-net fishery of California and Oregon has been furnished by Mr. Alexander:

> The fyke net has been found to be the most economical device yet employed for carrying on the catfish fishery. It has many advantages over the drag seine. The fyke net can be set and left remaining in the water for an indefinite length of time without the fish dying or making their escape. With the drag seine, the fish caught at each haul must be cared for immediately if they are to be kept alive, which involves considerable extra labor.
>
> The fyke nets employed on the Pacific Coast do not differ materially from those used on the Atlantic seaboard and on the Great Lakes. They are from 12 to 20 feet in length, the size largely depending on the locality. In places where the current runs swiftly, smaller nets are used than in localities where there is little or no current. The usual type consists of a tapering bag distended by four hoops from 3 to 4 feet apart. The hoop at the mouth is about 3½ feet in diameter, the one at the end 12 to 16

inches in diameter. As a rule, there is only one funnel, situated nearly in the middle of the net. There is no rule for the size of net, mesh, or hoops; each fisherman carries out his individual ideas as to what is best suited to the conditions. The size of mesh is usually 2½ to 3 inches, but the nets used by the Chinese have much finer meshes, those near the apex measuring not more than half an inch. Most of the fyke nets used in California for the capture of catfish are set without leaders; if the latter are used, they vary from 15 to 25 feet in length.

The average cost of such fyke nets as the Chinese use is $15; those employed by the white fishermen cost $10 or less, having a larger mesh.

In setting a fyke net the ends are fastened to stakes driven into the bottom, the leader—if one is used—being kept in position in the same way. In places where there is little current, the bag end of the net is made fast to a stake, but where the current runs swiftly it is allowed to swing freely by its mouth fastenings. Where the tide ebbs and flows, the mouth of the net is changed at each turn of the tide.

In Oregon the fyke net is used wholly for the purpose of taking catfish, although other species are frequently caught in it. The nets are of the same pattern as those of California. In most cases they are set double—that is, one leader directs the fish into two nets. The leaders are 150 to 200 feet long, and 16 feet deep. The bag end of the nets is made fast to stakes to keep them in shape and position, the water being still where this method is used.

The leaders are so made that they can be easily converted into drag seines, which is often done, and hauled over the same ground where the nets were set. This practice is only resorted to when the catfish become scarce or other fish are desired.

At Antioch, Courtland, Bouldin Island, and many other places on the San Joaquin and Sacramento rivers, trawl lines (locally known as trot lines) take catfish for the city markets, local consumption, and family use. The length of the lines varies with the river or slough in which they are fished. In the narrow sloughs and upper courses of streams they are about 100 feet long, with hooks at intervals of 2 or 3 feet, but in the wide sloughs and the lower parts of rivers they are often 700 to 800 feet long, with 250 to 300 hooks. When the current is swift, a wire ground line is used, but in other situations the bottom line is of twine. The hooks are small, being about the size of mackerel hooks employed in the New England fisheries. One end of the trawl is made fast to the shore, the other end to a stone which serves as an anchor. The line is placed either about parallel with the shore or, if the current be not swift, directly across the course of the stream or slough. The hooks are baited with fish or meat, beef hearts being a favorite bait.

In the aggregate, considerable quantities of catfish are taken with hand lines. Fish thus caught are rarely marketed, except those obtained by the Chinese. Many of the catfish sold in the Chinese fish markets of Portland are taken with hook and line. At places on the Sacramento River drop nets or dip nets, baited with meat or fish, are fished from wharves. Often large hauls of catfish are made in this way. Such nets are usually operated by boys, and the fish taken are apt to be small.

Catfish are usually dressed by the fishermen before they are sent to market, the cleaning being done on the fishing-grounds. The nets are hauled two or three times a week, usually in the afternoon, according to the demand for and abundance of fish, while the forenoon is spent in dressing and boxing the fish, which are kept in the live-cars until required. The fish are prepared for market by removing the skin, head, and viscera, and packed in boxes holding about 150 pounds, no ice being used.

The fishermen supplying the Sacramento market usually deliver their fish alive to the dealers, who have live-cars conveniently located and can dress the fish as needed. The San Francisco and Portland fish markets are so far from the water front that the dealers can not keep the fish alive.

THE FISHING SEASON FOR CATFISH.

In California, fishing for catfish is done throughout the year, with but little variation from month to month, as the receipts of the San Francisco dealers given on page 393 will show. The catch is, however, smallest in July and August. Mr. Alexander reports that from October to June a few fishermen find employment in Oregon in taking catfish for the Portland market. During the summer months, when salmon are very abundant, there is little demand for catfish.

QUANTITY AND VALUE OF THE CATCH OF CATFISH.

As much the largest part of the catfish yield of California is consigned to San Francisco, Sacramento, and Stockton, figures showing the receipts in those cities will give a fair idea of the quantity caught. Mr. Alexander's inquiries at Sacramento and Stockton and the writer's examination of the books of the San Francisco dealers showed that in 1893 the shipments to those places were as follows:

	Pounds.
San Francisco	43,975
Sacramento	59,025
Stockton	36,000
Total	139,000

The quantity of catfish sent from the principal shipping centers on the Sacramento and San Joaquin rivers, as determined by Mr. Alexander, were as follows, the difference between these and the foregoing figures, amounting to about 33,000 pounds, representing the aggregate of a number of minor shipments of which no record could be obtained:

	Pounds.
Red Bluffs, Fremont, and Knights Landing	40,000
Courtland	13,550
Isleton	12,000
Rio Vista	2,290
Bouldin Island	23,000
Jersey Landing	15,000
Total	105,840

The catch by persons who make something of a business of fishing for catfish was not under 150,000 pounds in 1893, and fully 50,000 pounds additional would not more than cover the catch by farmers, boys, and fishermen in other branches, most of which is consumed locally.

The gross value to the fishermen of the catfish caught for market was $6,358, and the total value of the fish to the State in the year named may be estimated at $8,500, making a very moderate allowance for the catfish used for home consumption.

The quantity of catfish taken for sale in the Columbia basin in 1893 was about 90,000 pounds, with a value to the fishermen of $2,800. Comparatively large numbers were also consumed by lumbermen, farmers, and others who fished for their own use. The receipts of catfish in Portland in 1893 amounted to 75,000 pounds.

The contention of the California fish commissioners in several of their reports already cited, that the value of all the catfish caught annually and consumed as food would more than equal the annual appropriation made by the State in the interests of the fisheries and fish-culture, has probably been verified in a number of years. In 1893, when the fishery is known to have been less extensive than formerly, the appropriations exceeded the value of the catch by only $1,500.

EDIBLE QUALITIES OF CATFISH.

While the consumption of catfish in California is not large, the fish are well-liked by many people; others, however, regard them as very inferior fish. When taken from the cooler, deeper waters, they have a good flavor, and deserve to rank high among the resident fresh-water fishes of the Pacific States, but when caught in warm, shallow, muddy sloughs and ditches they naturally have little value as food.

Mr. Alexander says that fishermen, with few exceptions, have little praise to offer in behalf of the catfish. Nearly all with whom he conversed said their edible qualities were of a low grade. He believes, however, that many people think differently, and that the quantity of catfish eaten in some localities indicates that the fish are rather popular. The amount consumed can not be due to the cheapness of the fish, for at times other fish reach so much lower prices that it would seem no catfish would be bought. Mr. Alexander thinks that, while a large part of the catfish is eaten by Chinese and the poor of the numerous nationalities found on the west coast, considerable quantities must be consumed in restaurants under fictitious names, just as sturgeon and sharks are served as "tenderloin of sole."

The dealers in San Francisco and Portland do not attach much importance to the catfish and do not value its edible qualities highly, but in Sacramento they speak well of the fish.

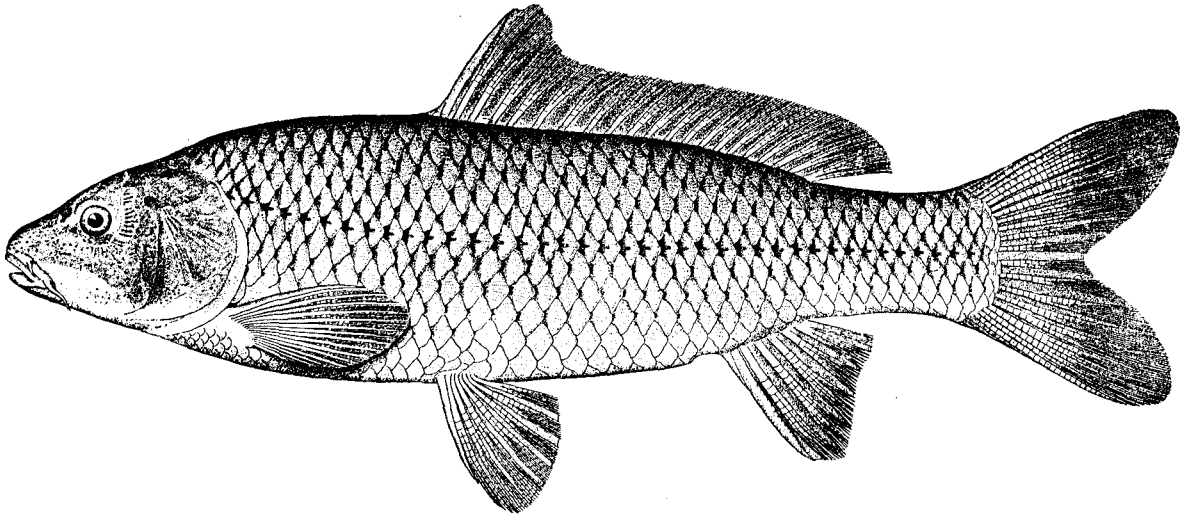
Drs. Jordan and Gilbert regard the bullhead as the best food-fish found in Clear Lake, California, with the exception of the Sacramento perch and rainbow trout.

THE CATFISH TRADE.

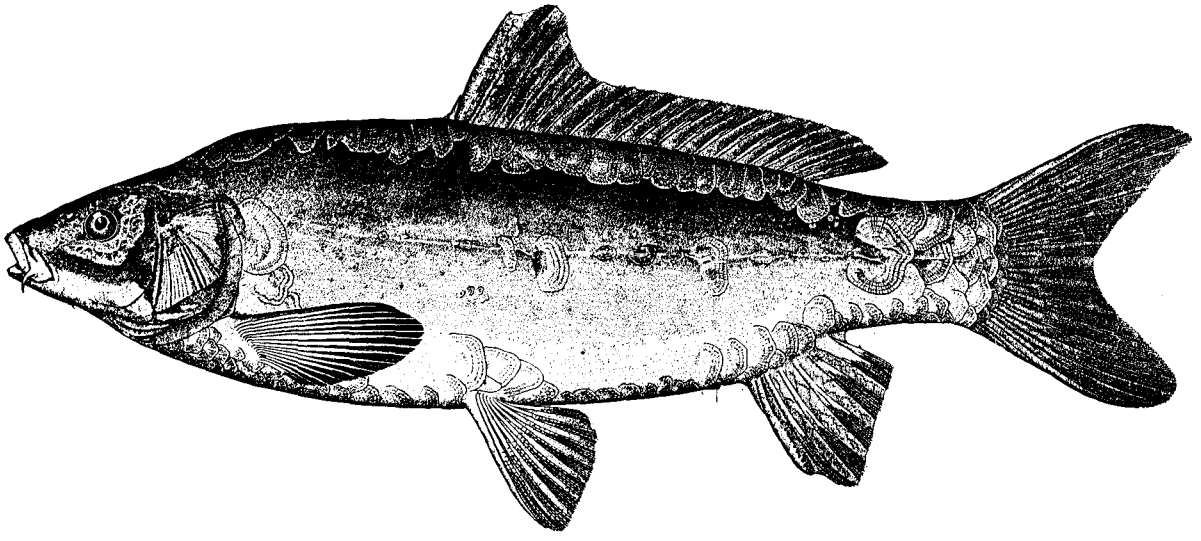
The principal marketing centers for catfish are San Francisco, Sacramento, Stockton, and Portland. The last-named place has the most extensive trade. In proportion to its population, San Francisco receives much fewer catfish than any of the other cities mentioned.

Catfish can not be said to be common in the San Francisco markets. The demand is usually very limited. At times, however, when other fish are scarce, they meet with ready sale at good prices. In 1893 the average daily receipts were less than 150 pounds, and in 1894 under 100 pounds. In no month during those two years did the daily receipts run over 250 pounds on an average, and in July and August, 1894, they were under 30 pounds a day.

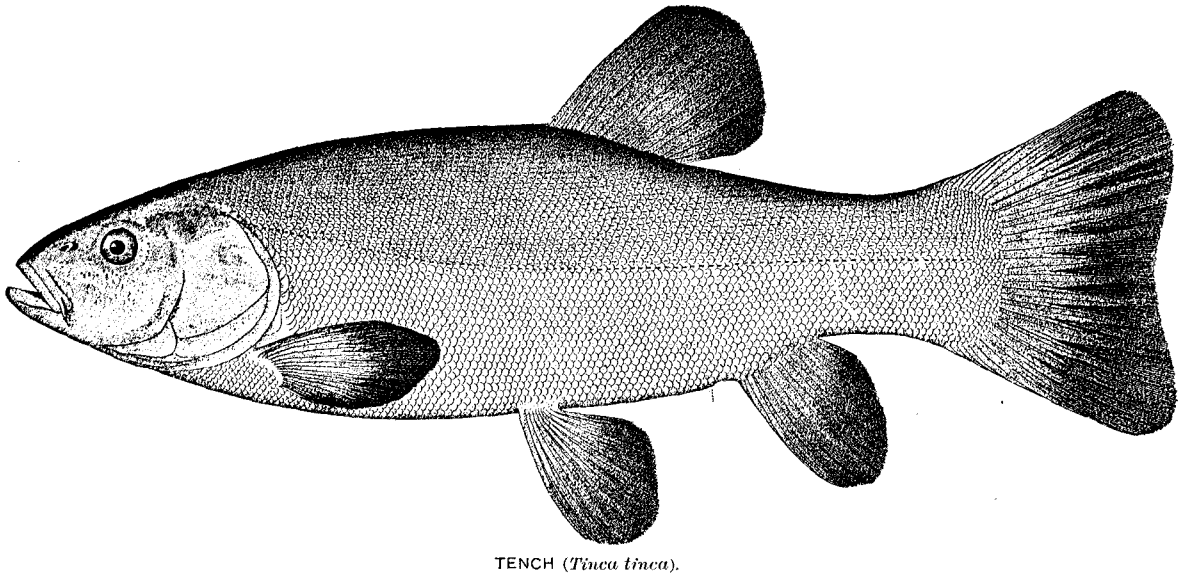
An examination of the books of the San Francisco dealers by the California fish commission and the writer showed that in 1893 the aggregate receipts of catfish were 43,974 pounds, and in 1894 were 31,055 pounds. The decrease in 1894 was due to a marked diminution in the receipts during the last six months of the year, as will appear from the following statement. In 1893 the largest quantities were handled in September, and in 1894 in April.



ASIATIC CARP; SCALE CARP (*Cyprinus carpio*).



GERMAN CARP; LEATHER CARP (*Cyprinus carpio coriaceus*).



TENCH (*Tinca tinca*).

Statement by months of the number of pounds of dressed catfish handled by San Francisco dealers in 1893 and 1894.

Months.	1893.	1894.
January	1,515	4,117
February	2,576	1,096
March	5,408	4,766
April	4,115	5,290
May	3,565	2,978
June	3,035	2,630
July	2,619	695
August	950	357
September	6,400	2,473
October	6,347	2,795
November	4,082	1,526
December	3,362	1,732
Total	43,974	31,055

There is little or no sale for round catfish in San Francisco, and those which reach the dealers in such condition are dressed by them before being exposed for sale. The fish shown in the foregoing table were dressed weights, which represent about two-thirds the original weights. The dressing consists in skinning, eviscerating, and removal of the head.

The price commanded by catfish in the San Francisco market has greatly decreased in the past few years. In 1888 the average price to consumers was 17 cents a pound; in 1889 it was 10 cents; in 1891, 7 cents; in 1892, 6 cents, and in 1893, 4 cents.

There is very little reshipping of catfish by the wholesale fish-dealers. Fully three-fourths of the receipts of catfish in San Francisco are consumed locally, and but few are sent beyond the limits of the State.

The catfish trade of Portland is comparatively large. The quantity of fish handled in 1893 was 75,000 pounds of dressed fish, with a retail value of $3,750 and a cost price of $2,250.

As elsewhere stated, the quantity of catfish handled at Sacramento and Stockton in 1893 was 59,025 pounds and 36,000 pounds, respectively, having about the same retail value per pound as in San Francisco.

THE CARP.

HISTORY OF INTRODUCTION.

The carp (*Cyprinus carpio*) has been planted in all the States of the Pacific and Rocky Mountain regions, and is now one of the most widely distributed fishes. At a comparatively early date the local fish commissioners became impressed with the desirability of planting the carp in the sloughs, bayous, and shallow waters generally, which were either destitute of fish or, to quote the California commissioners, contained only "the worthless and unpalatable fish of the warm waters of the great valleys in the interior of the State." From the outset a very active interest in the cultivation of the carp sprang up in most of the States, and numerous demands for fish for stocking local waters came from farmers and others.

The carp was first imported into California in 1872, when Mr. J. A. Poppe, of Sonoma County, brought five fish from Holstein, Germany, and put them in private

waters. These fish appear to have multiplied rapidly, and it is recorded * that Mr. Poppe did a thriving business in selling their progeny for stocking purposes.

In 1877, in exchange for eggs of the California trout, the California fish commissioners received 88 young carp from Japan; these were retained for breeding purposes.

The United States Fish Commission, in May, 1877, imported carp from Germany, and in 1879 supplied 298 fish to the California commission; 60 of these were placed in Sutterville Lake, near Sacramento, and the remainder in a private pond in Alameda County, where they were at the disposal of the State authorities.

The foregoing lots, aggregating only 394, represent all the carp from outside the State planted in California up to the time the consignment to private applicants was begun by the United States Fish Commission in 1882.

The United States Fish Commission began the distribution of carp to applicants in Idaho, Oregon, and Washington in 1882, and has continued to supply them as requested up to the present time, comparatively large consignments being made in recent years. Most of the original plants were made in private waters, but by the breaking of dams, the overflowing of ponds, and other accidents, the fish have in some localities reached rivers and other public waters.

The carp was introduced in Nevada in 1881, when the State commissioner distributed to applicants some that had been supplied by the United States Fish Commission. In the two subsequent years numerous assignments were made by the national commission, 190 fish being sent to nine applicants in 1882 and 2,285 to more than 100 applicants in 1883. Since that time there have been calls for but few fish for stocking purposes.

GENERAL RESULTS OF CARP PLANTING.

A detailed account of the early results of carp introduction in the Pacific States, based on the testimony of the recipients of fish, is given in an article entitled "Some results of carp culture in the United States," compiled by Charles W. Smiley, and published in the Report of the United States Fish Commission for 1884.

As early as 1879 the carp had become extensively acclimatized in private waters in California and furnished a large amount of food to people living in the interior of the State; this outcome was chiefly due to the distribution from Mr. Poppe's private ponds. In 1880 the commissioners reported that wherever introduced the carp had grown rapidly in size and numbers, and by 1884 they had become so generally and successfully planted in the waters of the State that few calls were made for them, and the commissioners reported that the supply was enormous, the market price at times being only 1½ cents a pound.

The history of the introduction of carp in the open waters of the Columbia basin is not known. It is probable that the fish accidentally gained access to the river by the breaking of dams or the flooding of ponds. It has become exceedingly abundant in the lower Columbia and its tributaries, especially the Willamette River. At The Dalles and Celilo the fish are also very numerous. Recent investigations by the Fish Commission have shown that the fish also inhabits the Snake River as high up as Glenn Ferry. Mr. Barnum reported the fish as abundant at Weiser, and cited its occurrence at Huntington, Ontario, Payette, and other points on the river.

*The introduction and culture of the carp in California. By Robert A. Poppe. Report U. S. Fish Comm. 1878, pp. 661–666. Also Reports California Fish Commission, 1874–75 (p. 12), 1880 (p. 10), and 1893–94 (p. 74).

Carp have become numerous in Clear and Silver lakes, near Spokane, Wash., and are held in considerable esteem.

Marked and immediate results attended the planting of carp in Nevada. In 1884 Mr. Thomas Oliver, who had carp ponds near Carson City, was reported to have thousands of young carp for sale, the progeny of eleven small fish received two years before. The report of the Nevada fish commission for 1889–90 stated that Mr. Oliver's fish had multiplied so rapidly that he produced more than enough to supply his neighbors and the State commission with plants. An earthquake in June, 1887, however, destroyed these flourishing ponds.

Mr. Taft, of Diamond Valley, in 1890, produced fish for the Eureka market and local consumption. The Humboldt River near Winnemucca was said to have an abundance of carp in 1890, some of the fish weighing 5 pounds and upward; they were sold in the Winnemucca markets, and were rather highly esteemed.

In 1881 Hon. Thomas B. Rickey planted some carp in reservoirs and ditches connected with Alkali Lake, in Douglas County. The Nevada fish commission report for 1889–90 stated that the fish had increased beyond all expectations in Alkali Lake, from which many fish had been taken and salted for home use.

ECONOMIC IMPORTANCE, FOOD VALUE, AND INJURIOUS QUALITIES OF CARP.

In the Pacific States, as elsewhere, opinions differ widely as to the edible qualities of the carp, and as to whether the fish is not more injurious than useful. The various views entertained depend to a considerable extent on local conditions and are often based on limited observation and experience. Prejudice and preconceived ideas have also led to the formation of opinions favorable and unfavorable to the fish.

The present feeling toward the carp in California, Oregon, Washington, and Idaho is generally adverse, and seems to represent a reaction from the favorable attitude which prevailed for a number of years after the acclimatization of the carp. The most extravagant statements regarding the food value of the fish were then entertained. We find in some State reports such superlative expressions as "carp are the most delicious fish that swim"; "carp as food-fish have no superior," etc.—which excellence has hardly been claimed even by many who are thoroughly acquainted with and most favorably impressed with the edible qualities of the carp. With this high ideal in mind, it is not surprising that disappointment overtook those who stocked their ponds with these fish.

Outside of the question of its food value, the carp is, in the Pacific States, condemned on a number of other grounds, which will be mentioned.

In reservoirs and lakes, its habit of stirring up the mud and sediment makes the water roily. Reference is elsewhere made to the planting of fry of the predaceous muskellunge in Lake Merced, near San Francisco, in order to secure the destruction of the carp, which were very abundant and constantly kept the water muddy. As this lake was one of the reservoirs for the water supply of San Francisco, the matter had considerable importance. Sea lions were previously placed in this lake for the same purpose. Mr. Babcock writes as follows on this subject:

> Carp have entered the Blue Lakes in Lake County. The Blue Lakes, three in number, were formerly very striking and beautiful bodies of water. A. V. La Mott now tells me that lower Blue Lake is so muddy that its beauty is gone, the carp keeping the water roiled all the time. Lake Merced, property of the Spring Valley Water Company, in the city and county of San Francisco, was so damaged by

carp as to be almost useless to the company. The company employed 4 fishermen by the month to seine the lake, and during that time—some four months—bought 19 good-sized seals [i. e., sea lions] taken near Cliff House. These seals were placed in Lake Merced in 1891, and for a time the company employed men to go over the lake to pick up the pieces of dead carp that were so numerous as to be dangerous to the purity of the water. In the summer of 1895, at the request and expense of the water company, I engaged several Italian fishermen to go to the lake, and under our supervision they used all kinds of drag nets and seines in the lake and were unable to take any carp or any other fish than sticklebacks. The seals have grown very thin. Another effort was made in same manner with like result in fall of 1895. I am of the opinion that there are no carp, big or little, in the lake at this time. The coming season the company will try again for carp, and if none is found the seals will be killed off and large-mouth black bass placed in the lake.

A rather wide-spread opinion prevails that the carp consumes or uproots the wild celery on which wild ducks feed, and "it is reported that these game birds have diminished in numbers of late wherever in this State their feeding-grounds have been invaded by the carp."

Carp are credited with eating other and better food-fishes, but the charge seems almost too trivial to notice. The ingestion of live fish must be very rarely if ever undertaken, and is inconsistent with the anatomy and known habits of the carp.

The habit of eating the spawn of other fish is ascribed to the carp in the Pacific States, as in other parts of the country. From a statement hereafter quoted, it will be seen that by some the scarcity of Sacramento perch in California is attributed to this cause.

The San Francisco *Evening Bulletin* of May 29, 1894, contained the following editorial notice of the carp and catfish under the caption "Where the fish commission went astray." The article may be quoted to illustrate the sentiment entertained by many persons against the carp, and to show the general grounds for that sentiment.

When the fish commission a few years ago undertook to stock the rivers and sloughs of California with catfish and carp, the *Bulletin* deprecated that sort of enterprise. Pains were taken to acquire information from various sources about the value of these species as food-fish, in addition to what was personally known from observation on western rivers. It was found that these fish were relatively of small value, and that this was overbalanced by the injury they would do in decreasing the number of better fish.

The German carp had already been tried in ponds and lakes on private estates. Not a single favorable report could be obtained. The tenor of the reports were that the fish were a nuisance, and that efforts were being made to exterminate them. Ponds and small lakes were drained off, but the fish went into the mud and lived for weeks. When the water was turned on, the fish were as active as ever. They multiplied with amazing rapidity. But nobody seemed to want them, except the few who were still bent on making experiments. These fish have multiplied in the rivers and sloughs until in many places they have become a nuisance. Like the English sparrow on the land, they are beyond extermination, and are everywhere execrated.

Now comes the *Oregonian* and reports that carp have become so plentiful in the sloughs and bays along the Columbia that fishermen have offered to supply farmers with any desired quantity for manure at $5 a ton. The carp are gross feeders, consuming better food-fishes and wild celery and grasses on which wild ducks feed and fatten. It is reported that these game birds have diminished in numbers of late wherever in this State their feeding-grounds have been invaded by carp.

Then the fish commissioners made another unfortunate experiment, against the strongest protests that could be put forth. They introduced the hated and almost worthless catfish to the waters of California. These fish, like the carp, have multiplied rapidly. It was reported, in answer to the protests made at the time, that only a superior kind of catfish would be introduced, against which there could be no valid objection. But they turned out to be the same old toughs that have occupied western rivers and bayous to the exclusion of better fish. These catfish are voracious feeders on young trout and salmon. Their value is so low that very few seek them. The Chinese sell them occasionally, as they do carp, if they can find a customer. But most consumers turn away from these fish in disgust.

The fish commissioners introduced to the waters of California, among some of good quality, two species of what were called edible fish that now have come into the category of nuisances. If every one of these fish could be removed from the water to the land, and there employed as fertilizers, a substantial gain would be made.

Drs. Jordan and Gilbert, in a paper* on the fishes of Clear Lake, California, condemn the carp in severe terms. They say of this fish:

Everywhere very common; burrowing into the mud among the tules or in shallow waters, thus keeping the shoal waters roily all the time. This species is regarded as worthless for food. It destroys the eggs of the Sacramento perch and also devours the *Vallisneria* or water celery, on which the canvasback and other ducks feed. In California this species is a nuisance, without redeeming qualities.

The remarks of these writers on the Sacramento perch and the catfish in this lake are also applicable to the question of the destructiveness of the carp:

Archoplites interruptus (*Perch*). Formerly very common, but now becoming scarcer, as its spawning-grounds are devastated by the carp. The destruction of this valuable fish is one of the most unfortunate results of the ill-advised introduction of the carp into California waters.

Ameiurus nebulosus (*Catfish*). Extremely abundant and destructive to the spawn of other species. It is, however, a fair food-fish and much less objectionable than the carp.

The following statements concerning the destruction of vegetation by carp in California are from a letter from the late Mr. Ramon E. Wilson, secretary of the California fish commission, dated November 12, 1891:

I took advantage of the first opportunity presented, November 3, to visit the duck-shooting preserve of the Tule Shooting Club, located in the heart of what is known as the "Suisun Marshes," lying midway between Benicia and Suisun. These marshes for twenty years have been famous for duck shooting, and for the past ten years have been preserved by five clubs. Each of these clubs has, from year to year, supplemented the natural and indigenous growth of vegetation by planting non-indigenous seeds and grasses, until about two years ago the ponds, ditches, and sloughs had so grown up with vegetable matter that upon the opening of the season it was almost impossible to push a boat through the dense growth. Last year, the season of 1890, it was discovered that a marked change had taken place. The cause was attributed to the winter, which was a rather severe one, in that there were many overflows and freshets occasioned by heavy storms. This year the change in the respect mentioned was much greater. It was early reported in the spring that there was very little sign of vegetable growth in any of the ponds. Investigation followed, and it was found that fish in large numbers, ranging from a few inches in length to 15 pounds in weight, had invaded the grounds and taken entire possession of all the waters. These fish came, say, in May and remained until about the latter part of July—that is, the bulk, but many remained later. We are convinced that these great numbers came to spawn. About August, this great school, if you can so call it, suddenly disappeared—that is, the larger ones and the majority of the whole. Their going was not unlike the grasshopper in effect on vegetation—not a sign or remnant left. The result is that to-day, where these same ponds have heretofore afforded unlimited food supply for surface-feeding ducks in the early part of the season and a like supply of celery bulbs for the canvasbacks and redheads for the balance of the season, there is absolutely not a single sign of vegetation. At the time mentioned I carefully examined the beds of the ponds and found them positively barren of vegetable matter. Notwithstanding the emigration, if it can be so called, of the larger fish, the waters are still alive with the same fish, ranging from 2 to 8 inches in length. These ponds, heretofore quite clear, are now nothing more than mud holes. That this fish burrows in the mud there is no question. The beds of the waters are not unlike a sieve in appearance, with holes, round in form, ranging from one-half inch to 3 inches in diameter. The banks of the ponds and sloughs are quite like the bottoms. The fish have burrowed to the depth of a foot in many places, and it can be readily seen that it has been done for the purpose of getting at the roots of the vegetable growth.

Following out your suggestion, I secured three of the largest specimens of the fish. I caught

* Bulletin U. S. Fish Commission, 1894, p. 141.

them myself in one of the ponds. I should say each weighed three-fourths of a pound. I sent them to Dr. Jordan, wrote to him my experience, and am now in receipt of his reply. I quote:

"The three specimens mentioned in your letter have been received. They are, of course, the ordinary carp (*Cyprinus carpio*). I will have them opened to see if, perchance, the contents of their stomachs may throw any light on the question at issue. I should think there would be little doubt that the carp might destroy the water celery and so interfere with the food of ducks."

What I have said, as the result of my own observation, is true from evidence, by way of correspondence, which has accumulated in my office, and applies to all the marshes on the Sacramento and San Joaquin rivers for a distance of quite 100 miles. The irrigating ditches throughout the San Joaquin Valley are full of these fish, and it is no "fish story" to say that they burrow into the banks and make breaks in the levees.

The carp is very unpopular in the upper Columbia, at The Dalles and Celilo, on account of its supposed destructiveness to salmon spawn. It is used to some extent by the German families of that section and also in the fishing-camps, but the consumption is light. At Umatilla and Arlington complaints are also made of the carp.

At Huntington, on the Snake River, Oregon, some carp are caught which find a sale among the farmers of the neighborhood. Along the same river, at Payette and Ontario, some favorable mention of the carp as a food-fish is made, but the sentiment of the people is generally against it and the fish has no economic value.

At Spokane, carp are sold in limited quantities to German families at 3 to 3½ cents a pound.

Mr. Wilcox reports that carp are found constantly in the Portland market, although the abundance of the fish is such that at times it can not be sold at any price.

Mr. James Crawford, fish commissioner of Washington, reports that carp and catfish have recently begun to be recognized as of some importance as food-fishes in that State, and that in 1892 at least $2,000 worth of these fish were disposed of in local markets and in inland towns along the Union Pacific and Northern Pacific railroads.

Without desiring to ignore any injurious qualities the carp may possess, the opinion may be ventured that the fish is credited with doing much harm that it may not be responsible for, and that the evidence on which the carp is so severely condemned is, in the Western States, as elsewhere, wholly insufficient at present, whatever may be the result of an impartial investigation of the matter.

In the November 5, 1891, issue of *Forest and Stream* is the following editorial reference to carp in California:

Nearly two decades ago, and five years before the United States imported the fish from Germany, Mr. J. A. Poppe placed five small carp in one of his ponds at Sonoma, Cal. Nine months later (May, 1873) his stock had grown to 16 inches in length, and 3,000 young fish were obtained from the first breeding. The fish were sold to farmers throughout the State, and some were shipped to Central America and the Sandwich Islands. The increase of the species, especially in the marsh or "tule" lands, was remarkable, and the demand continued steady. Now a reaction appears to have set in, and a most unjustifiable style and amount of abuse is being heaped upon a really valuable food-fish, which has also long held a worthy place among the anglers' favorites in countries wherein it was best known. The qualities which led to the action of the Government in behalf of carp acclimation were the following:

(1) Fecundity and adaptability to the processes of artificial propagation.

(2) Living largely on a vegetable diet.

(3) Hardiness in all stages of growth.

(4) Adaptability to conditions unfavorable to any equally palatable American fish and to very varied climates.

(5) Rapid growth.

(6) Harmlessness in its relations to other fishes.

(7) Ability to populate waters to their greatest extent.

(8) Good table qualities.

These properties still exist and no amount of unreasoning prejudice can alter or reduce them. When we are told that the carp is a kind of sucker and "sucks the roots out of the banks of the ditches, causing the banks to wash out," we are bound to reply that California is noted for the variety and size of its suckers, but the carp is not one of them. The habit referred to is not observed in the carp, and the real culprit must be sought in some other direction. It is gravely asserted also that the food of the ducks and other wild fowl is consumed by the carp and the game birds are deserting the marshes in consequence. Again, it is charged that the salmon and trout waters are being invaded and the eggs devoured on the spawning beds. Carp in water having a summer temperature of 54° would be about as untimely as oranges on the tundra at Point Barrow. We shall next hear that the carp has utterly destroyed the salmon industry of Alaska and driven the seals out of Bering Sea. As a matter of fact, California has many native fishes of the carp or minnow family, some of which swarm in the irrigating ditches, while others inhabit trout waters, and certain of these are known to be very destructive of eggs. In the Pit and McCloud, for example, may be found a large species of *Ptychochilus,* known as the Sacramento "pike," which is really a giant minnow, growing to a length of 5 feet. This, or something like it, is probably the fish for whose sins the carp is now suffering in the estimation of many good people of California. Before passing final judgment on the subject, send some of the cold-water carp and the burrowing nuisance to some one who knows the fishes of the State for identification. Dr. Jordan, at the Leland Stanford Junior University, will settle all doubts for you, and *Forest and Stream* will take pleasure in aiding investigations of any sort into the habits of fishes.

In a letter dated September 25, 1891, Mr. Ramon E. Wilson, at that time secretary of the California fish commission, called the attention of the United States Fish Commissioner to the fact that carp had been taken at the McCloud River station of the United States Fish Commission, and that Pitt River and Squaw Creek, in the vicinity, were swarming with the fish. Mr. Wilson expressed the fear that this raid of carp in the upper waters of the most important salmon river of the State, the Sacramento, was a serious matter. In reply, the United States Fish Commissioner stated that it did not seem possible that the carp could injure the salmon, whose spawning beds are located in the cold upper portions of the streams, and that it would be contrary to all experience to find carp thriving in such situations. The Commissioner suggested that the fish reported in such numbers in the Pitt River might not all be carp, but some other members of the carp family, such as *Orthodon, Lavinia, Pogonichthys, Mylocheilus, Ptychocheilus,* etc.

In attributing to the carp the scarcity of canvasback and other ducks in a given region, there should be proof that the carp does and other fish do not eat and uproot large quantities of *Vallisneria;* and the influence of market hunters and indiscriminate killing by sportsmen must not be overlooked. The scarcity of canvasback ducks in most streams probably antedates the advent of the carp in noteworthy numbers, and, as in the Potomac, was coincident with spring shooting and with the activity of pot-hunters using swivel guns. Mr. John P. Babcock, chief deputy of the California fish commission, states that he thinks ducks in that State have changed their feeding-grounds; miles of lands in the San Joaquin Valley are now covered with ditches and miles of alfalfa now grow where a few years ago there was a desert; and the main market supply of ducks comes from that region instead of the Suisun Marshes. He thinks, however, that the carp have proved very objectionable in this region, and in a letter communicates his observations, as follows:

The carp have destroyed almost all the wild celery of the lower Sacramento and Suisun Marshes. They reach all the ponds during high water, and, as soon as celery comes up, they eat the shoots, and, in many of the best ponds on the shooting preserves, have taken roots and all of the celery. They have not destroyed the tule grass to any noticeable extent, if at all. The damage has been to the

better grasses. Many of the clubs planted wild celery in 1891, 1892, and 1893, but the carp destroyed it all, and it is claimed by observing men that the celery is entirely destroyed. The clubs resort every season to baiting their ponds with grain, and in these ponds the carp move in droves that W. P. Whittier tells me look like a tidal wave, as they move from one side to the other.

The following observations on the food and the feeding-habits of the carp have been furnished by Dr. Rudolph Hessel, who superintended the first importation of German carp by the Government in 1877, and the foremost authority in the United States on carp-culture. Dr. Hessel's remarks were prompted by the letter of Mr. Wilson previously quoted, an extract from which was submitted for an expression of opinion.

In connection with an extract from a letter of Mr. Ramon E. Wilson, California fish commission, relating to the suspected destruction of wild celery and other vegetation in the Suisun Marshes in the vicinity of San Francisco, Cal., by the carp, I will give you my observations, extending over a period of many years, regarding the habits of the carp (if I may be allowed to so term its mode of living, and the likes and dislikes of that fish), cautioning you, however, not to regard such observations as authority.

It is true that I have paid a great deal of attention to the habits of the carp in Europe and in our eastern waters, but I am not familiar with the waters of the Pacific Coast, and, for this reason, my conclusions should not be taken as final.

It is well known that the carp is not very particular as to its food. It feasts upon animal as well as upon vegetable food. It seems to be an established fact, however, that animal food is preferred, hence their persistent hunt in the mud and about the roots of water plants for worms, crustacea, and larvæ. At the earliest stages of its existence, from a few weeks to a few months old, the young carp can be seen scrutinizing water grasses and the under parts of floating leaves, etc., for diminutive and almost microscopic animals for feeding purposes. Later on they do not despise larger animal substances in the rivers; but where there is a perceptible scarcity of that kind of food in rivers and stagnant waters, they ascend into tributaries, creeks, and bayous, ostensibly going for vegetable food, in reality, however, delving, digging, burrowing, and hunting in the mud and about the roots of the water vegetation for animal food, as indicated above. No one need, therefore, be surprised if at such vigorous exertions of the carp the growth of vegetation generally will not be promoted and the water will not become any clearer. Many a plant will thus be uprooted, rise to the surface, and perish, and this may have been the case with the celery plants in the Suisun Marshes, too, to a certain extent.

The carp is very numerous and prolific in the Potomac River. There are specimens from 20 to 30 pounds, but that they go for the water celery has not been noticed here as yet. Water celery grows in abundance in places where the river flows slowly, especially about the so-called flats, but any injury to its growth, or a reduction of its density, not to speak of its total destruction, has not been heard of, as far as I know, with two exceptions only, not attributable, however, to the carp, but to high water in the spring of 1882 and 1889, when every kind of vegetation was swept away by the floods, and consequently water celery disappeared from the river during the two years subsequent to those freshets.

I must not forget to call your attention to the fact that turtles, too, are not averse to a meal of water celery. Frequently I have seen "red-bellies" and "yellow-bellies" feasting in the dense growth of Potomac celery upon that plant. Another point: For years I have kept quite a number of these species of turtles for ornamental purposes in a small pond about this station and fed them with water celery taken fresh from two ponds stocked with a great number of old and young carp, which never touched the celery, though it must be admitted that they did loosen the roots in their hunt for animal food.

In conclusion, I reiterate that I am not familiar with the fauna of the Suisun Marshes, but my impression is that, upon closer investigation, there may perhaps be found additional causes for the disappearance of the water celery and other vegetation therein, besides the undeservedly much-abused carp.

The carp may be very destructive to the spawn of certain fishes; this is probably the most serious charge that can be lodged against it. At the same time, no examinations, by competent persons, of the stomach contents of carp appear to have been made in the Pacific States or elsewhere. Even if it should be demonstrated that the carp consumes large quantities of fish spawn, it would not differ in this respect from a host of native species whose shortcomings in this respect are usually overlooked. If

we condemn the carp for this pernicious propensity, without conclusive evidence, what are we to do with the basses, trouts, salmons, sturgeons, and the entire sucker and catfish tribes, with known spawn-eating tendencies? There can be no question that in the waters of the Pacific States the large indigenous representatives of the carp family—the Sacramento pike (*Ptychocheilus*) and the squawfish or Columbia River chub (*Mylocheilus*)—are immeasurably more destructive to spawn than the carp. They are notorious spawn-eaters; the most attractive bait with which to catch them is fish spawn; and on the spawning-grounds of salmon and trout, where the character of the water is not adapted to the carp and where it is either entirely absent or quite uncommon, these fish are almost always present in large numbers and are known to subsist largely on the ova of salmonoid fishes.

Considering the question of the relation between the carp and the scarcity of the perch in California, attention is directed to the report of the board of State fish commissioners for 1883–84, in which the decrease in the abundance of the perch is commented on and other factors than the carp assigned as the cause of the scarcity. The beginning of the scarcity of Sacramento perch dates from 1881 or 1882, and was probably antecedent to the general abundance of carp in public waters. The remarks of the fish commissioners in the report cited are as follows:

> In former years this fish was very plentiful, but has become very scarce in the last few years, owing to several causes, viz:
>
> (1) We believe the greatest cause of disappearance is due to the reclamation of our tule lands by closing the sloughs, whereby ingress and egress are stopped, causing them to deposit their spawn in the rivers, and the spawn is lost by being covered with sediment.
>
> (2) By a continual drain upon the supply by Chinese and other fishermen, who are ever on the alert to find their hiding-places.

Many people in California think catfish are to blame for the scarcity of Sacramento perch. Reference to this matter is made in the remarks on the catfish.

The fact that carp uniformly command a higher price in the principal markets of the country than do many fish with well-established reputations as good food-fishes should prevent the reiteration of the statement that the carp is of no value as food. The additional facts that in the United States the carp has greater money value and is consumed in larger quantities than any other fish taken from private waters should be conclusive evidence of its food value and economic status.

A great deal more has been expected of the carp than has ever been claimed by those whose experience entitle them to speak on the subject. In the United States, which is so bountifully provided with salt-water and fresh-water food-fishes, the chief utility of the carp lies in its adaptability to cultivation in natural and artificial waters in the lowlands and plains which are either destitute of food-fish or contain species inferior to the carp in size or edible qualities. Throughout the Western States there are closed waters, containing few or no desirable fish, in which the carp is susceptible of successful cultivation and is the equal in food value of any of the fish which are found in the same situations. It is to the stocking of such waters that the carp is eminently adapted, and it is thus being utilized by thousands of families in which it is the chief if not the only available food-fish.

The carp is preeminently a pond fish, and when reared in ponds or similarly closed waters it will have food qualities, the degree of excellence of which will depend on the character of the water. Discrimination in the planting of carp should entirely obviate any necessity for considering the injurious qualities of the fish, except as a precautionary measure.

The "Abstract of the Eleventh Census," in a table showing the extent of carp-culture in the United States in the decade ending in 1890, gives the following data for the States of California, Oregon, Washington, Nevada, Idaho, and Utah:

Number of carp-culturists	1,006
Number of ponds and other bodies of water in which carp were planted	1,241
Number of carp planted	101,617
Value of carp sold or used from private waters	$15,324

The field inquiries conducted by the Fish Commission through Mr. W. A. Wilcox showed that the sales of carp by the fishermen increased annually from 1889 to 1892. Figures drawn from the books of the San Francisco dealers for the years 1893 and 1894 indicate a continuation of the increase, the aggregate receipts in the latter year being about 20 per cent larger than in 1893. Following is a statement of the quantity and value of the carp taken for market in the Sacramento and San Joaquin rivers during a series of four years, as determined by Mr. Wilcox:

Years.	Pounds.	Value.
1889	51,214	$1,734
1890	58,113	1,974
1891	59,618	2,016
1892	65,662	2,191
Total	234,607	7,915

The foregoing fish were taken with seines and fyke nets. The average gross price received by the fishermen was a little over 3 cents a pound each year. In addition to these fish, large quantities are known to be taken for local sale and home consumption in counties remote from the coast, for which no statistics are available.

San Francisco is naturally the principal market for carp on the Pacific Coast. An examination of the records of the wholesale fish-dealers of that city by the writer and the California fish commission showed the receipts to have been 35,653 pounds in 1893 and 42,580 pounds in 1894. The largest quantity handled in any one month was 10,142 pounds in January, 1894. The figures for each month in the years named are given in the following table. In addition to these, many thousand pounds of carp are handled by the Chinese dealers, of which no accounts can be obtained. The catch of the Chinese fishermen can not be ascertained, owing to their suspicious disposition and their failure to keep any records. Mr. Babcock states that large quantities of carp are offered for sale in the Chinese markets every morning. It is likely that their aggregate trade in this fish is larger than that of all the other dealers.

Statement by months of the number of pounds of carp handled by San Francisco dealers in 1893 and 1894.

Months.	1893.	1894.
January	784	10,142
February	709	4,755
March	4,936	6,798
April	3,191	2,839
May	660	767
June	1,589	699
July	4,650	729
August	1,725	383
September	1,531	4,396
October	3,982	4,960
November	6,319	4,461
December	5,577	1,642
Total	35,653	42,580

The average retail price received by the San Francisco dealers for carp during the past few years has been about 4 cents a pound. The average weight of those exposed for sale in the city markets is 5 pounds. The largest seen by Mr. Paladini, one of the oldest dealers, weighed 30 pounds, while Mr. Cuneo, of the American Union Fish Company, has handled a fish whose weight was 33 pounds.

In discussing the striped bass, reference is made to the observations of Mr. Alexander, which showed that in the Sacramento and San Joaquin Rivers the carp constitute the principal food of the bass. Further investigation will doubtless indicate that a number of other fishes (black bass, steelhead, and Sacramento perch, for instance) also subsist, in part at least, on carp.

THE TENCH.

The tench (*Tinca tinca*) is a fish of the carp family native to Europe. It has been somewhat extensively planted in the United States by the national fish commission. In foreign countries it reaches a maximum weight of 12 pounds. The fish is covered with very fine scales and is shapely and handsome. Its habits are very much like those of the carp. The flesh is firm and white, and is considered very palatable. In 1895 a number of shipments of yearling tench were made to the Pacific States; 50 fish were placed in Older Springs, Washington County, Oreg.; 400 were put in Fourth of July Lake, Fetz Lake, and a pond in Spokane County, Wash., and 758 in Diamond Lake, a lake and a pond in Kootenai County, and a pond in Latah County, Idaho, the first-named lake receiving 500 fish. In February, 1885, 20 tench were sent to a private applicant in Virginia City, Nevada.

THE GOLDFISH.

The goldfish (*Carassius auratus*) is an ornamental fish, without value as food. Numerous plants have been made by the United States Fish Commission in private waters in the Pacific States, and the fish has, in some instances, probably escaped into lakes or larger streams and there become acclimatized. It readily interbreeds with the carp, to which family it belongs.

THE AWA.

In the report of the California fish commission for 1876–77 the following reference is made to the introduction of the Hawaiian awa (*Chanos cyprinella*) in California waters. No further mention is made of the fish in the State reports, and there is no record of their survival or capture:

> In exchange for some salmon and trout eggs, sent to the Hawaiian Islands, we received in July last nearly 100 fish called "awa." These we placed in a small stream at Bridgeport, in Solano County, where they could have free access to brackish and salt water. They are said to be the most valuable food-fish of the Hawaiian Islands, of fine flavor, and thrive in fresh, brackish, and salt water. Where they have access to salt water they grow to weigh an average of 5 pounds. We have reason to believe they will find congenial homes and grow and multiply in the waters of this State.

THE SHAD.

HISTORY OF EXPERIMENTS IN CALIFORNIA.

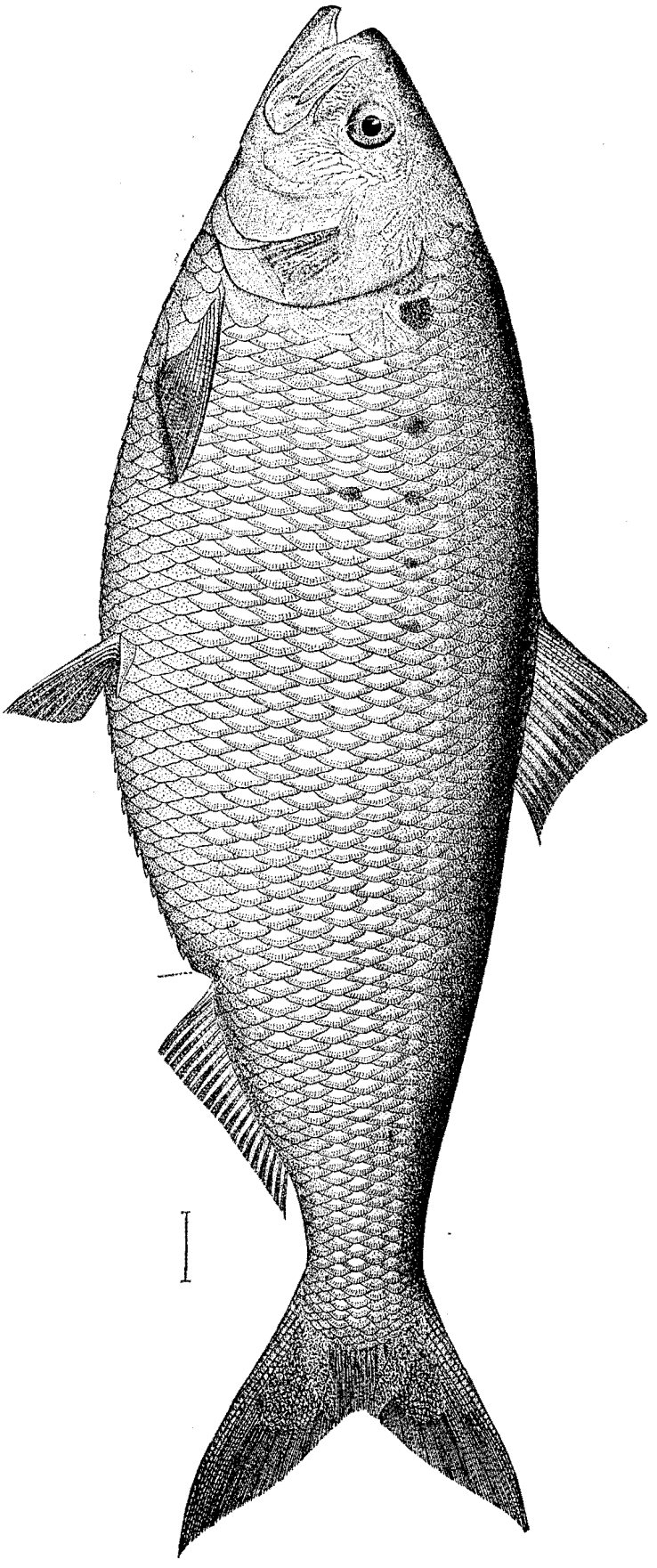
The shad (*Clupea sapidissima*) was first introduced into the waters of the Pacific Coast in 1871. The feat of transporting the fry across the continent was at the time considered so remarkable and has had such a prominent influence on fish transportation that the original accounts of the experiment, as contained in the reports of the California fish commission for 1870–71 and the New York fish commission for 1871, may with propriety be quoted at some length. The possibility and the desirability of introducing the fish into the rivers of the west coast appear to have been first suggested by the California fish commission, as may be seen from the following extract from their report:

Your commissioners made arrangements with Mr. Seth Green, the noted pisciculturist of Rochester, N. Y., for the importation of a lot of young shad to be turned into the Sacramento River. No shad proper (*Alosa præstabilis*) are found in the rivers of the Pacific Coast, while there are found several varieties of the same family, such as herring, anchovies, and sardines. As shad readily enter rivers while muddy from the spring freshets, and spawn in waters of a temperature as high as 65°, there was reason to hope that if the shad could be brought here alive and turned into the river they would find suitable food, and in time go to the ocean and return to propagate their species. As the shad is very prolific, each full-grown female yielding from 50,000 to 80,000 eggs, and as the flesh is esteemed to be nutritious and valuable food, it was deemed proper to make the first experiment of importing new varieties with the young of this fish. The eggs of the shad are hatched in from two to four days after they are spawned; therefore, if there were no other reason, time alone would prevent the importation of the eggs.

Mr. Green felt so much doubt as to the possibility of transporting the young fish for so great a distance that he determined to superintend the experiment in person. He left Rochester, N. Y., with an assistant, on the 20th of June, with 15,000 of the young fish just hatched, contained in eight tin cans holding about 12 gallons of water each. The water had to be changed at every convenient opportunity, as on a part of the journey the weather was quite warm. Constant attention had to be given to prevent the water in the cans from reaching a higher temperature than 80°. At Chicago he lost a few fish from a film of oil from the machinery of the waterworks with which the water attempted to be used was covered. At Omaha the river water killed a few. The cause of this he had not time to investigate. The water of Bear River (discharging into Salt Lake) and the waters of the Humboldt and Truckee rivers were found to agree with them and contained plenty of food.

Mr. Green arrived on the 27th of June. As it was advisable to put the young fish in the river at as high a point as practicable, for the reason that the instinct of the shad is, like that of the salmon, to return to spawn at the same place where it was hatched, they were the same day transferred to the cars of the California and Oregon Railroad and taken to the Sacramento River at Tehama. Here the temperature of the water was found to be 60° F. Upon dipping up the river water in a glass and pouring a lot of the young fish into it they were found to be lively and the water to contain large quantities of some minute substance on which they fed. All the conditions being favorable, they were turned loose in their new home.

It is expected they will remain in this river until about January, by which time they will be 3 or 4 inches long. They will then go to the ocean to return the next year weighing from a pound to a pound and a half, ready to commence the increase of their kind. Thus far the experiment has been a success. The water of the river is adapted to them. It contains the proper kind of food for their young, and the waters of our coast are filled with the sand flea, a small species of the shrimp, on which the fish feed after reaching the salt water. The only thing to be feared is that there may be in the ocean some kind of a fish which may so completely exterminate them that none will be left to come back and spawn. If, after one or two years, even one shad is taken in the river the result will be satisfactory, as it will demonstrate the fact that all the conditions are favorable to their successful



SHAD (*Clupea sapidissima*).

propagation in the waters of our rivers. We could then, at a trifling expense, fill our waters with this valuable fish. When first hatched and in a condition proper to be transported, one freight car would bring over 2,000,000 of them. If, after two years, none should be taken, it would not then be well to abandon the experiment.

Mr. Seth Green's account of his trip across the continent with the young shad, and his opinion of the success of the experiment, are as follows:

On the 19th of June, 1871, I started, at 6 a. m., from Mull's fishery, 10 miles below Albany, on the Hudson River, with 12,000 young shad in four 8-gallon milk cans. They had been hatched the night before at the establishment under charge of the New York commissioners. I arrived at Rochester at 10 p. m. and changed the water, substituting that from the Genesee River without injury to the fish. I arrived at Cleveland at 7.45 next morning, put 200 shad in Lake Erie, and changed the water again. The fish were then fresh and lively, without any signs of sickness. I again changed water at Toledo, and when I arrived at Chicago, at 7 p. m., the fish were still in good order. Here I first tried the water from the city waterworks, but found there was too much oil in it, so I went to the lake. Having tested the water and found that it would answer, I put 200 fish in Lake Michigan, and on June 21 started with cans newly filled, at 10.45 a. m., for California. I carried an extra can of water, for before me was a long stretch of almost arid land. Still I was fortunate enough to find some places between Chicago and Omaha where I could get a few pails of water and make a partial change. The fish were still in good order when we arrived at Omaha, but there I could not find any water in which they would live five minutes. The way I tested the water was by filling a tumbler and putting a few fish in it. It was easy to tell at once, by the behavior of the fry, whether the water agreed with them or not. I did not get a full change until I reached Laramie River. From Omaha I did not find any good water for 400 miles, and the only way I kept my charges alive was by drawing the water out of the cans into pails and pouring it from one pail to another until purified, this process being assisted by my getting a little ice water from the car tanks.

June 22.—Bad water all day, with the thermometer 100° in the shade from 9 a. m. to 4 p. m. I used ice water the entire day, a very little at a time, and had hard work to keep the temperature of the water below 82°. I began to feel blue and doubtful of the result. The fish suffered considerably, but the weather began to get cold toward night, and I got the temperature of the water down to 75° at 9 p. m., the fish recovering somewhat.

June 23.—I arrived at Laramie River at 5 p. m., and got a good change of water, fish doing well, and I began once more to feel hopeful and encouraged. We had a frost that night, and next morning, at 7, I changed water at Green River, where it was in proper condition. At 2 p. m. I got another change from a stream in which there were trout, and again at Ogden, where I put 200 fish in the river.

June 25.—The water was changed at the Humboldt River. The water was good and continued good all the rest of the way.

June 26.—I arrived at Sacramento, and took the fish up the river 275 miles from Sacramento, in company with Messrs. Redding and Smith, the California fishery commissioners. In their presence I deposited the fish in the Sacramento River the same night at 10 p. m. There were about 10,000, in good order.

On the sixth and seventh days out they began to be very busy, looking for food. Whenever I changed the water, they would clean up all the food there was in five minutes. They did not suffer for food as long as the sac lasted on their bellies—that is, for about five days—then they needed sustenance. If I could get a change of water often enough from running streams, I could carry them a long way, as nearly all streams are filled with small insects. With this view I examined the water of the Sacramento where I put them in, and found plenty of food for the young fry. I then went down to the Pacific Ocean, and ascertained that there were plenty of sand fleas, which are the principal food that the old shad live on in the Atlantic.

And now, in conclusion, I can only say, that if they do not have shad in the Pacific Ocean there will be but one cause—the roily water caused by washing the mountains down for gold. However, I think the fish will get through all right. I examined the river where it looked so roily, and found it quite clear on the surface for a few inches down. The tendency of the roil was to settle to the bottom. The young shad will find the clear water, and if it does not get very much worse than it was when I was there, they will succeed. But if these do not, more must be sent, for any amount of young fish can be taken to California by making the proper preparations beforehand.

The second plant of shad in the waters of California was made in 1873. In June of that year, Mr. Livingston Stone, of the United States Fish Commission, had started for California in a specially equipped car containing shad fry, together with a large number of young fishes of several other species. He had gotten as far as Nebraska, when his entire stock was lost and his car destroyed by the collapse of a railroad bridge over the Elkhorn River. On hearing of the disaster, the California fish commission telegraphed Mr. Stone to return to the Hudson River and secure another lot of shad. He obtained 40,000 fry from the New York State hatchery at Castleton, and transported them to the Pacific Coast at the expense of the United States Fish Commission. On July 2, 1873, 35,000 healthy fry were placed in the Sacramento River, near Tehama.

All the subsequent plants of shad in California waters were made directly by the United States Fish Commission, the place of deposit being the Sacramento River, at Tehama. Between 1876 and 1880, inclusive, 574,000 fry were planted, as follows: 99,000 in 1876, 110,000 in 1877, 150,000 in 1878, and 215,000 in 1880. Since 1880 no shad fry have been introduced into the State.

The total number of young shad planted in the Sacramento River was 619,000

STOCKING OF THE COLUMBIA RIVER BASIN WITH SHAD.

The first attempt to introduce shad into the waters of the northern part of the west coast was made by the United States Fish Commission in 1885, when a consignment of 900,000 fry, destined for the rivers of Washington tributary to Puget Sound, was sent out in a special car. By the washing away of a railroad bridge, so much time was expended that nearly the entire consignment was lost, and the original intention to go to the Puget Sound region was abandoned. Of the 60,000 fry that survived, 50,000 were planted in the Willamette River, at Portland, Oreg., and 10,000 in the Snake River, near its junction with the Columbia, at Ainsworth, Wash.

The following year, efforts to stock the Columbia River were continued. To guard against loss incident to delays en route, eggs as well as fry were placed on the car, which left Havre de Grace, Md., May 9, with 1,000,000 young shad, 200,000 eggs on trays, and 385,000 eggs in jars. The eggs on trays were all lost in transit and 50 per cent of the fry perished, while of the eggs in jars less than 10 per cent were lost. At Albany, Oreg., on the Willamette River, 550,000 fry were planted, and at Wallula Junction, Wash., on the Columbia River, 300,000 more deposited.

The aggregate plants of shad fry in the Columbia basin in 1885 and 1886 were 910,000. No additional shipments to that region have since been made.

INTRODUCTION OF SHAD INTO COLORADO RIVER.

In 1884, 1885, and 1886, relatively large plants of shad were made by the United States Fish Commission in the Colorado River with a view to ascertain whether the waters of that stream and its tributaries are suitable for the existence and multiplication of that fish. The reasons for expecting satisfactory results from the stocking of this river are thus stated in the report of the Commissioner for 1885:

(1) The Colorado is free from alkaline salts and of a suitable spring and summer temperature; the other physical conditions are also favorable.

(2) The Colorado empties into the Gulf of California, which extends south for 700 miles before reaching the ocean, and it is thought that the warm waters of the lower part of the gulf would be a barrier to keep the shad from being lost in the Pacific. The shad then would return to the Colorado and Gila to spawn.

The plants aggregated 2,651,000, of which 953,000 were deposited in 1884, 848,000 in 1885, and 850,000 in 1886. These fish were all planted at The Needles, in Arizona. These experiments were considered sufficiently extensive to test the adaptability of the river, and no further plants were contemplated.

It was expected that by 1887 or 1888 the results of the experiment would be known. Information has never reached the Commission, however, that adult shad have been taken in any of the tributaries of the Gulf of California, although, in the absence of special efforts with suitable apparatus, the outcome of the experiment should not necessarily, for the present, be regarded as a failure.

SHAD PLANTED IN UTAH AND IDAHO.

In 1873, while en route to California with a consignment of young shad, Mr. Livingston Stone left 5,000 fry at Ogden, to be placed in Great Salt Lake basin. The fish were deposited in the Jordan River, a few miles above its outlet in Great Salt Lake. In 1887, 984,000 more young shad were placed in the Jordan River. A plant of 1,925,000 fry was made in Utah Lake in the next year. Deposits aggregating 2,265,450 fish were made in the Weber River at Ogden, Bear River at Montpelier, Idaho, and Bear Lake, Utah and Idaho, in 1891. In 1892, 1,998,000 fry were placed in the Bear River at Cache Junction, Utah.

GENERAL RESULTS IN CALIFORNIA, OREGON, WASHINGTON, AND UTAH.

In order to insure protection to the shad in the event of the survival of the fry and the return of the mature fish, the California legislature enacted a law prohibiting, under a heavy penalty, the taking of shad prior to the year 1877. The existence of this law, which was of course entirely proper, made it difficult, if not impossible, to determine with satisfactory accuracy just when the results of the experiment were first manifested. From what can now be learned, mature shad first appeared in the waters of California in 1873. It appears that May 10, 1873, the California fish commissioners paid $50 as a reward for the first shad taken, and in their report of 1872–73 they state that while grown shad were not due in the rivers until 1874, they had, nevertheless, had three specimens in their hands and had heard of the capture of two others.

In a letter to Professor Baird, dated April 30, 1874 (published in *Forest and Stream* May 21, 1874), Mr. S. R. Throckmorton stated:

> The first shad taken on this coast, as verified by my own observation, was caught in a trap in Linsoon Bay, a branch of the harbor of San Francisco, about the 1st day of April, 1873. I purchased the fish and placed it in alcohol and presented it to the Academy of Sciences of the State of California. It is a male fish, 1 year 9 months and 20 days old, is 17 inches in length, and 3 pounds in weight. Two other shad were taken in the same locality during the summer of 1873—male fish and smaller in size.

In 1874 and 1875 sixteen full-grown shad were reported to have been taken at Vallejo and in the Sacramento River; the fish commissioners also learned of others taken in the same years.

The increase of shad in the waters of California has been uninterrupted and rapid since the first capture of the grown fish. The following important references to the appearance of shad in the Sacramento River and elsewhere in 1877 are from the report of the California fish commission for 1876–77:

> Shad, in their season, are becoming quite numerous in the Sacramento River. The experiment of their importation to this coast has resulted satisfactorily. The river is of proper temperature and furnishes an abundance of food for young fish before they go to the ocean. There can be no doubt

that the first shad brought from the Hudson River in 1871 have been to the ocean, returned, and spawned. No shad were placed in the river during the years 1874 and 1875, yet shad two years old were quite numerous this year, and they must have been the product of the first importation. It may be safely asserted that we now have shad born in the Sacramento. As it is illegal to take this fish prior to December of this year, probably there has been no systematic fishing for them, yet numbers have been accidentally caught in traps and nets; probably not less than 1,000 were thus taken during the winter and spring of 1877. They return from the ocean at an earlier season of the year than in the northern Atlantic States, in this respect corresponding to the periods when they return to the rivers of South Carolina and Georgia. The first reported this year were taken in Sonoma Creek, January 6; the latest two at Sacramento, June 20. These latter were full-grown fish, a male and a female, on their return to the ocean after having visited their spawning-grounds. * * * We are frequently urged to make larger importations of shad and fill the rivers immediately. This is impossible with the appropriation at our disposal. * * * We believe, however, that by 1878 shad will be sufficiently numerous in the Sacramento to warrant the attempt at taking ripe fish for the purpose of artificial hatching in our own waters. Should we be successful, we can save the expense and risk of importation, and all our appropriate rivers can in a few years be filled with this valuable fish. Having this in view, we would respectfully ask that you recommend the passage of a law restricting the catching of shad at all other times except between January 1 and April 1 of each year. This, if faithfully observed, would give part of the fish an opportunity to reach their spawning-places.

* * * * * * *

It is well known that salmon, after going to the ocean, invariably return to the river of their birth for the purpose of reproduction, and this was supposed to be the instinct of the shad, yet we have information of shad having been taken at Wilmington, and others in Russian River, * * * points on the coast separated by more than 400 miles. It may be possible that as these fish become more numerous they will return in schools to the Sacramento, the young following their elders who have once made the journey. Should they continue to enter different rivers on their return from the ocean, they will soon stock all on the coast that are appropriate to them.

During the spring of 1879 several thousand mature shad were sold in San Francisco, and it was reported by the fish commissioners that a few were found in the markets almost every month. In 1880 it was stated that they were beginning to increase by natural reproduction, as specimens of all sizes were found in the Sacramento River and Monterey Bay. Up to 1883 their increase was regarded as marvelous and the supply was considered as almost unlimited. During that year a law was in force forbidding their capture, but enough were incidentally taken to show their great abundance. In 1885 and 1886 numberless young shad were reported to be hatched in the tule lakes in the Sacramento–San Joaquin delta, and the supply was said to equal if not exceed the demand; the California fish commissioners estimated that a million good-sized shad were taken from the waters of the State in 1886.

At the present time the shad is one of the most abundant fishes of California, and the quantity taken, while actually less than that estimated in 1886, is enormous, and the wholesale and retail prices are less than in any other State.

In 1882 shad were taken in Rogue River, in southern Oregon, and have since been reported from time to time in other small coast rivers of the State.

Shad were taken in the Columbia River as early as 1876 or 1877. As fry were first artificially introduced into the basin of the Columbia in 1885, it is clear that the fish planted in California were the pioneers in the Columbia, although there is no reason to doubt that the large numbers of fry planted directly in that stream augmented the existing supply.

In a paper on the fishes of the Pacific Coast of the United States, published in the report of the California fish commission for 1880, Prof. W. N. Lockington refers to the taking of two specimens of the shad in the Columbia by Prof. D. S. Jordan.

About 1881 or 1882 shad became distributed along the Washington coast, and are now regularly found in all the coast bays and rivers. They appear to have reached Puget Sound in 1882. Mr. James G. Swan, of Port Townsend, communicated to the Fish Commission the information that on August 26, 1882, Mr. G. M. Haller, of Seattle, took a shad in Puget Sound in a gill net; the fish was small. Since that time shad have increased in size and numbers and are now regularly taken in Puget Sound and its tributaries, although not abundantly.

In 1891 shad reached the Fraser River in British Columbia, and in the same year they were reported from the Stikine River, near Wrangell Island, Alaska.

But meager reports have been received of the outcome of plants of shad fry in Utah and Idaho. No evidence of the survival and growth of those placed in the Jordan River has been met with, excepting an unverified statement that in 1876 a shad 3 inches long was taken in that river with a hook and line (see Report Deseret Agricultural and Manufacturing Society for 1875); there is no certainty of the proper identification of the specimen.

In November, 1888, Mr. M. P. Madsen, of Lake View, caught a 6-inch shad in the southern part of Utah Lake, about 15 miles south of the point where plants were made in the preceding June. Mr. Madsen reported the capture of another specimen in the same vicinity and of two others on the western side of the lake.* Under date of October, 24, 1889, Mr. A. M. Musser, fish commissioner of Utah, stated that another shad in fine condition had been taken in Utah Lake; its length was 13 inches and its weight 1 pound.

The following *résumé* of the results of the efforts to acclimatize shad on the west coast was given by the United States Commissioner of Fish and Fisheries in his report for 1887. Speaking of the fry deposited in the Sacramento River between 1871 and 1880, he says:

> From these slender colonies, aggregating less than 1 per cent of the number now annually planted in our Atlantic Slope rivers, the shad have multiplied and distributed themselves along 2,000 miles of coast from the Golden Gate of California to Vancouver Island, in British Columbia. They are abundant in some of the rivers, common in most of them, and occasional ones may be found everywhere in the estuaries and bays of this long coast line. Prior to our experiments on the west coast it was a dictum of fish-culture that fish planted in a river would return to it when mature for the purpose of spawning. The result of these experiments has been to demonstrate that this instinct of nativity, should it really exist, is in this case dominated by other influences, which have dispersed the shad planted in the Sacramento widely beyond the limits which we had assigned to them and in the most unexpected direction.
>
> The cause is probably to be sought in the genial influences of the Japan current, which brings the warmth of equatorial Asia to temper the extremes of Arctic climate on the southern shore of the Alaskan Peninsula, and, thence sweeping to the south, carries tropical heats to the latitude of San Francisco. Repelled on the one hand by the low temperature of the great rivers and fringe of coast waters, and solicited on the other by the equable and higher temperature of the Japan current, the shad have become true nomads, and have broken the bounds of the hydrographic area to which we had supposed they would be restricted. Following the track of the Asiatic current and finding more congenial temperature as they progress, it is not unreasonable to expect that some colonies will eventually reach the coast of Asia and establish themselves in its great rivers.

INFLUENCE OF NEW ENVIRONMENT ON HABITS OF SHAD.

The changes which have been wrought in the habits of the shad as the result of their introduction into new waters are extremely interesting and important from both biological and economic standpoints. In the absence of a special scientific inquiry,

* Deseret *Evening News*, Nov. 30, 1888.

no comprehensive remarks on this subject can be ventured, but enough is known, from even casual observation, to prove that certain well-marked habits of the shad on the Atlantic Coast have undergone noteworthy modification in Pacific waters, and the inference is proper that still further changes have occurred as a result of the new physical and thermic conditions, food supply, enemies, etc.

GEOGRAPHICAL DISTRIBUTION OF SHAD ON THE WEST COAST.

The present distribution of the shad on the Pacific Coast is from Los Angeles County, Cal., to Wrangell Island, Alaska. Following the major indentations, the known range of this fish now covers about 2,700 miles of coast line. Its distribution, considered from the standpoint of commercial importance, is from Monterey Bay to Puget Sound. It seems probable that the shad has become scattered along this extended coast as a result of the initial plants in Sacramento River. The suggestion of the United States Commissioner of Fish and Fisheries, in the report previously quoted, that the further extension of the shad's range to Asia may be expected, seems reasonable in the light of the history of the fish's movements up to this time.

On the California coast the shad regularly ranges as far south as Monterey, but the absence of suitable streams south of Monterey Bay makes its occurrence in that region probably accidental.

Several instances of the occurrence of shad as far south as Los Angeles County are known. In a "Report upon the edible fishes of the Pacific Coast, U. S. A.," by Prof. W. N. Lockington, in the report of the California fish commission for 1880, reference is made to the capture of shad as far south as Wilmington, Los Angeles County.

Mr. Arthur G. Fletcher, of the California fish commission, has made inquiries for the writer as to the recent presence of shad on the shores of Los Angeles County, and communicates the following notes: Four or five years ago (in 1890 or 1891), Harry Wallman, a fisherman, caught a 1-pound shad in a beach seine near East San Pedro; the fish sold for $1. In November, 1894, Chris. Hoffman, a fisherman, took in the same manner and at the same place two shad at one time and four at another, all 16 or 18 inches long. On December 3, 1895, a 12-inch shad was delivered to the cannery of the Hanniman Fish Company at San Pedro; it had been taken in a seine by J. Turner In a letter to Mr. Fletcher, Mr. Henry King, of Santa Monica, stated that in 1893 he caught a shad at Redondo Beach; it weighed about 1½ pounds, and was snagged with a line fished off the Redondo wharf. It is probable that other shad have been taken in this vicinity, but the fishermen as a rule are not well acquainted with the fish and might overlook it.

On the paranzella fishing-grounds off Drake Bay, north of the Golden Gate, shad are occasionally caught by the steamers; in the bay the drag-seine fishermen take small numbers at times.

In the Sacramento River the shad does not ascend as far as the salmon, and is not common above Sacramento; and in a letter dated November 26, 1895, Mr. Livingston Stone states that no shad have appeared in the upper tributaries of the Sacramento, owing to the low temperature of the water.

In September, 1894, a deputy of the California fish commission visited the Klamath River to watch the run of salmon, and obtained the following information about shad in that stream, which has been communicated by Mr. John P. Babcock,

the chief deputy: In July, 1891, two shad were taken; during July and August, 1892, seven were caught, ranging from 7 to 10 inches in length, and in August, 1894, but one was secured, which was 16 inches long.

The absence of special inquiries in the coast rivers of Oregon, south of the Columbia, makes it impossible to speak positively of the distribution and abundance of shad. They probably enter all the streams of suitable size, but as there is no fishing generally until the late fall run of salmon begins, only a few straggling shad are found, the main run having probably entered the river earlier in the season and gone out to sea by the opening of the salmon season.

In Rogue River, the southernmost stream in Oregon, a lot of shad was taken in 1883 by Mr. Charles T. Finély, of Ellensburg. Shad had also been obtained in that river in 1882, which had traveled up the coast from the Sacramento; they are now found in the river each year. In 1889 a shad was reported to have been caught in the Coquille River.

According to Mr. Alexander, very few shad are taken in any of the tributaries of the Columbia, but it is very probable that if proper apparatus were used they would be found in many places where they are not now known to exist. He says that no adult or small shad have as yet been caught in the Willamette River. Each season considerable salmon gill-net fishing is done in the river, and if there were any large shad there it is probable that one would occasionally be taken.

Mr. Malarkey, one of the largest fish-dealers in Portland, thinks the reason why shad do not go up the Willamette is that in the spring months, when they are first seen, the current of the Columbia is so swift that it forms a "back water" for several miles up the Willamette, which may have considerable influence on the movements of shad.

In the Columbia River the shad is regularly found as far as the Cascades, about 150 miles above the mouth of the river. A few appear to have gone even higher up the river, but there is no evidence that the shad occurs far above The Dalles. Mr. Charles F. Lauer, a fish-dealer at The Dalles, states that in 1893, when a Mr. Davis had a salmon wheel in position near that place, on several occasions from one to two dozen shad were caught in a day, in rather still water; and that in 1894 Mr. Davis also obtained a few shad about 2 miles above The Dalles on the Washington side of the river, in swift water. In 1893 one of the salmon wheels of Messrs Seufert Bros., at The Dalles, is reported to have taken two 6-pound shad. No one makes a business of taking shad at that point, and probably many of the fishermen do not know a shad when they catch it. Mr. I. H. Taffe, the proprietor of a salmon cannery and wheel fishery at Celilo, at the mouth of the Deschutes River, has never caught a shad at that place, and thinks these fish do not ascend the river so far. Inquiries and investigations of the Fish Commission in the upper Columbia River and in the Snake River elicited no information going to show the presence of shad. The fish is found in greatest abundance near the mouth of the river; it is caught, however, in considerable numbers wherever pound-net and drag-seine fishing is carried on.

Mr. Alexander reports that in 1893 fifteen shad were taken in traps at Point Roberts, Washington, near the mouth of the Fraser River; their average length was 15 inches and they weighed about 2½ pounds each. Mr. Charles H. Townsend, naturalist on the United States Fish Commission steamer *Albatross*, states that on September 23, 1895, Mr. Drysdale, superintendent of the salmon canneries at Point

Roberts, Washington, informed him that 300 or 400 shad were caught near that place during the summer fishing operations.

In Fraser River, British Columbia, whose mouth is near the international boundary, in latitude 49°, accounts of the occurrence of shad have been given in the annual reports of the inspector of fisheries. The report for 1891 records the capture of the first shad, as follows:

> I wish to mention the fact that a very fine full-grown shad, containing well-developed ova, was caught in the river in the latter part of July last, by one of Mr. Wadham's fishermen, and sent to me by that gentleman. I am in a position, therefore, to vouch for the excellent quality of the first shad known to have been caught in the Fraser River.

In July, 1892, according to the inspector's report, several shad were caught in the north arm of Fraser River. In the same month a number of fine shad were taken at Rivers Inlet, north of the northern end of Vancouver Island, in latitude 51° 30′. In 1893 shad were said to be getting more plentiful in Fraser River and at Rivers Inlet.

In a letter to the late John K. Luttrell, special agent of the Treasury Department, for the protection of the salmon fisheries of Alaska, Mr. John C. Calbreath, of Fort Wrangell, Alaska, refers to the capture of two shad at the mouth of the Stikine River in 1891, and reports none as being taken in 1892 or 1893. The mouth of this river is near Wrangell Island, in latitude 56° 30′. Mr. Townsend states that while at Sitka, on September 10, 1895, an alcohol tank, that had been loaned to the Natural History Society of that place, was returned to the *Albatross*. It contained a fine shad which had been obtained at Fort Wrangell by one of the members of the society. Whether the fish was taken at Fort Wrangell or in the Stikine River could not be ascertained. This specimen is now in Washington. It is a female, 15½ inches long, and weighs about 2 pounds. These are the only references to the occurrence of shad in Alaskan waters that have been met with. Commander Z. L. Tanner, U. S. N., who was for many years in command of the United States Fish Commission steamer *Albatross* during the fishery explorations of that vessel in Alaskan waters, never found the shad while making extensive collections of fish in the rivers of the Aleutian Islands.

MIGRATIONS AND MOVEMENTS OF SHAD.

The periodic movement of shad from the ocean into the fresh-water streams of the Atlantic Coast is one of its most characteristic and well-known habits. This migration begins in the early winter in Florida and involves all suitable streams as far north as the Gulf of St. Lawrence, which is reached in midsummer. The influx in each basin proceeds gradually from south to north, and the arrival in a given locality is usually about the same time each year and can be predicted with considerable accuracy. Prior to this regular advent of the schools, no shad are in the rivers, and after the completion of the spawning process, which ensues immediately on reaching the headwaters, the adults return to the salt water, and only stragglers are found during the remainder of the season or until the following year.

In the waters of California this well-marked habit of the shad has to a great extent been lost. From the figures given showing the receipts of shad in San Francisco from the Sacramento and other rivers, and from the statements made under the subject of spawning, it will be clearly seen that shad inhabit the rivers tributary to San Francisco Bay and the coastal waters of that vicinity throughout the year. It can not be stated with certainty that the same individuals remain in Sacramento

River, or San Joaquin River, or Suisun Bay during a whole year, but the fact is established that in every month and on every day it is possible to find shad in quantities in those waters.

It seems probable that the constant supply of shad in the northern tributaries of San Francisco Bay is kept up by the arrival of new bodies of fish from the salt water, which take the place of those that have spawned and gone to sea. The movement of schools in and out of the Golden Gate is well recognized.

Monterey Bay seems to be a loitering and feeding ground for shad bound to or from the Sacramento. According to the statement of the California fish commissioners in their report for 1878–79, the shad which leave the Sacramento River follow the coast to that bay, where they are supposed to find an abundance of food, for a few are taken in the fishermen's nets every week throughout the year.

As it is only during the salmon season that shad are caught in the Columbia River, very little is known of their movements and the times of their arrival and departure. They are caught from April to July, inclusive, but after the latter part of July few are taken. It is generally supposed that most of them enter the sea about that time. Mr. Alexander says that, as no person has been interested enough to study the migratory habits of the shad in the Columbia basin, nearly all the ideas advanced concerning them are speculation, but what is now known of their habits would indicate that a much larger proportion of the shad of this river enter the sea in a general body than do those inhabiting the Sacramento.

THE SPAWNING SEASON AND GROUNDS.

The change in the spawning season of the shad incident to their introduction to the waters of the Pacific Coast is one of the most interesting features connected with the results of acclimatization. On the Atlantic Coast the spawning season of the shad rarely lasts longer than five or six weeks in a given river basin, and in places is shorter during some seasons.

In California, according to the testimony of reputable dealers, shad are found with ripe spawn from December to August. Inasmuch as the ripe roe is often taken from the fish by the San Francisco dealers and sold separate, the dealers are in position to make accurate observations on this point. May, however, is the month when most of the shad in the Sacramento region are thought to undergo the spawning process. Many shad examined by the writer in May and June, 1894, contained ripe spawn, and the roe was often seen exposed for sale in the San Francisco market during those months.

The principal spawning-grounds for shad in California are in the lower parts of the Sacramento and San Joaquin rivers, in the numerous sloughs in the delta of those streams, and in the lakes of the so-called tule lands—alluvial islands in the beds of the rivers. These tule lands were at one time under splendid cultivation, but, becoming neglected, the river broke through the embankments and formed lakes of various sizes on the sites of former plantations. Some of the tule ponds are from 10 to 15 feet deep, but the average is only 5 or 6 feet. At some places near the point of communication with the sloughs or river the tule waters are very deep; one cut on Sherman Island, which was recently surveyed, was 65 feet deep within the levee. In these tule waters the shad and striped bass are found at all seasons, and are generally believed to spawn there. They are certainly well suited for spawning-grounds, the

conditions for the development of young shad being excellent; there is a large amount of vegetable growth around the shores and in the ponds, insuring an abundance of minute animal and vegetable food. The water runs out of the tule ponds less rapidly than the tide falls in the river, so that at low tide there is quite a fall at the breaks in the embankments; and, on the other hand, when the tide is coming in the tule ponds receive the water less rapidly through the narrow entrances than it rises in the river, and consequently there is a fall from the river into the ponds.

Regarding the presence of young shad in the San Francisco Bay region, Mr. Alexander remarks:

> Young shad are observed the year round, but they seem to be more numerous in the early part of the summer, when the weather is warm. They are mostly seen in and close to lagoons, sloughs, and in shallow places in the bay. Drag-seine fishermen, when fishing for bottom species, frequently catch young shad, but a person who brings them to market is guilty of a misdemeanor and subject to a fine. In consequence of this law, young shad are not exposed for sale, but are thrown away. In this manner thousands of shad fry are said to be annually destroyed.

Monterey Bay has, by some, been regarded as a spawning-ground for shad, but the waters of the bay must offer very slight inducements to shad, owing to the absence of fresh-water streams of any importance. The largest stream, the Salinas River, is shallow, short, and at times muddy, and it is doubtful if shad ever enter it; there is no record of the capture of shad at or near the entrance to the river. It therefore seems probable that Monterey Bay is a feeding and resting ground for shad that are bound for the Golden Gate, or for fish that have withdrawn from the fresh waters of the Sacramento region.

The inquiries of Mr. Alexander in the basin of the Columbia River led him to believe that the shad in that region spawn in May, June, and July. This conforms with the testimony of fishermen, dealers, and the State fish commissioners. The spawning-grounds are said to extend from the vicinity of Grays Bay to within about 40 miles of the Willamette; at least, that is where most of the fish with ripe eggs are caught, and it is naturally presumed that this is the general spawning-ground, the water and environments being supposed to be better suited to the fecundation of the eggs than elsewhere on the river. Young shad are very numerous during the whole of the salmon season and sometimes become a nuisance to trap fishermen. Small and large fish are found together and taken in all the traps in the river from Ilwaco to the Cowlitz River, more particularly in those situated off Chinook, Grays Bay, and Knappton. At times both large and small shad are abundant off Cottonwood Island, near the mouth of the Cowlitz River.

ABUNDANCE OF SHAD ON THE WEST COAST.

The present catch of shad in the Columbia River, Sacramento River, and San Francisco Bay and tributaries affords only an imperfect conception of the quantities of the fish occurring in those centers of its abundance. Dealers and fishermen say that it would be easily possible, should occasion require it, to treble or quadruple the quantity of shad now taken, by the use of proper apparatus and by carrying on the fishery with regularity and vigor.

In the Sacramento-San Joaquin delta, in the waters between the Golden Gate and the mouth of the Sacramento River, and in the lower Columbia River, shad exist in incredible numbers. It is probably safe to say that in either the Sacramento or the Columbia basin more shad could now be taken than in any other water-course in

the United States, but whether these west coast streams would long maintain such extensive fishing as is prosecuted annually in the Potomac, Delaware, and Hudson rivers is another question.

In all the streams where the shad is regularly found, each year's run shows an apparent increase over the preceding season. Under the existing conditions of the fishery, which result in the taking of only a small percentage of this fish, their further rapid increase in abundance may be expected.

In the lower courses of the Sacramento and San Joaquin rivers, in San Francisco Bay and the bays emptying into it, the shad is exceedingly numerous and appears to be increasing rapidly. Mr. Alexander states that in 1893 many fishermen and dealers in that region assured him that shad were then five times more abundant than they were three years before. During the early part of the summer of 1891 and 1892, shad were caught in such numbers and were sent to San Francisco in such quantities that thousands of pounds were thrown away weekly.

WEIGHT AND SIZE OF SHAD IN WATERS OF THE PACIFIC.

At a very early period it became evident that the waters of California were favorable to the growth of shad. It is probably a fact that the fish there attains a larger size than on the Atlantic Coast. It is also doubtless true that the average size of the fish taken for market is greater than in the East. This may in part be due to the use of nets with large meshes.

The average weight of the shad caught for market in California at the present time is over 4 pounds. The same differences in the size of the sexes which exist on the Atlantic Coast are observed in the West. On all the fishing-grounds large numbers of relatively small fish occur, which, if caught, would reduce the average, but the use of large-meshed gill nets keeps up the average, and as long as a conspicuous part of the catch continues to be taken in nets set primarily for salmon the high average will be maintained.

No shad as large as those sometimes taken in California waters have in recent years been reported from the east coast, and it is probable that no authentic record for the Atlantic rivers surpasses or even equals several verified instances of the capture of large shad on the Pacific Coast.

In 1880, Mr. W. N. Lockington recorded a shad sold that year in the San Francisco market that was 26 inches long, 9½ inches deep, and weighed 8½ pounds. Another of the same dimensions, but somewhat lighter, was sold in 1879. In 1885, some that weighed from 8 to 10 pounds were reported to be commonly taken, and of late even larger examples have been observed.

At times in recent years comparatively large consignments of shad received at San Francisco from the Sacramento region have been made up of fish whose average weight was 6 pounds or more. A large number of shad seen by the writer in San Francisco, May 24, 1894, weighed from 6 to 7 pounds. All the fish-dealers of that city report shad weighing 10, 11, and 12 pounds.

Reports of the taking of shad weighing 16 and even 18 pounds have been received, but they can not be verified. Records of the capture in the Sacramento of several specimens with a weight of 14 pounds can, however, be relied on, although such large fish must be extremely rare.

Since most of the shad taken in the Columbia River are obtained by means of traps and seines with a relatively fine mesh, the average weight of the fish caught is less

than in the Sacramento, although it is probable that there is actually little difference in the size of fish from the two streams. According to Mr. A. B. Alexander, the average weight of the shad caught in the Columbia is 2½ pounds and the average length is 15 inches, while of the fish selected from the catch to be sent to market the average weight is 3 to 4 pounds and the average length is 21 inches. The weight of the largest shad thus far recorded was 9 pounds, although examples 6, 7, or 8 pounds in weight are not especially rare.

FOOD OF SHAD.

Very little information on this topic can be given, owing to the lack of systematic study. It may be stated, however, that, as on the Atlantic Coast, the stomachs of shad taken in the rivers contain no recognizable food. Mr. F. C. Reed, of Astoria, Oreg., formerly State fish commissioner, states that during the past five years he has examined the stomachs of hundreds of Columbia River shad and has never yet found any kind of food in them. The fishermen of Monterey Bay are of the opinion that the relative abundance and scarcity of shad are determined by the absence or presence of shrimp. Mr. Lindsey, in charge of one of the fish firms, and several other fishermen reported that they always found shrimp in the stomachs of shad; in years when shrimp are plentiful there is always a corresponding increase in shad, but when shrimp are scarce few shad may be looked for.

ASSOCIATION OF SHAD WITH OTHER FISH.

In San Francisco Bay and tributaries shad associate largely with other marketable fish. They are found with salmon, herring, anchovies, smelt, and striped bass, and are caught in drag nets and gill nets employed primarily for those species. In the Columbia River shad are caught in pound nets with salmon, sturgeon, and otherfish. Drag seines take shad at the same time that salmon are caught.

SHAD FISHERY OF MONTEREY BAY.

This is the southernmost locality on the Pacific Coast where shad are regularly caught. Fishing is prosecuted at Monterey, Capitola, and Santa Cruz, but at Monterey and Santa Cruz it is of very little consequence. Shad are taken in the bay chiefly from May to July, but they are also caught in other months in small numbers. Mr. Alexander makes the following report:

> Only a few shad are taken by fishermen at Monterey. Each season, however, a few straggling individuals are caught, but the catch has never been great enough to lead the fishermen to suppose that this species will ever strike this part of Monterey Bay in paying quantities. The lack of fresh water on the south side of the bay seemingly precludes the possibility of this fishery reaching any commercial importance. So small has the catch been that no attempt has been made to manufacture nets especially adapted for the capture of shad. The fish which have been caught from time to time have been taken in the "three mesh" or trammel net while fishing for other species. The entire catch of shad for this season [1893] amounted to only 6 fish.

Capitola is the principal shad-fishing community on Monterey Bay. In 1893 there were 28 persons engaged in taking shad here; these used 7 gill nets, having a mesh of 5¾ to 6½ inches. The grounds are 1½ to 3 miles off shore. Occasional specimens have been taken in drag seines hauled along the beach. The fish have an average weight of 4 pounds and recently have yielded the fishermen about 2½ cents a pound. The principal part of the catch goes to San Francisco, a few being consumed

locally on the shores of the bay and in the adjacent towns. At Santa Cruz 15 shad fishermen used 12 gill nets. They fished on grounds 2 or 3 miles off shore. The catch in 1893 was quite small, and was sold locally at 6 cents a pound. In 1886 and 1887 shad were more numerous here than at any other time. In 1892 they were more abundant than for several years.

Of the shad fishery of Santa Cruz, Mr. Alexander remarks:

It is not much greater in importance than that of Monterey. In 1886 and 1887 shad were more plentiful than they have ever been since. The catch has gradually been falling off since 1887, and it now amounts to very little. Fishermen no longer look for shad to visit Monterey Bay in large numbers, for the catch each year indicates that the water and general surroundings of the bay are not suited to their habits. The first shad caught at Santa Cruz brought several dollars, and for a considerable time they were sold at high prices. It was common for fishermen to get from 75 cents to $1.50 a piece for them. As soon, however, as they began to make their appearance in considerable numbers in the market of San Francisco, the price immediately fell to a comparatively small figure. Fishermen persistently demanded high prices for a long time, and not a few Italians thought that they were suddenly going to amass a fortune from catching shad, but they soon found that this fishery would yield no greater profit than other branches of the industry.

The statistical inquiries of Mr. Wilcox relating to the Monterey Bay fisheries disclosed the following catch of shad in the years named, the values given representing the gross prices received by the fishermen:

Years.	Pounds.	Value.
1889	20,264	$810
1890	24,880	995
1891	30,120	1,205
1892	35,000	1,400

Regarding the future of the shad fishery of Monterey Bay, Mr. Alexander says:

If shad should greatly increase in numbers in all parts of Monterey Bay the fishermen would derive no greater benefit than from the barracuda, mackerel, etc., and in fact not so much, for the reason that the day has gone by when fishermen can expect to get large returns for these fish. Sacramento River and San Francisco Bay can supply the State with shad at nearly all seasons, which practically precludes the possibility of fishermen situated further south from gaining more than a meager share of the trade, even if shad should become numerous south of Golden Gate. If the population within a radius of 60 miles of Monterey Bay should greatly increase, the case might be different; but at the present time and under the existing circumstances, fishermen of Monterey Bay can do fully as well if not better by occupying their time fishing for other species.

SHAD FISHERY OF SAN FRANCISCO BAY AND TRIBUTARIES.

Early history.—In the remarks on the results of the introduction of shad to the Pacific Coast, reference was made to the first fish captured in California waters. The following additional notes on the early history of the fishery have been furnished by Mr. Alexander:

In a very few years after shad were planted in the Sacramento River, fishermen began to catch them in their nets. At first only a few mature specimens were caught. Frequently several months would elapse without a single fish being taken; suddenly, however, they would again put in an appearance, each time in greater numbers than before. Shad at that time were considered a great luxury, and the price was very high. The first specimens taken brought so much that fishermen who were fortunate enough to capture even three or four in a day did a lucrative business. The use of nets having less than a 7½-inch mesh being prohibited, very few small fish were caught. This was at that time a wise provision, for it gave the shad an opportunity to grow and multiply. This law, however, has never been repealed, and to-day, on account of the large-size mesh required by the statute, a great

deal of illegal fishing is being done. Little or no notice is taken of it in the case of the shad, however, for the reason shad are so numerous at most seasons that it is thought no perceptible decrease will be caused by the methods now employed.

The high price paid for shad did not long continue, for a marked increase in the catch was the result of the small fish planted from time to time by the United States Fish Commission. Most people could not afford to purchase this food-fish while high prices prevailed, and the demand came almost wholly from first-class restaurants, hotels, and wealthy families. It was not until about 1886 that the fish began to be generally consumed, at which time the price had fallen to 10 cents a pound, a few cents higher than salmon. Previous to this, comparatively few people on this coast had ever eaten shad, and considerable effort was put forth by dealers to increase the sale, the supply being greatly in excess of the demand. People in moderate circumstances not being familiar with the food value of this newly introduced fish, it was not unnatural for them to continue to buy such species as they had always been accustomed to, namely, sturgeon, salmon, herring, smelt, and rockfish. To-day shad are in large demand, but they have not taken the place of, or, in the estimation of many, rank with, the foregoing fishes.

The fishing-grounds.—The principal shad fishing-grounds in the vicinity of San Francisco are San Francisco Bay, San Pablo Bay, Suisun Bay, Karquines Strait, Sacramento River, and San Joaquin River. The comparatively few shad taken outside the Golden Gate are caught only incidentally and do not indicate any special resorts for the fish in the waters frequented by the paranzella fishermen. The hydrographic basin which finds its outlet through the Golden Gate is the most important shad ground on the west coast and is evidently admirably adapted to the growth and multiplication of that fish.

The concentration of the shad in the San Francisco Bay region seems to be due to the absence of suitable waters elsewhere on the California coast, and does not indicate any special tendency of the fish to remain in the waters where the fry were first planted. On the entire coast of California there are no streams of proper length, depth, temperature, volume, etc., to afford spawning-grounds for shad, with the exception of the Sacramento and San Joaquin rivers.

The following interesting statement of the physical relations existing between the waters of this region and the fish fauna is from the report of Mr. W. A. Wilcox, entitled "The fisheries of the Pacific Coast" (Report United States Fish Commission, 1893):

A large part of the salt-water and fresh-water fish received in San Francisco is taken in San Francisco Bay and its tributary bays and streams. This inland water area is of large extent and well adapted to the support of a large amount and variety of animal life. The quantity of fishery products annually withdrawn from these waters is enormous, but it is doubtful if the full resources are utilized or appreciated.

In a general way the dimensions of San Francisco Bay and the smaller bays connected therewith may be stated as follows: From the southern end of San Francisco Bay, bordering on Santa Clara County, to San Francisco is a distance of 25 miles, the width of the bay being from 2 to 10 miles. Between San Francisco and the entrance of San Pablo Bay the distance is 11 miles; San Pablo Bay is 10 miles long and from 8 to 10 miles wide. Karquines Strait, which connects San Pablo Bay with Suisun Bay, is 8 miles long and one-half to 1 mile wide. Suisun Bay is 16 miles long and from one-half to 6 miles wide. The total length of these connected waters is about 70 miles.

At the northern end of Suisun Bay, in Solano County, the two largest rivers in the State have their outlets. A peculiar feature of these rivers, probably not found elsewhere in the United States, is the relation existing between their respective sources and outlets. The San Joaquin takes its rise in the semitropical section of the southern part of the State, and flows northward hundreds of miles through a warm region. The Sacramento, with its headwaters among the perpetually snow-covered Sierra Nevada Mountains, flows south many hundred miles, and, through numerous passages, mingles with the San Joaquin and is lost in the tide waters of the bay. These two streams constantly carry with them a large amount of minute animal and vegetable life, much of which must find a congenial

home in San Francisco Bay, and furnish a large and varied quantity of food for the fish life of the fresh, brackish, and salt waters.

Another interesting feature of the bay is the almost uniform temperature of the water, there being only a few degrees variation at any season of the year. That the conditions are extremely favorable to the support of aquatic life is demonstrated in the rapid increase and permanent residence of the several fine food-fishes introduced from the Atlantic Coast by the Government. Some of the fishes thus acclimatized are naturally anadromous, but in San Francisco Bay, contrary to their usually migratory habits, they do not appear to have any desire to spend much if any of their existence in the ocean.

Another feature which has its influence upon the quantity of animal life present in San Francisco Bay is the absence of fishing banks or submerged chains of mountains off the coast of California adjacent to the Golden Gate. Fishing-grounds, such as are found off the coast of the Atlantic States, do not occur within many hundred miles of the California coast. It may therefore be assumed that during very stormy weather numbers of the near-shore marine fishes would seek food and shelter inside the Golden Gate, where, finding favorable conditions, many remain.

While considerable quantities of shad are taken in San Francisco Bay, that ground is much less productive than the bays and streams which enter it on the north. One of the best fishing-grounds lies between Penole Point, at the southern entrance of San Pablo Bay, and Martinez, on Karquines Strait—a distance of about 15 miles. Another good ground is at the head of Suisun Bay. The best grounds, however, are the Sacramento River below Sacramento and the San Joaquin River below Stockton, and the numerous sloughs at the delta of those streams. At times the fish are taken as far up the San Joaquin as Banta.

Mr. Alexander states:

By experience the fishermen of the Sacramento and San Joaquin rivers have learned the points where shad are most likely to be found; each locality has its best spots, and around these the nets are set. A fisherman who finds a good fishing-ground one season will seek the same place the next year. Fishermen who have discovered good grounds in various parts of the river are very careful about letting others know the spots, and will often go a long distance out of their way rather than let it be known where their favorite grounds are.

Fishermen.—The persons engaging in the shad fishery of this section are also engaged in the market or salmon fisheries, or both, shad now constituting only a small part of their catch and receiving but little special attention. They are for the most part natives of southern Europe, a large percentage being unnaturalized.

The number of fishermen taking shad varies greatly from time to time. Some months there may be several hundred in whose nets shad are caught in noticeable numbers, but those who set nets especially for shad probably do not number more than 100. In 1893 there were 90 persons who might be called regular shad fisherman; these belonged at San Francisco and at the various fishing stations between that place and the lower courses of the Sacramento and San Joaquin rivers.

The apparatus and methods.—In the San Francisco Bay region shad are now taken in salmon gill nets, in trammel or three-mesh nets, and in shad gill nets. No pound nets or traps, such as are so extensively employed on the Atlantic Coast for shad, are used in these waters; a few fish are incidentally obtained in drag seines.

The trammel nets are employed chiefly in San Francisco Bay and, in addition to shad, take rockfish, flounders, perch, and other species. This form of apparatus is very popular with the foreign fisherman, and is usually fished in conjunction with special shad gill nets. Each boat fishing regularly carries from 4 to 6 trammel nets, with an average value of $20 each. The two outer nets composing the trammel have a mesh of 14 or 16 inches; the inner piece is provided with a $5\frac{1}{2}$ or $5\frac{3}{4}$ inch mesh.

The special shad gill nets are 60 to 70 fathoms in length and 2 to 3 fathoms deep. They have a mesh of 5½ to 6 inches. During 1893 1,500 pounds of shad netting were received from eastern manufacturers by the San Francisco Bay fishermen. About 225 pounds consisted of cotton twine worth 75 cents a pound, and the remainder linen twine worth $1.30 a pound. The nets are hung by the fishermen. The average value of the cotton nets is $25 or $30; that of the linen nets $35 to $40.

Mr. Alexander's account of the method of setting gill and trammel nets for shad is as follows:

> Several nets are generally set together. Each boat carries 3 shad nets and 4 to 6 trammel nets. The boat is made fast to one end of the string and together they drift with the current, care being taken to evade all places where snags are known to be. Two men go in a boat; in setting the string, one man throws the nets out and the other keeps the boat in position with the oars. The nets are generally set across the stream or tide, but in a short time they will swing around in the direction of the current. After drifting a certain time, or when it is known that fish are in the nets, they are hauled. In most cases one man does the hauling. As the nets come in the fish are picked out, the nets being so stowed that they may be thrown out again without additional handling. As soon as a day's fishing is over or a good catch secured, sail is made and the fish are taken to the nearest railroad or steamboat landing and prepared for shipment to San Francisco.

While a great many shad are in the aggregate secured in salmon nets, their number is small compared with those obtained with shad and trammel nets. The size of the mesh of the salmon gill net (7 inches) ordinarily permits all but very large shad to pass through. Fish of small and medium size, however, are frequently caught, especially when the nets become tangled or doubled. Formerly a large part of the shad supply was obtained in this way, but the low prices now received lead fisherman in search of salmon to often throw away the shad that may be caught.

The boats used in the shad fishery are the felucca and the ordinary salmon skiff. The former is employed in San Francisco, Suisun, and San Pablo bays, the latter in the two last-named bays and in the rivers. At times in 1893 there were over 100 boats employed in taking shad in San Francisco Bay and tributaries, principally in apparatus set for other fish. The boats from which nets were set for the purpose of catching shad numbered about 40.

According to Mr. Alexander, more shad are caught in muddy water than in clear water. In parts of San Francisco Bay, where the water is comparatively clear, a net will take but few shad in a day, even when the fish are plentiful; in such places most of the catch is made at night, but in the rivers and in bays near the mouths of streams, where the water is thick, fishing may be done at any time. The best time for shad fishing is at the "slack tide." The fishermen endeavor to have their nets down then. The last of the ebb tide and the first of the flood tide are also considered good periods in the San Francisco Bay region.

Prices of shad.—The fish all leave the hands of the fishermen in a round condition. The price received varies much with the season, the day of the week, and the quantity of other fish in the market. At times each year shad will yield the fishermen 6 to 8 cents a pound, but this price seldom lasts more than a few days. The average in 1893 and 1894 was about 2 cents a pound; often, however, the fishermen could get only 5 cents for a full-grown shad, and it was not rare for a box of shad holding 80 pounds to bring only $1.

The average price of shad in recent years has steadily declined; it was about 5 cents a pound in 1889, 4 cents in 1890 and 1891, 2¾ cents in 1892, while in 1893 and 1894 it reached a figure below which it will probably not fall, as many fishermen will

cease to catch the fish if the value declines further, and the diminished output will maintain the price.

The place where shad are taken has no influence on the price. Fish from Monterey Bay, San Francisco Bay, and the Sacramento all command the same price, as no differences in the condition or food value are attributed to fish from different waters.

A feature of the shad fishery which is noteworthy to a person familiar with the conditions on the Atlantic Coast is that fish with ripe roe command no higher prices than others, although the roe is considered a delicacy and is quite extensively eaten.

SHAD FISHERY OF THE COLUMBIA RIVER.

The first year for which complete data are available showing the amount of the shad catch of the Columbia River is 1888. Mr. Wilcox made a canvass of the fisheries of the Pacific States covering that year and reported a total catch of 10,000 pounds in the river. These yielded the fishermen $500. He reports that about 1888 the first noticeable catch of shad was taken in the pound nets of Baker Bay, near the mouth of the river. The following year quite an increase was noticed, the nets often having half a dozen at a lift. This was not enough for the fishermen to waste any time over, and the few taken were either given away to anyone wishing to sample the new fish, or were returned to the water. A few found their way to the city market at Portland and quickly found sale, 10 cents per pound being paid the fishermen. The fish slowly worked their way up the river, the haul seines about 80 miles up taking some 200 pounds in 1889.

In 1892, when Mr. Wilcox again visited this region, he found that the shad had as yet received very little attention, and were taken only in seines and pound nets set for salmon. The special features of interest in connection with the shad were the much larger incidental catch, the increase in the average size, and the decrease in market value during the years intervening between the two inquiries. The quantity and value of those taken and sold during 1889, 1890, 1891, and 1892 were ascertained to be as follows, the catch shown being taken at or near the mouth of the river in Clatsop County, Oreg., and Pacific and Wahkiakum counties, Wash.:

Years.	Pound nets.		Seines.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1889	49,800	$4,979	200	$20	50,000	$4,999
1890	84,420	6,753	610	50	85,030	6,803
1891	116,388	6,983	13,000	780	129,388	7,763
1892	174,250	5,228	37,000	1,170	211,250	6,398

Mr. S. H. Greene, of Portland, Oreg., in May, 1893, communicated the following information on the shad of the Columbia River:

Regarding the results which have attended the introduction of the eastern shad in the waters of this coast, permit me to say that the cannerymen, marketmen, and fishermen all agree that so far as the shad of the Columbia are concerned, they are prospering beyond the most sanguine expectations. Six years ago this summer a shad was taken in one of the traps at the mouth of the river that weighed a fraction over 6 pounds. It was thought to be a wanderer from the California coast, but quite a number were taken that season weighing 2 pounds or so. At that time the fishermen and shippers at the mouth of the river got 16⅔ cents a pound (gross) by sending them to the Portland market, the marketmen paying freight, as they were considered quite a curiosity. Now you can buy dressed shad in most of the markets at 4 cents a pound. This fact is indicative of the prosperous condition of the shad. Last season some of our marketmen found it necessary to salt their surplus. One Portland

firm salted about 2 tons. Shad are taken either in the fish traps or drag nets. The gill-netters do not get them. The shad run 5 or 6 pounds in weight, but the greater majority are of about 2½ or 3 pounds weight. Frank M. Warren & Co. have canneries at Cathlamet, Wash., and at The Cascades, Oregon. Mr. Warren informs me that the shad are very numerous at both places. At The Cascades of the Columbia the fish wheels take great numbers of very fine shad, and all information at hand indicates that the shad of the Columbia are in a very prosperous condition.

Mr. A. B. Alexander, who in 1893 was detailed to make inquiries regarding the shad in the Columbia River, reported as follows on the shad fishery:

The shad fishery of the Columbia has little or no history, for as yet it can hardly be called an industry. All shad brought to market are taken incidentally. They are caught by thousands in traps and turned away, there being very little demand for them. The total amount sold at all points on the river in 1893, as near as can be estimated, was 85,000 pounds. This does not include the amount given away by fishermen. It is very probable that nearly as many of these fish are given away as sold. A fisherman who brings in a hundred or more shad disposes of what he can; the rest being left on his hands, he either gives them away or throws them overboard. I am told that it often happens that a large portion of the catch is disposed of in the last-mentioned manner. Nobody buys shad at the small towns on the river, for all desired can be obtained from fishermen by merely asking for them.

Nearly all shad of the Columbia are taken in traps or drag seines, principally by the former method; a few are also caught in salmon gill nets, but the number is so small that it is hardly worth mentioning. Occasionally a shad weighing 8 or 10 pounds is caught in a large-mesh chinook gill net, but the majority of those taken in this manner are caught in nets set for the blueback and other small salmon.

Fishermen make no regular business of sending shad to market; it is only when it is thought that the last supply is sold that another shipment is made. The dealers never send orders to fishermen, as at nearly all times the shipments they voluntarily make are amply sufficient to supply the demand. A large portion of shad is taken in traps, and it is a very easy matter for a fisherman to bail out one or two thousand pounds, or as many more as are wanted, take them to the nearest steamboat landing, and send them to Portland. If he gets a fair return, he is encouraged to repeat the experiment. It sometimes happens that a good day's work is made with little or no exertion; at other times word comes back that the fish have only brought enough to pay freight charges. This, of course, is discouraging, and he has little desire to make further shipments until he is quite sure that some returns will be made to him.

No such fabulous prices have been paid for shad on the Columbia River as have been received at different times in the market of San Francisco and elsewhere in the State. The early run of shad sells for 12 and 15 cents a pound; as soon as they commence to appear in any considerable number the price immediately falls until it reaches 5 or 6 cents, which is the average price. The fishermen are paid for early shad 4 and 5 cents a pound; this price does not last long, for it falls in proportion to the number taken, and very soon 1½ and 2 cents are all that can be realized. Frequently fishermen can not get even a cent a pound; when shad reach this figure few are brought to market. The demand for shad is as yet too small to hold forth any inducements to fishermen to engage in the industry. Owing to the limited demand, the price from year to year undergoes little change. The fish shipped from San Francisco are sold at from 4 to 5 cents more a pound than those caught in the Columbia; not because they are superior, but on account of the time of year they are shipped.

Portland is the only market of importance on the river, and during the season of 1893 handled 70,000 pounds of shad; of this amount 17,500 pounds were shipped from San Francisco. About 15,000 pounds were sold at Kalama and 1,500 pounds were consumed in Astoria. At Kalama one firm has paid some attention to shipping shad to neighboring States and Territories; in 1893, 10,000 pounds were shipped from this place. All the shad consumed in Oregon and Washington during the winter and early spring months come from San Francisco. The retail value of shad shipped from San Francisco is 10 cents a pound; average value of those caught in the Columbia, 5 cents. There is no regular demand for shad from any locality, and in consequence dealers buy only a limited amount at a time. Montana, Nevada, and Utah are as far east as Portland dealers ship shad. Occasional shipments are made to cities and towns on Puget Sound, but the amount which goes north is small. It is evident that the reason why shad are not more in demand in interior towns and cities is on account of their not reaching the consumers in good condition. While the fish may, and probably do leave

the market securely packed and iced, long before they reach their destination they are in need of more ice, and when a box of shad lies 24 hours or more, even under cover, with no ice on it, the contents are sure to be in poor condition.

Smoked and salt shad are not in demand, perhaps for the reason that few people here have ever eaten them cured in such a manner. It is very probable that if some individual should try the experiment of salting and smoking them he would be rewarded for his trouble, for the people of this locality eat more salt and smoked fish than elsewhere on the Pacific Coast. In all the markets and most of the grocery stores salt mackerel, cod, smoked herring, eels, and haddock are for sale. That there is considerable demand for these fish is plainly indicated by the quality kept, which is of the best.

That there is wanton destruction of both young and adult shad on the Columbia River is acknowledged by dealers, cannerymen, and fishermen. Large numbers of shad are dumped out of seines and left to die. This destruction goes on day after day during the spring and summer months, and, from what can be learned, a much greater number of fish rot on the beaches than are saved. Many shad are also annually destroyed in traps, or rather by trap fishermen. This is due to the manner in which the fish are taken out of the traps, little or no care being used to put them back into the water alive; they are so roughly handled that a great many of them die. No notice is taken of this unnecessary killing of shad, for the reason that they have no great commercial value.

The condition of the shad fishery of the Columbia River in 1894, when it was made the subject of inquiry by the writer, did not present any specially prominent features not referred to by the other observers quoted. The abundance of the fish has continued to increase, as demonstrated by its more frequent capture in the salmon nets, but the local demand has improved but little. The relatively small quantities saved for market, as compared with the possible catch, are sent mostly to Portland, where they are regularly exposed for sale and are always found on the bills of fare of the best hotels and restaurants.

The ruling retail price of shad in Portland in 1894 was 10 cents a pound. The fishermen receive about 4 cents a pound, net, but the sales at that price are limited, and the value falls too low for profit if the supply is increased even comparatively little. At Wallace Island, near Eureka, Wash., during the early part of the salmon season of 1894, 400 or 500 pounds of shad were caught daily in a salmon seine; some attempt was made to utilize these fish by shipping them to Portland dealers, but the price dropped so low (2 cents a pound) that the fishermen could not make the venture pay.

The Columbia River shad are of excellent quality, and during the time of their greatest abundance, April 15 to July 15, one would expect a large consumption in Portland and the other cities and towns adjacent to the river, but the abundance, cheapness, and popularity of salmon, together with the general unfamiliarity of the people with the edible qualities of the fish, make it probable that a number of years will elapse before a special shad fishery on the Columbia River will have local support.

The following additional references to the economic value of the shad in the Columbia River in 1890, 1891, and 1892, respectively, are extracted from the reports of Mr. James Crawford, fish commissioner of Washington, for the years named:

There has been no regular fishing for this fish, which, in the opinion of many, is the finest fish we have. What have been caught have been taken in pound nets set to catch salmon. Still there have been 50,000 pounds of shad taken in Baker Bay during the past season, netting the fishermen 5 cents per pound. Catching of shad promises to be, in the near future, one of the most valuable industries of the Columbia. Young shad have been seen this season in both Gray's Harbor and Shoalwater Bay.—(Report 1890.)

In my last report I mentioned the wonderful increase of this fish in the waters of the Columbia River, and this season the number coming into the Columbia to spawn was much larger than ever

before known. Shad weighing as much as 9 pounds have been frequently taken, and although there has been no special effort made to catch them, and what have been taken were caught in pound nets set for salmon, 50,000 pounds is a safe estimate of the catch of 1891. This amount has been disposed of in the markets of Portland, Astoria, and the cities of Puget Sound. Five cents per pound was received for the fish, making the value of catch $2,500.—(Report 1891.)

This desirable table fish continues to increase in number and size in the waters of the Columbia River, and, although no effort has been made to take them, enough have been caught to net the owners of pound nets, traps, and set nets about $2,000. They have been taken as far up the river as the Cascades, about 150 miles. The shad is not a native of the Pacific Ocean, but was first introduced by the United States Commission of Fish and Fisheries into the Sacramento; later some were placed in the Columbia River. From this beginning they have increased until they are considered a staple article among the fish-dealers. Their flavor and size will compare favorably with the shad of the Hudson River.—(Report 1892.)

STATISTICS OF THE SHAD CATCH OF THE PACIFIC COAST.

Figures are available to show the quantities of shad taken and sold in the Pacific States in each of the years 1888 to 1892, inclusive. These statistics are based on the field inquiries of Mr. W. A. Wilcox, agent of the Commission, and represent the results of the examination of records of fishermen, dealers, and transportation companies. In each State the yield shows a large annual increase since 1888, although the value of the fish to the fishermen was less in 1892 than in the previous year, when the output was over 20 per cent smaller. The yearly decrease in the average price per pound received by the fishermen illustrated by the table herewith presented (until in 1892 the average gross price was under 3 cents) suggests a reason for the diminished output in the subsequent years, which is disclosed by incomplete statistics gathered in San Francisco and elsewhere.

Summary of the quantities and values of shad sold by fishermen of the Pacific States from 1888 to 1892.

Years.	California.		Oregon.		Washington.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1888	90,871	$6,513	10,000	$500	200	$50	101,071	$7,063
1889	263,788	10,833	29,990	2,999	21,010	2,055	314,788	15,887
1890	318,140	11,891	50,100	4,008	36,092	2,860	404,332	18,759
1891	445,006	15,856	70,500	4,230	59,900	3,590	575,406	23,676
1892	526,494	14,372	109,000	3,270	103,350	3,183	738,844	20,825

PRICES OF SHAD ON THE WEST COAST.

The first shad taken on the Pacific Coast were regarded chiefly as curiosities and brought extraordinary prices, and even after the supply became comparatively regular the market value of the fish continued very high for some years.

Mr. J. H. Kessing, who has been in the fish business in San Francisco for forty years, states that when shad were first caught in California they were in great demand and he sold them at wholesale at $10 to $15 each; many brought $1 to $1.50 per pound. These prices are confirmed in the early reports of the California fish commission. By 1880 the abundance of shad had reduced the market price to the consumer to 20 to 25 cents a pound. In 1887 and 1888 the average price was about 10 cents a pound, while at the height of the season it was sometimes as low as 5 cents. In 1889 the average retail market value of shad was 5 cents a pound; in 1890 it dropped to 4 cents; in 1891 it was 3 cents; in 1892 it was not over 2¾ cents; in 1893 and 1894 it was 2 cents or less. During the years 1893 and 1894 the prices often fell to one-half or 1 cent a pound, and thousands of fish could not be disposed of at any price. To protect themselves against

losses arising from too great a stock, the dealers were obliged to restrict their receipts. Of course, at the figures last quoted the fishermen who sell on commission get no returns.

In the Columbia River the prices for shad have never been as high as in California, although they have at times ruled almost as low. About 1887, when the fish first began to be numerous, the salmon fishermen and shippers of the lower river received about 16 cents a pound (gross price) by sending their shad to Portland. In 1893 and 1894 the general retail price in Portland was 10 cents a pound, the fishermen receiving about 4 cents a pound, net. It is only by placing a limit on the supply that these prices are maintained. Fishermen who have endeavored to utilize the shad incidentally taken in their salmon nets have, as a rule, received such low prices that no inducement was offered to continue the shipments. At times in the past three years only 2 cents a pound could be realized by the fishermen on fish sent to market, a price entirely too low to pay for time and expense.

FOOD QUALITIES OF THE SHAD.

Notwithstanding the great abundance of the shad in the vicinity of the principal seaboard cities and towns of the Pacific States, a large proportion of the people of the west coast are totally unfamiliar with the food value of the fish, and it is eaten by only a comparatively small part of the population. While the price of the shad is such that it is within the reach of everyone, the supply of other fish that have been long in popular favor is also sufficiently abundant to keep the prices relatively low. As salmon, the prime favorite of the public, is most plentiful and lowest priced at the time when the shad is found in the markets in greatest numbers, the latter meets with only a limited demand.

With the exceptions of some complaints about the bones, no one speaks in disparaging terms of the edible qualities of the shad; and if it did not have to compete with an almost unlimited supply of salmon, herring, smelt, anchovies, flounders, rockfish, and other species for which there is a strong local sentiment, there is no doubt it would occupy the very front rank in popular estimation among the fishes of the coast.

One potent reason why the shad has not advanced farther in popular esteem is the poor condition in which it reached the consumer, about the time when its remarkable abundance first brought it into notice. The lack of care in the preservation of fish which has characterized the fishing industry of the west coast naturally led to the early deterioration of so delicate a fish as the shad, and people who ate the fish a number of years ago acquired a distaste for it, which has continued. It is gratifying to note that in the past few years there has been a radical change in the state of preservation in which the shad reaches the consumer, owing to the plan of the San Francisco dealers to restrict the receipts and to purchase, as far as possible, only the quantities that they can probably dispose of before the fish become tainted, one day's catch supplying the next day's trade.

Of the opinion held regarding the edible qualities of the shad in the Columbia River region, Mr. Alexander says that the dealers consider the shad a very palatable and valuable fish, and greatly regret that the demand for it does not increase. People have so long been accustomed to eating salmon and smelts that they have formed a prejudice against all other fish. The fishermen all say that shad are excellent, and they fail to see why there should be so little call for them.

THE SHAD TRADE OF SAN FRANCISCO.

San Francisco is the principal shad market of the Pacific States, as it is for all other fishery products intended for immediate consumption. All the fish-dealers who purchase their supplies directly from the fishermen handle shad, and the amount of their trade in this product constitutes a reliable basis for estimating the extent of the shad fishery in California. The San Francisco dealers get their shad from San Francisco, San Pablo, and Suisun bays, Sacramento and San Joaquin rivers, and Monterey Bay.

In 1894 the writer made a thorough examination of the records of the San Francisco dealers, and noted the quantities of shad handled by them in the preceding year and in 1894 up to June. For the remaining months of 1894 the California fish commission, through Mr. John P. Babcock, the chief deputy, obtained similar data and courteously supplied them to the United States Commission of Fish and Fisheries. Mr. Babcock also procured some information for 1893 from several firms. The figures thus acquired permit the presentation of a table, showing for each month in 1893 and 1894 the actual quantities of shad received in San Francisco.

The aggregate receipts in 1893 were 429,136 pounds and in 1894 were 270,807 pounds, these amounts being the round or gross weights of the shad.

There is not a day in the entire year when shad may not be found in the San Francisco markets, and during nine months it is one of the commonest and cheapest fish exposed for sale in that city. During July, August, and September, when the salmon fishing is at a low ebb or totally suspended, the supply of shad is much less than at other times.

In 1893 the largest receipts were in May and November; in 1894 in January and May. The average monthly receipts in the former year were 35,761 pounds and in the latter 22,567 pounds. During the three months ending December 31, 1893, more shad were handled than in any previous period of similar length; in that time 227,874 pounds were received, an average of over 75,000 pounds per month. A detailed summary of the monthly receipts is given in the following table:

Statement by months of the number of pounds of shad handled by San Francisco dealers in 1893 and 1894.

Months.	1893.	1894.
January	6,588	41,266
February	19,185	11,767
March	19,546	17,747
April	32,389	39,115
May	80,557	57,823
June	36,184	22,027
July	3,319	7,941
August	2,796	2,029
September	698	475
October	53,652	24,229
November	96,340	38,110
December	77,882	8,278
Total	429,136	270,807

A condition of the San Francisco shad market, by no means rare, is thus referred to by Mr. Babcock, in a letter dated May 9, 1895:

The run of prime shad is on again. The markets all show fine fish this morning, and I made a canvass of them all for retail figures. Chinatown dealers offered me 6, 7, and 8 pound shad for 10 and

15 cents each; all were in good condition and fresh. The Clay-street marketmen asked only 2 cents a pound retail for dressed fish, and said they had sold but few. The Pioneer Fish Company said they had not sold 1 pound at retail this morning, and that they would have to dump their fish this afternoon; wholesale price, 1 cent a pound. In the California market, Leon was offering to deliver fish at your house for 5 cents a pound, and would sell fish over the counter for 10 cents apiece.

The receipts of shad in San Francisco could be greatly increased if the dealers did not discourage their shipment by the fishermen, owing to the very low prices which prevail when the supply is large. All the firms dealing extensively in shad are obliged to restrict the receipts in order to protect themselves and their fishermen from loss. Shad have at times been thrown away because of the impossibility of selling them, or sold at ridiculously low prices. Thus, in October, November, and December, 1893, when the preceding table shows large receipts, the prices were sometimes hardly sufficient to cover the transportation charges. A shipment of 1,500 pounds of fine shad, sent in by a Sacramento River fisherman in the third week of November, brought only $1.50, and about the same time another lot of 795 pounds sold for only $1.

At the present time, fewer shad are probably handled in San Francisco than in 1890, 1891, 1892, or 1893. The supply of salmon in that city determines the quantity and price of the shad sold. Owing to increased shipments of Puget Sound salmon to San Francisco of late, the market has been partly closed to shad; these salmon are cheap fish, which the San Francisco dealers are able to buy at 1 to 1½ cents a pound. When salmon are scarce, shad and other cheap fish are in demand.

The action of the dealers in curtailing the receipts of shad in the past two years has resulted in fewer gluts, and conditions have been altogether more satisfactory than formerly. At the present time, when the dealers desire a consignment of shad, they have only to telegraph or telephone to one of their agents on the fishing-grounds and the required quantity will be on hand the next morning. By this method the fish reach the consumer in a much better condition than where the receipts are unrestricted and the fish are held over from day to day.

Practically the entire quantity of shad handled by San Francisco dealers is sold and eaten fresh. The Chinese prepare small quantities of salt shad; the fish they utilize this way have often been on the dealers' stands for several days and can be obtained very cheaply. The fish are lightly pickled for one or two days and are then hung up to dry on the roofs of their houses. Although there are several smokehouses in San Francisco, no shad are smoked. The experiment of thus treating shad has been tried and abandoned, owing to the little demand for them prepared in this way; there is, however, some sale for smoked salmon and sturgeon.

Mr. Thompson, of Oakland, who has been engaged in the smoked-fish business for a number of years, has given more attention to smoked shad than anyone else on the west coast. In 1893 he is reported to have smoked between 11,000 and 12,000 pounds of shad, which had a retail value of $1,440, or about 12 cents a pound.

Mr. Alexander reports that about half the shad which go to San Francisco dealers are reshipped out of the city to various parts of the State. Some shipments are made to Salt Lake City, Denver, and points in Mexico. The fish are cleaned, iced, and packed in boxes holding 100 to 200 pounds. When shad are to be sent very long distances, or to a warm climate, one box is placed within another. Fish prepared for distant shipment are split down the belly and packed with ice, but those intended for local consumption are split down the back.

THE WHITEFISH.

In 1872 and 1873 Professor Baird, the United States Fish Commissioner, sent to the California fish commission from Lake Superior 50,000 eggs of the common whitefish (*Coregonus clupeiformis*) in two lots; many of these perished during transportation. The survivors (25,000 in number) were hatched in an extemporized structure on Clear Lake, in which the young were placed. Clear Lake is a large body of water in Lake county, in the Coast Range, about 80 miles northwest of Sacramento, and was selected for this purpose by the California authorities because of the supposed advantages it afforded, it containing few other fish, having a suitable temperature and other physical conditions, and being so placed that it could be readily seined.

In 1875 the United States Fish Commission sent 20,000 whitefish eggs from Lake Michigan; these were successfully hatched at Berkeley and deposited in Tulare Lake on March 29, 1875. This lake, the largest in the State, was thought by the California commissioners to have the requisite temperature, food supply, etc., for the whitefish, and the introduction of that species was much desired by the people living near the lake.

Larger plants were made in various parts of the State in 1877 and 1879, the eggs being furnished by the national fish commission. In 1877, 75,000 fry were put in Donner Lake, in Nevada County; 50,000 in Sereno and other lakes, in Placer County, and 175,000 in Lake Tahoe, in the extreme eastern part of the State, partly in Nevada. In 1879, fry were planted as follows: 70,000 in Lake Tahoe; 70,000 in Donner Lake; 60,000 in lakes in Nevada County; 225,000 in Eagle Lake, in Lassen County; 100,000 in Tulare Lake; 10,000 in Mark West Creek, in Sonoma County; 10,000 in San Jose Water Company's reservoir, in Santa Clara County; and 20,000 in Chabot Lake, in Alameda County.

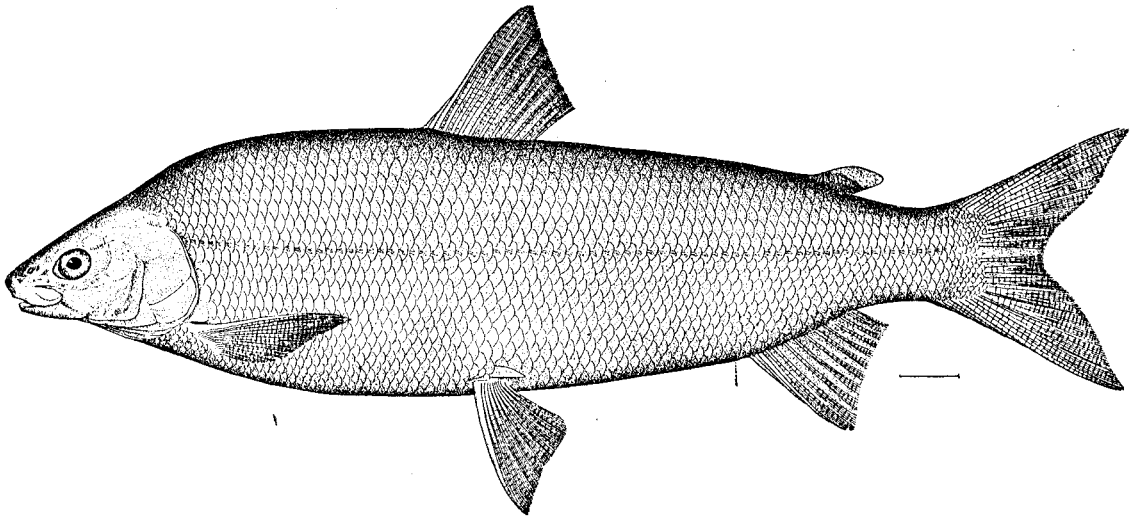
In January, 1883, the United States Fish Commission delivered 500,000 eggs at the hatchery of the California commission at San Leandro. No record of the results of this consignment has been met with.

Whitefish fry were introduced into a number of Oregon lakes in January and February, 1889, by the United States Fish Commission. The largest deposit, numbering 400,000, was made in Klamath Lake, near Linkville, at the southern end of the lake. About 100,000 fry were placed in Kullaby Lake, near Astoria; 75,000 in Chetaw Lake, in Wasco County; and 10,000 in Laddis Lake, in Multnomah County.

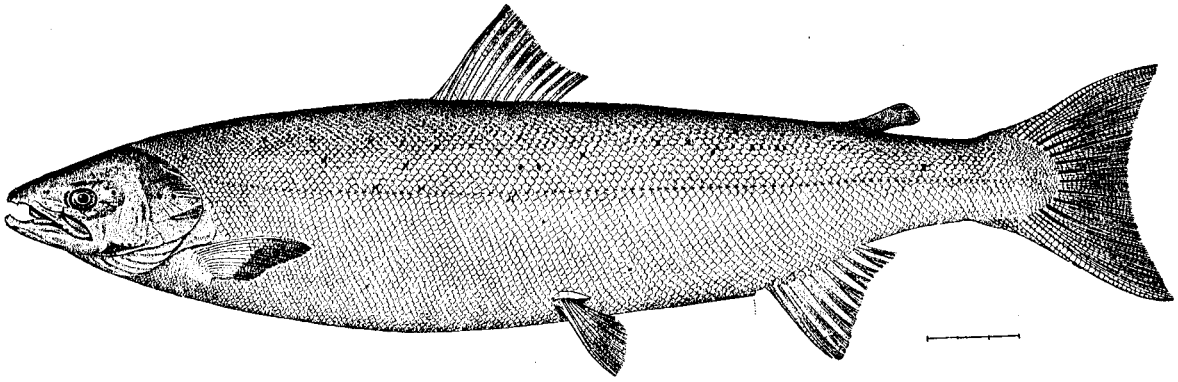
The plants of whitefish in Washington have consisted of 375,000 fry placed in Washington Lake at Seattle; 300,000 in Lacamas Lake, in Clarke County; and 10,000 in Silver Lake, at Castle Rock. These deposits were made by the United States Fish Commission in February, 1889.

In Cœur d'Alene Lake and Pend d'Oreille Lake, in Idaho, in the basin of the upper Columbia River, very large deposits of fry were made by the United States Fish Commission in February, 1889. In the former lake 1,930,000, and in the latter 1,300,000, young whitefish were planted. Hayden Lake, a small body of water north of Lake Cœur d'Alene, received 20,000 fry at the same time.

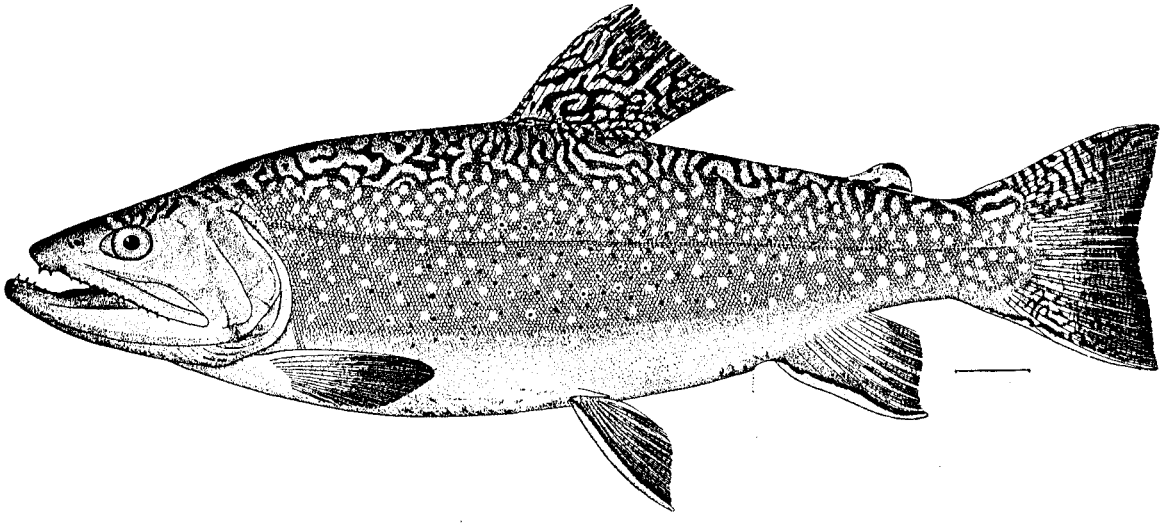
The results attending the introduction of whitefish into California waters have been extremely meager, if not altogether negative. While it is possible that the fish have in certain waters been overlooked, owing to the nonprosecution of commercial fisheries and the absence of scientific investigation, it is known that they have not attained economic importance anywhere in the State and have never been taken, in recent years, in some of the waters in which they were planted.



WHITEFISH (*Coregonus clupeiformis*).



ATLANTIC SALMON (*Salmo salar*).



EASTERN BROOK TROUT (*Salvelinus fontinalis*).

The reports of the California fish commission for the years following the first whitefish plants contained several references to the taking of large fish. The report for 1875–76 stated that several mature whitefish had been caught in Clear Lake in the winter of 1875, and in the report for 1876–77 the commissioners say of this fish:

> We believe they have lived in Clear Lake, also in Tulare. It is reported in a Lake County paper that a whitefish was taken in Clear Lake April 10, 1876, which measured a foot in length. We have no positive information that they have found a congenial home in Tulare Lake, but have heard reports that a few have been seen.

In the commissioners' report for 1878–79 it is stated that the fish had thrived and that reports of the capture of a few mature fish in Tahoe, Tulare, and Clear lakes had been received. The report for 1883–84, however, casts considerable doubt on the supposed taking of eastern whitefish in California waters. The commissioners say:

> The results accruing from the planting of this kind of fish in our waters are not fully known to the commissioners, and * * * we have no reliable data as to whether they are a success or not. There are native whitefish that are caught in lakes Bigler and Donner, which have been taken for those planted by the former commissioners. * * * There has been no showing of the eastern whitefish so far. * * * Up to August 30 (1884) not one has been taken, so far as the commissioners have any knowledge.

In the report of the California fish commission for 1893–94, which contains a review of the outcome of the introduction of non-indigenous fish, no results are said to have attended the planting of whitefish. The inquiries of the United States Fish Commission have not disclosed the existence of any eastern whitefish in California waters. In a recent report* on the fishes of Clear Lake, no species of whitefish is reported.

Mr. F. C. Reed, of Astoria, has often made inquiries about the whitefish planted in the lake in that vicinity, but has learned nothing. The fishermen have no means of catching them if the fish are really there, and would hardly know them if caught.

In Washington and Idaho a number of reports of the taking of whitefish have been received, but the possibility of mistaking the native whitefish (*Coregonus williamsoni*) for the introduced species is so great that it would require actual specimens in order to settle the question in a given locality. The fact that most if not all of the supposed eastern whitefish have been caught with a hook casts considerable doubt on the correctness of the identification. The native whitefish, which is widely distributed in the Pacific States, readily takes the hook, but the common eastern species very rarely bites at a baited hook. The average weight of the native whitefish is under 1 pound and the maximum is about 4 pounds. The eastern whitefish sometimes attains a weight of over 20 pounds, and fish weighing 10 pounds are common, although the weight is usually only 3 to 5 pounds.

Hon. George T. Myers, of Portland, has kindly interested himself and others in ascertaining the results of planting whitefish in Washington and has forwarded several communications on the subject. Mr. Myers mentions the reported capture in recent years of a number of whitefish with hook and line in lakes Washington, Sammish, and other waters where the eastern fish was planted, and states that a fisherman formerly living on lakes Michigan and Superior says that he has caught some of the fish which were identical with those he had previously taken in the Great Lakes.

---

* List of Fishes inhabiting Clear Lake, California. By David S. Jordan and Charles H. Gilbert. Bull. U. S. Fish Com. 1894, pp. 139–140.

Mr. James Crawford, fish commissioner of Washington, writes as follows:

I have yet to hear of any whitefish being caught in any of the waters of the State. I have heard of some strange fish having been seen in the waters of Lake Washington, but no one knew what they were. Some whitefish were planted in Lake Lacamas in this (Clarke) county, but, although I have made repeated inquiries about them, I could never hear of any having been seen. It may be that because whitefish do not take a hook they have never been caught.

Inquiries by Mr. William Barnum in Idaho in 1895 elicited the information from several sources that eastern whitefish had been taken in lakes Pend d'Oreille and Cœur d'Alene, but the evidence is that the fish in question were of some other species. A specimen of supposed eastern whitefish obtained at Cœur d'Alene City, from the lake of that name, proved to be Williamson's whitefish.

The large, cold, deep lakes of Idaho, in which plants were made, are apparently as well adapted to the growth and multiplication of the whitefish as Lake Superior. While there may be an abundance of mature whitefish in those waters, their existence might be entirely overlooked in the absence of deep-water gill-net fishing and special scientific investigation. The inquiries of the Fish Commission representatives in 1894 and 1895 failed to throw any light on the presence or absence of the eastern whitefish in lakes Cœur d'Alene and Pend d'Oreille.

THE ATLANTIC SALMON.

The attempt to acclimatize this valuable food and game fish on the Pacific Slope was made in 1874, when the "aquarium car," in charge of Mr. Livingston Stone, of the United States Fish Commission, carried numerous species of eastern fish across the continent.* Four hundred and fifty small Atlantic salmon (*Salmo salar*) obtained in the Penobscot River, Maine, were among the consignments; of these, 305 survived and were deposited, June 12, 1874, in the Sacramento River at Redding.

In 1890, 200,000 eggs were consigned to the Fish Commission station at Fort Gaston, Cal. Of these, 194,000 were successfully hatched, and in May, 1891, the young were placed in a pond. Capt. W. E. Dougherty, the superintendent, reports that they were fed until about the last of July, when, having attained a very considerable size, they were liberated in the Trinity River.

The deposit of young fish placed in the Sacramento River in 1874 has yielded no known results. The fish undoubtedly succumbed to physical causes or were devoured by enemies, the planting being entirely too small to warrant the expectation of success. The only reference to the matter subsequent to the planting is contained in the report of the California fish commission for 1874–75:

None of the eastern salmon have been seen since they were placed in the Sacramento River. It is hardly expected that they should be as yet, as without doubt they have gone to the ocean, not to return until the spring of 1876, when we have to hear of some of them being caught on their return for the purpose of spawning. It will be interesting to learn in after years if they will cross with the Sacramento salmon and produce a new variety.

Captain Dougherty states that the salmon planted in 1891 did well, and that some of them were subsequently taken by Indians, having reached full size. No other report of these fish has been received.

* See Report California Fish Commission, 1874–75.

THE LANDLOCKED SALMON.

In January, 1878, the United States Fish Commission sent to the California fish commission, from Grand Lake Stream, Maine, 50,000 eggs of the landlocked or Schoodic salmon (*Salmo salar sebago*). These were hatched at San Leandro by the Californian authorities and in March and April deposited in various waters. In their report for 1878–79 the commissioners say:

> As the landlocked salmon are natives of the cold lakes of Maine, we have thought the most appropriate places for the distribution of the young fish would be in our mountain lakes; but, for purposes of testing their fitness to thrive in warmer waters, a portion were also distributed to lakes in the valley and on the coast, as follows: Donner Lake and other lakes near the summit, 10,000; San Francisquito Creek, Espenosa Lake, etc., 10,000; Tulare Lake, 15,000; San Leandro Creek and Lake, 2,500; Arroyo Laguna, near Sunol, 700; reservoir at almshouse, San Francisco, 1,000; Echo Lake, El Dorado County, 250.

A somewhat more detailed statement of the distribution of these fry is given in the report of the United States Fish Commission for 1881, page 894. Sereno and Chabot lakes and Laguna Honda are mentioned as receiving fry.

In the report of the California commission for 1881–82 figures are presented showing the distribution in 1881 of 20,100 landlocked salmon fry in Prosser Creek, Donner Lake, Lake Tahoe, and in various waters in Santa Cruz, Marin, San Mateo, Alpine, and other counties. These fry resulted from a shipment of 25,000 eggs from Grand Lake Stream, donated by the United States Fish Commission.

The report of the United States Fish Commission for 1881 shows that in the spring of 1882 a shipment of 10,000 Schoodic salmon eggs was sent to the California authorities; the resulting fry, 5,433 in number, were placed in Prosser Creek, Blue Lake, and Lake Honda.

In 1884 the United States Fish Commission sent 30,000 landlocked salmon eggs from Maine to the California fish commission. These were hatched with a reported loss of 7½ per cent, and the fry were distributed as follows: 5,000 in Independence Lake, 10,000 in Donner Lake, 10,000 in Bigler Lake (Lake Tahoe), and 300 in Butterfly Creek.

In 1890 the United States Fish Commission station at Fort Gaston, Cal., received 20,000 eggs of landlocked salmon from Maine. The disposition made of the fry is not known to the writer.

Thirty thousand eggs were sent to the California commission in February, 1892, and the fry were turned over to the Country Club. The eggs arrived in poor condition, and only a small percentage hatched. The fry were planted in the preserve of the club.

In March, 1895, 10,000 eggs were delivered to the Country Club of San Francisco for stocking waters on the club's preserve in Marin County; 3,000 fry were produced. At the same time, 10,000 eggs were sent to the California fish commission. These were hatched with heavy loss (60 per cent). Mr. Babcock states that the fish are retained at Sisson, but will be placed in Lake Tahoe in 1896.

A number of plants of landlocked salmon have been made in Nevada from spawn furnished by the United States Fish Commission. The nature of the early work in Nevada is obscure, and no account of the first plant or plants has been met with. In

the report of the State fish commissioner for 1881–82, the first reference to the fish is found, the commissioner there stating that in 1881 he again commenced hatching landlocked salmon. The eggs were first forwarded by the United States Fish Commission in December, 1882. From this consignment, consisting of 15,000 ova, 14,000 fry were hatched and placed in the Truckee and Carson rivers in June, 1883. In 1890, 1891, and 1892, 70,000 eggs were sent to the Nevada fish commissioner. No records are available showing the disposition made of the fry resulting from the shipment in 1890. The fry from the 1891 consignment were distributed as follows: Truckee River, 7,000; Humboldt River, 5,000; Carson River, 2,500; Lake Tahoe, 2,500. The plants in 1892 consisted of 4,500 in Truckee River, 4,000 in Humboldt River, 4,000 in Carson River, and 500 in Lake Tahoe.

The published details of the results attending the planting of salmon fry in 1878 are very meager. No reference was made to the matter in the State commissioners' reports until 1884, when it was stated that the plant in 1878 had been only a partial success; that only a few fish had as yet been taken, and that the catch had been about the same as last season, of which no mention is made. The State report for the years 1885–86 says of the landlocked salmon:

> Some small plants were made by former commissioners. The fish increased and thrived. Many large ones have been captured during the last and present year.

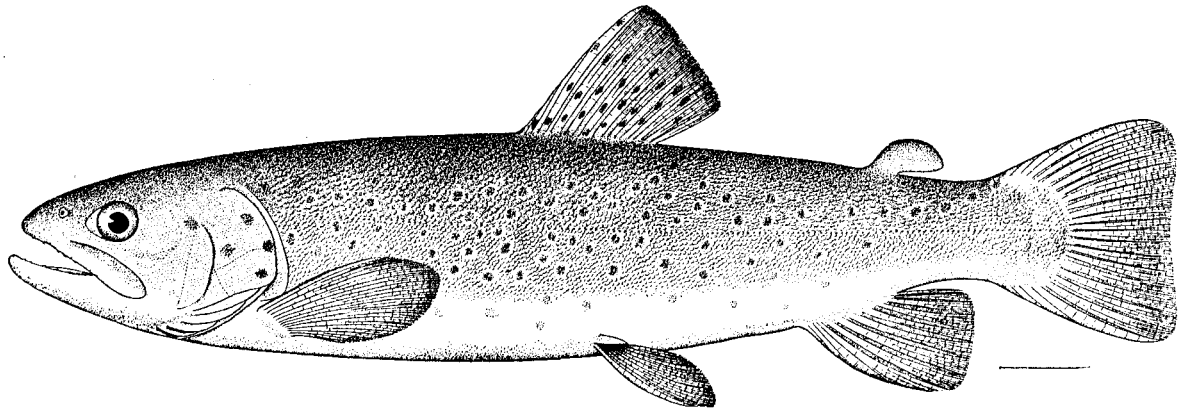
Mr. E. W. Hunt, deputy of the California fish commission, in a report dated September 30, 1891, made the following reference to landlocked salmon:

> I have been making inquiries about the landlocked salmon planted in Donner and Independence lakes. There have been two or three caught in Independence Lake during the spring and summer, weighing from 1½ to 3 pounds. The professional fishermen on the lake do not think that they hybridize. They are decreasing instead of increasing. None have ever been caught in Donner Lake that I can hear of.

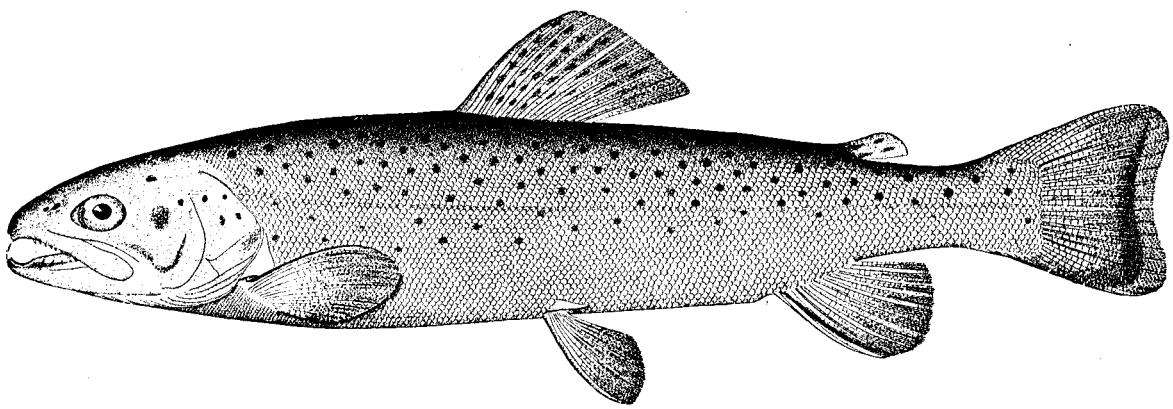
Mr. John P. Babcock states that of the fry placed in Lake Tahoe nothing had been heard up to December, 1895. Mr. Babcock thinks it possible that, as they so closely resemble the so-called "silver-side trout" of Lake Tahoe (*Salmo mykiss henshawi*), some of them may have been taken and not reported. He also furnishes the information that the fry resulting from the shipment of eggs for the Country Club in 1892 were placed in lakes on the club's preserve in Marin County, and several fine specimens were taken there in 1895. The club reports that the fish are doing finely.

In Nevada the results of the introduction of landlocked salmon seem to have been quite marked. The following quotations from the reports of the State fish commission will be sufficient to show the general outcome:

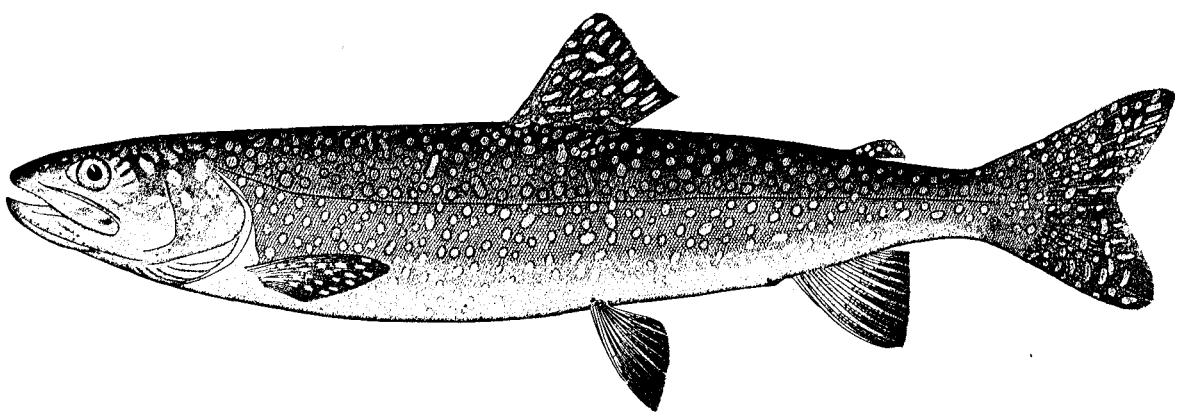
> The landlocked salmon furnished by the United States Fish Commissioner were planted in the same waters with the McCloud River salmon. The plants were small, and from the large bodies of water to be stocked I had but little hope of reporting at so early a day as this. No attempts, other than ordinary angling, have been resorted to in determining their condition. Sportsmen and fishermen have had numerous good catches of these most desirable food-fish, and an undeniable verdict as to their superiority for our waters comes from every intelligent person accustomed to the habits of fish. They do well in the Truckee and Carson, proofs of which I have in the returns made to me by fishermen this season. I await the reception of more spawn, that I may be able to introduce them into every stream in the State. (Rept. 1883–84, pp. 4–5.)
>
> Mr. H. G. Parker, while fish commissioner, made one plant in Lake Tahoe and Truckee River. During the past few years many of these fish, weighing from 1 pound up to 3½ pounds, have been taken. * * * Of my 1891 plants, several, from 2 to 10 inches in length, have been seen, thus showing our waters are adapted to their growth. (Rept. 1891–92, p. 12.)



VON BEHR TROUT OR EUROPEAN BROWN TROUT (*Salmo fario*).



LOCH LEVEN TROUT (*Salmo trutta levenensis*).



LAKE TROUT, SALMON TROUT, OR MACKINAW TROUT (*Salvelinus namaycush*).

THE VON BEHR TROUT.

The fish resulting from 25,000 eggs of the Von Behr or European brown trout (*Salmo fario*), sent from Northville, Mich., to Fort Gaston, Cal., in January, 1892, were placed in California waters in 1893 and 1894. In 1893 the plants consisted of 10,700 yearlings in Supply Mill and Fish Tang creeks, near Hoopa Valley, Humboldt County; 50 yearlings in Three Creeks, near Hoopa Valley, Humboldt County, and 178 yearlings in Redwood Creek, Humboldt County. The yearlings planted in 1894 were: 100 in Elk River, near Eureka; 981 in Larrabee Creek, a tributary of Eel River, and 2,715 in the preserves of the Country Club in Marin County. In December, 1892, 300 yearling fish from the Leadville station of the United States Fish Commission were supplied to an applicant in Idaho for planting in a private pond near Reynolds, Owyhee County. This fish occasionally reaches a weight of over 20 pounds, but the average is only 5 or 6 pounds.

THE LOCH LEVEN TROUT.

In February, 1894, 20,000 eggs of the Scotch lake trout (*Salmo trutta levenensis*) were sent to the California commission from the Northville station of the United States Fish Commission. The eggs were hatched at Sisson and the fry placed in a lake near the hatchery, to be retained as brood stock. Under date of December 6, 1895, Mr. J. P. Babcock, of the California commission, writes that the fish have done well, and in July, 1895, 250, about 3 inches long, were deposited in Webber Lake, Nevada County. Several thousand are supposed to be still on hand at Sisson. The Loch Leven trout is very similar to the brown trout in size and appearance.

THE LAKE TROUT.

Attempts have been made to introduce the lake trout (*Salvelinus namaycush*) into California and Nevada. This fish is also known as the salmon trout or Mackinaw trout. From the commercial standpoint, it is the most valuable of the so-called trouts of the United States. It is generally distributed in the Great Lakes, being especially abundant in lakes Superior, Michigan, and Huron. In 1893 over 15,000,000 pounds were taken in the Great Lakes, for which the fishermen received more than $600,000. The fish attains a large size, and is an excellent game and food fish. It is adapted to clear, cold, deep lakes, in which it has been known to reach a weight of 90 pounds.

In November, 1894, the United States Fish Commission sent 100,000 lake-trout eggs to the California fish commission. The eggs were hatched with a loss of only about 7 per cent, and in May, 1895, 65,000 fry were placed in Lake Tahoe, the remainder being retained at the Sisson hatchery.

In 1885 the United States Fish Commission sent 100,000 eggs to the Nevada fish commission. One lot of 25,000 eggs was lost in transit, but the other arrived in good condition. In December, 1889, the Nevada commissioner received another consignment of 30,000 eggs, which were hatched with little loss. The State reports do not show where these fry were planted, and no data are at hand giving the results of the early plants, but Mr. George T. Mills, fish commissioner of Nevada, states that the lake-trout fry planted in 1889 have done well and are multiplying. They were planted mostly in Lake Tahoe and are now occasionally taken by the fishermen of that lake. The largest Mr. Mills has any account of weighed 11 pounds; this is above the average of trout now taken in the Great Lakes.

THE EASTERN BROOK TROUT.

PLANTING OF BROOK TROUT IN PACIFIC STATES.

Extensive attempts to acclimatize the eastern brook trout (*Salvelinus fontinalis*) have been made in several of the States of the Pacific Slope. The first plants, made more than twenty years ago, have been supplemented in recent years, and the fish has been given a wide distribution, especially in California and Nevada.

As early as 1872 the California fish commission began their efforts to introduce this favorite game fish into the State waters, and purchased 6,000 young fish for that purpose. The plants were made in three equal installments—in the North Fork of the American River, in the headwaters of Alameda Creek, and in the San Andreas reservoir near San Francisco.

In 1875 the California fish commission purchased 60,000 brook-trout eggs in New Hampshire and hatched them at Berkeley, with a loss of 4 per cent. The fry were distributed in public waters of the State, about 20,000 being placed in lakes and streams in Mendocino, Sonoma, Napa, and Yolo counties; 20,000 in Calaveras Creek (in Alameda and Santa Clara counties) and other streams tributary to San Francisco Bay; 10,000 in Prosser Creek, Nevada County, and 10,000 in the North Fork of the American River, in Placer County. In January, 1877, 133,000 additional eggs were obtained by purchase in the East. The young fish resulting from these eggs were planted in suitable waters in Siskiyou, Contra Costa, Alameda, Placer, Nevada, Santa Cruz, San Mateo, Monterey, Los Angeles, San Diego, Yuba, and Santa Clara counties.

New Hampshire and Wisconsin furnished eggs in 1878 and 1879 to the number of 70,000. The fry resulting from these were extensively distributed, the North Fork of the American River and the Truckee River receiving the largest plants. In 1880 41,500 fry were distributed. From that time up to 1890 the reports of the California commission do not show any brook trout handled. In the latter year, however, 100,000 eggs were purchased in New Hampshire, and 83,000 fry were produced and distributed in tributaries of the Sacramento and Klamath rivers. In the same year the North Pacific Game and Fish Club privately planted 25,000 young trout in Robinson Creek.

The most extensive brook-trout propagation by the California authorities was carried on in 1892, when 317,000 fry were distributed, the eggs being taken in Marlette Lake, Nevada, where the fish had been acclimatized. The following year 251,000 fry were hatched from eggs obtained in Nevada, and in 1894 266,000 more fry were planted under the same conditions.

The aggregate deposits by the State commission numbered 1,228,000 fry, which were placed in nearly every county having suitable waters. For detailed statements of the waters stocked, the reports of the California fish commission should be consulted.

In May, 1893, the United States Fish Commission made plants of young brook trout in California, as follows: 50 yearlings in Three Creeks, near Hoopa Valley; 215 yearlings in Redwood Creek, at Berry's Crossing, and 5,900 yearlings in Supply Mill and Fish Tang creeks, Hoopa Valley. These fish resulted from a lot of 20,000 eggs from New York, which were hatched and reared at Fort Gaston (Cal.) station of the United States Fish Commission.

The brook trout appears to have been successfully introduced into Nevada waters at a comparatively early date, but a history of the matter is not at hand. The Nevada

fish commissioner, in his report for 1881 and 1882, speaks of having hatched brook trout, but no details are given and no mention of the subject is made in his two preceding reports, going back as far as 1877, implying the carrying on of private fish-cultural work before the formation of a State fish commission. In 1883 a reservoir of the Virginia and Gold Hill Water Company yielded 250,000 eggs of the brook trout, which, when hatched, were distributed to the Carson, Walker, Truckee, and Humboldt rivers, each receiving 40,000 fry. About 3,000 fry were also placed in Washoe Lake. In 1885 or 1886, 50,000 eggs were taken from the same reservoir, but the details of the distribution are not recorded. In 1887, 500,000 eggs were obtained from fish caught in Marlette Lake, and in 1888 the same number was taken in that water. The combination of the resulting fry with the young of the native trout of Lake Tahoe in the distribution tables published by the State commissioner makes it impossible to record the waters in which plants were made. Large numbers of fry were deposited in 1889 and 1890, but no details are available.

The planting of fry by the Nevada commission was continued in 1891 and 1892. In the former year 545,000 fish were allotted to private waters or public streams, the Truckee, Carson, and Humboldt rivers receiving 410,000 fry. In the latter year the plants aggregated 362,800 fry, of which 220,000 were placed in the rivers named and 65,000 in Lake Tahoe. In 1893 the State distributed 430,000 brook trout, the plants being mostly in the Truckee, Carson, and Humboldt rivers and Lake Tahoe. The eggs were taken from fish that had been introduced.

Plants of yearling brook trout were made in Oregon and Washington by the United States Fish Commission in the fall of 1894. Sixteen hundred fish were equally apportioned to the South Fork of the Umatilla River, near Gibbon, Oreg., and to a tributary of Dead Point Stream, near Hood River Station, Oreg. The fish put in Washington waters consisted of 375 yearlings in Twin Lake, 750 in Mountain Lake, 750 in Kelly Lake, 750 in Hooker Lake, 1,150 in Cranberry Lake, 1,150 in Johns Lake, and 51 in Washington Lake—a total of 4,976. All of these fish were reared at the Fish Commission station at Leadville, Colo.

STATUS OF THE BROOK TROUT IN THE PACIFIC STATES.

While detailed information is wanting regarding the outcome of the attempts to colonize the brook trout in this region, and while the results of plants in many places are unknown to the writer, enough has been recorded in the State reports and elsewhere to show that the fish has become adapted to numerous waters, where it has spawned and now constitutes a permanent addition to the list of game fishes of the section. As early as 1880 the results of brook-trout planting in California had become noteworthy. In the report of the California fish commission for that year it is recorded that—

> The South Yuba and the North Fork of the American rivers, which originally contained no fish above the high falls on each stream, are now well stocked with trout. We have also stocked other streams, which naturally contained no fish, or from which all the fish had been caught.

In the report of Mr. J. G. Woodbury, superintendent of hatcheries, published in the report of the California fish commission for 1889–90, the following references are made to the results of planting eastern brook trout in 1875, 1877, 1878, and 1879. After mentioning the waters stocked, he says:

> In all these short coast streams, which become warmer and diminish in volume as the summer advances, they have not reproduced themselves—at least I can not learn that they have been caught for a number of years past; but in all the high Sierra streams where these trout were planted they

can now be caught quite plentifully. The integrity of their characteristics in all their virgin beauty is maintained. A number of these fish were caught during the past summer in Blackwood Creek, Lake Tahoe.

About four years ago a few of these fish were planted in a small lake on the mountain side back of McKinney's place, Lake Tahoe. Last year Mr. McKinney told me that a number of eastern trout had been caught in that little lake, one of which weighed 3 pounds. He said they were fierce fighters and had a delicious flavor. Some of these eastern trout have been caught 30 miles down the river from the place where they were first planted in the North Fork of the American River. It seems to me very probable that the eastern brook trout, as they become older and larger, will drop farther and farther down the main stream, and ascend other branches to spawn, and thus becoming acclimated will gradually stock all the streams in the State accessible from the first stream in which they were planted.

Mr. John P. Babcock, in response to an inquiry, contributes the following interesting notes on the eastern brook trout in California:

The *fontinalis* has been given a very wide distribution in the streams of the State, almost every stream having been stocked at different times since the fish's introduction in 1872.

None of the plants in the immediate coast streams has been successful. In the small streams of the higher altitudes the fish has done fairly well.

Take the Truckee basin: The Nevada and California commissions have made liberal plants in Lake Tahoe. A few have been taken from the lake. Our men seining for spawning *mykiss* in spring of 1895 took one *fontinalis* that weighed 3¾ pounds. It is highly marked and of a deep, stocky build; we have it in the office. It is the only *fontinalis* taken in the lake with our seine, though we have taken many thousands of cut-throats. Of the streams that come into Tahoe from the west, Blackwood and Taylor creeks afford the best *fontinalis* fishing; the trout, though not large, are common. Very few specimens have been taken from the Truckee River proper, but in a number of its small tributaries they have been and are doing well, notably in Prosser Creek and its very small tributary, Alder Creek. A few *fontinalis* weighing over 2 pounds have been taken from Prosser Creek. In Alder Creek the brook trout predominate, as they do in Cold Stream, a small creek above the town of Truckee, but in none of the other small streams of the region does the *fontinalis* exceed 20 per cent of the catch, while the rainbow trout (*Salmo irideus*) introduced to these waters exceeds 70 per cent of the catch for the past four years.

In Lake of the Woods, a small sheet of water above and near Webber Lake, in Sierra County, specimens of *fontinalis* were taken the past season (1895) that weighed over 3 pounds, and one 2-pounder was taken from Webber Lake.

The brook trout have done well in the headwaters of American, Yuba, and Feather rivers, though they confine themselves to the smaller waters. The same may be said of the small streams in the Shasta region, the small creeks around the town of Sisson being well stocked. Large plants have been made in Sacramento and McCloud rivers, but no fish have been taken except in headwaters of small streams.

In the Klamath region they have not been a success.

In the Yosemite Valley country the plants have been very successful, and some fine fishing is to be had in Bridal Veil Creek and near Wawona in some of the lakes.

The fish placed in the King River region are reported as doing well.

In southern California, in spite of repeated efforts, they have not done well.

Speaking of the introduction of these fish in general, it can not be said to have been as successful as anticipated. They do not seem to hold their own against the natives; they have added but little to the attractions of the sportsmen, who do not consider them the equal of either the cut-throat or rainbow trout in gameness or flavor. They take the same flies as the natives. In Lake of the Woods, however, they take the spoon only, and can not be called to the surface with flies. The commission will make no further efforts to propagate these fish. We obtained the main supply of *fontinalis* spawn from Marlette Lake, in Nevada.

About 1892 a hybrid between the brook trout and the Dolly Varden trout (*Salvelinus malma*) was produced at the Sisson hatchery of the California fish commission. Two thousand eggs of the latter fish were fertilized with brook-trout milt. The experiment has been repeated each year up to the present time, and a large number of small fry is on hand. Mr. Babcock writes, under date of December 18, 1895, that

some of the specimens now at Sisson are about 7 inches long. In November, 1895, a few eggs were taken from the hybrid fish, and an effort will be made to hatch them. Mr. Babcock states that the crosses exhibit very beautiful colors.

Only meager data are at hand relating to the outcome attending the planting of the numerous trout fry in Nevada waters. It is known, however, that the fish have not only survived in most of the waters stocked, but have proved an economic commodity for sale in local markets and for home consumption. The fact that all of the spawn previously mentioned (amounting to more than 3,000,000 ova) was taken from wild fishes, is in itself sufficient evidence of the adaptability of this fish to the waters of Nevada and of its successful introduction.

The acclimatization of brook trout in the Humboldt River has been very successful; the report of the Nevada commissioner for 1893–94 states that good catches have been made and that an encouraging future awaits the fish in that stream.

Hon. George T. Mills, Nevada fish commissioner, writes as follows regarding the eastern brook trout in the Carson River and elsewhere in Nevada:

> The *S. fontinalis* do not seem to have increased in that stream. Their scarcity I attribute to their leaving the main stream for the many side streams, and from there out in irrigating ditches, where they perish. In other small streams in the State where they have been placed, they are a success beyond our expectation. With us they are extremely hardy, and the fry will stand almost anything. For example, in July of this year, I sent 20,000 to some creeks in the northeastern part of this State—12 hours by rail, 70 miles by wagon—with the loss of only one fish. This I think phenomenal.

Sufficient time has not yet elasped to determine the results of the planting of yearling trout in Oregon and Washington in 1894.

THE MUSKELLUNGE.

In May, 1893, the New York fish commission furnished to the California fish commission 100,000 fry of the muskellunge (*Lucius masquinongy*) from Chautauqua Lake. The United States Fish Commission gave free transportation of the fish to Ogden, Utah, from which place the consignment was under the auspices of the California commission. The fish reached their destination in good condition, and 93,000 were placed in Lake Merced, near San Francisco.

The introduction of this species was undertaken at the solicitation of the Spring Valley Water Company, of San Francisco, which paid half the expense of transportation from Ogden. It having been learned that the muskellunge grows rapidly, is a voracious feeder on live fish, and has excellent game qualities, it was thought to be a desirable fish to plant in the reservoirs of the company to check the proliferation of carp and afford sport. Carp existed in great abundance in Lake Merced and Palisidas Lake, which are reservoirs for the water supply of San Francisco; and these fish kept the water constantly stirred up and consequently muddy. The desirability of keeping the carp in check was probably the chief reason for the importation of the muskellunge.

The muskellunge fry were put in private water under an agreement with the water company permitting the State to take such fish for breeding purposes and distribution as might be desirable.

The planting of muskellunge in Lake Merced appears to have been a failure, although sufficient time may not yet have elapsed to fully decide the matter. In June, 1894, the California commission employed some drag-net fishermen, who made hauls in every part of the lake, but obtained no muskellunge, and the commissioners, in the report for 1893–94, express the belief that the fry have not survived.

The muskellunge is a magnificent food and game fish, sometimes reaching a weight of nearly 100 pounds. Further efforts will doubtless be made to secure its colonization in California.

THE PIKE OR PICKEREL.

On September 15, 1892, 76 yearling pike (*Lucius lucius*), sent from the station of the United States Fish Commission at Quincy, Ill., were placed in the Boise River, near Boise, Idaho. In the preceding December a plant of 400 pike was made in Lake Cuyamaca, California, near San Diego, and another of 100 in the Feather River, in Butte County, Cal. These fish were also yearlings from Quincy.

Mr. Arthur G. Fletcher, of the California fish commission, visited Lake Cuyamaca in January, 1896, and found that the pike had survived. In two hauls of a small seine near the shore, 4 fish under 8 inches long were taken; 2 of these, which were forwarded to San Francisco, were females with well-developed ova. Pike are said to be more numerous than any of the other eastern fishes—black bass, yellow perch, catfish, and crappie—that were planted in the lake at the same time as the pike. Mr. J. E. Friend, of San Diego, recently caught with rod and line 2 pike that weighed 2 pounds apiece. Professor Jordan has identified as the little pickerel (*Lucius vermiculatus*) one of the small specimens obtained by Mr. Fletcher.

THE EEL.

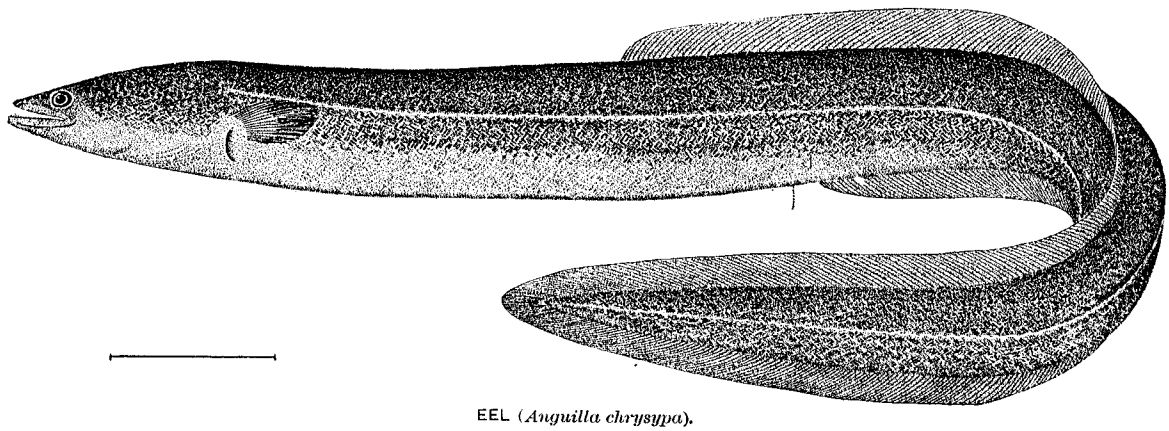
HISTORY OF INTRODUCTION.

As early as 1871 the California fish commission contemplated the introduction of the common eel (*Anguilla chrysypa*) into the Sacramento River,* and in 1873 an effort was made to import eels from the east coast. Acting in behalf of the California fish commission, Mr. Livingston Stone, of the United States Commission of Fish and Fisheries, started from Charleston, N. H., with an "aquarium car," containing, besides a large number of other fish, 1,500 eels from Martha's Vineyard, Mass., and 40,000 from the Hudson River, New York. The car passed beyond Omaha with the eels in good condition, and the prospects were favorable for the safe arrival on the Pacific Coast of between 20,000 and 30,000 eels, when the car was wrecked in a railroad accident and the entire stock was lost.

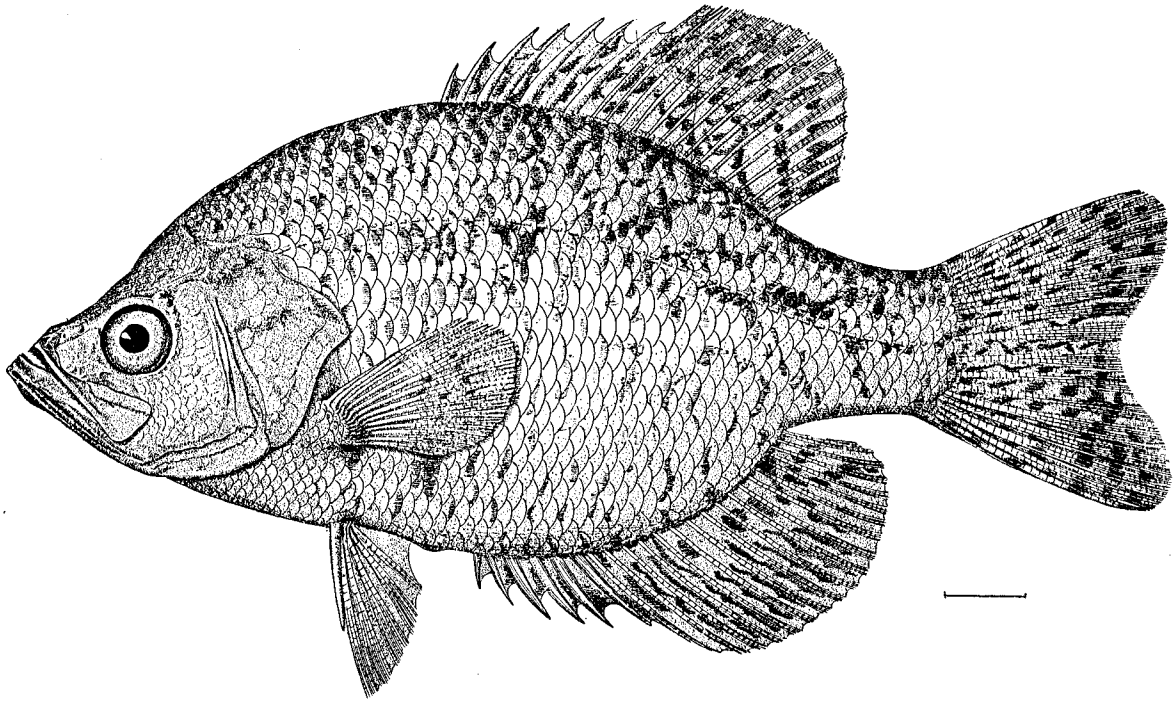
In 1874 the attempt to introduce the fish was renewed and successfully carried out by Mr. Stone in the new "aquarium car," to which frequent reference is made in this paper. The original consignment consisted of about 2,000 small "fresh-water" eels from Castleton, N. Y., on the Hudson River, and several thousand small "salt-water" eels from New York Harbor. The loss of the former lot in transit was almost complete, but the eels taken from salt water stood the journey well. On June 12 the fish from the Hudson River, then reduced to 12 in number, were placed in a slough of the Sacramento River near Sacramento. The eels from New York Harbor, about 1,500 in number, were deposited in an inlet of San Francisco Bay, near Oakland.†

* Report of the Commissioners of Fisheries of the State of California, 1870–71, p. 14.

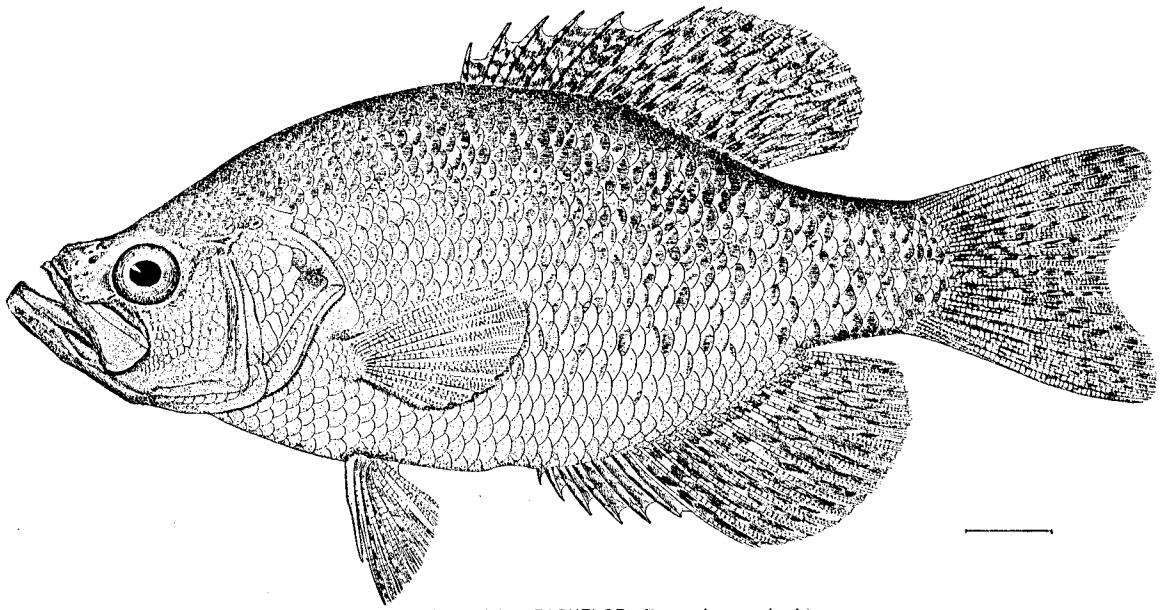
† In a tabulated statement accompanying Mr. Stone's report of the trip with the aquarium car, these eels are said to have been placed in lakes at Sutterville, a town on the Sacramento River, near Sacramento. (Rept. Cal. Fish Com., 1874–75, pp. 6, 30, 32.)



EEL (*Anguilla chrysypa*).



CRAPPY; STRAWBERRY BASS; CALICO BASS (*Pomoxis sparoides*).



CRAPPY; SAC-A-LAI; BACHELOR (*Pomoxis annularis*).

The planting of eels in waters of California was next accomplished in 1879 under the same circumstances that attended the introduction of several of the other fishes to which reference is made in this paper. The transportation of the fish across the continent was again superintended by Mr. Livingston Stone, whose report* contains all that is recorded regarding the history of the experiment. The supply of eels consisted of about 3,000 individuals obtained by Mr. Seth Green in the Hudson River, New York, and about 500 others secured by Mr. H. W. Mason in the Navesink River, New Jersey, in connection with the taking of striped bass intended for the same shipment. The tank of eels from the Hudson River was thrown away en route, as Mr. Stone saw that there was no possibility of their reaching the coast alive; the others (about 500 in number) reached Sacramento on June 18 in good condition and were deposited in the Sacramento River and Alameda Creek.

In July, 1882, Mr. J. G. Woodbury, of the California fish commission, took 10 eels from the Shrewsbury River, New Jersey, to California, in connection with the transportation of striped bass. They were carried west without loss by keeping them in a well-ventilated box in which moist eelgrass was placed. These eels were apparently larger than those in the previous plants, being from 12 to 24 inches in length. They were planted in Suisun Bay in water about a foot deep, on the edge of the tules. "On being put into the water they immediately bored straight down into the soft mud, and in a moment were all out of sight."

OUTCOME OF THE EXPERIMENTS.

The results of the introduction of eels to California waters are not fully known, and reports of the capture of the fish are unsatisfactory and somewhat contradictory. The first reference to the taking of an eel in California appears to be that given in the biennial report of the State commissioners for 1874–75. They say:

> Of the fresh-water eels placed in a tributary of the Sacramento River, we learn that one had been caught in Willow Slough, in Yolo County, which had grown to be more than a foot in length. We have no knowledge that the salt-water eels placed in Sacramento Bay have ever been seen.

In the report of the commissioners for 1876–77 it was stated that a few eels had been caught, but they had not become numerous. The next report recorded the capture of several "taken in the fresh water, near Sacramento, full grown, and 3 feet in length." In 1880 the commissioners stated:

> Occasionally we hear of an eel being captured, but as yet they have not shown an increase in proportion to that of other imported fish.

The statements regarding this fish in the report for 1883–84 conflict somewhat with the foregoing:

> Eels, placed in our waters by the former commissioners, have not been a success. It is probable that the place where they were deposited and where they have made their home has not yet been discovered; at all events, none have been taken since they were planted. It seems to us that they ought to do well in our inland waters, as they are fond of the bottoms of ponds or streams where *mud* prevails, as is the case in our lakes and rivers.

Under the probably erroneous caption, "The first California eel caught," the *American Naturalist* for April, 1882 (page 326), contains this note:

> The San Francisco *Chronicle* of February 8 reports the catch by George Bird of the first eel, resulting from the plant of 12,000 made by the California fish commissioners. It was caught on the easterly shore of San Francisco Bay and measured 3 feet in length.

* Report on Overland Trip to California, 1879. (U. S. F. C. Rept. 1879, pp. 637-644.)

In 1894, when the writer visited the Pacific Coast, no eels were at any time seen in the markets of San Francisco or other cities, and the following statement, based on his observations, was printed in a report* embodying the data on certain phases of the fishing industry obtained at the time:

Inquiries regarding the results of the attempted acclimatization of the eel (*Anguilla chrysypa*) on this coast are apt to elicit misleading information unless great care is exercised. In the San Francisco markets one learns that eels are not infrequently exposed for sale, and that both salt water and river fishermen catch them occasionally, but an examination of the reported eels usually shows them to be lampreys.

According to Mr. Charles Cuneo, of the American Union Fish Company, San Francisco, eels are occasionally caught in the vicinity of San Francisco in seines and other fine-meshed nets operated for other fish, but they are quite scarce. A few come from San Francisco Bay and a few are taken by the steamers using drag nets outside the Golden Gate. Mr. Cuneo says a steamer will sometimes bring in 10 or 12 pounds of eels. Those exposed for sale in the San Francisco markets are small, usually being only 10 to 12 inches long. The wholesale price is 10 to 15 cents a pound.

In view of the hardiness and great prolificness of the eel, it is somewhat remarkable that it has not gained a firm hold in California and become abundant. It is, of course, possible that the failure to catch more of them has been due to the absence of suitable pots or traps, but the fact that the fish are so seldom taken with the various forms of apparatus now used can only be explained by their actual scarcity, and in their last report (1894–95) the California fish commissioners regard the eel as one of the fish from whose attempted introduction "no result can be said to have come."

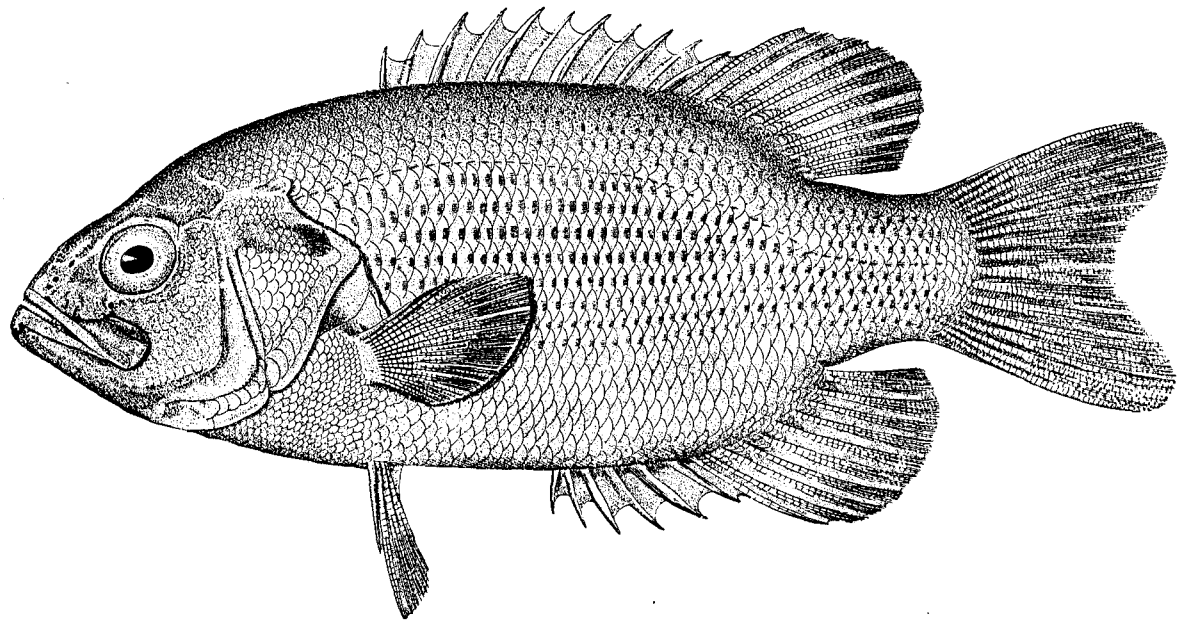
While the eel is a highly esteemed food-fish in the principal markets of the Atlantic States, is easily caught, and yields good returns to fishermen, it is perhaps fortunate, on the whole, that it has not attained abundance on the Pacific Coast. It is known to be very destructive to the spawn of shad and other important food fishes, and if it existed in large numbers in the California rivers it might seriously reduce the supply of salmon, striped bass, and other river fish by resorting to the spawning grounds and devouring the ova.

THE CRAPPIES.

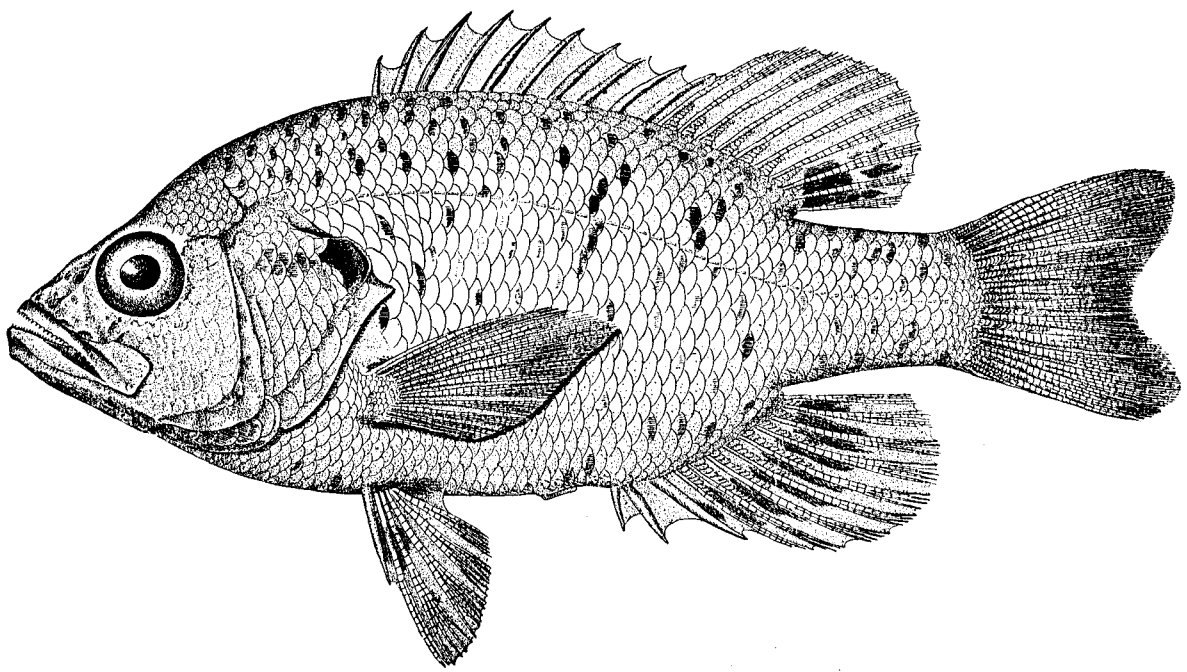
The crappy, sac-a-lai, or bachelor (*Pomoxis annularis*), and the strawberry bass or calico bass (*Pomoxis sparoides*), have been distributed in California, Washington, and Idaho, from the United States Fish Commission station at Quincy, Ill. The first plants were made in Washington. In 1890, 285 yearling crappies were placed in Lake Washington, near Seattle; the following year 220 were put in Loon Lake and 50 in Liberty Lake, near Spokane; in 1892, 25 were planted in Deer Lake near Loon Lake, and in 1893, 18 were put in Shepherd Lake. A plant of 388 yearlings was made in 1892 in the Boise River, near Boise City, Idaho. In Lake Cuyamaca, near San Diego, Cal., 285 yearlings were deposited in 1891. The largest consignment was made in 1895, when 50,000 fry were sent to the California fish commission station at Sisson. Mr. Babcock writes that none of these lived.

While most of the fish belonging to this genus which have been distributed in western waters are known to have been of the first-named species, it is certain that

* Notes on a Reconnoissance of the Fisheries of the Pacific Coast of the United States in 1894. Bulletin U. S. Fish Commission, 1894, pp. 223–288.



ROCK BASS (*Ambloplites rupestris*).



WARMOUTH BASS (*Chænobryttus gulosus*).

the plants have included some strawberry bass or calico bass (*P. sparoides*), which inhabits some of the same waters as the crappy or bachelor. Both these members of the sunfish family are valuable food and game species, attaining a length of 1 foot and a weight of 1½ pounds.

THE ROCK BASS.

Four full-grown rock bass (*Ambloplites rupestris*) obtained in the Missisquoi River, Vermont, were taken to California by Mr. Livingston Stone in 1874 and deposited in Napa Creek, a tributary of San Pablo Bay, on June 12. No known results have attended the planting of these fish, although the black bass placed in the same waters at the same time have greatly multiplied.

The rock bass or red-eye perch is found in the Mississippi and Ohio valleys and in the Great Lakes. It attains a weight of 1½ pounds, is a hardy, gamy fish that takes the hook readily, and is a palatable pan-fish. Like the black bass, it builds a nest and protects its young.

THE WARMOUTH BASS.

A few small plants of this member of the sunfish family (*Centrarchidæ*), to which the black bass, rock bass, and crappy belong, have been made in California, Washington, and Idaho. It is a hardy species, adapted to quiet waters, and is naturally found in the coast States from Virginia to Texas, in the Mississippi basin, and in the Great Lakes. It closely resembles the rock bass in size, habits, food value, and game qualities.

Four hundred yearling warmouth bass (*Chænobryttus gulosus*), from Quincy, Ill., were placed in Lake Cuyamaca, near San Diego, Cal., in 1891. In the same year 100 yearlings were deposited in Feather River, near Gridley, in Butte County, Cal. A plant of 201 yearlings was made in Boise River, near Boise, Idaho, in 1892. In Loon Lake, Washington, 29 yearlings were placed in 1892. No reports from any of these fish have been received. Of 12 fish delivered to the California fish commission in June, 1895, 6 were alive in December, 1895, in a pond at Sisson.

THE SUNFISHES.

Small plants of the green sunfish (*Lepomis cyanellus*) and the blue-gill or blue bream (*Lepomis pallidus*) have been made in public waters of Washington and California by the United States Fish Commission. The Washington consignments consisted of 25 yearlings in Loon Lake and 25 in Lake Colville in 1890; 300 in Loon Lake and 150 in Deer Lake in 1891, and 9 in Deer Lake in 1892. In 1895, 12 yearlings were delivered to the California State hatchery at Sisson, 18 were put in Elsinore Lake, and 18 in the Balsa Chico River. A few sunfish were accidentally introduced with other fish into Lake Cuyamaca near San Diego in 1891.

It is not known with certainty which of the numerous species of sunfish inhabiting the United States have been taken to the Pacific States; but as the shipments were made from Quincy, Ill., and as both of the species named are common in that vicinity, it is probable that they have been introduced. Dr. Jordan has identified as *Lepomis cyanellus* specimens of sunfish obtained in Lake Cuyamaca by Mr. Fletcher, of the California commission.

THE BLACK BASSES.

HISTORY OF INTRODUCTION.

Plants of both large-mouth black bass (*Micropterus salmoides*) and small-mouth black bass (*M. dolomieu*) have been made in the Pacific States. The small-mouth fish, however, was introduced much earlier and in larger numbers. It appears to have been first taken to California in 1874 by Mr. Livingston Stone in his "aquarium car." The original lot consisted of 75 full-grown spawning bass from Lake Champlain, Vermont, and 24 small fish from St. Joseph River, Michigan. Two of the large fish and 12 of the small ones were lost in transit. The adult fish were placed in Napa Creek and the immature lot in Alameda Creek.

The probable extermination by anglers of the fish put in Napa Creek led the commissioners to renew their attempts to acclimatize the black bass, and in 1879 they had Mr. Stone take out 22 fully matured fish from the East. These were put in the Crystal Spring reservoir of the Spring Valley Water Company, in San Mateo County, with the assurances of the company that the fish would be protected and be at the disposal of the commission should they increase. Shortly before this a small lot of black bass seems to have been imported by a sporting club and placed in Lake Temescal, in Alameda County, near Oakland.*

From 1879 to 1889 no bass appear to have been planted by the California commission, although in the meantime the fish had probably been distributed privately from the waters previously stocked; thus, in 1889, it was reported as being in the Russian River. In 1889 the State authorities began the distribution of black bass from planted waters, chiefly the San Andreas reservoir, and 500 fish from 6 to 9 inches long were deposited in Clear Lake in Lake County, Thermalito Reservoir in Butte County, and Sweetwater Lake in San Diego County.

In the following year small lots of bass were put in Clear Lake, Blue Lakes, Pajaro River, Laguna de San Luis, reservoirs in Monterey and San Luis Obispo counties, and a lake at El Monte in Monterey County, the aggregate plants being 357. Some bass were taken from the reservoir of the Spring Valley Water Company in 1891 or 1892, but the number was quite small and no details of the distribution are recorded. In 1893, 155 fish were sent out by the State commission. The extent of the work in 1894 eclipsed all previous records. The State authorities sent a deputy to the Russian River, where in May the wild fish were seined. The number caught and distributed was 9,350, which were chiefly consigned to public waters not previously stocked. The

*In a report of Mr. J. G. Woodbury, California superintendent of hatcheries, printed as an appendix to the biennial report of the State fish commission for 1889–90, the following statements are made:

"Seth Green brought the first black bass to California. These were brought out at the expense of a sportsmen's club and placed in Temescal Lake, near Oakland. The second lot of black bass was brought out by B. B. Redding, for the California fish commission, and planted in the Crystal Springs reservoir, near San Mateo, with the permission of the Spring Valley Water Company."

Mr. Woodbury gives no further particulars, and is certainly in error in claiming that the two lots mentioned by him were the first and second, respectively, taken to California. He has overlooked the bass carried by Mr. Stone in 1874. The fish planted in Temescal Lake probably comprised the second lot transported to the State.

largest plants were made in Fresh-water Lake, Humboldt County (2,000); San Joaquin River, near Herndon, Fresno County (1,000); Lake Yosemite, Merced County (1,000); Stony Lake, Humboldt County (500); Keweah River, Tulare County (500); Garvey Lake, San Gabriel, Los Angeles County (500); Irvine Lake, Orange County (500). Small waters in Alameda, Los Angeles, Santa Barbara, San Bernardino, and Tulare counties also received fish.

The distribution of small-mouthed black bass by the California commission was further extended in 1895. Mr. Babcock furnishes the information that from the landlocked overflow ponds of the Russian River 25,600 fry were collected by the commission's agents, and that the fish was given a much wider distribution in the State, applications from almost all counties being filled.

The United States Fish Commission in December, 1891, placed 1,990 yearling large-mouth bass in Lake Cuyamaca near San Diego, and 620 in the Feather River near Gridley. In June, 1895, a carload lot of 2,500 large mouth bass was sent to the California fish commission. The fish were retained in ponds at Sisson. In the same month 50 fish were put in each of the following California waters: Buena Vista Lake near Bakersfield; reservoir near San Diego, and Elsinore Lake near Elsinore.

The plants of black bass in Oregon have not been numerous, although considerable interest has been manifested by anglers in securing the acclimatization of the fish in the State. In October, 1892, 500 yearling large-mouth fish were placed in the upper part of the Willamette River near Salem, and in July, 1895, 75 yearlings were deposited in Doves Lake near Salem; 25 in Mill Creek, a tributary of the Willamette River, and 75 in Big Creek, a branch of the Powder River.

Comparatively numerous plants of yearling large-mouth bass have been made by the United States Fish Commission in Washington during the past few years. In 1890 Washington, Loon, and Colville lakes received 1,220 fish; in 1891, 125 fish were sent to Loon and Liberty lakes; the following year 3,547 fish were planted in Clear, McDonald, Loon, Deer, American, Liberty, and Gravelly lakes. Clear, Padden, and Shepherd lakes, a private lake in Spokane County, and a public lake in Skagit County were supplied with 400 fish in 1893. The shipments in 1895 consisted of 625 fish, deposited in Loon, Cavanaugh, Silver, St. Clair, Welty, and Clear lakes, the aggregate plants in Washington being 5,442.

In the Boise River, near Boise, Idaho, 1,597 yearling large-mouth bass were planted by the United States Fish Commission in November, 1892.

In 1888 the Nevada fish commission exchanged 30,000 young eastern brook trout for small-mouth black bass, the other party to the transaction being the Spring Valley Water Company of San Francisco. The number of bass received is not stated in the official report, but it probably amounted to several thousand. Some were planted in Carson River and Washoe Lake, and about 1,000 were placed in a private reservoir near Carson.

The noteworthy results attending the planting of black bass in Utah warrant reference, although the general discussion of fish acclimatization in that State is not considered in this paper. In September, 1890, the United States Fish Commission delivered 300 yearling large-mouth bass to Mr. A. M. Musser, the State fish commissioner, by whom they were placed in Weber River, near Ogden. At the same time 1,418 yearlings were planted in Utah Lake, at Battle Creek. In 1893 two lots of 25 fish each were supplied to applicants in Salt Lake City.

RANGE AND ABUNDANCE IN PACIFIC STATES.

With very few exceptions, the black bass have survived and multiplied in all the waters in California in which they were planted, so that they have become one of the most widely distributed game fishes of the State. The State fish commissioners have refrained from depositing fry or yearling bass in waters already stocked with salmon or trout, but have restricted the distribution to lakes, reservoirs, ponds, and rivers in which the predaceous bass could do no damage. It seems only a question of time, however, when the bass will naturally find their way into and become abundant in all those rivers in which they have not already been planted.

Very prompt results attended the planting in Napa and Alameda creeks in 1874. In their report for 1874–75 the California commissioners stated that during the latter year black bass had been caught in Napa Creek and that large numbers of young had been observed. The fish planted in Alameda Creek were said to have been seen, but none had been taken. The report for 1876–77 stated that the fish had increased; that many had been caught, and that by June, 1878, the young could be taken for stocking other streams. The next biennial report (for 1878–79) records the probable extinction by anglers of the fish put in Napa Creek, none having been caught in the two years named.

The adult bass placed in the reservoir in San Mateo County in 1879 rapidly increased, and in 1880 the State commissioners hoped in another year to take the young for distribution. Fish imported by the Sportsmen's Club of San Francisco about the same time and placed in a lake in Alameda County had also increased and were subsequently utilized in stocking other waters. The San Mateo County reservoir served as the principal source of supply for the State commission until 1894, since which time the young for distribution have been mostly taken from the Russian River.

In the *American Angler* for April 9, 1887, Mr. Charles Kaeding records the arrival at San Francisco on March 2 of the first black bass from the Russian River. The fish was taken at Guerneville and weighed 2¼ pounds. By 1889 or 1890 the Russian River had become well supplied, although the California authorities stated that up to that time not many public waters had been stocked. Numerous applications for bass were made to the State commission in 1890, and over 800 yearlings were obtained for planting from waters that had been previously stocked. The abundance of the fish in Russian River was attested by the large number of yearlings taken for distribution in 1894 and 1895 from the overflow waters of that stream, the aggregate collections being 35,000. Large numbers of young fish were seen in the river itself in 1895. Mr. Babcock believes the stocking of the Russian River was done by private parties, as there is no record of plants made in that stream under State auspices.

In their report for 1893–94, the California commissioners said that they could quote from many letters showing the most remarkable growth of black bass in streams and lakes which had never before been stocked. Besides the numerous closed waters in which the fish are found, the following rivers, in addition to the Russian, are also stocked: Tule River, headwaters of the American River, headwaters of the San Joaquin River. A few have also been reported from the Sacramento River at Colusa. Jordan and Gilbert record the small-mouth bass from Clear Lake.

Mr. Fletcher, deputy of the California fish commission, reports that black bass are doing very well in Lake Cuyamaca, and that a great many have been taken in the last two years. Mr. J. E. Friend, of San Diego, who passed some weeks on the lake in the latter part of 1895, took 3 large-mouth black bass weighing 2½ to 3½ pounds each.

Regarding the outcome of the plants of bass in Washington waters, Mr. Alexander reports that as far as he has been able to learn nearly all the bass are thriving and are in a fair way to soon become plentiful enough to give the anglers sport and supply many tables with food.

Clear Lake, 14 miles from Spokane, is one of the waters in which the United States Fish Commission has deposited bass, plants being made in 1892 and 1895. In August, 1895, Mr. William Barnum, of the Commission, visited this lake and found the fish abundant. Silver Lake, about 2 miles distant, has also been successfully stocked, and bass were numerous in 1895. Otter Lake, a small lake in the vicinity, was privately stocked with fish from Clear and Silver lakes in 1894. The question of stocking Medical Lake with bass from Clear Lake has been under discussion for some time, and several plants of fish have been made. The peculiar character of the water in Medical Lake, however, is thought by some to militate against the success of the experiment. King Lake, near Medical Lake, has also been planted with bass from one of the neighboring lakes. In 1895 black bass were reported abundant in Loon and Washington lakes.

No information as to the outcome of planting bass in Nevada has been received since 1892. Up to that time the fishermen of Carson River and Washoe Lake had taken no fish, according to the State fish commissioner's report.

Mr. W. H. Ridenbaugh, of Boise, Idaho, has a pond connected with the Boise River, 1½ acres in extent, in which large-mouth bass are abundant. Another pond of 2½ acres was drawn off in 1892, and 2,240 bass, averaging half a pound each, were placed in the Boise River. No fishing has as yet been done in the river, and it is not known how the fish are flourishing. The eventual stocking of the Snake and Columbia rivers from this stream is not improbable. Mr. Ridenbaugh has never heard of any bass being caught by anglers or in any other way in the Boise River. He has watched for them in the irrigation ditches, especially after a break, when the water was low, but has never seen one, and is inclined to believe that the fish have gone down the Boise River into the Snake River. The latter is sluggish and deep in places, and apparently well suited to bass. Mr. Ridenbaugh thinks it will one day be a great bass stream.

Under date of December 21, 1895, Mr. Ridenbaugh informs the Commission that his first stock of black bass was obtained in St. Joseph, Mo., and shipped to Boise by express. The lot consisted of 50 fish about 6 inches long. These were placed in his smaller pond eight years ago, and during the last four years he has caught annually about 60 fish, weighing 1 to 1½ pounds. The larger pond was stocked with small fish from this pond and with bass received from the United States Fish Commission.

Large-mouth black bass are now exceedingly abundant in Utah Lake, Utah, the lake having been stocked by the single plant in 1890. The economic result of this successful introduction is more important than in any other State.

The large-mouth bass reaches a greater weight than the other species; in the Great Lakes, Mississippi Valley and Eastern States, the maximum is about 8 pounds, but in the warm southern waters a weight of 15 or more pounds is attained. The maximum weight of the small-mouth form is about 5 pounds.

As yet there is little occasion on the part of fishermen and anglers in the Western States to know the characters distinguishing the two species of basses, since only one of them has been planted in a given locality; but as the fish receive a wider distribution by natural and artificial means the two kinds will in time be sometimes found in

the same waters, and it will often be a matter of interest to anglers and others to learn which fish has been caught. The color markings and the general appearance of the two basses are usually sufficient to distinguish the species, as the accompanying figures will show, but the most satisfactory and conclusive feature by which they may be separated, whatever the age or condition of the specimens, is the number of rows of scales on the side of the head. In the large-mouth bass the scales are relatively large and in about 10 transverse rows, while in the small-mouth species these scales are quite minute and in about 17 rows.

FISHING FOR BLACK BASS.

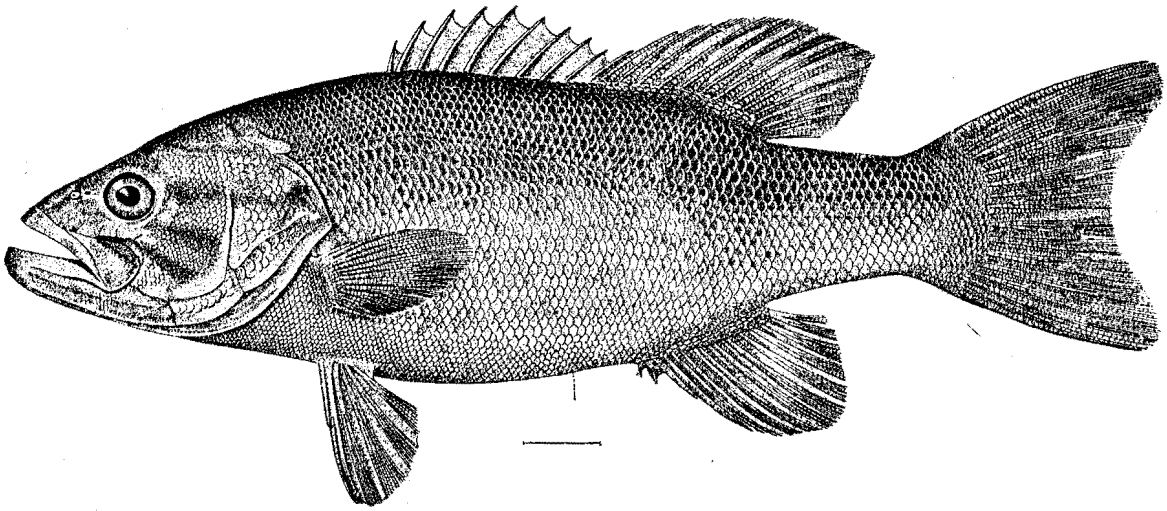
In California the black bass is not a commercial fish. It is seldom, if ever, seen in the markets of San Francisco or other large cities, and when exposed for sale is usually an indication of a violation of law on the part of some fisherman.

The only legal method of taking bass in California is with hook and line. A favorite fishing-ground is the reservoir of the Spring Valley Water Company in San Mateo County, where fishing is by permit, and only 20 bass are allowed to be caught at one time by one person. Mr. Alexander reports that the guests at the Hotel del Monte, Monterey, are permitted to fish in the lake and reservoir in the hotel grounds. The catch is limited to 12 fish to a rod. Bass a foot in length have been taken in the lake, and some 18 inches long have been caught in the reservoir at Thermalito.

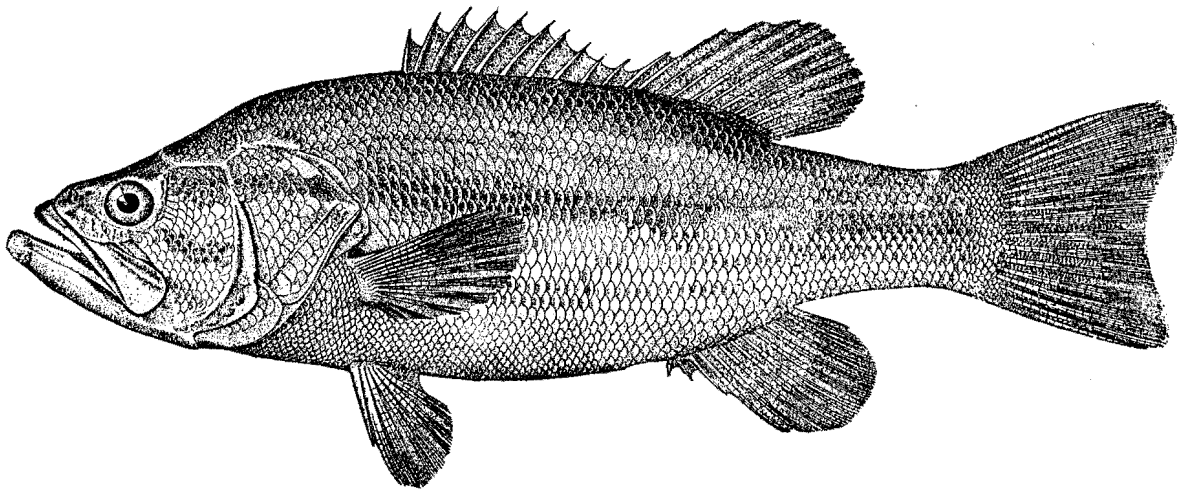
Some bass angling has been done in the Russian River, where the fish are abundant, but it is said the fishing is not good. Considerable illegal fishing has from time to time been reported in this river. Mr. Alexander states that several fishermen with drag seines made comparatively large hauls in 1894, much to the indignation of the State authorities and the people in the vicinity. In July, 1894, arrests were made and conviction had for using dynamite to kill bass. Several hundred bass were found floating in the river after the explosion of a submerged charge of powder, and dead fish are said to have lined the sides of the river and caused a strong stench for some time.

The bass in Clear Lake and other lakes near Spokane, Wash., afford fine sport to anglers. The fish usually weigh 1 to 1½ pounds. Minnows are used for bait, and even dead or mutilated ones will prove attractive lures. The black bass sold in the Spokane markets are taken in Silver and Clear lakes with hook and line, no netting being permitted. Mr. E. Michael, a fish-dealer of Spokane, reports that he pays the fishermen 12½ cents a pound for bass and retails them at 15 to 17 cents a pound. He handles about 150 pounds a week during a season of about 10 weeks.

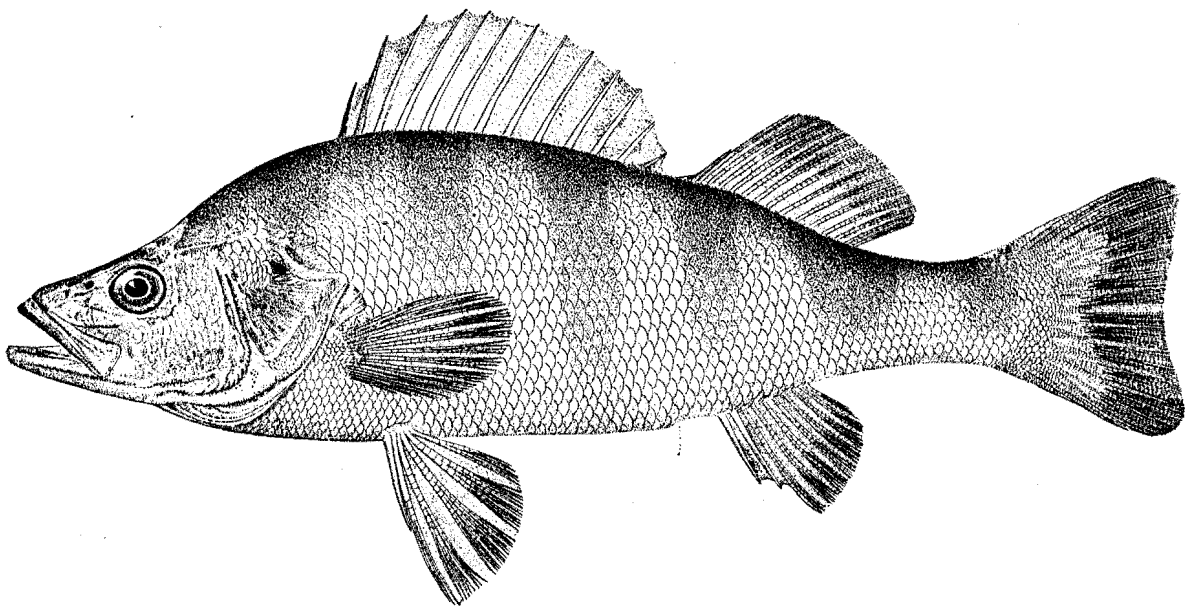
In Utah Lake, Utah, the large-mouth black bass has become a fish of considerable commercial value. In 1895 Mr. William Barnum, of the United States Fish Commission, learned at Salt Lake City that one dealer in that place was receiving about 500 pounds a week from Utah Lake. The fish are very highly esteemed, and retail readily at 20 cents a pound. The usual weight of the fish taken for market in Utah Lake is 1 to 1½ pounds, but a few specimens weigh 3 to 4 pounds. A fish weighing 4½ pounds is recorded. The bass is said to be the only high-priced fish used by the Chinese, who are very fond of it. The *Deseret Evening News* of September 26, 1895, reported that 12,000 pounds of bass had already been taken that season from Utah Lake. The report of the Utah commissioner for 1894–95 states that 60,000 pounds of black bass were caught in Utah Lake in those years, most of the fish being shipped to Colorado. Fishing is done with lines.



SMALL-MOUTH BLACK BASS (*Micropterus dolomieu*).



LARGE-MOUTH BLACK BASS (*Micropterus salmoides*).



YELLOW PERCH OR RINGED PERCH (*Perca flavescens*).

THE YELLOW PERCH.

The yellow or ringed perch (*Perca flavescens*) is one of the most important food-fishes of the Middle Atlantic States and the Great Lakes. It is also of considerable economic value in the Mississippi Valley. Its average weight is under 1 pound, but under favorable conditions it sometimes reaches a weight of several pounds. The annual output in the coast and lake States is worth over $250,000. Attempts have been made by the United States Fish Commission to acclimatize this fish in California, Washington, and Idaho, in lakes, rivers, and ponds. The results of the plants, which aggregated 7,830 yearling fish, have not been reported to the Fish Commission, with two exceptions.

In December, 1891, 3,000 yearling yellow perch were placed in the Feather River, in Butte County, Cal., and 3,980 yearlings in Lake Cuyamaca, near San Diego, Cal. This fish seems to have been successfully introduced into Lake Cuyamaca. Mr. Fletcher, of the California fish commission, reports that large numbers have been taken by anglers; specimens obtained by him have been identified by Dr. Jordan.

Some plants of yearlings were made in Washington in 1890, 1891, and 1895. In the first-named year 25 were deposited in Loon Lake and 30 in Lake Colville; in 1891, 500 more were put in Loon Lake; and in 1895, 200 were planted in South Palouse River, 50 in Loon Lake, 100 in Lake St. Clair near Tacoma, and 100 in Silver Lake.

Mr. J. A. Borden, of Spokane, who had caught yellow perch in the Potomac River, states that these fish are plentiful in Loon Lake. Mr. E. Michael, one of the principal fish-dealers in Spokane, handles yellow perch and reports that they sell well.

Newman Lake, in Idaho, received 200 fish, and private ponds near Hauser and Shoshone, in the same State, 200 more, in 1895.

In 1873 Mr. Livingston Stone attempted the introduction of yellow perch into California. His ill-fated aquarium car contained 110 specimens of this fish from the Missisquoi River, Vermont. The attempt seems to have elicited some criticism, to which the following letter of Mr. Stone, in the issue of *Forest and Stream* for March 19, 1874, was a reply. It appeared under the title, "Is the yellow perch a good fish to introduce into California?" and may be appropriately quoted in view of the subsequent successful planting of the species, as just mentioned:

I should like to ask those who are so horror-struck at the prospect of introducing yellow perch (*Perca flavescens*) into the State of California whether they suppose that any given fish is the same in quality all over the world, or that the yellow perch is a poor fish everywhere because it happens to be where they have known it. If they do, I advise them to take what spare time they have and read themselves up in natural history. They will then find that it is one of the most common facts of natural history that fish, as well as food and fur-yielding animals, vary almost indefinitely in quality with their habitat. Why does not the fur of the California mink bring as much as that of a Labrador or Lake Superior mink? The reason is obvious. The climate of California does not produce such good fur as the climate of Labrador or Lake Superior, even on the same animals. It is exactly the same with fish. Different climates, and especially different waters, produce fish of entirely different qualities, though of the same variety. The bass of our southern waters is not the same as the bass of Saratoga Lake and Lake Champlain, but a far inferior fish. So with the yellow perch. In some warm waters it is a poor fish enough, but it is not so in the cold, pure lakes of New England or northeastern New York. I will agree with my friend Mr. Mather, if he insists upon it, that the yellow perch he is acquainted with is a miserable fish and not fit to take to California. But the yellow perch of Saratoga Lake and Lake Champlain and Monadnock Lake, in New Hampshire, is an entirely different thing. Mr. Mather must come and eat some of them before he puts them down so summarily. If he will, I have no doubt that he will also agree with me that the yellow perch of these localities is a very sweet, firm, and excellent fish when in season. I am sure if he should eat some Saratoga Lake perch off the table of my friend Mr. Moon, that he would say that the yellow

perch is about as good a fish as he had ever eaten. Anyone who is in the habit of going to Saratoga Lake knows Mr. C. B. Moon, of the Saratoga Lake House, the reputation of whose game and fish dinners is world-wide, and no one who is acquainted with Mr. Moon can have a shadow of a doubt that he is an unimpeachable judge of the qualities of game and fish. I wrote to Mr. Moon for the purpose of getting his opinion on the merits of the yellow perch, and he sent me the following reply:

"Your letter is arrived making inquiries in regard to the yellow perch. I use a large quantity of these fish every season. I consider them a most excellent fish indeed. Many of my customers at the lake give them the preference above all other fresh-water fish on account of their sweetness and flavor. They increase rapidly when introduced into good waters, and I am sure they would be a hardy fish to ship, and any section of the country might well feel glad to have them introduced."

Now as to the actual charges against the yellow perch, that they are "bony and predaceous." I say, What of that? The shad is very bony, but a capital fish nevertheless. The brook trout is more predaceous than the perch, but he is the king of fresh-water fish nevertheless. Saying that the perch is bony and predaceous does not make out a case against him. The question is whether these disadvantages affect his good qualities. I think very decidedly that they do not. I reaffirm that the yellow perch of northern and northeastern waters is a very sweet and excellent fish when in good condition, and people must call them worse names than bony and predaceous before they can put them down.

Besides possessing edible qualities of an excellent character, the yellow perch has other merits. It is a hardy fish and can probably be introduced successfully where other fish would fail. It is very prolific also. Not but that other fish are equally so, but the eggs of the yellow perch will hatch under circumstances that would be fatal to other eggs, so that the perch is in consequence practically more prolific than other fish. It is also exceedingly easy to hatch the spawn of yellow perch artificially, which is another advantage.

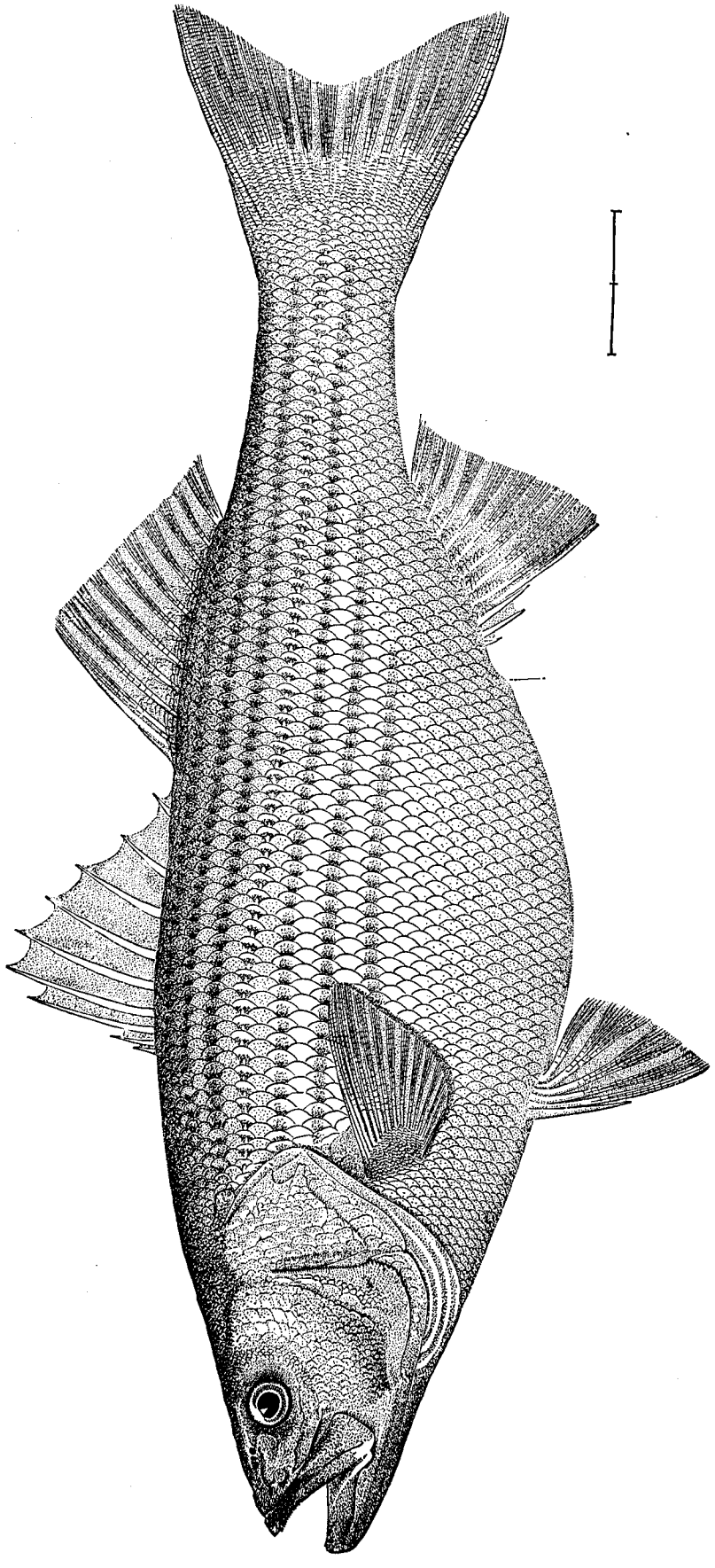
If this is not a sufficient vindication of the attempt (which, by the way, I would have it understood, had the full sanction of the California fish commission) to introduce the yellow perch into the waters of the Pacific Slope, let me add that it is at all events far preferable to most of the fish at present existing in the fresh waters of California, and even if it destroyed four-fifths of the other fish there it would replace them by a better kind.

For instance, the fish of Clear Lake are (I give the local names, for I do not yet know the scientific names) the California salmon trout, white perch, shapaulle, hitch, suckers, chy, roach, spotted sunfish, mudfish (mud suckers), blackfish, trout, bullheads, viviparous perch. The fish of the Sacramento River are trout, salmon, chubs, perch, hardheads, Sacramento pike, viviparous perch, split-tails, suckers, herrings, sturgeon, crabs, lamprey eels. The varieties of these two localities comprise most of the fresh-water fishes of northern and central California, and I think it safe to say, with the exception of the salmon, trout, and possibly the viviparous perch and blackfish, which latter is quite rare, that there is not one of these fish that is superior to the yellow perch of New England and northern New York, which it was proposed to take to California.

THE WALL-EYED PIKE OR PIKE PERCH.

In 1874 Mr. Livingston Stone transported sixteen full-grown wall-eyed pike or "glass-eyed perch" (*Stizostedion vitreum*) from the Missisquoi River, Vermont, to California, where they were deposited June 12 in the Sacramento River opposite Sacramento City. There has been no report of the survival, capture, or multiplication of these fish, with the exception of the taking of a single specimen in a slough of the Sacramento River, mentioned in the fish commissioners' report for 1874–75.

The California fish commission has been desirous of securing a large consignment of wall-eyed pike from the United States Fish Commission for introduction into certain lakes and ponds of the State, and a shipment will probably soon be made from Lake Erie. This is one of the best food-fishes of the Great Lakes, and would doubtless readily become acclimatized in some of the shallower and warmer waters of California. In the Great Lakes, it is most abundant and important in Lake Erie, the shoalest and warmest member of the system. Its maximum weight is fully 30 pounds, but the average of those taken in the Great Lakes is from 5 to 10 pounds.



STRIPED BASS (*Roccus lineatus*).

THE STRIPED BASS.

HISTORY AND RESULTS OF INTRODUCTION.

The striped bass (*Roccus lineatus*) was first introduced into the waters of the Pacific Slope in 1879, at the same time that a consignment of eastern lobsters was taken across the continent. The acclimatization of this species was undertaken at the suggestion of Mr. S. R. Throckmorton, then chairman of the California fish commission. In a letter* to Professor Baird, recounting the history of the experiment, he says:

> I have long had the impression that the great bay of San Francisco, together with the bays of San Pablo and Suisun connecting with it and the number of creeks running into them, affording a variety of qualities and conditions regarding temperature and saline properties, together with feeding material, would be well adapted to the propagation and growth of striped bass.

In July, 1879, Mr. Livingston Stone, of the United States Fish Commission, made a collection of living striped bass in the Navesink River, New Jersey, for transportation to California. He obtained 132 fish from 1½ to 3 inches long and 30 medium-sized specimens. Twenty-five of these died during transportation and several were thrown away, but the remainder, about 135, reached California in good condition and were deposited in Karquines Strait, at Martinez.

The second and only other plant of striped bass in California waters was made in 1882, when Mr. J. G. Woodbury, of the California fish commission, carried about 300 fish, 5 to 9 inches long, from the Shrewsbury River, New Jersey, to Suisun Bay, where they were deposited at Army Point, about 3 miles from the preceding plant.

The results attending the attempted introduction of striped bass in California have been most remarkable, considering the very meager plants. While the second deposit of young fish undoubtedly added to the supply, the fish, in the three years intervening between the two experiments, had already gained a foothold, as the following data will show. The California authorities, however, were not certain that the fish had become sufficiently acclimatized or that enough of them had survived to insure the perpetuation of the supply.

Mr. Throckmorton, in the letter to Professor Baird before referred to, records the capture of striped bass in 1880, as follows:

> Some six or seven months after the time of placing them in the water, I heard that one of 8 inches in length had been taken in the Bay of Monterey, which is about 100 miles south of this, and is an open roadstead on the Pacific Ocean. All of the circumstances were of so doubtful a character that I gave the rumor but little attention, until about the 1st of July, eleven months after the planting of the young fry, at the time about 1½ inches in length, in the Straits of Karquines, there was brought to me a very handsome striped bass taken in this harbor, measuring 12¼ inches in length and weighing 1 pound. The fish was in the highest condition, the milt full and ripe, and the flavor fully up to the best specimens of the fish at the East. The exceedingly rapid growth indicates the adaptability of the waters of this bay to its development.

In their report for 1880, the California commissioners give some additional notes on the occurrence of the fish:

> The 150 striped bass brought in 1879 and placed in the waters of the Straits of Karquines are probably increasing. One of these fish was caught in the bay near Sausalito and brought to market and identified. We have heard of a few others having been captured at Monterey and near Alameda.

* Bull. U. S. Fish Commission, 1881, pp. 61–62.

Subsequent reports of the California commission contain a number of references to the presence and capture of striped bass. The following extracts may be given as bearing on the growth, distribution, and multiplication of the fish:

Striped bass have been taken in the Bay of San Francisco weighing 4 pounds, and one taken in the Bay of Monterey in September, 1883, weighed nearly 17 pounds. It will be some time before striped bass will be very plentiful, as the immense area in which they travel will have to be well stocked before any one place would have any considerable numbers for the fishermen to work upon. In October, 1883, one was caught in the Sacramento River weighing 16 pounds. This and other catches are strong evidence that the striped bass will propagate in our waters. March 3, 1884, a striped bass weighing 4 pounds was for sale in a San Francisco market. March 11 there was one offered for sale that weighed 18½ pounds. (Report for 1883–84.)

Quite a number have been caught from year to year, increasing in weight every year. Last year several were caught weighing over 20 pounds, and during the past winter one was caught weighing 35 pounds. I have been watching for the young fish, the progeny of those brought out in 1882, and during the past spring I heard that they were being caught by the thousands and offered for sale in the market. I hurriedly went up to the market to see if it were true. I found there a lot still unsold, averaging from a half to three-quarters of a pound in weight. I was delighted to see them, knowing that those brought out from New Jersey must have kept together in the muddy waters of our bay till they matured and spawned and their young had been successfully reared. But, knowing that the young striped bass run in schools, I became alarmed lest the many Chinese nets in our bay and the lower Sacramento and San Joaquin rivers would soon destroy the greater part of them. I immediately visited the newspapers and they kindly published a notice of the arrival of the numerous strangers, of their great importance, and the danger of their destruction if they were not protected. Your honorable board petitioned the board of supervisors to pass an ordinance to prohibit catching them under 8 pounds in weight. This they quickly did. A similar petition would be advisable to the boards of supervisors of Marin, Sonoma, Solano, Contra Costa, Alameda, San Joaquin, and Sacramento counties. The young bass will most certainly visit the waters of all these counties, and their protection for a few years is of vital importance.

I have since learned from the marketmen that from three to four thousand of these fish were sold in the market before the ordinance was passed, and that it has since been in the newspapers that these fish have been caught and sold in other counties around our bay. The arrival of so many young of this fish at one time in our markets shows conclusively that the striped bass have successfully reproduced themselves in our waters. (Report of superintendent of hatcheries, in report for 1888–90.)

DISTRIBUTION OF STRIPED BASS.

The known range of this fish in the Pacific States includes only California. It has distributed itself so widely on the California coast, however, that its occurrence in Oregon and even Washington waters is probably only a question of time, supposing that it does not already occur there.

The center of the fish's abundance is San Francisco Bay and its tributaries. It is found all over San Francisco Bay, Suisun Bay, San Pablo Bay, and the lower course of the Sacramento and San Joaquin rivers. The bass regularly ascends the San Joaquin River for a distance of 20 miles above Bouldin Island. During a visit to the upper San Joaquin, in November, 1895, Mr. Babcock learned that a catfish fisherman at Grayson, about 100 miles above the mouth of the river, had for two years been taking a number of 1-pound and 2-pound striped bass in a slough near that place. They go up the Sacramento River as far as Sacramento, but were not common at that point at last reports. In 1893 Mr. Alexander learned of their capture near Fremont, about 7 miles above Sacramento.

On May 30, 1894, in Suisun Bay Slough, a number of bass weighing 4 pounds and upward were taken with minnow bait on a regular angling rod. Several examined contained anchovies and file worms. This is a new locality for the fish, although several years ago they were reported to occur there.

In Tomales Bay the fish occur sparingly. According to Mr. Babcock, of the California fish commission, they are quite numerous in Creamery Slough, a very small slough between Tomales Bay and Russian River. The water is made extremely salt by evaporation, and no other salt-water fish of commercial importance are found in it.

In Russian River the striped bass is now plentiful. It made its appearance there about 1890. In that year a 6-pound fish was taken on a hook baited with a minnow, and in 1891 the salmon gill-net fishermen began to catch the fish. One weighing 16 pounds has been taken by them within a few years. The species ascends the Russian River a distance of 20 miles, to Guerneville.

The striped bass is found regularly but not abundantly in Monterey Bay. At Monterey a half-pound specimen was taken by the *Albatross* in 1890, which was supposed by Mr. Charles H. Townsend* to have been the first caught south of the Golden Gate. As early as 1880, however, they had been reported from that locality. In 1893 only one was taken at Santa Cruz, according to Mr. Alexander's inquiries. In that year the first striped bass were taken by Capitola fishermen.

Until 1894 the striped bass was not known to range south of Monterey Bay. In September of that year, however, two were taken in a seine at Redondo Beach, Los Angeles County, thus extending their distribution about 360 miles, following the coast line. Each weighed about 6 pounds.

Reports of a more extended coastwise range of the striped bass than that assigned have been made. In April, 1887, in a letter to Professor Baird, Mr. Horace D. Dunn, of San Francisco, stated that he was informed that these fish had been taken at places as widely separated as San Diego and the Oregon line.† In the report of the California fish commissioners for 1883–84 it is said "bass have been taken as far north as British Columbia." While there is no reason why this fish should not be found as far north and south as the points given, no records of its capture, except as before stated, are available, and the inquiries of the agents of the United States Fish Commission, covering the years 1888 to 1894, inclusive, failed to disclose the occurrence of striped bass as far south as San Diego or north of California.

MIGRATIONS, MOVEMENTS, SCHOOLING, ETC., OF THE STRIPED BASS.

Although striped bass may be taken in the waters between San Francisco and the Sacramento delta at any time during the year, they are more abundant in certain months than in others, and there is no doubt that the migratory habits which characterize the fish in its native waters have not been entirely lost on the Pacific Coast. They are sometimes observed schooling in and off the mouths of sloughs. A dozen or more may often be noticed playing and circling near an eddy. At times, Mr. Alexander says, they will hover persistently about places where two strong currents meet, to the discomfiture of the fishermen, whose nets are liable to injury if set in such places. They often go in large schools. In referring to their abundance, mention is made of the presence of a numerous body of fish on the Berkeley Flats, in San Francisco Bay, in June, 1894, and in the San Joaquin River in December, 1893.

The bass seem to prefer the waters of the San Joaquin to those of the Sacramento, the former being warmer and clearer. The water in the sloughs that connect the two rivers all flows from the Sacramento into the San Joaquin. Striped bass are scarce in the Sacramento, and some of the salmon fishermen of that stream have never caught them. Salmon are much more plentiful in the Sacramento than in the San

* *Forest and Stream* May 8, 1890.

† Bull. U. S. Fish Com. 1887, p. 50.

Joaquin. Nearly all of the fish which begin the ascent of the latter stream finally get into the Sacramento by way of the sloughs.

Mr. Alexander could learn of the capture of no striped bass distant from the California shores. The fish seems to follow the coast closely. If it wandered far to sea, either in schools or in scattered bodies, the fishermen would probably soon know of it, as hundreds of trammel nets are set in the open waters off the Golden Gate. The felucca fishermen who resort to the grounds around the Farallone Islands, about 30 miles offshore, have never reported striped bass in that vicinity.

SPAWNING SEASON AND GROUNDS.

The observations thus far made on the spawning of the striped bass in California waters are not conclusive, but what has been determined indicates a protracted spawning period such as characterizes the shad in the same region. The inquiries of Mr. Alexander and the testimony of dealers and fishermen seem to show that the principal spawning time is from April to June; but Mr. Babcock, of the California fish commission, who has devoted considerable attention to this fish, has found striped bass in the San Francisco markets containing ripe spawn in each month between December and May. On May 26, 1894, he examined a large fish with fully matured ova, and during the same month the writer saw a number of specimens, in the San Francisco markets, from which the eggs were running.

The delta of the Sacramento and San Joaquin rivers undoubtedly includes the principal breeding-grounds of the striped bass. The tule waters, the sloughs, and the lagoons are well adapted to the fish. In the tule waters, to which reference was made in treating of the shad, striped bass are found at all seasons and are generally believed to be there for the purpose of spawning. At Jersey Landing, on the lower San Joaquin River, the fishermen find bass nine months in the year and always get more fish there than in the united stream below Black Diamond.

Small striped bass 4 to 5 inches long are frequently caught in drag seines in and off the mouths of sloughs, and Chinamen also catch them in their fyke nets, according to Mr. Alexander.

The California fish commissioners, in their report for 1891–92, state that the striped bass should be protected while on their spawning-grounds and that their capture under 2 pounds in weight should be prohibited.

ABUNDANCE OF THE STRIPED BASS.

The increase in the abundance of the striped bass in San Francisco Bay and tributaries has been uninterrupted and rapid. While the fish is far less numerous than the shad and will probably never rival that species in abundance, the appearances are that in a few years the supply will exceed the demand. Between 1889 and 1892 the yield of striped bass in California increased 250 per cent. In 1893 the quantity handled by the San Francisco dealers was 5 times greater than the entire catch of the State in 1889 and 1½ times greater than the total output in 1892. In 1894 the receipts of the dealers were over 80 per cent greater than in the previous year.

An idea of the abundance of the fish may be gained from the following statement communicated by Mr. Babcock: On June 19, 1894, the fishermen struck a school of striped bass on the Berkeley Flats in San Francisco Bay; on June 20 one boat caught 1,500 fish and the other boats made large hauls. These fish weighed on an average 6

pounds apiece. The fishermen reported that until two weeks before that time not a great many bass had been taken in the bay. It is doubtful if in recent years at any point on the Atlantic Coast so large a catch of striped bass—9,000 pounds—has been taken by one boat in one day's fishing. The great abundance of striped bass at that time led Mr. Babcock to think that in ten years they would equal the shad in numbers.

Another illustration of their abundance may be given. Between December 15 and 25, 1893, Mr. William Crane, of Bouldin Island, on the San Joaquin River, and another fisherman using a seine caught and shipped to San Francisco 6,000 pounds of striped bass. These fish were taken in San Joaquin, Middle, and Old rivers.

WEIGHT OF STRIPED BASS.

The average weight of the striped bass now caught for market in California is between 10 and 12 pounds; those weighing 15, 18, and 20 pounds are common; many weighing 20 to 30 pounds are found, and larger fish are sometimes taken. A very careful examination of the receipt books of the San Francisco dealers made by the writer in May, 1894, yielded accurate data and disclosed the capture of some larger fish than had previously been recorded. The average weight of 1,461 fish was found to be 11 pounds, as shown by the following detailed statement, by months, for 1893 and part of 1894, giving the number of fish on the dealers' books whose weights were entered:

Table showing by months the average weights of 1,461 striped bass handled by San Francisco dealers.

1893.	Number of fish.	Total weight.	Average weight.	1894.	Number of fish.	Total weight.	Average weight.
		Pounds.	*Pounds.*			*Pounds.*	*Pounds.*
January	35	253	7	January	143	1,456	10
February	45	338	7½	February	31	334	10⅝
March	151	1,219	8	March	10	114	11⅜
April	50	648	13	April	29	435	15
May	56	731	13	May	31	435	14
June	1	9	9				
October	22	312	14¼	Total	244	2,774	11⅜
November	208	2,534	11⅜				
December	649	7,305	11¼	Grand total	1,461	16,123	11
Total	1,217	13,349	11				

The largest striped bass heretofore recorded from California waters weighed 45 pounds. It was taken in San Francisco Bay on June 16, 1889, and was noticed in *Forest and Stream* of July 11, 1889. In the issue of the same paper for November 20, 1890, mention is made of the capture of a striped bass of 40 pounds' weight, and reports of others of similar size have been received. In May, 1893, one was sold in San Francisco that weighed 49 pounds, which is the largest reported up to this time. There is no reason to doubt, however, that the California striped bass will attain the size reached on the Atlantic Coast—over 100 pounds.

Comparatively few of the striped bass shown in the preceding tabulation had their individual weights recorded on the dealers' books, the entries usually being for a number whose aggregate weight only was given. Separate entries for five that weighed over 30 pounds each were found in the records for 1893. These were as follows: May, one weighing 49 pounds; October, one weighing 37 pounds; November, one weighing 40 pounds and one weighing 39 pounds; December, one weighing 32 pounds.

FOOD OF STRIPED BASS.

The introduced carp appears to be the principal food of the striped bass in California, and in the fresh waters is the almost exclusive food. Mr. Babcock has opened hundreds of bass for the purpose of ascertaining the nature of their food, and has never seen any other fish than carp in their stomachs. He has heard, however, of small catfish being found in them. Mr. Alexander's examinations of many bass in the San Francisco market showed that whenever food of any kind was present in the alimentary tract it was in nearly every instance carp. A 10-pound carp is said to have been found in the stomach of one bass. His conclusions are that, taking the season through, carp will be found in the stomachs of 7 out of every 10 bass sold in San Francisco or caught in the rivers.

At Capitola, on Monterey Bay, crabs have been taken from the stomachs of bass, and it is probable that in the salt water a great variety of fish food is ingested.

ORIGIN OF THE STRIPED BASS FISHERY.

It was just ten years after the planting of striped bass in California waters that a special fishery for them was inaugurated. While they had been taken in considerable numbers during the five or six preceding years, it was not until 1889 that the fishermen directed any special effort toward their capture. Even at the present time comparatively few of the many fishermen in the San Francisco Bay region are provided with apparatus specially adapted to the taking of striped bass, but their increasing abundance is yearly resulting in drawing more attention from the fishermen, and it seems only a question of a few seasons when this fishery will have attained considerable magnitude.

THE FISHING-GROUNDS FOR STRIPED BASS.

The striped bass is found in greatest abundance and is taken in largest quantities in the lower part of the San Joaquin River. It abounds in the ponds, marshes, and sloughs connecting with the river, and is there found at nearly all seasons.

According to Mr. John P. Babcock, chief deputy of the California board of fish commissioners—and his opinion is borne out by the testimony of the fishermen—the striped bass appears to remain in the delta of the San Joaquin and Sacramento rivers throughout the year. When the run of salmon begins in the spring, and the waters of Suisun Bay below the mouths of the rivers are filled with salmon nets, only a few striped bass are taken, perhaps not more than one to three daily by the entire fishing force, while at the same time, in the San Joaquin River, at Jersey Landing, Antioch, Bouldin Island, and other places in the lower course of the stream, the salmon fishermen take striped bass at every tide or at every haul of their nets.

The San Joaquin fishermen have found that a northerly wind makes the striped bass more numerous in the main river. The explanation of this phenomenon—which appears to be well recognized—is that the relatively shallow water in the sloughs and ponds is made roily or is too much agitated by the wind, and the fish seek the deeper water of the river.

Striped bass are taken in the Sacramento River, but, as elsewhere mentioned, in much smaller quantities than in the San Joaquin River. Good fishing is at times done between the mouth of the Sacramento River and San Francisco, in Suisun and San Pablo bays, and the northern part of San Francisco Bay.

Mr. Alexander reports that early in fall the fishing is carried on principally in the northern part of San Francisco and Suisun bays, and that as the season advances striped bass gradually move up the river, the fishermen endeavoring as far as possible to keep with them. In the winter the main body of the fish is found in the waters constituting the delta of the Sacramento and San Joaquin rivers. The fishing is at its height between October and February, attaining its maximum in December. The fish appear to be found in larger numbers in San Francisco Bay adjacent to San Francisco in summer than at other times.

In Monterey Bay there are no regular fishing-grounds for striped bass, the few taken being caught only incidentally. At Monterey and Santa Cruz only a small number have ever been obtained. None was taken at the former place and only one at the latter in 1893. More are found at Capitola than elsewhere in the bay. In 1893, which was the first year in which striped bass were caught by the fishermen of that place, 25, weighing 260 pounds, were obtained in a drag seine in September.

APPARATUS AND METHODS EMPLOYED IN CAPTURE OF STRIPED BASS.

In San Francisco Bay and the waters tributary thereto gill nets and purse seines are employed in the capture of striped bass. Drag seines used for other fish and salmon gill nets also take striped bass incidentally.

In 1893 there were 31 regular striped-bass fishermen in California. These used 12 boats, worth $1,400; 24 gill nets, worth $600, and 3 purse seines, worth $450.

The striped-bass gill net is from 60 to 70 fathoms long and 25 to 30 meshes (or about 14 feet) deep. It has a mesh of 6½ or 6¾ inches. The cost is about $25.

The purse seine was introduced in 1892, and is said by Mr. Alexander to give satisfaction to the few fishermen who use it. The seine is like a small mackerel seine, being 200 to 225 feet long and 14 feet deep. The cost is $150. The comparatively small size of this seine makes it adapted to use in the sloughs and similar waters where a full-sized purse seine could not well be handled.

The purse-seine fishermen set their seines only when striped bass are visible. As soon as they are observed schooling or playing at the surface, the boats are put in motion and the seine is set. The seine, being small, is quickly set, pursed, and made ready for another trial, and many hauls may be made in the course of a day. Three men usually go in each boat, and sometimes two boats are employed to set a seine, but this is often done from one boat.

When the day's fishing is over, the fishermen take their catch to the nearest steamboat landing or railroad station, most of the fish being shipped by water. Nearly all the steamers plying between Sacramento, Stockton, and San Francisco make numerous stops in the fishing districts and take on board the striped bass, shad, salmon, and other fish that have been brought in. The principal dealers in San Francisco have packing boxes at the different landings, which are used by the fishermen in making their consignments, each dealer usually receiving all the fish caught by certain fishermen. The fish are packed without being cleaned or iced.

ANGLING FOR STRIPED BASS.

The anticipation of fine sport with the striped bass which the California anglers entertained when the successful introduction of the fish was assured has not been fully realized. Up to the present time comparatively few bass have been taken with the rod, and the fish has not evinced the gamy disposition which characterizes it on

the Atlantic Coast. In May, 1890, a 6-pound fish was taken in Russian River with a minnow bait. In May, 1894, some weighing 4 pounds and upward were caught with minnows in Suisun Bay Slough. Other captures might be reported, but the number taken has been out of proportion to the trials made. Whether they do not bite so readily as in its native waters or whether the California fishermen have not used the proper gear, at the proper time, and in the proper places, is not known.

STATISTICS OF THE CATCH OF STRIPED BASS.

Following is a statement of the quantities of striped bass caught and sold by California fishermen in 1889, 1890, 1891, and 1892, as determined by Mr. W. A. Wilcox, field agent of the United States Fish Commission. The values given represent the gross prices received by the fishermen.

Summary of the striped-bass catch of California in 1889, 1890, 1891, and 1892.

Years.	Pounds.	Value.
1889	16,296	$4,073
1890	20,119	4,021
1891	30,674	4,602
1892	56,209	6,488

Complete figures for later years are not available, but the catch for 1893 and 1894 may be approximately determined by the receipts of these fish by the San Francisco dealers. In 1893 the estimated yield of striped bass was 90,000 pounds, valued at $10,000, and in 1894 it was not less than 170,000 pounds, for which the fishermen were paid $16,100.

The aggregate value of the striped bass taken in California up to and including the year 1894 was between $45,000 and $50,000. The practical importance of the introduction of this fish to the Pacific is further emphasized when the foregoing figures are contrasted with the cost of its acclimatization. The entire expense connected with the matter was only a few hundred dollars. The investment now yields an annual return of $15,000 or more, and may be expected to greatly increase from year to year. Few achievements of fish-culture in public waters are comparable to the financial success of this experiment.

FOOD QUALITIES OF THE STRIPED BASS.

The very high price which the striped bass commanded, even after it ceased to be a curiosity in the San Francisco market, is evidence of the esteem in which it is held in California. It is generally regarded as one of the choicest fish of the State, and its addition to the food-fish supply is much appreciated by the public, the fishermen, and dealers. It is in demand throughout California and is consumed along the entire Pacific Coast of the United States and in most of the interior States of the West.

Mr. Babcock furnishes the interesting information that in May, 1895, Mr. J. P. Haller, manager of the Sacramento River Packers' Association, canned several hundred pounds of striped bass as an experiment. The fish were selling at 2 cents a pound at Black Diamond, and 500 to 600 pounds could have been obtained daily from salmon fishermen making Black Diamond their headquarters, while the fishermen above that place took many more fish than the Black Diamond men. The manager reported to Mr. Babcock that he was much pleased with the canned bass; that it was fully equal

to the white Alaska salmon, and that he thought the association would in a year or two make a regular pack of striped bass. Through the courtesy of Mr. Babcock, the writer had an opportunity to sample a can of striped bass and was much pleased with the flavor of the fish as thus prepared.

THE STRIPED BASS TRADE OF SAN FRANCISCO.

Probably seven-eighths or more of the striped bass caught in California are sent to San Francisco, where the larger part of the yield is consumed; but a somewhat important trade in this fish is carried on by the San Francisco dealers with other cities and towns of the West. The wholesale dealers sell to retail dealers, hotels, and restaurants in San Francisco, and make consignments to Oregon, Washington, Utah, Nevada, Arizona, New Mexico, and Mexico, as well as to numerous California towns. The entire striped bass catch reaches the consumer in a fresh condition. The only people who eat the fish salted are the Chinese, and the quantity they consume is not large. Mr. Alexander remarks on this point:

> The Chinese are heavy buyers of striped bass, but they, as a rule, purchase fish inferior in quality, which have lain in the market much longer than they ought. Such fish can be bought comparatively cheap, on an average from 5 to 7 cents a pound. The Chinese method of dressing striped bass which are to be salted is to split them down the back, the head being left on. They are then washed and salted in barrels, where they remain for a week or ten days, at the end of which time they are taken out and dried on flakes or hung on lines arranged on the tops of houses or in back yards. This is the usual way Chinese cure all kinds of fish not eaten fresh.

The inquiries of Mr. Wilcox in 1892 showed that the receipts of striped bass by the San Francisco dealers were about 5,000 pounds in 1890, 25,000 pounds in 1891, and 50,000 pounds in 1892; these figures are based on estimates furnished by the different dealers. Data for 1893 and 1894 were obtained from the books of the dealers by Mr. Babcock, of the California fish commission, and the writer. The actual quantity handled by wholesale dealers was 80,793 pounds in 1893 and 149,997 pounds in 1894. The dealers' receipts, by months, are shown in the following table, which illustrates the times when the fish are most abundant:

Statement of the number of pounds of striped bass handled by San Francisco dealers in 1893 and 1894.

Months.	1893.	1894.
January	3,448	14,177
February	3,087	12,572
March	5,403	9,002
April	8,351	9,038
May	7,232	9,413
June	4,353	4,820
July	2,950	7,521
August	2,655	6,863
September	8,507	10,218
October	6,820	23,192
November	10,473	17,950
December	17,514	24,631
Total	80,793	149,997

PRICES OF STRIPED BASS TO FISHERMEN AND DEALERS.

The prices first paid for striped bass were, like those for shad, very high. Even as late as 1888 the ruling price in the San Francisco market was $1 per pound. By April, 1890, however, on account of the increasing abundance of the fish, the price

dropped to 18 cents a pound and has since ruled lower each year. At times in 1893 and 1894 striped bass could be bought at prices that were within the reach of even the frugal Chinese. Referring to the San Francisco market, Mr. Alexander states:

> In the month of September, which is the close season for salmon, striped bass command a good price, but it is only for a short time, for as soon as salmon begin to appear again the price drops to a low figure. It can not be said that salmon alone causes the price to fall, for it is partly due to striped bass being caught in considerable numbers at that time, and it is a combination of circumstances which makes it possible to buy the fish at most seasons at a reasonable figure.

From 1889 to 1892 the average price received by the fishermen fell from 25 cents to 11½ cents a pound. During 1893 and 1894 the prices received by the San Francisco dealers ranged from 4 to 30 cents a pound, the average price being about 10 cents. The average net price to the fishermen was 2 to 3 cents less.

In December, 1893, when large consignments of bass were received at San Francisco, the prices fell to a very low figure. A dealer who made returns at only 3 cents a pound incurred the great displeasure of the fishermen. On June 21, 1894, the day following the large catch on the Berkeley Flats in San Francisco Bay, the wholesale price in San Francisco was 3½ cents and the retail price 7½ cents a pound.

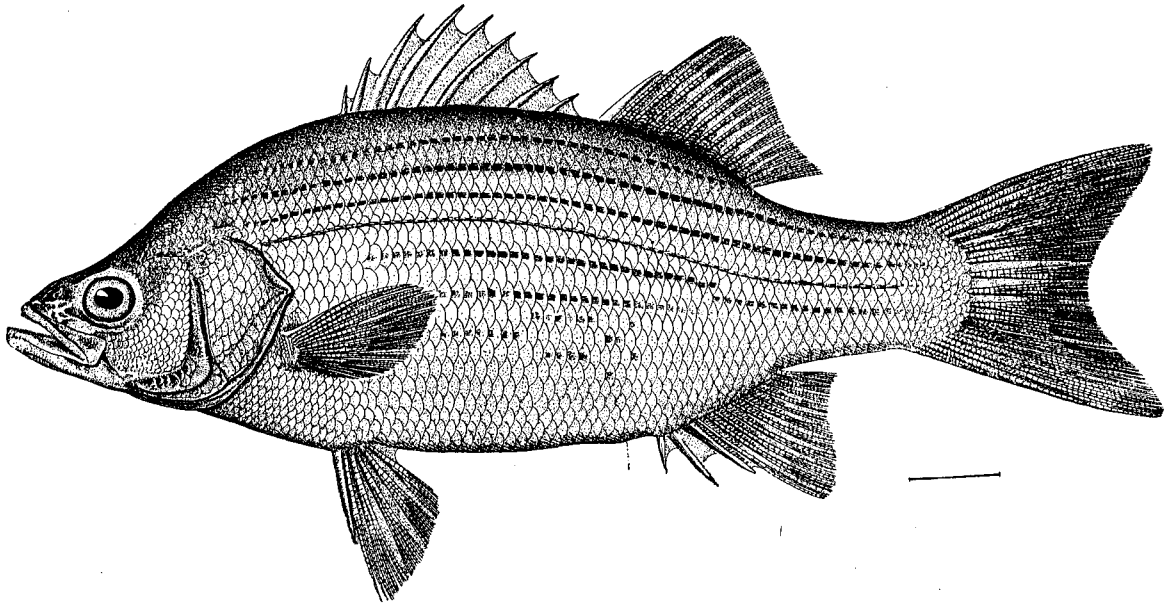
Writing under date of July 24, 1895, Mr. Babcock says that striped bass did not yield the fishermen over 5 cents a pound taking the year through, and that the San Francisco dealers had undersold the New York dealers every month, as shown by the quotations in the *Fishing Gazette*. During November, 1895, the receipts were very heavy, and on November 9 the retail price in San Francisco was only 6 cents a pound.

THE WHITE BASS.

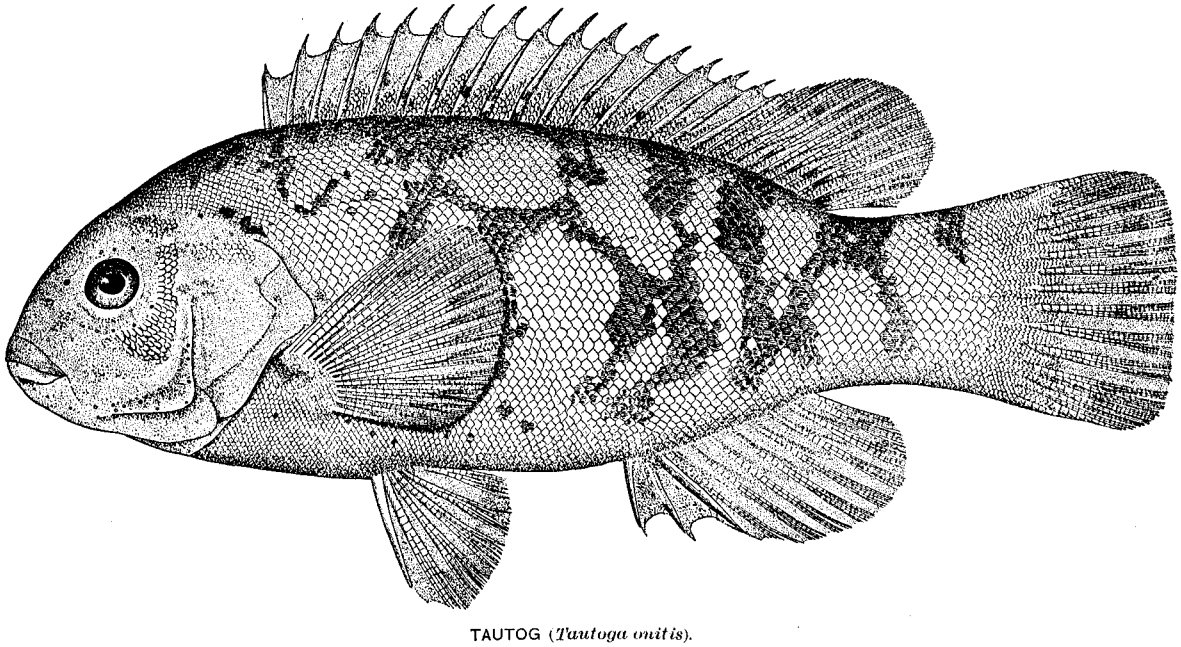
Twelve yearling white bass (*Roccus chrysops*) from Quincy, Ill., were delivered to the California fish commission at Sisson in June, 1895, at the time the carload of large-mouth black bass was sent to that State by the United States Fish Commission. Five of these were alive in December, 1895, and will be retained for breeding purposes. This fish, which is abundant in the Great Lakes and the Mississippi Valley, may be regarded as a landlocked striped bass and is an excellent food-fish. It is doubtless well suited to the warmer lakes, sluggish streams, and bayous of the Pacific States. It is adapted to cultivation, reaches a weight of 3 pounds, and is quite gamy.

THE TAUTOG.

Mr. Livingston Stone, of the United States Fish Commission, carried specimens of the tautog (*Tautoga onitis*) from the Atlantic to the Pacific coast in his aquarium car. The fish were obtained at Woods Hole, Mass., and were deposited in San Francisco Bay near Oakland, June 12, 1874. They were of small size, and the number planted was 23. There is no evidence that anything ever came of this small deposit of fish in this large body of water. In the report of the California fish commission for 1876–77, it is stated that some tautog had been reported to have been seen in the San Francisco market, but no subsequent references to their appearance have been met with. In 1873 Mr. Stone included tautogs in the collection of live fishes which he attempted to carry to California, but they were lost in the wreck of the transportation car.



WHITE BASS (*Roccus chrysops*).



TAUTOG (*Tautoga onitis*).

THE AMERICAN LOBSTER.

HISTORY OF PLANTS.

A full account of the planting of eastern lobsters (*Homarus americanus*) in the Pacific Ocean has been given in the paper by Mr. Richard Rathbun, entitled "The transplanting of lobsters to the Pacific Coast of the United States," published in the Bulletin of the United States Fish Commission for 1888. The following notes on the history of the plants are largely abstracted from Mr. Rathbun's report, to which recourse should be had by those desiring a more detailed discussion of the subject than is given in the present paper.

Five attempts have been made to introduce eastern lobsters to the Pacific Coast. The first trial was a failure, owing to a railroad accident; the others were successful to the extent of reaching the coast with live lobsters and depositing them in suitable waters.

The first attempt to transport live lobsters across the continent was made in 1873 by Mr. Livingston Stone, who represented the United States Fish Commission and the California fish commission in the matter. Lobsters constituted only a small part of the contents of the aquarium car, which had been stocked with a number of eastern fresh-water and marine fishes. The start was made with 162 lobsters obtained from Woods Hole and Massachusetts Bay. By the breaking of a railroad bridge over the Elkhorn River near Omaha, the aquarium car was wrecked and the contents lost. Forty lobsters had survived the journey to that point.

In 1874 Mr. Stone undertook the transportation of another lot of lobsters, under the auspices of the California fish commission. The consignment consisted of 150 egg-bearing lobsters procured in Boston. The losses en route were very large, only four lobsters reaching the coast alive. These were deposited in San Francisco Bay, at Oakland, on June 12. At Salt Lake City, Utah, two lobsters were put in Great Salt Lake.

Efforts in this direction were not renewed until 1879, when, under Mr. Stone's direction, the United States Fish Commission made the third attempt to introduce lobsters into the Pacific Ocean. The lot consisted of 22 females, to which were attached about 400,000 eggs nearly ready to hatch. Between Boston and Albany 40,000 eggs hatched. The trip to California was made with the loss of only one lobster, the remainder being deposited in excellent condition off Bonito Light-house in a sheltered position a few miles outside of the Golden Gate.

Nine years later the Fish Commission sent a relatively large number of adult and embryo lobsters to California, in a special car in charge of Mr. J. Frank Ellis. The lobsters, which were collected at Woods Hole, consisted of 254 males and 360 females, 8 of the latter carrying eggs on the swimmerets; 150,000 loose eggs were also added to the consignment. The losses on this trip were quite large, amounting to 282 adults. In Mr. Rathbun's opinion the heavy mortality was due to the weak condition of the lobsters incident to the spawning and molting conditions. Of the eggs, 75 per cent reached the west coast safely. The place selected for the planting of the lobsters was Monterey Bay. On June 23, 162 lobsters were placed in the sea about three-fourths of a mile off shore from Pacific Grove, in water 12 fathoms deep with rocky bottom. A second plant of 95 lobsters was made July 1, a mile off Point Lobos, to

the south of Carmel Bay, in water 30 fathoms deep with rocky bottom. The remaining lobsters, 73 in number, which were being retained in a floating car at Monterey, were chiefly intended for planting at some point on the northern coast of California. One of the bottom boards of the car having become detached by the heavy swell, all but 30 of the lobsters rapidly made their escape into Monterey Bay. On July 4 the steamer *Albatross* left San Francisco with the 30 lobsters on board, the lot consisting of 13 males and 17 females. These were planted the following day in 13 fathoms of water off Trinidad Light-house, this point having been selected because of the favorable conditions of temperature, bottom, and water, which were thought to more closely resemble those of the lobster's natural home than any other place on the California coast. The eggs were hatched on the grounds, and 104,000 young lobsters obtained, 2,000 of which were planted in San Francisco Bay and 102,000 in and off Monterey Bay.

The last shipment of lobsters to the Pacific Coast was made in January, 1889, the season for the trial being different from that of the previous experiments. The lobsters were collected at Woods Hole, and numbered 279 males and 431 females, 63 of which carried eggs. The shipment was made in a United States Fish Commission car, in charge of Mr. J. Frank Ellis. These lobsters were intended for the Washington and Oregon coasts. The start was made from Woods Hole January 14, and the lobsters were planted January 22. Owing to the failure of a part of the arrangements, the lobsters destined for Yaquina Bay, Oregon, could not be deposited in that place, and the entire plant was consequently made on the coast of Washington. Of the 710 lobsters with which the journey was begun, 233 survived the trip and were placed as follows: 88 off Cape Disappointment, at the mouth of the Columbia River; 22 in Shoalwater Bay, and 123 in Puget Sound, near Port Townsend.

The following table is a recapitulation of the plants of lobsters on the Pacific Coast. The aggregate deposits of adults amounted to 590, a large number of which were egg-bearing females.

Summary of the American lobsters planted on the Pacific Coast of the United States.

Year.	Localities.	Adults.	Embryos.
1874..	San Francisco Bay	4	.....
1879..	Pacific Ocean, near Golden Gate	21	.....
1888..	Pacific Ocean, off Monterey	162	93,000
	Pacific Ocean, off Point Lobos	95	.....
	Monterey Bay	45	9,000
	Pacific Ocean, off Trinidad Light-house	30	2,000
1889..	Pacific Ocean, off Cape Disappointment	88	.....
	Shoalwater (Willapa) Bay	22	.....
	Scow Bay, Puget Sound	24	.....
	Off Hudson Point, Puget Sound	25	.....
	Off Wilson Point, Puget Sound	74	.....
	Total	590	*104,000

*In addition to these, the female lobsters planted had attached to them several hundred thousand eggs.

DESIRABILITY OF INTRODUCING LOBSTERS TO THE PACIFIC COAST.

The Atlantic lobster would unquestionably be a very acceptable and important addition to the fishery resources of the Pacific States. The spiny lobster, locally called crawfish, which now takes the place of the lobster in the markets of the coast States, is a valuable food product; but it has only a limited distribution, not occur-

ring north of Point Conception, California, and is probably inferior in quality to the true lobster. The long stretch of coast line north of Point Conception is destitute of crustacea which now have economic value, with the exception of the large crab (*Cancer magister*). Mr. Rathbun, in the paper already cited, says:

The omission of the true lobster from the aquatic fauna of the Pacific Coast has been considered by the inhabitants of that region a great misfortune, and while its absence causes neither suffering nor affliction, it is much desired both as an article of commerce and as an added variety to the food supply. The scheme [to attempt its colonization] has received the approval of high authorities, and the benefits to be derived from the introduction of so useful a species are generally admitted.

SUITABILITY OF PACIFIC COAST WATERS TO THE EASTERN LOBSTER.

In the paper by Mr. Rathbun before referred to, that writer considers in detail the question of the suitability of the west-coast waters to the existence of the lobster. His remarks on this subject are so opportune that they may be appropriately quoted:

The North Atlantic and North Pacific oceans have much in common with respect both to their physical and biological characteristics. Identical species of fishes and marine invertebrates inhabit the northern parts of both oceans, and the number of related forms in the two regions is very great. The natural resorts of lobsters on the eastern coast—rocky, gravelly, and sandy bottoms, covered in places with kelp and rockweed, and with an abundance of aquatic life suitable for food—occur throughout the North Pacific region from California to Alaska. Temperature, however, is probably to be regarded as the most important factor determining the fitness of the region for this new food product, and it is the only one which we can now pretend to measure, although we have little data respecting it for the western coast.

On the Atlantic Coast the lobster ranges from Delaware to Labrador, being most abundant between the Cape Cod region of Massachusetts and the Gulf of St. Lawrence and Newfoundland. Its bathymetrical distribution is from the littoral zone (in some localities) to depths of probably 50 to 60 fathoms, but the fishery is chiefly carried on inside of a depth of 30 fathoms. It apparently does not migrate up and down the coast to an appreciable extent, but moves off into deeper water with the approach of winter in order to escape the severe cold.

This writer next enters into a discussion of the water temperatures of the two sides of the continent, comparing the mean temperature of a number of localities on the Atlantic Coast with that of San Francisco and Cape Disappointment. A chart is introduced which shows for the entire season the water temperature at San Francisco and Vineyard Sound light-ship. Mr. Rathbun's statements on the adaptability as regards temperature of the places in which plants were made are as follows:

The water temperature at Monterey is probably not very different from that at San Francisco, while Trinidad Light-house is intermediate in position between San Francisco and Cape Disappointment. At both of these observing stations the records indicate ranges of temperature falling within those of the New England coast, and therefore presumably favorable to the existence of lobsters. * * * By reference to the chart it will be seen that the temperature is far more equable at San Francisco than in Vineyard Sound, having a range of only about 10° in the one case and of over 30° in the other. The yearly range at San Francisco corresponds to that in Vineyard Sound from May 20 to the last of June and from the first part of October to the middle of November, seasons during which the lobsters are on the inshore grounds, the former being also the regular hatching season. In case lobsters become colonized on the coast of northern California it will therefore be interesting to observe if the more equable temperature of that region has any influence in bringing about a change in their customary habits. Will their offshore migrations be less pronounced and their breeding season prolonged? Another matter which the temperature comparison suggests is as to whether the more severe cold of the eastern winters is essential to their welfare or not. There is nothing to prove the case one way or the other, but the fact that lobsters seek shelter from the extreme cold would rather indicate that they might not suffer from its absence. An additional question of interest to the biologist concerns the effect upon the existing fauna of the introduction of the eastern lobster on a large scale. Will it to any extent disturb

the general balance of life in that region, reducing the prominence of some species and perhaps aiding others in their struggle for existence? Only the future can decide this matter, but in any event the addition of the lobster to the Pacific waters could produce no harm for which the inhabitants would suffer.

Mr. A. B. Alexander, fishery expert on the Fish Commission steamer *Albatross*, thinks that some parts of the Alaskan coast afford better conditions for the lobster than exist on the shores of the Pacific States. He writes as follows on this point:

The geographical position, temperature of water, and general character of the bottom in many parts of Alaska are, in the opinion of the writer, much better suited to the requirements of the lobster than that part of the coast lying below or south of Cape Flattery. The whole archipelago of southeastern Alaska contains many places where the lobster would be more likely to live and multiply than at any place on the Pacific Coast.

The temperature and other environments of this region correspond more closely to the home of the lobster on the Atlantic Coast. It is quite evident that lobsters require a great change in temperature of water, far greater than they would find off the Pacific Coast below 50° north latitude, from the fact that they are only found in latitudes where the water undergoes such a change.

The coast of southeastern Alaska is cut up into hundreds of islands, both large and small, forming numerous bays, channels, and estuaries, very similar to the coast of Maine and some parts of Nova Scotia and Newfoundland. From Massachusetts to the Gulf of St. Lawrence is where lobsters abound in greatest numbers, and in this region the water in summer is comparatively warm and in winter extremely cold, elements perfectly congenial to this crustacean. In Alaska the water annually undergoes, to a much less degree, the change which takes place in the latitudes above mentioned. All things considered, no great mistake would be made in planting lobsters in the waters of southeastern Alaska. The harbor of Sitka would be an excellent place to try the experiment; also at Hooniah. There are many localities equally as good above Prince of Wales Island, namely, Howkan, Nichols Bay, and Shakaan; or at Loring, Revillagigedo Island, and several more points farther up the Behm Canal.

RESULTS OF EXPERIMENTS IN PLANTING LOBSTERS.

No economic results have attended the planting of lobsters on the Pacific Coast, and, although the capture of several adult lobsters in years subsequent to the plants has been recorded, no specimen of lobster from the Pacific Ocean has been preserved, or identified by a scientific authority.

The reasons for the absence of results are unknown. Whether the negative outcome has been due to the nonadaptability of the Pacific waters to the lobster, the destruction of the plants by natural enemies before propagation had ensued, the failure of fishermen to catch the lobsters, or the scattering of the relatively small plants over a large area and the failure of the sexes to come together, can not be determined. It may be that it is yet too soon to expect noticeable results, at least from the plants made in 1888 and 1889, while the small deposits in the earlier years may be dismissed from consideration. The following extract from Mr. Rathbun's report bears on this question:

The lobster is, to the best of our knowledge, a slow-growing species, not attaining a length of 10 inches within at least 5 or 6 years from the time of leaving the egg, and by some it has been computed that the growth is even less rapid. The 565 lobsters recently planted on the coasts of California and Washington can not in themselves be regarded as a direct addition to the food supply. They are only a breeding stock, and any increase in their numbers must be derived from the growth of their progeny, also taking into account the young embryos placed in the water off Monterey in 1888. The number of embryos planted by the Fish Commission was about 100,000. Supposing that they all lived, we could not at the end of five or six years have an addition of more than that number of adult lobsters in the Monterey region, and until that time there would be no additions to the original stock of breeding lobsters. At the end of the first year, or during the first breeding season following their introduction, a maximum of 1,800,000 eggs and embryos would be all that could be expected from the

original lot of females planted, under the most favorable circumstances, and provided they all lived that long. Prolonging these conditions, the maximum number of eggs would not be increased from year to year before the fifth or sixth year. It is probable, however, that the original stock of adult lobsters will not keep entirely together, and some will undoubtedly become the prey of fishes. Moreover, lobster embryos are subject to great mortality, and only a very small percentage reach maturity. If at the end of six or even ten years a few thousand only compose the colony off Monterey, the experiment may be considered as successful, but when once it has been firmly established on so large a basis the annual increase will be much more rapid.

Mr. Rathbun states that during 1889 a few of the adult lobsters deposited in the Monterey region had been seen in shallow water, and that young lobsters about 4 inches long were reported to be observed from time to time. Of the reported occurrence of the latter he remarks that full credence can not be given the statements until the specimens have been examined by someone competent to identify the species.

During the past few years several reports of the capture of lobsters on the Pacific Coast have been circulated. In 1893 notice of the taking of lobsters in the vicinity of Monterey was published. Mr. Alexander diligently investigated the matter and reported on it as follows:

Reports are frequently circulated that lobsters have been taken by the fishermen of Monterey, but each time the investigation which has followed has proved the story false. Those not familiar with the lobster easily mistake the fresh-water crayfish for that animal. During the past season a report was circulated through the press of this coast that several small eastern lobsters had been caught at Monterey, and, to add strength to the story, it was stated that samples had been sent to the Fish Commission for identification and word had been sent back that the samples received were the genuine eastern lobster. Such reports are very misleading and have caused considerable inquiry to be made concerning the lobsters planted on the coast in 1888.

The writer has had occasion to interview the fishermen of Monterey several times during the past four years, but has never been able to find a man who was certain he had caught a lobster. Prof. Charles H. Gilbert saw the specimens that were taken this summer, and states that they were fresh-water crayfish.

That several of the lobsters planted at Monterey have been caught there is little doubt. Captain, Nichols, of the United States Navy, says that several years ago he ate a lobster which was purchased at a market in Oakland; being an eastern man, and having taken an interest in the fisheries all his life, it is to be presumed that he is correct in what he says. The questions arise, Who caught the lobsters? and, Have they been exterminated? The white fishermen say they have never been guilty of saving what they supposed to be lobsters, but are of the opinion that the Chinese have caught and sold many specimens, but of this there is no direct proof. From what can be learned it would seem that the lobsters planted here were either caught before they had time to increase, or the character of the bottom and general surroundings was not suited to them for propagating.

No traces of the lobsters planted off Trinidad, Cal., have ever been found. The fishermen of that locality have made diligent search for them with such appliances as they had, but to no purpose. Captain Nichols, in charge of the light-house board of California, has had lobster pots made and set on and near the spots where they were planted. This kind of apparatus has also met with negative results.

The following very positive references to the lobster on the coast of Washington are found in the report of the State fish commissioner for 1890:

I have endeavored to ascertain if any young lobsters have been seen since. I find that quite a number have been seen by fishermen in Port Townsend Bay, and also in Shoalwater Bay. I met two gentlemen on Grays Harbor who had each taken one, one being taken at the mouth of the Hoquiam River, and the other near Peterson Point, close to the entrance of Grays Harbor. As both these gentlemen were from States bordering on the Atlantic, they were perfectly familiar with the lobster in all its different stages of growth, and both agreed that it was a genuine young lobster they had taken. The gentlemen, after examining them, returned them to the water. From this evidence there can be no doubt that the effort to transplant lobsters into the waters of our State has been successful, and in a few years will have stocked the Puget Sound as well as Shoalwater Bay and Grays Harbor. As the lobster requires about five years to mature, the present legislation for their protection is ample.

THE EASTERN OYSTER.

WHEN AND WHERE INTRODUCED.

The shipping of live eastern oysters (*Ostrea virginica*) from the Atlantic seaboard to the Pacific Coast quickly followed the completion of the first transcontinental railroad. It is stated that the first oysters were taken to California in or about 1870 by Mr. A. Booth, of Chicago. The business rapidly increased, and has continued to be of great importance up to the present time. It is recorded* that the first shipment consisted of three carloads of large oysters and that the market was overstocked, so that the consignees, to avoid loss, were obliged to plant in San Francisco Bay all the stock that were not promptly disposed of. This enforced planting of oysters resulted favorably, and was the beginning of a business which has since grown to large proportions.

It is probable that the first consignments consisted of oysters intended for immediate consumption, but in a very short time the practice was inaugurated of importing seed oysters for planting in San Francisco Bay, and this eventually became the ruling custom. Recently, however, a new company has been shipping marketable oysters to San Francisco.

The necessity for shipping eastern oysters to the Pacific Coast arose from the small size and poor quality of the native species (*Ostrea lurida*). This has a very objectionable coppery flavor, which greatly diminishes its food value, although the comparatively large consumption indicates that a taste for it may be acquired.

The supply of eastern oysters on the west coast is kept up by large shipments from the East. In recent years from 50 to 100 carloads have been sent annually to California and planted in San Francisco Bay, where they remain until they attain a suitable and profitable size for marketing. The oysters are shipped in freight cars holding 80 to 90 barrels and are usually three weeks on the cars. The business is carried on chiefly in the fall months, and losses en route are quite small. One-year and two-year old seeds are planted on the grounds in the southern part of San Francisco Bay for three and two years respectively. Their growth is considered rapid, and they retain their original flavor to a large extent, or, at least, do not acquire the metallic taste of the native oyster.

Full accounts of the conditions and methods of the eastern oyster industry of San Francisco Bay will be found in the report by Captain Collins referred to and in the article by Mr. Charles H. Townsend in the Report of the United States Fish Commission for 1889–1891. The special interest in this connection which the paper of Mr. Townsend possesses is the reference to the question of the propagation of the eastern oyster in the waters of California, for unless natural reproduction ensue the species can hardly be considered as acclimatized. The opinion has been generally entertained and is still quite prevalent that the eastern oyster does not and will not propagate in San Francisco Bay, owing to the supposed unfavorable physical and other conditions.

*Report on the Fisheries of the Pacific Coast of the United States. By J. W. Collins. <Report U. S. Fish Com., 1888.

Some remarks of Mr. Townsend on this point will be quoted. His complete report should be consulted by those desiring to fully investigate the matter:

The interesting fact that oysters do propagate in San Francisco Bay, in certain favorable localities at least, calls for some explanation as to the long acceptance by the public of the statement that there has been no natural increase. * * * During occasional visits to the oyster beds in 1889, I found proof of considerable natural propagation of the eastern oyster in the southern part of San Francisco Bay, and transmitted evidence of the same to the United States Commissioner of Fish and Fisheries, who directed that an examination be made in order to determine to what extent this had taken place. * * * The investigations of this subject have simply disclosed the facts that the oyster has to some extent adapted itself to the new habitat in common with the other introduced species, and that in spite of many unfavorable conditions it is slowly increasing.

* * * * * * *

Not only are the chances for the fixing of spat diminished by the use of ground in some places where there are very few old shells upon the bottom, but almost all of the shells of *Ostrea virginica* are returned from the marketmen to the principal oyster company, who sell them for the manufacture of lime instead of using them for the improvement of the beds. These shells of eastern oysters, if returned to the beds where they were grown, or to other portions of the bay, would certainly increase the chances for the fixation of spat set free from the beds where adult oysters are growing. It is probable that careful attention to this matter of increasing the fixing surface required by the young oyster might make just the difference between rapid self-propagation and the present slow increase.

One of the first indications I had of the natural propagation of the oyster was the finding of young oysters six months or a year old upon beds where those three or four years old were kept. They were in most instances attached to clusters of dead shells of the small native oyster. Very few were to be found attached to adult specimens of *Ostrea virginica*, but this may be explained by the fact that such oysters are frequently handled and "laid out" to keep them well upon the surface and prevent any settling in the mud. The handling is done in order to select and clean the largest for market, the others being also cleaned of the ever-accumulating native oysters, which would involve the destruction of such small eastern oysters as might be among them upon the shells of the large oysters.

The fact of young eastern oysters being attached to anything is proof that they grew in the bay where they were found, for oysters do not have the power of fixing themselves a second time. All these small oysters are knocked off the large shells with a small cleaning hatchet, and the operation is a necessary one, as the extremely productive natives cluster upon the larger species in such numbers as to greatly interfere with their growth.

In October, 1891, I discovered some oysters of large size in certain sloughs of the south bay, where they had long escaped the stingrays in consequence of bars which shut off the sloughs from all but the highest tide. These were the largest oysters ever seen at San Francisco, and had evidently lain there for several years. More recently I obtained a quantity of oysters, apparently two years old, in Oakland Creek. As the oyster beds maintained there several years ago by Mr. Doane, now of the Morgan Oyster Company, have long since been abandoned and the stakes removed, it is evident that a limited number of oysters have found conditions suitable for their development and growth, even in this muddy place. They are no longer found on the mud flats, where they were originally kept, but live in the mud of the channel, from which I obtained them with tongs.

Mr. Cleaveland Forbes, of the Spring Valley Water Company, informed me that several years ago he found full-grown eastern oysters upon the piles of an old narrow-gauge railroad trestle, across a slough, near Dumbarton Point, and that the men of his party frequently found many upon banks composed of shells of the native species, near where the pipes of the company cross the bay.

Mr. H. D. Dunn has recently reported, through the press, the discovery of a full-grown eastern oyster near Mile Rock, in the Golden Gate.

It is possible that during the long time eastern oysters have been kept in the bay they have become in a measure acclimated, and that there is a constantly increasing tendency to propagate—that is, the progeny of oysters grown here become hardier with each generation and better adapted to the colder but more equable waters.

During my latest examinations of the bay (May and June, 1891) eastern oysters, very large and old, were found in the following places near the sites of former oyster beds: Several adhering to the piles of the narrow-gauge railroad trestle across San Leandro Bay; a few upon the rocks at the extreme

north point of Sheep or Brooks Island, near low-water mark; a few upon the rocks at Point San Pedro (at entrance to San Pablo Bay). Those from San Leandro Bay doubtless originated as spat from the oyster bed near the entrance to that bay, at the end of the bay northwest from the island. Those from Sheep Island had merely drifted as young across the half mile of distance from the old beds near Ellis Landing, while the San Pedro oysters originated upon the beds between Marin Island and Point San Quentin, a couple of miles distant.

Mr. H. D. Dunn informed me that wild eastern oysters had been reported to him from some other place near Point San Pedro, but I did not discover them, being without a pilot. These finds are very interesting, as showing not only the breeding of the oyster in various parts of the bay, but that the species began breeding several years ago when oysters were laid out in those northern parts of the bay. At Point San Pedro oysters are directly exposed to the influences of the Sacramento River. But the largest and most important tract of oyster propagation is in the region of the natural shellbanks of native oysters along the east side of the bay, beginning at Bay Farm Island and extending well southward and off into deep water. Here wild eastern oysters may be found during the low tides that expose the outer portions of the shellbanks. At this place they are numerous, and when the tides are sufficiently low it is possible to gather them by the score, ranging in size from yearlings to those several years old. This deposit is at least 4 miles removed from the nearest site of a former oyster bedding-ground, and there is no doubt about the oysters upon the whole tract being of volunteer growth. A channel several feet wide separates this tract from the old bed on the north, while it is nearly 10 miles to the nearest beds on the south.

Examination of two or three hundred oysters gathered in this region shows the fixing surface for the spat to have been the shells of the native oyster (*Ostrea lurida*). Indeed, there is nothing on this whole bank but clean shells of the native species. The bank is exposed to heavy seas during the season of strong winds, and many eastern oysters doubtless become buried beneath the easily drifted shells of the small natives. It is probable that there is a very great production of eastern oysters here that we know nothing of, as the whole tract is accessible to stingrays, which prey upon every kind of shellfish outside of the stake-protected beds. It is also probable that the heavy seas which at times sweep across this shallow section of the bay and actually break up the clusters of native oysters by rolling them toward the beaches, have an injurious effect upon newly fixed eastern spat by burying them beneath the drifting shells.

Considerable quantities of wild eastern oysters are annually gathered upon this and other shellbanks in the bay. They are retailed in Oakland and Alameda at $1.50 per 100, or sold to the oyster companies who lay them out on their fenced beds for further growth. They are obtained when unusually low tides happen to expose them. No tonging or dredging is done, the oysters being gathered by hand. The work is performed chiefly by boys. I have no means of knowing the quantity of oysters derived from this source.

It appears, therefore, that there are other parts of San Francisco Bay as good for oyster-culture as those now inclosed, and that the increase of wild oysters now growing there would be more rapid if they were inclosed and afforded similar protection from heavy seas, stingrays, etc.

Several attempts have been made to acclimatize oysters on the Washington coast. Mr. Townsend reports that many years ago two sacks of eastern oysters were placed in Budd Inlet, Puget Sound, near Olympia. They are known to have lived for several weeks, but were soon lost sight of. A few sacks of oysters were also planted in Willapa (Shoalwater) Bay, near Oysterville, a number of years ago. They lived, but no increase in their numbers was ever observed.

In 1894, pursuant to urgent solicitations of the people of the State, the United States Fish Commission sent a carload of eastern oysters to Willapa Bay. The consignments consisted of 80 barrels of large oysters from Raritan Bay, Princess Bay, Newark Bay, Keyport, East River, and Chesapeake Bay. The oysters arrived in excellent condition and were planted near Bay Center on November 11, Mr. Townsend superintending the planting. These will be carefully protected until sufficient time has elapsed to demonstrate the adaptability of this bay to the growth and multiplication of the species.

EXTENT OF THE TRADE IN EASTERN OYSTERS.

The business of planting eastern oysters in San Francisco Bay, and of taking them up for market when they have attained sufficient size, is one of the most important branches of the fisheries on the Pacific Coast. In 1888 the quantity taken from beds in San Francisco Bay and sold was 117,000 bushels, and the output has increased annually since that time. Over 100 persons are employed, and nearly $300,000 is invested in vessels, shore property, cash capital, and oyster-grounds.

The inquiries of Mr. W. A. Wilcox, agent of the United States Fish Commission, have shown the quantity and value of the yield of eastern oysters from 1888 to 1892 inclusive to have been as follows, the figures for the last four years named being extracted from Mr. Wilcox's paper* in the Report of the United States Fish Commission for 1893:

Years.	Bushels.	Value.
1888	117,000	$465,375
1889	120,000	480,000
1890	125,000	500,000
1891	130,000	520,000
1892	146,000	584,000

THE SOFT CLAM.

The existence of the soft clam or long clam (*Mya arenaria*) of the Atlantic Coast on the shores of California was first suggested in 1874, when Dr. W. Newcomb described it from San Francisco Bay as a new species under the name *Mya hemphillii*, recognizing that it was distinct from the native *Mya* of the Puget Sound region. It is interesting to observe that it is also found on the coast of Japan.

In a paper entitled "*Mya arenaria* in San Francisco Bay,"† by Dr. R. E. C. Stearns, it was shown that since 1874 this clam had become abundant along the eastern side of San Francisco Bay, although it was not known north of that bay. The author had, however, received specimens from Santa Cruz, on Monterey Bay, 72 miles south of the Golden Gate.

In discussing the origin of the clam in San Francisco Bay, Dr. Stearns gives the opinion that the original mollusks were accidentally taken to the Pacific Coast with carloads of eastern oysters destined for planting near San Francisco. He writes as follows on this point:

> From whence came the seed which has produced the abundance of this species which has spread and is now spreading rapidly along the shores of San Francisco Bay?
>
> Examine the ancient shell heaps and mounds found hereabout, and one may find the thin broken valves of the *Macomas*, but not a fragment of the shell of *Mya*. One may find the shells of the native *Haliotis* and *Olivella* and the beads and money or ornaments made from them; the bones of the common California deer, of the whales, and perhaps other animals, all of which are still to be found in the neighborhood or not many miles away, but not a piece of *Mya*. The ancient clam-diggers, whose kitchen middens are met with in many places on the Alameda and other shores of the bay, whose skeletons and implements are sometimes exhumed or discovered, had "passed over to the majority"

*The Fisheries of the Pacific Coast, 166 pages, 14 plates.

†American Naturalist, xv, 1881.

centuries before the advent of *Mya arenaria* in California waters. To proceed to the question, Was the seed of this mollusk introduced from the waters of the Asiatic shores of the North Pacific or from the American shores of the North Atlantic? If artificially introduced, of which there can be no doubt, from which direction does the extent and character of the traffic of our commercial intercourse make it most probable that the species came or was brought? By water on the steamships from Japan, or by railroad 3,000 miles overland from the Atlantic seaboard?

With the completion and operation of the transcontinental railroad, our oyster men, many of whom have a large capital invested in the business, commenced the importation of small oysters (*O. virginica*) from the Atlantic side by the carload, for planting in San Francisco Bay, where in a season or so they attain a merchantable size, growing exceedingly fat. * * * There is no similar traffic with Japan, and it is hardly possible that the fry of *Mya arenaria*, if it did adhere to the bottom of the Japanese steamers in Japanese ports, would be able to hold on for so long a time or for so great a distance with the friction of the water against the bottom of the steamer constantly operating to sweep it off. Native oysters are also imported from various points in Washington Territory and planted in the bay, but we have no knowledge of the *Mya* existing at any point in the region from whence these latter oysters are brought.

The soft clam has attained great economic importance in California. As early as 1881, as Dr. Stearns shows, it was the leading clam in the San Francisco and Oakland markets and had superseded to a great extent the native clams (*Macoma nasuta* and *Tapes staminea*). That writer referred to the value of the soft clam and the desirability of its further distribution in the following words:

In the presence of the fact of the rapid increase of this truly excellent edible—next to the oyster the most valuable, either as human food or fish bait, of any of this class of food—and the inference from its spreading so readily in San Francisco Bay that other places along the coast might prove equally congenial to it, it would be a wise, public-spirited act if the captains of our coasting vessels would take the trouble and incur the slight expense attending the planting of this clam at such points as their vessels touch at in the ordinary course of business.

In the report of the California fish commission for 1885–86 the commercial value of the soft-shell clam is thus referred to:

During the last few years soft-shell clams have been taken in great quantities. The spawn is supposed to have been brought to this coast with the eastern oyster. They have covered the flats surrounding San Francisco Bay. The number taken by bushels can not be obtained, as they are marketed in San Francisco by the box, each box holding about 2 gallons of solid meat. Two hundred and fifty boxes, or 500 gallons, are consumed daily, making the annual consumption 156,500 gallons.

The inquiries of the agents of the Fish Commission, covering a continuous period from 1888 to 1892, have shown the extent of the soft-clam fishery and trade of California in those years. The great bulk of the output is sold in San Francisco, and the quantity handled by the dealers of that city, as shown in the following table, represents approximately the quantity taken in the State. The unit of measure is a box holding about 50 pounds of clams in the shell. The receipts of soft clams are seen to be increasing, while the consumption of native clams has varied but little in recent years. The ruling price to the consumer has been about $1 a box for several years.

Table showing the quantity of soft clams handled by San Francisco dealers.

	Boxes.
1888	31,200
1889	18,500
1890	25,000
1891	30,000
1892	40,000

According to Mr. Charles H. Townsend,* naturalist on the Fish Commission steamer *Albatross*, a large part of the soft-shell clam supply comes from San Pablo Bay, where *Mya arenaria* is found to the exclusion of all other mollusks, and where "this species is apparently as abundant as if it had always existed in these waters."

In 1884 the existence of the soft clam in great abundance in Shoalwater Bay, Washington, was shown. The history of the presence of the eastern clam in that locality was given by Dr. Stearns in the following letter to Professor Baird, published in the Bulletin of the United States Fish Commission for 1885:

I have examined the box of clams which just came to hand from Donald Macleay, esq., president of the Board of Trade, Portland, Oreg. Mr. Macleay states that they are the eastern clams, and found at Shoalwater Bay, Washington Territory, which is correct as to their original (indirectly) and present habitat. I was aware of the presence of these clams at the locality given by Mr. Macleay some months ago, and it would be wise to put the matter on record. Captain Simpson, a public-spirited citizen of San Francisco, of the firm of Simpson Bros., extensively engaged in the lumber trade, employing a great many vessels in their business, informed me that he had at one time (or at various times) sent up the coast by their captains a quantity of *Mya arenaria* for planting in Shoalwater Bay, and it, *Mya*, had multiplied wonderfully, and now (at the time of our conversation, May, 1884) this clam was abundant there. The clams planted by the direction of Captain Simpson were obtained by him in San Francisco, where *Mya* now "rules the roost," its increase in San Francisco Bay and excellent quality having nearly superseded the native clams, the latter being now seldom seen on the stalls of the fish markets.

Mr. Townsend says that the soft clam has been introduced into Puget Sound from Shoalwater Bay. It is stated that about six or seven years ago the original plants were taken from Shoalwater Bay by the engineer of a coasting steamer and deposited near Tacoma. They are reported to have greatly multiplied and to have been taken in large quantities for food.

OTHER ANIMALS SUITABLE FOR INTRODUCTION.

FISHES.

The remarkable success which has attended the attempts to acclimatize fishes in the Pacific States naturally suggests a continuance of the experiments. While there is a great abundance of valuable native food-fishes in the fresh, brackish, and salt waters of the Western States, and while the introduction of additional fishes is not generally needed, nevertheless it is doubtless true that it is desirable to augment the existing food supply of some sections by transporting several valuable eastern fishes which would be very welcome to the people of the West.

There are, in all the Pacific States, but more especially in Oregon and Washington, lakes and other waters now barren of food or game fishes, into which the introduction of native species or of eastern fishes could be readily accomplished.

A number of fishes, the introduction of which has already been attempted and has either proved a failure or only a partial success, might with propriety be given a further trial in waters now destitute of desirable species. Among these are the rock bass, the Atlantic salmon, the muskellunge, and the pike perch.

Care should be exercised in transplanting fishes to avoid the introduction of predaceous species into waters already containing desirable fish. The putting of black bass or pike perch in a trout stream, for instance, should be discouraged, as should the liberation of black bass or other sunfishes in salmon streams.

* Report on observations respecting the oyster resources and oyster fishery of the Pacific Coast of the United States. Rept. U. S. Fish Comm., 1889–1891.

Dr. C. H. Eigenmann, in a paper on the food-fishes of the California fresh waters, contained in the report of the California fish commission for 1888–1890, calls attention to the comparative scarcity of species in the fresh waters of the State. He says:

There is comparatively a very limited variety of fishes in California. A stream which in the Mississippi Valley would harbor 75 or 100 different species of fish would in California scarcely contain 20. This is due to two causes:

(1) Many of our streams become entirely dry during the summer, and no species that does not migrate to the sea, or the lower or higher water courses, can exist in them.

(2) It is a law in the distribution of fresh-water fishes that the greater the water system the larger the number of species of fish found in any of the tributaries. The tributaries of the Sacramento thus have much fewer species than the tributaries of the Mississippi, and the tributaries of the Mississippi much fewer than the tributaries of the Amazon. To be more precise, one naturalist has caught as many species of fish in one of the tributaries of the Mississippi in a day as there is known from the entire region west of the Sierra Nevada.

By saying that the number of species of fresh-water fishes is limited, I do not wish to imply that the food-fishes are less in number or inferior in quality, merely that we have less variety—a defect which can be remedied by introducing other species. The most prominent food-fishes of the Mississippi Valley which are not indigenous to California are the various catfishes, the buffalo, pickerels, most of the sunfishes, especially the black bass, perches, and the bass. Several of these have already been introduced.

Mr. A. B. Alexander, fishery expert on the *Albatross*, regards mackerel (*Scomber scombrus*), bluefish (*Pomatomus saltatrix*), and haddock (*Melanogrammus æglifinus*) as among the most desirable fishes that could be introduced into these new waters. He says:

The species of deep-sea Atlantic fish that would be most appreciated by the Pacific Coast people, in the opinion of the writer, are the mackerel, bluefish, and haddock. It is quite evident that no other fish would meet with such sale as these, for the reason that all three species are best when eaten fresh, which would suit the tastes of the inhabitants of every city on the west coast. Salt fish are in no great demand, and as a rule those which are brought to market in any other state except fresh are seldom called for.

The haddock, if successfully planted on the Pacific Coast, would meet with a demand equal to any salt-water fish brought to market. The haddock is a profitable fish to buy as compared to the red rockfish and cultus-cod, there being less waste to it.

The mackerel is in demand the world over, and if introduced on the Pacific Coast would be appreciated by fisherman, buyer, and consumer. There is little doubt that mackerel would live and propagate on that part of the coast from Monterey Bay southward. Monterey Bay would be a good locality to plant young fry, for the reason that the Pacific mackerel are found in that bay as numerous as anywhere on the coast, and it is but reasonable to suppose that where one species is found the other would live, as both species are found in the Atlantic, and some years in the same locality.

It would not be advisable to make a planting of haddock farther south than the latitude of San Francisco. It is very probable that in the vicinity of Cape Flattery would be a better place.

The well-known predaceous habits of the bluefish might be regarded as a drawback to the transplanting of the fish, although there can be little doubt it would prove a highly esteemed addition to the food and game resources of the coast. The hake (*Phycis chuss*), the cusk (*Brosmius brosme*), and the pollock (*Pollachius virens*) could also be acclimatized as easily as the haddock, but as they are less valuable as food they need not be further considered.

The scup or porgy (*Stenotomus chrysops*) would unquestionably find a congenial habitat in San Francisco Bay and in other shore waters of the coast, and it would also be a well-received addition to the fresh-fish supply of the region. As a food-fish, it is superior to the viviparous perches now so extensively consumed in San Francisco.

The following correspondence, which passed between the California fish commission and the United States Fish Commission regarding the acclimatization of alewives, is self-explanatory:

[Letter of California Fish Commissioners, dated May 10, 1895.]

We have had some correspondence with reference to the introduction of the alewife into California waters, and would be glad to have your opinion as to the advisability of such a step. We are informed that the young fish can be taken in great numbers in Maine waters when going to sea from the spawning-grounds, and if such is the case it would not be a difficult matter to secure the right kind of fish for transportation. Do you consider them a desirable fish for our waters, and would the conditions here be favorable to their development?

[Letter of United States Commissioner of Fish and Fisheries, dated May 16, 1895.]

Regarding the transplanting of alewives from the east coast to California, permit me to say that there is little doubt that the waters of your State are adapted to the alewife, and there is every reason to believe that the introduction of the fish would prove as successful as that of the shad. At the same time this commission is not satisfied that the acclimatization of the fish is necessary or even desirable. As food-fish, both the branch alewife (*Clupea pseudoharengus*) and the glut herring or summer alewife (*Clupea æstivalis*) are inferior to the shad, and the low estimation in which the latter fish is now held in San Francisco suggests that the smaller and less valuable alewives would meet with little favor on the part of the fishermen, fish dealers, and the general public. If introduced into the Sacramento River and San Francisco Bay they would doubtless be excellent food for the striped bass and other fish-eating species; but there is already a great abundance of carp, which are known to constitute the principal food of the striped bass, and the introduction of the alewives for this purpose does not seem to be demanded. While it is the habit of these fish to return to the sea, like the salmon and shad, the branch alewife at least is susceptible of cultivation in landlocked lakes and other waters, where it might have economic value or furnish food for black bass or trout.

Alewives are found along the entire eastern coast of the United States north of Florida, and there are important fisheries in North Carolina, Maryland, and Massachusetts. Fish for transplanting could therefore doubtless be as readily secured in other States as in Maine. This Commission does not propagate these fish. It is not possible to transport the adult fish across the continent, and it would probably be unfeasible to carry yearlings, and, in the opinion of this Commission, the acclimatization of the alewives in California could only be accomplished by means of fry.

THE DIAMOND-BACK TERRAPIN.

There is probably no fishery product of the Eastern States whose introduction to the west coast could be more easily consummated and prove more welcome than the diamond-back terrapin (*Malaclemmys palustris*). The wide distribution of the animal on the Atlantic seaboard—from Rhode Island to Mexico—suggests that it would probably live along the entire coast of California and possibly farther north.

In an article* on the fisheries of the Pacific Coast prepared by the writer the following reference to the diamond-back terrapin and the west coast native terrapin is made:

The question is often asked by eastern fishermen and dealers whether the diamond-back terrapin is found on the Pacific Coast; and, if not, whether there is an acceptable substitute therefor.

The diamond-back terrapin (*Malaclemmys palustris*) does not exist on the west coast, and the genus is not there represented. The California terrapin (*Chelopus marmoratus*), the only member of the order which has yet attained commercial prominence on the coast, is much inferior to the diamond-back in food value. The conditions seem excellent for the successful introduction of the diamond-back terrapin to the west coast. The extensive salt marshes around San Francisco Bay and in other places would doubtless supply a suitable habitat for the animal, whose high food value would in time bring it into active demand and stimulate cultivation and a profitable trade.

---

*Notes on a reconnoissance of the fisheries of the Pacific Coast of the United States in 1894. Bulletin United States Fish Commission 1894, pp. 223–288.

THE BLUE CRAB.

The writer believes that the introduction of the common crab (*Callinectes hastatus*) of the Atlantic Coast to the waters of the Pacific States would not only prove a valuable addition to the food resources of the region, but would be very acceptable to the fishermen, dealers, and consumers, and would serve as an important substitute for the large crab (*Cancer magister*) now so extensively utilized on the west coast.

It can not be said that the introduction of the small eastern crab is demanded by any present scarcity of the native crabs. The principal reason for its transportation would be to afford a new variety of cheap food and to offer a new object of capture to the fishermen. It would also doubtless serve an important function in supplying food to various fishes, and also in furnishing, as on the east coast, an important bait in line fishing.

Of the relative merits of the east and west coast crabs as to food value, there is room for little difference of opinion. The smaller species has a much more delicate and palatable flesh. Another reason why the importation of the blue crab may be desirable is the advent of large numbers of visitors from the Eastern States, to whom their native soft-shell and hard shell crabs would prove very acceptable.

As to the feasibility of transplanting crabs from the Atlantic to the Pacific seaboard there can be little question. The introduction could doubtless be accomplished with facility. The crabs are fully as hardy as the lobster and are more easily handled.

The adaptability of the waters of the Pacific Coast to the crab will at once suggest itself to anyone who will study the thermal and other physical conditions of the two coasts. On the Atlantic seaboard the blue crab ranges from Cape Cod to Mexico, and it would thus seem to be better suited to the waters of California than is the lobster.