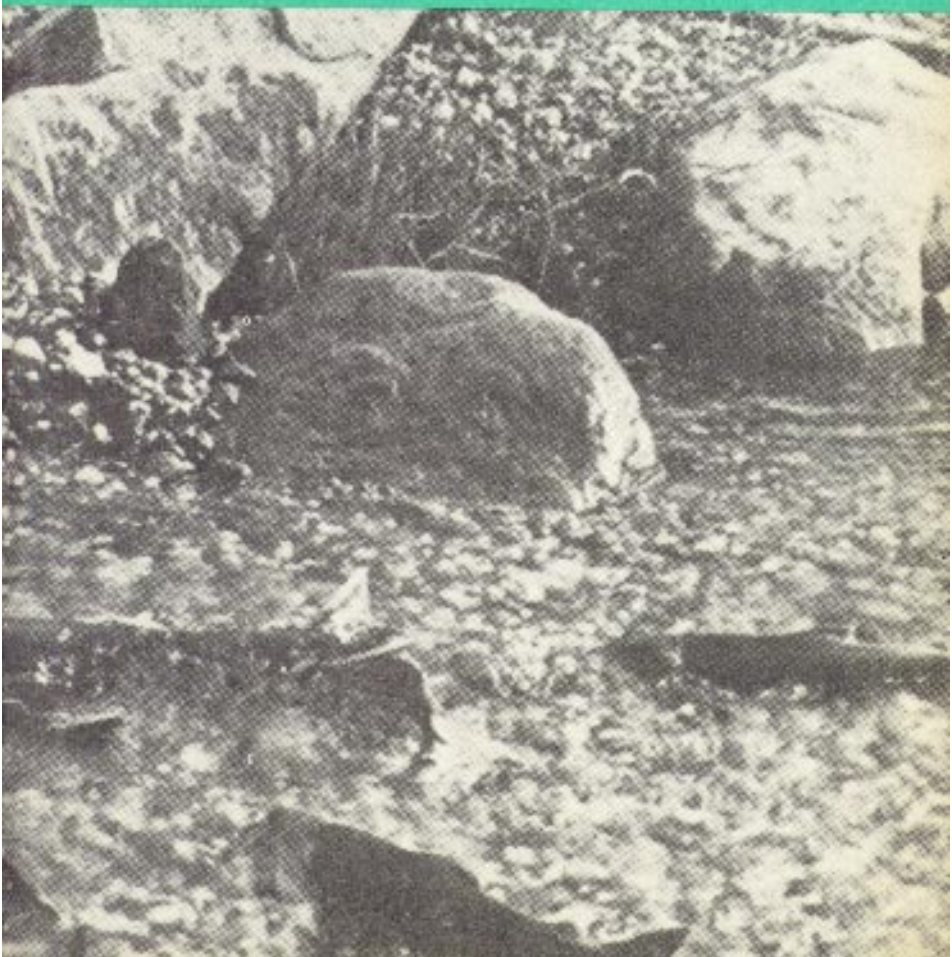
ANADROMOUS FISHES OF CALIFORNIA



NOTE TO READERS

This electronic document is a scanned version of the printed booklet that was very popular and offered free to the public for as long as it was in print. Funds have not been available for several years either for reprinting, or for revision. Nevertheless, the booklet contains information on anadromous fishes that is as valid today as when originally written. Do keep in mind, however, that the document is old, so serious researchers are advised to consult libraries or Department of Fish and Game staff for up-to-date information on the species described. Anglers should consult current fishing regulations for seasons, size and bag limits, or any other requirements for take of these animals. Many of the fishes, particularly the salmonids that occur in California, have in recent years been afforded protection under either the California Endangered Species Act or the Endangered Species Act of 1973, the Federal equivalent. Other anadromous salmonids are being seriously considered for protection under one, or both, of these acts. Management of these species will become an even greater challenge in the future as California's population and demands from all sectors for water and other habitat continues to increase.

FOREWORD

Anadromous fish are those curiosities of the animal world which grow and mature in the ocean and then swim into fresh water, sometimes as much as two thousand miles, to reproduce. The general public would probably regard them as no more than curiosities (or would refuse to believe that they really exist) if it were not for the most publicized member of the group—the salmon. The salmon's publicity stems from several factors, four of which are:

1. It is very good to eat.
2. It is worth money.
3. It is fun to catch.
4. In many places its movements into fresh water are far too conspicuous to be overlooked.

The salmon is not the only fish to make a success of this way of life. Other unrelated forms have developed it quite independently. In size they range from tiny sticklebacks to sturgeon which might outweigh a hundred thousand sticklebacks. They include some of the most primitive fish-like vertebrates and some much more advanced types. They include a good many of our finest food fishes and one (the stickleback) which I feel sure most Americans would not consider as food until the only alternative was death by starvation. They include some of our finest game fishes, and some which have no game qualities but which serve as food for game fishes. Finally, they include our most studied fishes (the Pacific salmons) and some about which we know very little.

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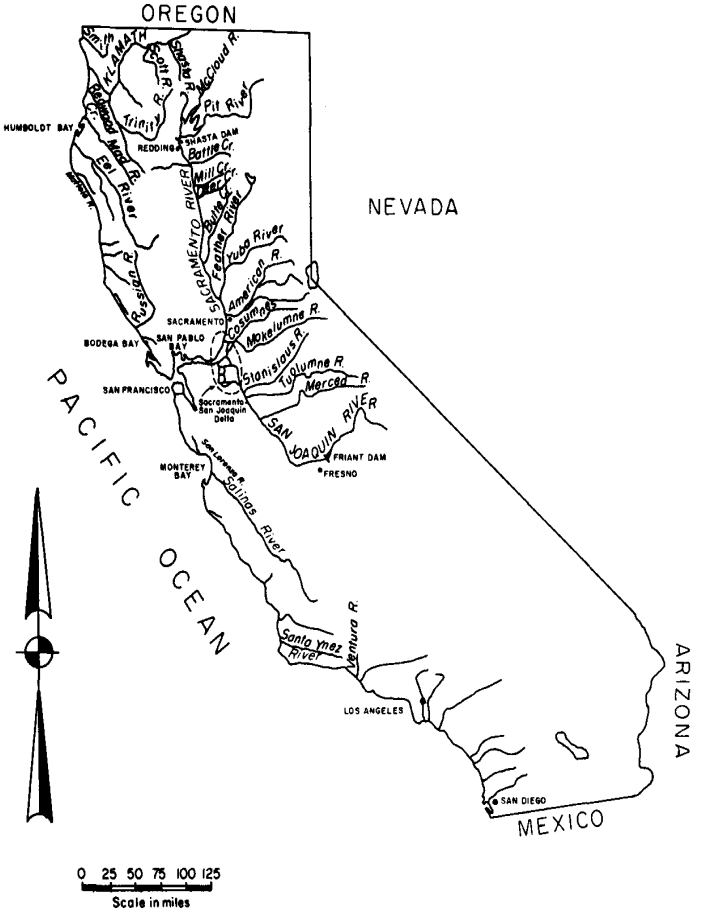
Donald H. Fry, Jr. was the dean of California Fish and Game's fish biologists. His keen interest in nature was coupled with an inquisitive mind and meticulous workmanship. A recognized authority on Pacific salmon and steelhead trout, Fry was also an expert in bird identification and wildlife photography.

Fry's career in Fish Biology began with the Department of Conservation's Division of Fish and Game in 1928, while he was still a student at Stanford University. Fry was appointed Assistant Fishery Biologist at the California State Fisheries Laboratory on Terminal Island upon receiving his master's degree in zoology later that year. In 1943, he took charge of the Division's salmon research in the Sacramento and San Joaquin Valleys, where he initiated several programs that have since become basic to salmon research and management.

In 1947, Fry was placed in charge of the Division's central California Marine Laboratory, then at Stanford University. In 1957—1958, he studied the fishes of Lake George in Uganda, under the auspices of the United Nations, to help the African nation meet its food needs. After his return to the Department of Fish and Game in 1958, Fry moved to Sacramento to head the newly created Research Analysis Section, a position he held until his retirement in 1973.

CALIFORNIA STREAMS



Some of the California streams used by anadromous fishes.

THE ANADROMOUS FISHES OF CALIFORNIA

INTRODUCTION

The term anadromous * means "up running" and is used to refer to fishes which spend part of their lives in the ocean but move into fresh water to spawn. Salmon are the best known anadromous fishes but there are many others, including important food and game fishes such as steelhead trout, sturgeon, striped bass, and shad. Lesser known and less highly regarded species have the same habit.

There are varying degrees of anadromy. The most extreme examples move from hundreds of miles at sea to hundreds of miles up a river, while some borderline species only move from brackish water a short distance into fresh water to spawn. We have included the latter if a large part of the population regularly moves out of brackish water to fresh water at spawning time.

Many fishes are able to cope with extreme changes in the salinity of the water they inhabit. The technical terms for them is *euryhaline* and they may or may not be anadromous. The term comes from *eury* meaning broadly and *haline* meaning salty. Such forms often live in river estuaries where tidal action results in rapid changes in salt content. A moderately well known California native, which is euryhaline but not anadromous, is the starry flounder. It is normally marine, but has been known to move many miles into fresh water. Much better known, but not found in California, is the tarpon. Some sharks are euryhaline, including the dangerous bull shark, which moves between the Atlantic Ocean and Lake Nicaragua through many miles of moderately fast river. We are including euryhaline fishes only if we are reasonably sure they make a definite migration into fresh water to spawn. So little is known of the movements and of the spawning habits of some species that it is quite possible that we may have omitted some which will later be found to be truly anadromous. For example, the striped mullet, *Mugil cephalus*, is a euryhaline species which occurs worldwide in warm seas and is often seen in bays and estuaries from Los Angeles County south. It also enters the Colorado River. Using the scanty and conflicting evidence available it is possible to make a case for calling it anadromous, catadromous, or marine. I have not included it in this booklet. (Catadromous is defined below.)

Anadromy is one type of spawning migration, but there are other similar ones. A brief summary:

Anadromous—Migrating from the ocean or brackish water to fresh water to spawn.

Adfluvial—Migrating from a lake to a stream to spawn. We are not including a species in this paper because it is adfluvial, but are including those which are adfluvial in some areas and anadromous in others.

* Pronunciation of the word bothers many. The syllables are: a nad ro mous with the accent on the second. Dictionaries mark it a-năd'ro-mus.

Catadromous—Migrating from fresh water into the ocean to spawn. There are no known runs of catadromous fishes in California. The best known catadromous fishes are the American and European eels, both of which spawn in the Atlantic ocean.*

The degree to which different species depend on an anadromous existence is quite variable. For example, all species of trout and chars are capable of living a wholly freshwater existence, but there are two species of salmon (pink and chum) which appear to be totally unable to reproduce successfully unless they grow to maturity in salt water and spawn in fresh.

Many species of fishes have both anadromous and freshwater forms. The latter are often referred to as "landlocked", whether or not the fish have a clear path to and from the sea. Often the fish are physically blocked from reaching the ocean. For example, fish in a reservoir or lake may be unable to leave. Fish in some streams of the high Sierra have a clear passageway to the sea, but no way of returning because of waterfalls. Goldwater fishes may be effectively landlocked in the colder headwaters of a stream because temperatures are too high for them in the lowland parts of that stream or in the ocean in that area. Dolly Varden trout are strictly landlocked in California, which is the southern tip of their range, but anadromous forms are very common farther north, particularly in Alaska.

Many fish can be referred to as "optionally anadromous". In the coastal streams of California the young of steelhead trout and coastal cutthroat trout may go to sea or may remain in the stream until maturity and then spawn without ever having left fresh water. Trout near the headwaters of a stream are the more apt to remain in fresh water. There is evidence that resident and anadromous forms in the same stream may be genetically different, but there seems to be enough mixing of these strains so that some young of resident parents may go to sea and vice versa.

Some fish might even be called "unintentionally anadromous". Floods will sometimes wash fish out to sea. In southern California, for example, there are occasional violent floods which will fill the pools of a trout stream with silt and gravel. When the water recedes there are no trout to be found and from one to three winters later a few steelhead will be seen trying to find their way back to the mountains via the Los Angeles River or some other unlikely-looking stream. It is not unreasonable to suppose that some rainbow trout had survived an involuntary trip to the ocean, but absolute proof is lacking.

Which Fish Has Been to Sea?

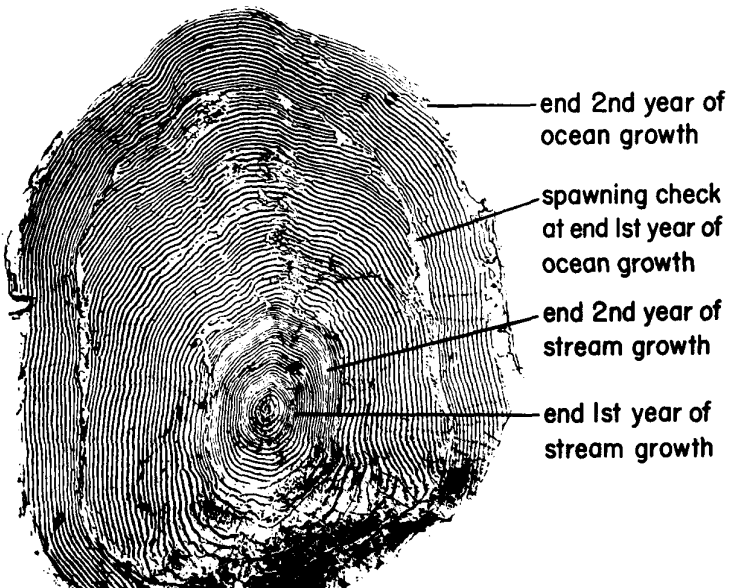
Occasionally an angler will catch a trout that puzzles him—has it been to sea or hasn't it? The angler has a right to be puzzled.

* Two specimens of the true eel, *Anguilla* have been taken. in the Sacramento-San Joaquin Delta. One, an American eel *A. rostrata*, was taken in 1964; the other, a European eel, *A. anguilla*, in 1969. It is highly doubtful that either got there on its own power. Attempts were made to establish the American eel in California in 1874, 1879, and 1882, but there were no known recoveries (Skinner, 1971).

Young trout and salmon undergo a decided change in appearance before or during their seaward migration. They become more silvery, red colors fade or disappear, scales get looser. Usually the fish grow enough faster in salt water so that the difference between freshwater growth and saltwater growth is quite apparent on the scales under a microscope. On most subspecies of trout and species of Pacific salmon the parr marks (large vertical oval or rounded spots on the sides) will gradually disappear whether or not the fish goes to sea. None of the criteria given are infallible. Trout which enter a lake or reservoir and some of those which remain in some of our larger rivers such as the Klamath will show much the same changes and be quite difficult to tell from a sea-run individual. When a trout leaves the ocean and reenters fresh water it will gradually regain some of the appearance of a stream trout. In general the sea-run trout has grown faster and is therefore younger than a stream trout of the same size. A 1½ -lb stream trout will tend to have a bigger head and mouth and a more mature appearance. The sea-run individual will have a face that is more rounded and looks more like that of a 6-inch fish.

In our smaller coastal streams any trout over 1½ lb is almost certain to be sea-run—a rainbow or cutthroat would not be at all likely to grow to that size without going to sea. A brown trout might, but most of our smaller coastal streams have no browns at all and none has many.

In large rivers such as the Sacramento, Klamath, and Trinity, a stream trout of 2 or 3 pounds is a distinct possibility and larger ones are not out of the question, but the odds heavily favor a trout over a foot long being sea-run unless its appearance is very much that of an older, more mature, stream trout. When in doubt, scrape 20 or 30 scales off the side of the fish above the lateral line. If you have access to a low power microscope (30—50 X), clean several scales by water soaking them, then rubbing between thumb and forefinger. Mount between two microscope slides and find a scale that has circuli (concentric rings) extending outward from a very small central disk. A large disk means that the scale is a regenerated one; i.e., it is replacing one which was lost. Look at the circuli, starting at the center of the scale. Disregard the first 3 or 4. The next 10—30 should be quite close together. If there is then a sudden increase in the space between circuli it means that feeding conditions got much better for the fish and this in turn usually means that it had entered the ocean, or at least the estuary. Some individuals will stay awhile in the estuary and then move into the ocean. Such fish may show a two-step increase in the spacing of the circuli. A gradual narrowing of the spaces between circuli (in either fresh or salt water) indicates winter growth, which is slower than summer growth. The winter zones are used by fisheries workers to determine the age of a fish. A ragged line cutting through the circuli clear around the scale is a “spawning check”. The outer edge of the scale was resorbed during the strain of the spawning period and probably some circuli were lost entirely. Unfortunately, not all scales are as clear cut as the one illustrated. If feeding conditions in the stream (or hatchery)



Scale from a 28-inch steelhead near the end of its fourth year of life, showing two years of stream life and two years of ocean life, it spawned at the end of its first year of ocean life and was caught when returning to spawn a second time. Scales of Pacific salmon are similar but the fish die after spawning and their scales never show a spawning check. *Photomicrograph (40X) by Leo Shapovalov.*

were extra good, a change from fresh to saltwater growth may not be clear enough to show when (or if) it happened.

In California there is ordinarily no problem in determining whether or not a salmon has been to sea. In general, if it is over a foot long it has made the trip unless it is living in a place from which it cannot reach the ocean. North of California there are some lakes and large reservoirs which salmon can pass through on their way to spawn. When the young are migrating to the sea a few

may remain in the lake and never complete the migration. These are known as residuals. In California there are no such reservoirs or lakes with extensive spawning areas above them, but there are a few places which might produce small numbers of residuals in an occasional year.

Kokanee are landlocked sockeye salmon which grow to maturity in lakes. In more northern waters kokanee are sometimes found living in lakes to which other salmon (including anadromous sockeyes) regularly ascend from the ocean. Kokanee in California are all in waters which cannot be reached from the sea.

Some king and silver salmon have been planted in a few California lakes or reservoirs. Sometimes they grow quite well, but in California they have never reproduced well enough to create landlocked runs, although they have occasionally done so in other areas.

The ability to create both anadromous and freshwater populations is not confined to the salmonids. Several unrelated species, which now exist in California, have both anadromous and landlocked populations. These include the Pacific lamprey, the American shad, the threespine stickleback and the striped bass.

INTRODUCTION OF ADDITIONAL SPECIES OF ANADROMOUS FISHES

Of the 20 species of anadromous fishes described in this booklet, 16 are native and 4 were introduced. Two of these four (the striped bass and shad) were introduced with the hope of establishing them as anadromous fish. The other two (brown trout and brook trout) were introduced to establish them as freshwater species. In Europe the brown trout occurs in both resident and anadromous forms (known respectively as brown trout and sea trout). In eastern North America there are both freshwater and anadromous brook trout. In California a few of the browns appear to have developed anadromous habits but as yet none of the Eastern brook trout are even suspected of having done so.

Introducing a freshwater fish to a new area is relatively easy, and at present virtually 100% of California's warmwater stream, lake, and reservoir fishing is for introduced species. To establish a new species it must be released in waters which are of suitable temperature and purity, the food supply must be adequate and there must be adequate habitat for young and adults and for spawning. Introducing a far-ranging anadromous species such as salmon can be far more difficult and is much less apt to succeed. Not only does the freshwater habitat have to be adequate, but so does that of the adjoining ocean. The route from ocean to spawning ground must provide clear passage at the time of year when the fish will use it, and the fish must be able to find their way home at the correct time of year and through ocean currents which their ancestors never encountered.

All efforts to introduce anadromous Atlantic salmon *(Salmo salar)* to the Pacific Coast have failed, although a landlocked strain has been established in Oregon. Efforts to introduce Pacific salmon *(Oncorhynchus)* to South America have been unsuccessful, but there have been some long distance salmon transplants which succeeded. In New Zealand, king salmon *(Oncorhynchus tshawytscha)* are well established, but sockeye salmon *(0. nerka)* of a normally anadromous strain have managed to avoid extinction by becoming landlocked. Russian fisheries men have succeeded in establishing Pacific salmon in some Arctic streams of European Russia.

In at least three areas introduced trout have prospered as freshwater fishes and later started to develop or redevelop the anadromous habit. The European brown trout, *Salmo trutta,* has done this on our Pacific Coast and the rainbow trout, *S. gairdnerii* (a native of western North America), has apparently established an anadromous run in the Eerste River in South Africa and possibly in some nearby streams as well. Both of these species have established anadromous runs in extreme southern South America.

WHY LIVE ANADROMOUSLY?

There obviously must be some important advantages in living an anadromous existence or the habit would not have developed independently in such widely differing creatures as lampreys, sturgeon, shad, salmonids, sticklebacks, and striped bass. The advantages must be great enough to pay for the extra energy and risk involved in the migration from fresh to salt water and back again. Greater safety for the eggs in fresh water and a better food supply in the ocean appear to be the chief benefits for the salmon.

At some time in their lives all anadromous fish must be able to move from fresh to salt water and at a later date they must move back again. Most aquatic creatures cannot adjust to any great change in salt content (such species are called stenohaline). The bodies of all fishes have a higher salt content that of fresh water and fresh water tends to permeate into their bodies through gills, gut, and skin. The amount of fresh water which would enter the body would soon be fatal if there were no mechanism to eliminate it. Freshwater fishes cope with this problem by producing large quantities of very dilute urine. This water removal requires energy which, in turn, requires additional food. Most saltwater fishes have the opposite problem. Bony fishes have a salt content much lower than that of the ocean water and, if there were no mechanism to prevent it, the water in their bodies would permeate outward until the body salt content was in balance with that of the ocean. (In this connotation the term “salts” includes the sum total of all salts—not just sodium chloride.) Such fishes have to drink seawater to overcome this dehydration, and have to have a mechanism for getting rid of the excess salts. The process is complex and energy consuming; it involves special salt cells in the gills and mouth lining, and a kidney which can excrete very concentrated urine. Sharks and hagfishes solve the problem differently—they do have a salt content which is in balance with ocean water.

To be able to live in both fresh and salt water a fish must obviously be equipped to cope with either of the two sets of problems outlined above and must be able to shift physiological gears as often as habits and circumstances dictate. The requirements are severe, but there are rewards. There is a great deal of estuarine habitat which changes salinity with the tide and the only fishes which can make extensive use of **it** are those euryhaline forms which can thrive in rapidly changing salinity. Furthermore, freshwater fishes which can withstand an ocean excursion are able to move from stream to stream, and their progeny quickly become established in nearby coastal streams, some of which might otherwise have no fishes at all.

Even though an adult fish may be able to adjust to changes in salinity, its eggs and newly-hatched young usually lack this ability; thus, the anadromous parents require a freshwater environment at spawning time.

Because anadromous forms have evolved separately in various unrelated families, it is not likely that the habits shared by them could develop in exactly

the same way in all of them. Such evolution could occur along somewhat the following lines:

1. A freshwater species overpopulates its environment and food becomes a serious problem. (Most fish over-reproduce and reach this condition quickly.) The older (and larger) young appropriate the best feeding spots and permit no trespass by smaller individuals, who are forced to keep looking. Many arrive at the upper limits of brackish water.

2. Some individuals are able to endure brackish water better than others and penetrate short distances into the estuary to feed, especially at critical times. This gives them an advantage which enables them to survive when others starve.

3. Descendants of these individuals inherit the ability to withstand brackish water and through thousands of generations the fish with the most such ability survive best and penetrate into areas which are more saline and more extensive. The fish have gradually become euryhaline.

4. Some individuals spend much of their time in brackish or salt water but have a regular migration into fresh water to breed. They have now become anadromous.

5. Saltwater excursions are extended and now include the ocean.

6. Ocean migrations increase in length, but adults all return to the streams to spawn.

7. The length and severity of the journey results in so many deaths that relatively few survive to spawn a second time.

8. Those that put the greatest part of their fat and energy into egg and sperm production on the average produce more young and on the average are less apt to survive to spawn again.

9. Eventually, surviving to spawn a second time becomes too unusual to be an important factor in egg production, and the fish which put all their energy into spawning once produce the most young.

10. Death after one spawning becomes universal for that species. This extreme adaptation is by no means universal among anadromous fishes.

Survival Advantages and Disadvantages of the Anadromous Habit

Some of the habits of anadromous fishes are important advantages to the species, but there are offsetting disadvantages.

The need to make long spawning migrations inflicts obvious hardships on the fish. Sometimes the benefits far outweigh the hardships and the fish prosper, but the very existence of the population will be threatened if the hazards of the journey become increasingly great and too few spawners are able to complete the trip.

For a species which must spawn in fresh water an obvious advantage in being anadromous is that far more fish can spawn in a stream than could possibly find

enough to eat there. Salmon take full advantage of this; adults don't feed after they have entered fresh water on their spawning migration.

Most young silver salmon remain in their stream until they are a little over a year old. They migrate to sea in the late spring after they have grown large enough to greatly increase their chances of survival in the ocean. Soon after the seaward migrants have left, many of our small coastal streams and tributaries to larger streams dry up to a mere trickle or become intermittent and the recently hatched young which remain behind may become badly crowded or even stranded before the summer is over. Mortality is often high and would be worse if any large number of yearling silvers were also to remain in the stream. The yearlings would not only have a hard time finding enough to eat, but would also consume large numbers of the young of their own kind and would consume much of the food that would otherwise be available to such fry and fingerlings. (In some areas young silver salmon are serious predators on the smaller young of other salmonids.)

The migratory pattern of fall-run king salmon in the San Joaquin Valley enables them to make use of streams which, during the summer, are much too warm for any salmonid. The kings enter these streams in the fall after the water has cooled, and their young leave in spring before it gets too warm. Silver salmon and steelhead don't have a chance in this area because their young must spend a full year in the stream.

Migrating fish are relatively easy targets for predators because the latter can wait for the food to come to them. Young salmon partially counteract this by making their seaward migration usually at night and staying near cover during the day. When the water is muddy, young salmon will migrate day or night.

Not all predators which eat migrating anadromous fishes are resident in the stream all year. Some have developed feeding movements of their own. Bears, seals, eagles, gulls, and humans are among the more obvious ones. Green sturgeon take advantage of spawning eulachon in the Klamath River, but (like eagles and gulls) probably do more scavenging than actual preying.

CLASSIFICATION AND NAMING OF FISH AND OTHER ANIMALS

The animal kingdom includes well over a million diverse forms which fall into the various lesser groups. The following divisions are now used to classify them:

Phylum
Class
Order
Family
Genus
Species

Appropriate subgroups (such as subspecies) or supergroups (such as superfamilies) may be used to increase the number of divisions.

The phylum is the largest basic division of the animal kingdom; about 23 are usually recognized. Each phylum contains animals of basically similar structure. Five of the more familiar ones are: Protozoa (one-celled animals), Porifera (sponges), Mollusca (snails, slugs, squid, etc.), Arthropoda (insects, spiders, crustaceans, etc.), and Chordata. The Chordata or chordates are divided into four subphyla, of which the Vertebrata or vertebrates form one. Vertebrates in turn are divided into seven *classes,* as follows:

Jawless fishes; i.e., the hagfishes and lampreys. Members of this group have cartilage skeletons and no jaws. (Two species of California lampreys are anadromous and are described in this paper.)

Cartilaginous fishes; i.e., the sharks, skates, rays, and chimaeras. Members of this group have jaws and cartilage skeletons. No California species is anadromous and it seems possible that no species anywhere is. Some do go long distances into fresh water, but we know of none that do so to give birth to young.

Bony fishes. They have jaws and all adults have some bone in the skeleton. (In some primitive forms the only bone is in the skull; the remainder of the skeleton is cartilage.) Bony fishes include the vast majority of the creatures we ordinarily think of as fishes.

Amphibians, which include frogs, toads, and salamanders.

Reptiles, which include turtles, lizards, crocodiles, and snakes.

Birds.

Mammals.

Bony fishes are divided (by some authorities) into more than 20 orders and several hundred families. The anadromous bony fishes found in California are confined to five orders, as follows:

Acipenseriformes. This is by far the most primitive group of bony fishes treated here. These fishes have skeletons which are mostly cartilage, but true

bone is found in the skull and shoulder girdle. The group includes the sturgeons (family Acipenseridae), two members of which are found in California; both are anadromous.

Clupeiformes. Includes the herrings (family Clupeidae), of which one species found in California is anadromous.

Salmoniformes. Includes several families, two of which include the majority of the anadromous fishes found in California. These families are the Salmonidae (including salmons, trouts, and chars) and the Osmeridae (smelts).

Gasterosteiformes. Includes the sticklebacks (family Gasterosteidae); the one species found in California includes anadromous and freshwater subspecies.

Perciformes. (perch-like fishes). This is the largest order of fishes; it includes over 100 families and several thousand species, but only one California species is anadromous.

Common and Scientific Names

All languages have names for the common animals and some animals may acquire several names. The term “salmon” is pretty well understood along the Pacific Coast, but when we try to pin down a particular kind of salmon we may have problems. For example, one species of salmon is known, among other things, as king, silver, spring, dog, blackmouth, tyee, chinook, and quinnat salmon. A second species also includes “silver” on its list of aliases, and a third species is often called dog salmon. The use of “official” common names is one good way to reduce such confusion. The California State Legislature selected king salmon as the official common name for one species and has used it in a good many places in the law. Later, the other Pacific Coast states and Canada selected “chinook salmon” for the same species. New Zealand (which introduced the species from California waters) calls it quinnat. For an official common name to be of any real use it must be acceptable to the public and in most instances should refer to a single species. Any of the three official common names listed for the king salmon can qualify on both counts. Common names based on the English language might not be readily accepted in Russia or Japan and vice versa. Scientific names get around this difficulty. The scientific name of the king salmon is *Oncorhynchus tshawytscha*. This name will definitely identify it anywhere in the world, but is not apt to become popular with the public. Scientific names need not be this unpronounceable. Many are not, and some have, on occasion, become generally accepted common names. The scientific name is intended to show relationship as well as to identify. As a result, if a species of fish is shown to be more closely related to those in another genus it may be placed in that genus and the scientific name changed accordingly. This can be confusing even to fisheries workers who are keeping up to date in their field. Such disadvantages are a relatively minor price to pay for the system of names that has brought order out of what was heading toward

absolute chaos. Before the present system was developed, animals were scientifically known by descriptive phrases, sentences, or short paragraphs. Try to image applying such a method to the more than a million species which we now recognize.

The accepted starting point of modern zoological nomenclature is Linnaeus' monumental *Systema Naturae,* tenth edition, 1758. Linnaeus established the system of binomial nomenclature wherein each species is given two names, consisting of the name of the genus to which it belongs, followed by the name of the species. Sometimes there are minor variations within a species and a third (subspecific) name is added. The steelhead rainbow trout is named *Salmo gairdnerii gairdnerii* and the Kamloops rainbow trout is *Salmo gairdnerii kamloops.* The use of subspecific names is considered optional and most authors avoid them except where they are really needed.

The first time a publication begins a description or detailed discussion of a species it is customary to include not only the scientific name but also the name of the author who published the original description of that species; adding the date of publication is optional. Thus, the brown trout is *Salmo trutta* Linnaeus, 1758. The genus *Salmo* includes other trout and the Atlantic salmon; the species *trutta* refers only to this species of trout; it was described by Linnaeus and the description was published in 1758. Quite often, after a species has been described, a later author will conclude that it should be moved to another genus (frequently to a newly created genus). The name of the original author is usually retained but placed in parentheses; thus, the king salmon was first named *Salmo tshawytscha* Walbaum, 1792, but later was moved to a new genus and is now *Oncorhynchus tshawytscha* (Walbaum. 1792).

As can be imagined there is room for innumerable disagreements in matters of classification and nomenclature. This booklet does not a ways agree with the "American Fisheries Society Special Publication No. 6, A List of Common and Scientific Names of Fishes from the United States and Canada, Third Edition, 1970". That publication is so valuable that many American fisheries workers are using it as a court of final appeal, which it was never intended to be. Some authorities disagree with certain of the names and spellings used by the AFS. Both before and after the appearance of the AFS publication, such disagreements created instances in which two scientific names for the same fish were both in such common use that either could be regarded as correct. The AFS has greatly improved this situation but cannot be expected to eliminate it entirely. This is especially true in a field where additional evidence is being rapidly accumulated.

USE OF THE DISTRIBUTION MAPS

A distribution map shows the freshwater habitat of the anadromous form of each species or subspecies described. When a fish has both anadromous and freshwater populations only the range of the former is shown. There is no map included for the Eastern brook trout which is sometimes anadromous on the Atlantic Coast but never in California. We have discussed the species briefly. The Dolly Varden has a very limited distribution in California and is never anadromous here. Because it is our only native char and is abundant and anadromous farther north we have made an exception and shown its freshwater distribution in California.

The maps show only those areas where the species appears with fair regularity. If a species is very abundant in some areas and quite rare in others, its map may not show the areas where it is rare. This has required some subjective decisions and splitting of hairs. Usually such situations are discussed in the text.

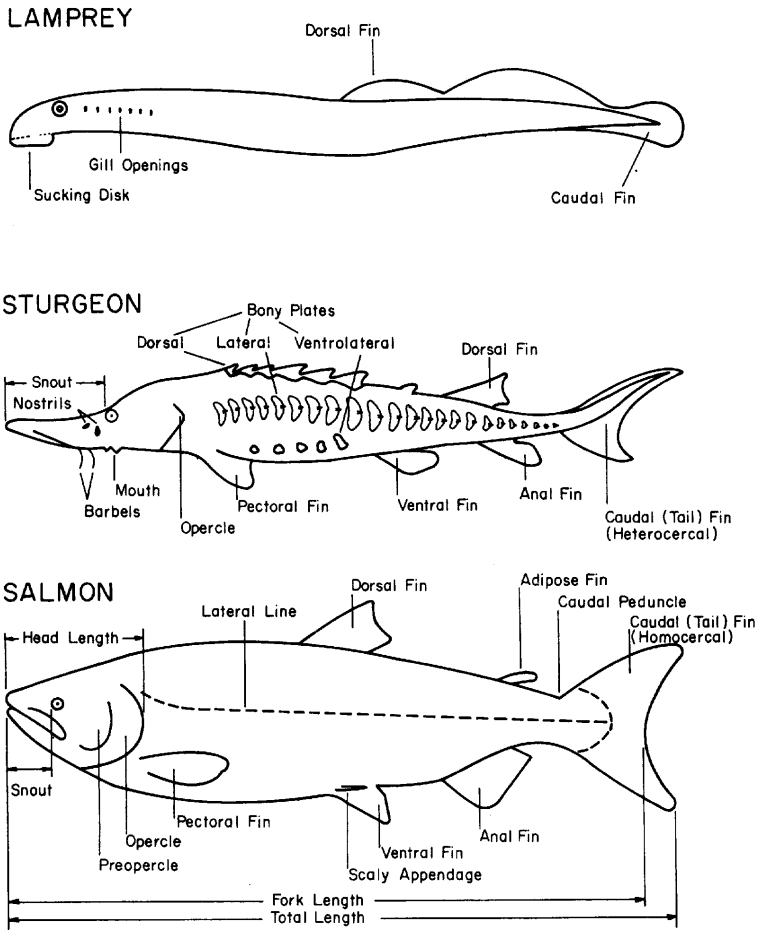
Distributions given in the ma p and text are intended to be as up to date as possible (1972). Dams and fish planting programs keep modifying the distribution of anadromous fishes—especially salmonids.

KEY TO THE FAMILIES OF ANADROMOUS FISHES

The purpose of this key is to help the reader identify fish he suspects may be one of the anadromous ones described in this booklet. It is not intended for use in identifying any of the more than 600 nonanadromous species which have been recorded from California waters.

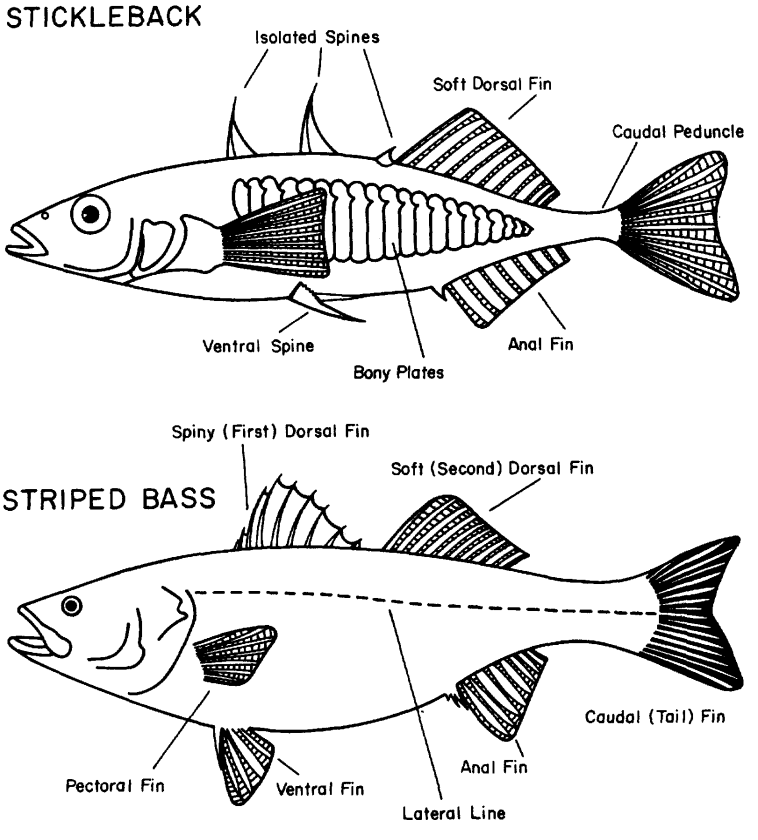
Suppose you have a sturgeon and a shark and want to try out the key. Read the first statement. Whenever the statement is true and does not identify the fish go to the next number. When the statement is not true go to the “alternate choice” which may be the next number or may not. The first statement reads, “no jaws or paired fins etc.” Each fish has paired fins and jaws. Go to the “alternate choice” No. (2), “...jaws and paired fins present, gills covered by an opercle (bony gill cover).” You have reached a point at which no description fits the shark. It has paired fins and jaws but no opercle. Your “alternate choice” is No. 1, “...no jaws etc.” There are no anadromous sharks in California and no sharks are described in this booklet. Your sturgeon still fits—it has an opercle. The next statement is, “...sides with five rows of isolated bony plates...sturgeon family ..." This fits, it identifies the fish as a sturgeon and gives the page reference.

Characters being described	Alternate choice	Description
1	(2)	No jaws or paired fins. Mouth a sucking disk. Seven gill openings on each side of the head. Lamprey family, **Petromyzontidae.** Page 24.
2	(1)	Jaws and paired fins present. Gills covered by an opercle (bony gill cover).
3	(4)	Sides with five longitudinal rows of isolated bony plates. Mouth on underside of head, well back from tip of snout. Upper tail lobe much larger. Sturgeon family, **Acipenseridae.** Page 32.
4	(3)	Not as above.
5	(14)	Dorsal fin single, soft rays only.
6	(7)	Dorsal fin base long (over 16 rays). Many California species, non anadromous.
7	(6)	Dorsal fin base short (7 to 16 rays), some part of its base directly over the midpoint between tip of snout and fork of tail. Base of ventral fin beneath base of dorsal. Mouth small to moderately large, maxillary never extending far behind rear of eye. No photophores (luminescent spots) on body.
8	(11)	Adipose fin present. Eyes not directed upward.
9	(10)	Scales relatively small, more than 100 in first row above lateral line. On fish over 3 inches: scaly appendage at base of ventral fin. On fish under 4 inches: parr marks always present (except on pink salmon, *Oncorhynchus gorbuscha*), snout rounded and slightly overhangs lower jaw. Salmon family, **Salmonidae** (includes salmons, trouts, and chars). Page 43.
10	(9)	No scaly appendage at base of ventral fin. Snout pointed or lower jaw projecting beyond snout or both. No parr marks. Scales moderately large, fewer than 80 rows on side. Eye smaller than gape (opening of mouth). Smelt family, **Osmeridae.** Page 85.
11	(8)	Adipose fin absent.



Diagrams naming some of the external parts of lamprey, sturgeon, and salmon.

Characters being described	Alternate choice	Description
12	(13)	Scaly appendage at base of ventral fin, belly with scutes, serrated. (The scutes feel sharp if you run your finger toward the head.) Herring family, **Clupeidae** (includes the American shad, *Alosa sapidissima*). Page 40.
13	(12)	No scaly appendage at base of ventral fin, belly without scutes. Many California fish fit this description; none is anadromous.
14	(5)	One or more dorsal fins and one or more dorsal spines, which may be part of the fin (or fins) or may be isolated.
15	(16)	Spines or spinous dorsal fin broadly connected to soft dorsal by membrane. Many California species fit this description, none is anadromous.
16	(15)	Spinous and soft dorsals not connected as above.
17	(18)	Two dorsal fins, separated by a narrow gap; first of spines only, second of soft rays preceded by one attached spine. Second dorsal not followed by detached finlets. Back with six to eight horizontal stripes.
18	(19)	Stripes blackish, eye small, less than ¼ head length; pectoral fins not reaching tips of ventral fins. Genus *Morone* (of the family *Percichthyidae*). Page 97.
19	(18)	Stripes orange brown, eye large, about ⅓ head length; pectoral fins reaching past tips of ventral fins. **Salema** (big-eye bass), *Xenistius californiensis*. Marine, not included in text. A small fish, sometimes mistaken for a young striped bass.
20	(17)	Dorsal fin preceded by three spines. The first two or all three isolated. Ventral spine strong and serrated. Stickleback family, **Gasterosteidae**. Page 93.



Diagrams naming some of the external parts of stickleback and striped bass.

THE LAMPREY FAMILY

Petromyzontidae

Lampreys are members of a primitive class of fish-like creatures, the cyclostomes, which are not true fishes and although eel-like in shape are in no way related to the eels (which are true fishes).

Cyclostomes have a simple, ribless, cartilaginous skeleton. They have no paired fins, but do have a median fin fold, the posterior part of which forms the tail fin. The gills are in a series of pouches along each side of the body. The gill pouches are supported by a network of cartilage (called the branchial basket) and each has an opening through the skin. Water is inhaled and exhaled through these openings. There is a single nostril on the midline. Cyclostomes have no jaws. In the adult form the mouth is surrounded by a sucking disk; there are numerous horny teeth on the disk itself and on the tongue. The sucking disk enables a cyclostome to attach itself to any solid object and especially to the fishes which form its prey. The teeth rasp their way through the skin and into the flesh of the prey. This way of feeding has been called predacious by some authors and parasitic by others. Some degenerate species do not feed after reaching the adult form.

Cyclostomes are divided into two groups: hagfishes, all of which are marine, and lampreys. Some lampreys are anadromous, one little known species is marine, and the remainder dwell in freshwater.

Lampreys have an odd life history. The young (known as ammocoetes) are blind; they have no teeth and no sucking disk. They live in streams, burrow in the mud, feed on vegetable matter, and live a somewhat worm-like existence. (Like worms they make excellent bait.) After some years they metamorphose into the adult form. Eyes and teeth develop and the wormlike life is abandoned. The anadromous lampreys become predacious and descend to the ocean, where they feed on a variety of fishes. As they approach sexual maturity they return to fresh water, but apparently not always to the same stream. They are persistent and effective in working their way past low waterfalls, low dams, fast rapids, etc. A lamprey lacks the speed and jumping ability of a salmon, but more than makes up for it by efficient use of its sucking disk, with which it can hold onto a rock and rest in fast current, then make a quick spurt of a few feet and grab another rock. In the worst places it will hold onto a rock, contract its body into a series of "S" curves, then quickly release its hold and snap its head forward and reattach itself. At some dams lampreys will leave the water and work their way up a wet vertical wall by this method. The lamprey engaged in wall climbing will have a short spasm of violent activity involving numerous mouth-holds on the wall, each one a fraction of an inch higher than the last. Then it will hang limply for a bit of well-earned rest. Frequently when there are great masses of lampreys working their way past an obstruction, one will lose its hold, knock several others loose, and all will fall or be swept downstream in a tangle of squirming bodies.

Lampreys spawn where there is flowing water over a gravel bottom. They build a nest by using their sucking disks to move some of the rocks and form a shallow depression with the displaced rocks at its downstream edge. The female extrudes her eggs into the depression, a waiting male fertilizes them, and the eggs settle into the cracks between rocks. After spawning all adults die.

LAMPREYS FOUND IN CALIFORNIA

In California there are two anadromous and one freshwater species of lamprey in areas which are now reachable by anadromous fishes. The two anadromous species are predacious. The freshwater species is a somewhat degenerate species which has lost both the anadromous and the predacious habit; it is called the Western brook lamprey, *Lampetra richardsoni* Vladykov and Follett, 1965. After attaining the adult form, the brook lamprey does not feed at all, but may live for months before becoming sexually mature, spawning, and dying. A second nonpredacious freshwater species, *Lampetra (Entosphenus) lethophaga* Hubbs, 1971, has been recently described from the Pit River in California and the upper Klamath River system in Oregon. Both areas are now out of reach of anadromous fishes because of high dams.

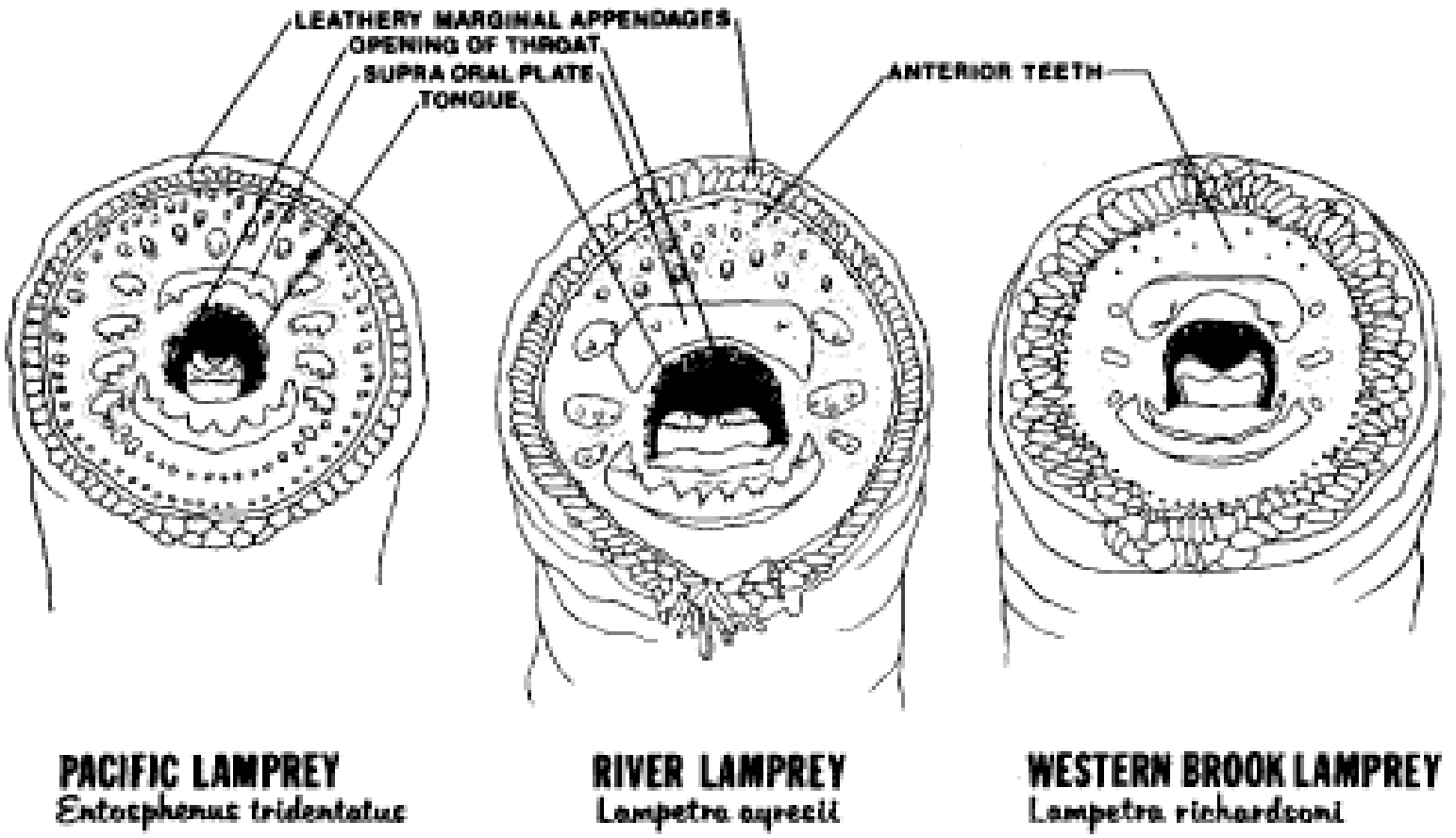
KEY TO THE LAMPREYS OF CALIFORNIA

(Pit River Excluded)

Characters being described	Alternate choice	Description
1	(4)	Teeth sharp, strong. Dorsal fins separated by a wide space.
2	(3)	Upper (supraoral) tooth plate with *three* well developed teeth.* Pacific lamprey, *Entosphenus tridentatus*. Page 27.
3	(2)	Upper (supraoral) tooth plate with *two* well developed teeth.* River lamprey, *Lampetra ayresii*. Page 30.
4	(1)	Teeth weak, dull, lateral teeth reduced in size and number. Dorsal fins separated by a narrow notch. Western brook lamprey, *Lampetra richardsoni*. This is a small nonpredacious, nonanadromous form and is not described in the text.

* To get the best view of the upper tooth plate you should point the lamprey away from you and look into its mouth from an acute angle from near the tail.

SUCKING DISKS OF LAMPREYS



Sucking disks and teeth of three California lampreys. The Pacific and river lampreys are predacious and have sharp, well developed teeth for rasping into the flesh of fishes. The western brook lamprey has last the predacious habit. Its teeth have degenerated and are small, weak, and dull. Redrawn from Vladykov and Follett (1965 and 1967).

PACIFIC LAMPREY

Entosphenus *tridentatus* (Gairdner, quoted in Richardson, 1836)

OTHER NAMES

Lamprey. Often mistakenly called “eel”.

RELATIONSHIPS

Not a true fish. Belongs to the lamprey family, **Petromyzontidae** (see page 24). This is the largest and by far the most common lamprey in California or on the Pacific Coast. There are three other species of lampreys in California, one of which is anadromous.

DESCRIPTION

Slender and eel-like (but is not an eel), roughly cylindrical forward, slightly compressed (flattened side-to-side) posteriorly. Has no paired fins and no jaws. The mouth is a sucking disk with numerous rasping teeth. Upper (supraoral) tooth plate has three well developed teeth. There are seven gill openings on each side, close to the head. There is a single nostril on top of the head just forward of the eyes. The two dorsal fins are high and well separated. The anal fin is a very low, broad ridge which may resemble a mere thickening of the skin at its forward end near the vent. On some individuals most of it would be undetectable from a side view, although it is readily seen from below. There is no gap between the anal and caudal fins.

Color: dull brown, blue gray, or mottled.
Length: to about 30 inches.

DISTINGUISHING CHARACTERISTICS

The three conspicuous teeth on the upper (supraoral) plate on the roof of the mouth (hence the name *tridentatus)*. The middle tooth is the smallest of these three (page 26). Any lamprey more than 14 inches long is this species.

DISTRIBUTION

This is the common lamprey of the Pacific Coast. Its usual range is from southern California to the Alaskan peninsula, but it has been recorded off Baja California, in the Bering Sea, and off Japan. From the Ventura River northward, it enters most California coastal and central valley streams that are not blocked by low flows or barriers.

HABITS

Some habits of this species are as described under "lamprey family".

The ocean movements of some individuals, apparently, are quite extensive, but detailed information is lacking.

The Pacific lamprey depends strongly on an anadromous existence. It must spawn in fresh water, where the young must develop. Landlocked runs are not found in many places. When a dam blocks a run the Pacific lampreys above it *usually* die out completely, but in some instances runs of landlocked lampreys have developed above the dam. The Klamath River above Copco Dam is an example. There appear to have been some dwarfed landlocked Pacific lampreys in the Klamath before the dam was built, but we do not know if they were part of a genetically distinct landlocked population or if they were descendants of sea-run parents. The dwarfed predaceous form is also found in the upper Pit River drainage.

Apparently it is the small form of Pacific lamprey which is responsible for most of the lamprey attacks on salmon and steelhead in the Klamath River. The large (anadromous) form rarely or never feeds when on its spawning run but the young sometimes do so when migrating downstream. Downstream migrants about five inches long demonstrated this by attacking and killing young king salmon a little shorter but much heavier than themselves when the two species were confined together in a live box. Adult salmon are sometimes found with scars made by Pacific lampreys and usually seem little the worse for it, but obviously we are not apt to see salmon that are killed at sea.

IMPORTANCE AND INTERESTING FACTS

Lampreys are now a little used resource in California, but would not be available in large commercial quantities. They are an excellent food fish if taken at or near the river mouths, but deteriorate rapidly as their spawning time approaches. California Indians found them fine eating and excellent for preservation by smoking. A different species of lamprey is regarded as an epicure's delight in parts of Europe.

There is strong prejudice against lampreys in this country: their feeding habits and appearance are both held against them.

Lamprey larvae (ammocoetes) make good live bait and may legally be so used in waters where they occur naturally.

A major fisheries disaster occurred in the upper four Great Lakes when the sea lamprey, *Petromyzon marinus*, found its way into them. Lampreys of this species had already become landlocked in Lake Ontario but Niagara Falls had kept them from getting farther. When the Welland Canal was built they worked their way into the other Great Lakes and demolished the lake trout fishery in each.

Catches in Lakes Huron and Michigan dropped from 10,000,000 lb per year to less than 2,000. An expensive crash program is bringing this problem under control. People ask if our species is apt to do similar damage to Pacific coast fisheries. The answer is *no!* Our fishes and lampreys have been living with (and on) each other for thousands of generations and are well adjusted to each other.

Pacific lampreys attached to the walls of a fishway. *Photo by author*

RIVER LAMPREY

Lampetra ayresii (Gunther, 1870)

OTHER NAMES

Lamprey, often mistakenly called "eel". The American Fisheries Society Special Publication No. 6 (1970) ends the name *ayresii* with a single *i*.

RELATIONSHIPS

Not a true fish. Belongs to the lamprey family, **Petromyzontidae.**

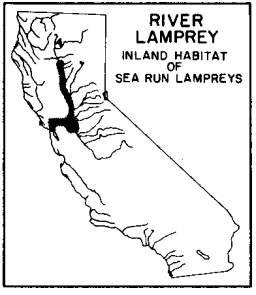
DESCRIPTION

Slender and eel-like in shape. Roughly cylindrical forward, slightly compressed posteriorly. Has no paired fins and no jaws. The mouth is a sucking disk with numerous rasping teeth. Upper (supraoral) tooth plate with two well developed teeth. There are seven gill openings on each side, close to the head. There is a single nostril, on midline slightly forward of the eyes. The two dorsal fins are well separated, the caudal fin is continuous with the second dorsal and the anal.

Color: metallic blue-black above, pale to silvery on sides and belly.

Length: to about **a** foot, but seven inches is more typical.

DISTINGUISHING CHARACTERISTICS



The upper (supraoral) plate on the roof of the mouth has only two teeth (three in the Pacific lamprey). Teeth are sharp and strong, those of nonpredacious (and nonanadromous) species are weak and dull.

DISTRIBUTION

From San Francisco Bay to Taku River in Southeastern Alaska. It has been recorded in the Sacramento River system upstream to Mill Creek and in the Delta, but not in the Klamath River or other California coastal streams.

HABITS

Anadromous, uncommon, and poorly known. Feeds in fresh water. See "lamprey family" and "Pacific Lamprey".

IMPORTANCE

Of no importance to sportsmen or commercial fishermen.

Lamprey scars on salmon. *Photo by J. H. Wales.*

THE STURGEON FAMILY
Acipenseridae

All sturgeons are either anadromous or freshwater. There are two Pacific Coast species, both anadromous. Sturgeons include the largest fishes to be found in fresh water and some are among the largest of all fishes. Largest of all sturgeons is the Eurasian beluga, *Huso huso.* An individual of 14 ft 2 inches and 2,250 lb is the largest on which we have both length and weight. Tsepkin and Sokolov (1971) list some bigger ones but do not give any weights. According to these authors three belugas 400, 490, and 490 cm long (13 ft 1½ inches, 16 ft 1 inch and 16 ft 1 inch) were caught in the North and Middle Caspian in 1937—1940; their ages ranged from 91 years to 118 years. The largest beluga known was caught in the North Caspian in 1940; the total length of this fish was *576* cm (18 ft 10¼ inches)". If this giant was the same shape as the *2,250* lb individual mentioned above it would have weighed roughly *5,300* lb. By way of comparison there are records of white sturgeon, *Acipenser transmontanus*, from the Columbia River weighing 1,387 and *1,285* lbs; the latter measured 12.5 feet. Again, there are unsubstantiated stories of much larger ones. The smaller Pacific Coast species is the green sturgeon, which is reputed to reach a weight of about 350 lb.

Sturgeon are very long lived, as demonstrated by the 118-year-old beluga listed above. When the big, old individuals are caught it takes a long time for small ones to grow large and replace them, and if the fishing pressure is high, very few will live long enough to grow really large. In many parts of the world foresters have harvested all the virgin timber and are now having to "make do" with much smaller second growth trees. A similar situation exists in most sturgeon fisheries.

Sturgeon are good eating. In cleaning one, some authors warn you to try to remove the notochord without cutting it as its contents are quite bitter. (This writer has used a quick rinse after cutting the notochord and has noticed no objectionable taste.) The notochord is a smooth flexible rod-like structure which in some primitive animals serves much the same functions a backbone does in vertebrates. The sturgeons have retained the notochord as a rod which runs lengthwise through the backbone. I have read that an easy way to remove it is to cut a few inches ahead of the tail and carefully sever everything except the notochord, then grab the tail and pull. According to an old French cookbook, attempting to cook an entire sturgeon will produce very unaesthetic results if the notochord is left in place— the chord lengthens and greatly distorts the fish. This is not apt to become a problem unless you are a pit barbecue enthusiast or have a much bigger oven than mine. Roasting a section of sturgeon will result in a surprising amount of notochord projecting out each end of the roast. It makes an interesting conversation piece.

THE CALIFORNIA STURGEON FISHERY

There are two species of sturgeon in California, the white *(Acipenser transmontanus)* and the green *(A. medirostris).* Little has been recorded about

the early history of the green sturgeon except that it was considered definitely inferior to the white.

When salmon gill netting was started in central California, sturgeon damaged nets and were destroyed by commercial fishermen at every opportunity. Until 1870, or thereabouts, only the Chinese found them of value. These fishermen often utilized only the notochord. Up to that time sturgeon had been abundant.

The westward movement brought Easterners with appetites for sturgeon and caviar to the Pacific Coast. About the same time, sturgeon were becoming scarce on the Atlantic seaboard. These factors served to create a more general demand for the species.

The commercial sturgeon fishery was short-lived. Fishing was principally by “Chinese sturgeon lines”, long lines suspended several feet above the bottom from which large unbaited barbless hooks were “dropped”. A cruising sturgeon would run into a dropper line, get impaled on the hook, struggle and get caught on more hooks. Gill and trammel nets also took many, but such catches were usually made while fishing for other species. The supply of sturgeon declined rapidly, and in 1901, when the Legislature temporarily abolished the fishery, white sturgeon were claimed to be on the verge of extinction. The fishery remained closed until 1910, was reopened for two years and then closed until 1916. In 1917, the fishery was again abolished by the Legislature, and the taking or possession of sturgeon was completely prohibited until 1954, at which time the fishery was reopened for sport fishing only. The fish had shown an encouraging increase during the 35 years of complete closure.

Angling is heaviest in Suisun and San Pablo bays but some sturgeon are taken well up the larger rivers. Catches are relatively small but variable since the population apparently undergoes long-term fluctuations.

WHITE STURGEON

***Acipenser transmontanus* Richardson, 1836**

OTHER NAMES

Sturgeon.

RELATIONSHIPS

Belongs to the sturgeon family **Acipenseridae.** There are two members of this family on the Pacific Coast. Both are found in California and both are anadromous. The white sturgeon is the larger, more common, better known, and better eating of the two.

Underside of head. Note pointed snout.

DESCRIPTION

The body is long, roughly cylindrical, and has a gradual taper to a thin caudal peduncle. The tail is strongly heterocercal (the backbone extends into the much larger upper lobe) The snout is short and broad. The mouth is toothless, protrusile, and sucker like; it is on the ventral side, beneath and a short distance behind the eyes. There are four barbels on the underside of the snout, nearer to its tip than to the mouth. The skin is smooth, but there are longitudinal rows of heavy bony plates, each with a sharp spine. (Sometimes the spines are worn away in very old individuals.) The lateral rows each have 38 to 48 plates.

Color: gray overall, but with some spots of paler gray.

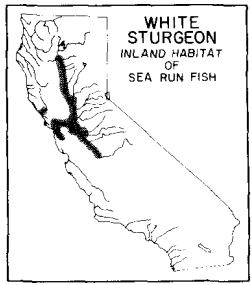
Size. There are confirmed reports to 12.5 ft and to 1,387 lb (not the same fish) and unconfirmed reports to 20 ft. Most white sturgeon taken by anglers are less than 6 ft, but a 9 ft, 405 lb individual was caught in the Sacramento River near the mouth of the Feather River in April 1972. It was more than 40 years old.

DISTINGUISHING CHARACTERISTICS

Sturgeons can be separated from sharks by the presence of an opercle (gill cover), a single gill opening on each side, and five rows of bony plates. (Sharks have no opercle, no bony plates, and have five to seven gill openings on each side.) The white sturgeon can be separated from the green by its gray color, and its 36 to 48 bony plates in the lateral row (the green has 23 to 31).

DISTRIBUTION

At sea, the white sturgeon has been found from Ensenada, Baja California, to the Gulf of Alaska. It is rare south of Monterey. In California, it is most abundant in the Sacramento-San Joaquin River system, particularly San Pablo Bay. It has been found in the Russian and Klamath Rivers.



HABITS

There is some question as to whether all known self-maintaining populations of white sturgeon are anadromous. Some sturgeon have been cut off from the sea by the construction of large dams. Shasta Lake, for example, was created in the early 1940's. Young sturgeon have been taken there but we don't know whether these youngsters are the children or grandchildren of sea-run fish. Sturgeon are so long-lived that individuals that were above the dam in the early 1940's could still be reproducing, but there has also been enough time for a landlocked generation to grow to maturity in or above the reservoir. A different situation involving landlocked, but presumably not-reproducing, white sturgeon is in the forebay of San Luis Reservoir. The water in this reservoir is pumped from the San Joaquin Delta and then flows by canal to the forebay. Some small sturgeon evidently pass through the fish screen and get as far as the forebay. It would seem quite likely that some will be (or have been lifted by pump from the forebay into the main San Luis Reservoir. Neither the forebay nor the main reservoir seems suitable for natural reproduction by sturgeon.

Some white sturgeon travel long distances at sea, as demonstrated by the individual taken at Ensenada. This fish could not have come from any river south of the Sacramento-San Joaquin system.

Department of Fish and Game studies indicate that in late winter and spring adult sturgeon migrate upstream into the Delta, using both the Sacramento and San Joaquin channels. Some are taken well up the Sacramento River past the mouth of the Feather River. By summer most have returned to the bays. Smaller fish (under 40 inches) are present in the Delta the year around.

Recently hatched sturgeon larvae (averaging ½ inch long) have been taken from late February until early June. Apparently most, if not all, of these larvae were spawned in the Sacramento River system above the mouth of the Feather River. There was no proof of spawning in the San Joaquin system. It could not be determined whether these larvae were white or green sturgeon, but the white is far more abundant in this area.

Actual spawning of either white or green sturgeon has not been described. Other species of sturgeon are known to migrate upstream and spawn in areas of fast water and coarse gravel bottom. Sacramento River sturgeon may spawn in both gravel bottomed areas and in areas with hard, smooth bottoms. The eggs settle to the bottom and are adhesive; i.e., they stick to rocks and debris. There

is nothing known about white sturgeon which would suggest that they do not behave in much the same way. Hatching time for some other species of sturgeon ranges from two to five days, depending partly on the species and partly on the water temperature (hatching time is less in warmer water).

Sturgeon feed by cruising close to the bottom. The barbels ahead of the mouth are sensitive to odor or taste. When something edible is detected, the protrusile mouth drops down and the food is sucked in. Crustaceans make up the bulk of the food of young sturgeon; larger sturgeon feed on clams, crustaceans, fish, and fish eggs.

IMPORTANCE

The white sturgeon supports a moderately important sport fishery for trophy-sized fish. The fishing is largely confined to the area from San Francisco a through the Delta, and the Sacramento River upstream to Colusa. More details are included under “Habits” above, and under ‘The California Sturgeon Fishery”, page 32.

White sturgeon caught in a trap operated by Fish and Game personnel to take smaller species for tagging. Weight 462 lb, age 45-47 years. August 1955.

GREEN STURGEON

***Acipenser medirostris* Ayres, 1854**

OTHER NAMES

Sturgeon.

RELATIONSHIPS

Belongs to the sturgeon family, **Acipenseridae.** This species and the larger and more common white sturgeon are the only two members of this family on the Pacific coast.

DESCRIPTION

The body is long, somewhat cylindrical and gradually tapers to a thin caudal peduncle. Tail is strongly heterocercal (the backbone extends into the much larger upper lobe). The snout is pointed, narrow, and depressed. The mouth is toothless, protrusile, and sucker-like, it is on the ventral side and beneath the eyes. There are four barbels on the underside of the snout. There are five rows of bony plates, each with a sharp spine. The lateral rows have 23 to 31 plates.

Underside of head. Note pointed snout.

Color: olive green with three longitudinal olive stripes on the body toward of the anus, one is on the midline of the belly, and one on each side.

Size: said to reach 350 lb, but most are much smaller than this.

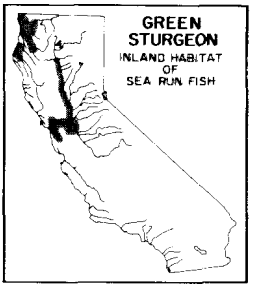
DISTINGUISHING CHARACTERISTICS

Sturgeons can be separated from sharks by the presence of an opercle (gill cover) and single gill opening on each side, and by the five rows of bony plates.

The green sturgeon can be separated from the white sturgeon by its color (olive green with three olive stripes as compared with gray and no stripes), by its fewer bony plates (23—3 1 in the lateral row as compared with 36—48), and by its pointed snout.

DISTRIBUTION

At sea the green sturgeon has been taken from Ensenada, Baja California, to the Bering Sea and Japan. It is rare south of Monterey, and is not a common species anywhere. It is found in some of the larger rivers from the Sacramento-San Joaquin system north, including the Eel, Mad, Klamath, and Smith Rivers in California. It has also been recorded from the Columbia and Fraser Rivers.



HABITS

The habits of this species are even less understood than those of the white sturgeon (page 35). Presumably the two are basically similar in most respects.

Tagging studies have demonstrated that some green sturgeon travel long distances at sea. Four individuals tagged in San Pablo Bay were recovered at the mouth of the Columbia River, a trip of over 600 miles, Another was recovered in Winchester Bay, Oregon. The longest movement of all was shown by one tagged in San Pablo Bay in July 1967 and recovered 21 months later in Grays Harbor, Washington, a distance of over 650 miles by water.

In the Sacramento-San Joaquin River system, the green sturgeon is much less common than the white. It has been recorded upstream as far as Red Bluff in the Sacramento River on spawning migrations.

Green sturgeon are found in the larger rivers of northwestern California, but, in the past, most references to sturgeon in that area failed to mention the species and some reports referred to the white sturgeon as being the more abundant. In complete disagreement with this, recent and moderately extensive fishery investigations in this area have positively identified good numbers of sturgeon, every one of which was a green. Most of the fish involved were from the Klamath River system, but some were from the Eel, Mad, and Smith Rivers, and some from Humboldt Bay. We are puzzled. Were the whites formerly the more common species, or did writers merely assume that white sturgeon were more common, possibly because they are the dominant species in the Sacramento and Columbia Rivers?

In the Klamath and Trinity, green sturgeon have been taken well inland. One individual which had been tagged in the Klamath moved upstream past Ishi Pishi Falls and was retaken at Happy Camp. This is near the upstream limit of their known distribution. The presence of very small green sturgeon well upstream in the Klamath system suggests that adults go well inland to spawn. (Some other better studied species of sturgeon are known to do this and to spawn in fast rocky rapids.)

Small young green sturgeon have been taken in the Sacramento River near Hamilton City and in the Sacramento-San Joaquin Delta, indicating that spawning takes place in the system.

IMPORTANCE

The green sturgeon is not common enough to be of importance to anglers in the Sacramento-San Joaquin system. In the Klamath, anglers are learning to catch them and the fishery is beginning to interest some of the more ardent fishermen.

HERRING FAMILY (CLUPEIDAE)
AMERICAN SHAD

Alosa sapidissima (Wilson, 1812)
Introduced

OTHER NAMES
Shad.

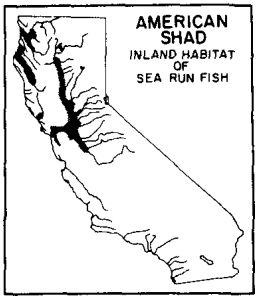
RELATIONSHIPS
Belongs to the herring family, four species of which are common in California: American shad (anadromous and introduced), threadfin shad, *Dorosoma petenense* (freshwater and introduced—it can withstand salt water); Pacific herring, *Clupea harengus pallasii* (marine); and Pacific sardine, *Sardinops sagax* (marine).

DESCRIPTION
Dorsal fin single, situated about the middle of the back. No adipose fin. Ventral fins directly below the dorsal, each with a fleshy appendage at its base. Mouth moderate, the rear of the maxillary being beneath the eye (with mouth closed). Head and body strongly compressed (flattened side-to-side), Body deep. The belly is sharp-edged and serrated (saw-toothed). No lateral line. Scales large and deciduous (easily lost). A row of black spots on the forward and dorsal part of the sides.
Color: metallic blue above, sides and belly bright silvery.
Length: to about 2½ feet. Females considerably larger than males.

DISTINGUISHING CHARACTERISTICS
The sharp-edged and saw-toothed belly will separate it from the herring and sardine. The row of spots high and forward on the side will separate it from the much smaller threadfin shad, which has a single spot and a greatly elongated last ray of the dorsal fin.

DISTRIBUTION

At sea from Ensenada to Alaska and Kamchatka. Not common south of Monterey. Has established itself in many of the larger streams from San Francisco north, In California the greatest numbers are encountered in the Sacramento River, its delta, and major tributaries. There are fewer in the San Joaquin River system. There are good runs of shad in the Russian, Klamath, and Eel Rivers, but appear to be no more than occasional strays in the Smith River.



Introduction of Shad

Shad are native to the Atlantic Coast. They were first planted in the Sacramento River in 1871, and additional plants were made for several years thereafter. They did remarkably well: by 1879, they were being taken in marketable quantities and by 1880 hey had spread as far as the Columbia River.

HABITS

Shad are very strongly anadromous. The adults can survive when landlocked, but we know of only one landlocked population that is reproducing. Shad fry were unintentionally included with striped bass which were being introduced into Millerton Lake (above Friant Dam). Several plants were made between 1955 and 1957, and again in 1965. Presumably these shad fry had never been in salt water but they are reproducing successfully. There is now (1972) a fishery in the lake. The shad are hard to find, but once located they can be caught in large numbers.

Shad spawning runs are from late April to early July. In many of the spawning streams some shad go as far upstream as they are able, but unlike salmon, shad do very poorly at ascending fishways and are apt to be stopped even by a relatively low dam with a fishway that would be excellent for salmon or steelhead. Formerly, shad ascended the Sacramento River to Redding, at least in some years. Since the construction of Red Bluff Dam, most of the run stops at that point. A few do get through the fishways at that dam, but we are not sure how much farther upstream they are now going.

Spawning takes place where there is good current in tidal fresh water or farther upstream. In California most of the spawning is over gravel or sand bottoms and well above all tidal action. A female may lay from 120,000 to 650,000 eggs. Many shad die after spawning.

After fertilization shad eggs are about ⅛ inch in diameter, transparent, and pale pink or amber in color. The eggs are not adhesive and are slightly heavier than water; they drift with the current near the bottom. Hatching is usually in 4 to 6 days but may take from as little as 2 to as long as 17 days, depending on the temperature.

Some young shad move downstream into brackish water soon after hatching but large numbers remain in fresh water into November; i.e., until they are 5 or 6 months old. By December most of them have left fresh water.

Judging from studies in other areas we would expect to find that in California most male shad mature in 3 or 4 years and most females in 3 to 5 years.

SHAD FISHING METHODS AND IMPORTANCE

In earlier years, commercial shad fishing was done with gill nets in the Sacramento-San Joaquin Delta. The fishery continued until 1957 when all gill netting was prohibited in the inland waters of California. The closure was primarily intended to protect striped bass and salmon. The shad didn't need the protection and for some years they were underutilized, but sport fishing for shad increased as more and more people discovered that they are an excellent game fish and are delicious when smoked.

A very popular method of angling for shad is wet-fly fishing in waters that can be negotiated in waist waders. It takes a powerful fly rod and the ability to cast a long line. Spinfishing from boat or bank is also popular. Shad "bumping" has its devotees among men who want fish in quantity. As usually practiced, this requires three men, a boat, an outboard, and a long-handled dip net with a cone-shaped "bag" of chicken wire. Bumping is done at night. The outboard is run downstream dead slow and is kept tilted to create a commotion on the surface. A man in the bow steers with an oar. The netter holds the net just behind the propeller and with the opening towards, the boat. The shad are attracted to the propeller's commotion and when one bumps the net it is lifted aboard. At times the action is very fast and catches are large. Virtually all the shad taken by bumping are males.

The importance of shad fishing has been greatly enhanced by its proximity to centers of population. The extreme example is in Sacramento, where most residents can drive to good shad fishing waters in 10 to 20 minutes.

Shad feed on animal plankton. In the Sacramento-San Joaquin Delta one study found 86% of their food to be the tiny opossum shrimp *Neomysis.* Two other types of small crustaceans (copepods and cladocerans) made up most of the remainder. Over 4,000 opossum shrimp were found in one shad stomach.

THE SALMON FAMILY

Salmonidae

Three genera of salmonids are found in California: the trouts *(Salmo),* chars *(Salvelinus),* and Pacific salmons *(Oncorhynchus).*

The family name was derived from the Atlantic salmon, which was given the scientific name *Salmo salar* by Linnaeus in 1758. (*Salar* is derived from *salio* to leap.) Trout were placed in this same genus. When English speaking settlers reached the west coast of North America they encountered fish resembling the Atlantic salmon, which, like it, migrated upstream to spawn. It was only natural that they also called these fish salmon. The scientific description of the Pacific salmons was by Walbaum in 1792. He put them into the genus *Salmo*. In 1861 a paper on salmonids was published by Dr. George Suckley, who had concluded that the Pacific salmons differed too much from the trout and Atlantic salmon to be retained in the same genus. Accordingly, he described a new genus, *Oncorhynchus,* in which he placed the Pacific salmons. This not too easily spelled or pronounced name means 'hook snout", which aptly describes the spawning males of this genus.

All members of this family have a prominent adipose fin. Ventral fins are abdominal and each has a scaly, fleshy appendage at its base. The rays of the dorsal fin are all soft. The lateral line is prominent. Scales are small and cycloid (cycloid scales have concentric rings but no cluster of sharp points near the posterior edge).

In the inland waters of California, trout are by far the most widespread and most numerous of the salmonids. They occur naturally in many waters and have been planted in almost all other suitable places and in a great many unsuitable spots as well.

Trout are in a process of rapid evolution. In California, they formed many local races or subspecies in waters that had been isolated long enough or this to happen. Years of indiscriminate planting have resulted in crossbreeding of these native stocks with hatchery fish; some subspecies have been crossbred out of existence. Hatchery stocks are now of somewhat uncertain ancestry.

In California, there are four species of true trout *(Salmo)* and three of the similar and closely related chars *(Salvelinus).* The former include the brown trout, *Salmo trutta;* cutthroat trout, *Salmo clarkii;* rainbow trout, *Salmo gairdnerii;* and golden trout, *Salmo aguabonita*. The chars include the Dolly Varden, *Salvelinus malma;* Eastern brook trout, *Salvelinus fontinalis;* and lake trout, *Salvelinus namaycush.*

The brown trout is an introduced species, and the different strains now in the State have interbred to such an extent that they can no longer be considered as separate subspecies. The golden trout (a native) is found only at high altitudes and hence is never anadromous.

Cutthroat trout are native and three subspecies are recognized: the coastal cutthroat, *Salmo clarkii clarkii;* the Lahontan cutthroat, *S. c. henshawi;* and the Piute cutthroat, S. *c. seleniris.* The coastal cutthroat is anadromous; the

other two never get a chance to be as they inhabit waters which drain into the deserts east of the Sierra.

Rainbow trout are also native; six subspecies are recognized. Of these, only the steelhead rainbow trout, *Salmo gairdnerii gairdnerii,* is normally anadromous over most of its range. It inhabits the coastal streams and the lower parts of the Sacramento River system. Three subspecies inhabit waters from which they cannot reach the ocean: the Eagle Lake rainbow, *S. g. aquilarum;* the Kern River rainbow, *S. g. gilberti;* and the royal silver rainbow, *S. g. regalis.* The last was described from Lake Tahoe but may not be a valid subspecies. The Shasta rainbow, *S. g. stonei,* was originally from the upstream parts of the Sacramento River system, but it has been hatchery reared, planted all over the State, and often crossed with other subspecies (including steelhead). There is little doubt that many individuals in suitable places have descended to the ocean and returned as steelhead, which no one would be likely to distinguish from *S. g. gairdnerii,* except on the basis of stream of origin. The Kamloops rainbow, *S. g. kamloops,* is a subspecies from British Columbia, which has been introduced into various waters including Shasta Lake where it crosses with the Shasta rainbow. Some marked Kamloops have passed through the turbines of Shasta Dam, migrated to sea and returned to the upper Sacramento River as "steelhead".

Of the three chars found in the State, only the Dolly Varden is native. It and the brook trout are both anadromous in parts of their range, but never in California. They will be discussed only briefly. The lake trout is never anadromous anywhere and will not be discussed further.

Five species of Pacific salmon (genus *Oncorhynchus)* are native in North America and six to eight in Asia. Authorities differ on the validity of two Asian species. In California the king (chinook) salmon, *Oncorhynchus tshawytscha,* and the silver (coho) salmon, *0. kisutch,* are abundant. The pink salmon, *0. gorbuscha,* is uncommon and erratic in its occurrence; the chum salmon, *0. keta,* is rare; and the sockeye salmon, *0. nerka,* is exceedingly rare in its sea-run form; but a landlocked form, the kokanee, *0. n. kennerlyi,* has been introduced into numerous coldwater lakes and reservoirs throughout the State and is reproducing satisfactorily in some of them.

In North America, as a whole, the order of abundance of the five salmon is altogether different from that just given. Pinks are the most abundant, followed, in order, by sockeyes, chums, silvers, and kings.

REQUIREMENTS AND HABITS OF SALMONIDS

Salmonids have many basic habits and requirements in common. All require cool or cold water. Prolonged temperatures higher than 70 F are usually detrimental and 80 F is usually quickly lethal to most species.[1] The temperature at spawning time is even more critical; with even the more tolerant species, 58 F is about the upper limit which eggs can survive.

All salmonids spawn in fresh water because their eggs will not survive anywhere else. Most kinds can, and do, spawn in streams and some can

* Rainbow trout have been known to withstand 86 F.

also spawn successfully in lakes. Of the salmonids found in California, only the lake trout is almost exclusively a lake spawner. Pink and chum salmon eggs can withstand being submerged in salt water for short periods; these two species do spawn successfully at the mouths of streams in areas that are covered with salt water at high tide. This does not occur in California.

The eggs of salmonids are larger than those of most fishes, the average for the different species being roughly from 4 to 8 mm (1/6 to ⅓ inches) in diameter. In general, the larger species have larger eggs. Salmonid eggs are yellow, orange, or red, and are spherical and heavy enough to sink fairly rapidly in water. As every trout fisherman knows, they are readily eaten by trout. Various other fishes, amphibians, birds, and mammals (including some humans) also regard them as delectable morsels. Since the incubation period is quite long, it is obvious that not many would survive to hatch if they were just left lying on the bottom. The standard salmonid way of protecting eggs is to bury them in clean gravel. The lake trout is again the exception. It releases the eggs over rocky areas or gravel beds and lets them settle into the spaces between rocks. In other salmonid species the females dig redds (nests), spawn in them, and cover the eggs with gravel. Smaller fish use finer gravel. The technique is much the same for all and is described in moderate detail for king salmon on page 76. Enough water circulates through the gravel to provide the oxygen needed by the eggs and newly-hatched fry. The fry hatch with much of the yolk in a large abdominal sac, which gives them a somewhat tadpole-like shape. As the yolk is absorbed over a period of weeks, the young wriggle their way upward through the spaces between rocks and usually emerge from the gravel about the time the yolk has been absorbed and the fish are ready to start feeding.

Once the young have emerged from the gravel, there is a tremendous difference in the habits of salmonids. Some species are never anadromous—every individual spends its entire life in fresh water (lake trout and golden trout, for example). Many spend from one to several years in fresh water before migrating to sea (Atlantic salmon, most anadromous trout, silver salmon, sockeye salmon). King salmon may migrate within a few months or may wait until they are yearlings. Chum and pink salmon invariably migrate quite soon after leaving the gravel.

The food of salmonids is animal material of a size suited to the fish in question. To a large extent they are opportunists and take what is most available. Juveniles in fresh water dine on insects and their larvae to a large extent, but will take young fish, including their own smaller relatives. Young sockeye salmon differ the most from the remaining salmonids. They are lake dwellers and most of their food is animal plankton, such as *Cyclops* and *Daphnia* (water fleas).

In the ocean even the bigger salmonids eat quantities of plankton such as euphausiids (krill), copepods, amphipods, and crab larvae. Squid and fish are also taken in quantity. Again, the sockeye salmon is the aberrant species. Its long, fine, gill rakers are especially well adapted for straining

the smaller forms of animal plankton out of the water; hence, the sockeye feeds more on plankton, less on fish and squid.

IDENTIFICATION OF SALMONIDS

Anadromous salmonids are among the more difficult fish to identify because in growing from a fingerling to an adult each individual goes through a most confusing series of changes in appearance. When in the ocean all salmonids look pretty much alike, but don't look at all like the parr-marked fingerlings they once were, or like the spawning adults they will soon become.

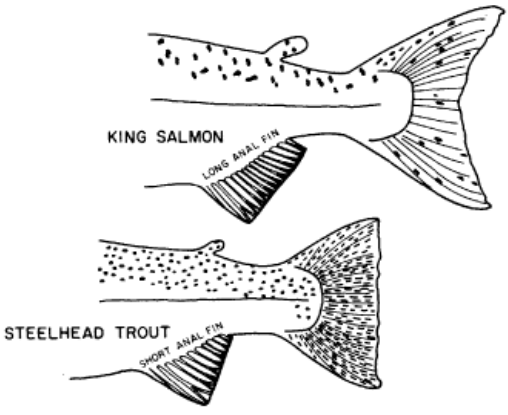
To assist in identification, we have included two keys: one for juveniles (fingerlings), the other for larger fish including adults in spawning condition.

The adult key assumes that the user has the fish, dead and in hand, preferably complete with gills and viscera.

The juvenile key will be easier to use if the fish is dead and in hand, but often a sufficiently sure identification can be made without killing the fish. Sometimes it cannot, but if you do kill the fish, it will be counted as part of your daily bag limit.

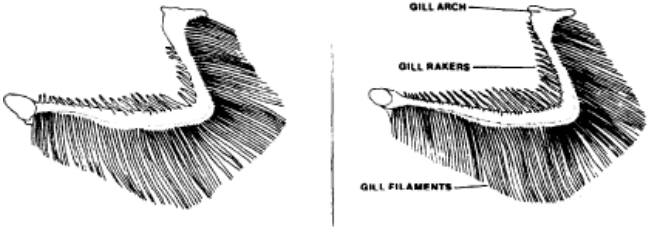
Attempting to identify juvenile salmonids can be an exasperating experience. There may be puzzling differences between a 2-inch and a 4-inch individual of the same species, or between either of them and an adult. Variation from one major watershed to another can be enough to confuse a careful observer, and fish from a dark, clear, and densely shaded stream will be quite different from those in an open, sunny, or slightly murky area.

To make identification easier, consider what species ate present in the area and familiarize yourself with the characteristics that separate them. In a coastal stream in Mendocino County all you would normally expect would be steelhead trout and silver salmon. With a little practice you should be able to identify even the juveniles without catching them—if the water is clear and if you can get really close. (Field glasses are a great help if they will focus close.) If you suspect something unusual you will have to have the fish in hand or in a dish or basin. Remember that larger juveniles are easier to identify; some characteristics that will easily identify a 4-inch fish simply haven't appeared in 2-inch individuals. Separating fingerling steelhead and cutthroat can range from easy to impossible, depending on the size of fish and the waters they came from. Experts have been known to go so far as to rear a few small fingerlings until they became identifiable. Rainbows and cutthroat will crossbreed in nature, which may add to the confusion.



ANAL FINS OF TROUT AND SALMON

On a salmon the base of the anal fin is longer, and there are more fin rays than on a trout.



Salmon gill rakers. **King salmon** (left) have fewer and shorter gill rakers than the kokanee (right) or the very similar sockeye (not shown). The latter two are better adapted for straining small food organisms out of the water.

KEY

ADULT SALMONIDAE

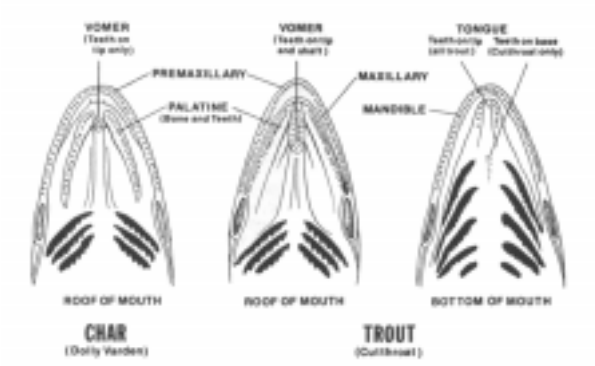
Trout (Salmo), Chars (Salvelinus), and Pacific Salmon (Oncorhynchus)

This key includes only those salmonids which are found below an altitude of 4,000 ft in waters draining into the Pacific Ocean.

To use this key read statement number 1 under "character being described" (Anal fin rays, 13 to 19). If the statement is true move to number 2. If the statement is not true move to the "alternate choice", in this instance number 10. Continue until the species is identified.

Characters being described	Alternate choice	Description
1	(10)	**Anal fin base long, 13-19 rays. PACIFIC SALMONS,** genus *Oncorhynchus*.
2	(3)	Gill rakers on first arch 28–40, long, slender, and rough. (Include the much smaller rakers at each end of the arch.) Adults with fine speckling but no black spots. Large young may have spots. **Sockeye salmon,** *Oncorhynchus nerka*, page 82.
3	(2)	Gill rakers on first arch 18–26, short.
4	(5)	No black spots other than fine speckles on body or fins. **Chum salmon,** *Oncorhynchus keta*, page 80.
5	(4)	Distinct black spots on body or fins.
6	(7)	Scales small, 170–229 in first row above lateral line. **Pink salmon,** *O. gorbuscha*, page 67.
7	(6)	Scales larger, fewer than 170 in first row above lateral line.
8	(9)	Mouth lining dark, including the gums next to and around the teeth. Pyloric caeca 140–185. **King salmon,** *O. tshawytscha*, page 74.
9	(8)	Mouth lining of lower jaw with a conspicuous pale band which includes the teeth and gums. Pyloric caeca 45–83. **Silver salmon,** *O. kisutch*, page 70.
10	(1)	Anal fin base short 8–12 rays.
11	(16)	Black spots present. Scales relatively large for this group; under 180 in first row above lateral line. Teeth on head and shaft of vomer. **Trout,** genus *Salmo*. (Continue with key to identify species.)

Silver salmon (left) have white gums around the teeth, while the inside of a king salmon's mouth is all dark. The silver salmon has the silver (gum) lining.



Trout have teeth on the tip and shaft of the vomer, but chars have them only on the tip. All trout have teeth on the tip of the tongue; only cutthroats have them on the base.

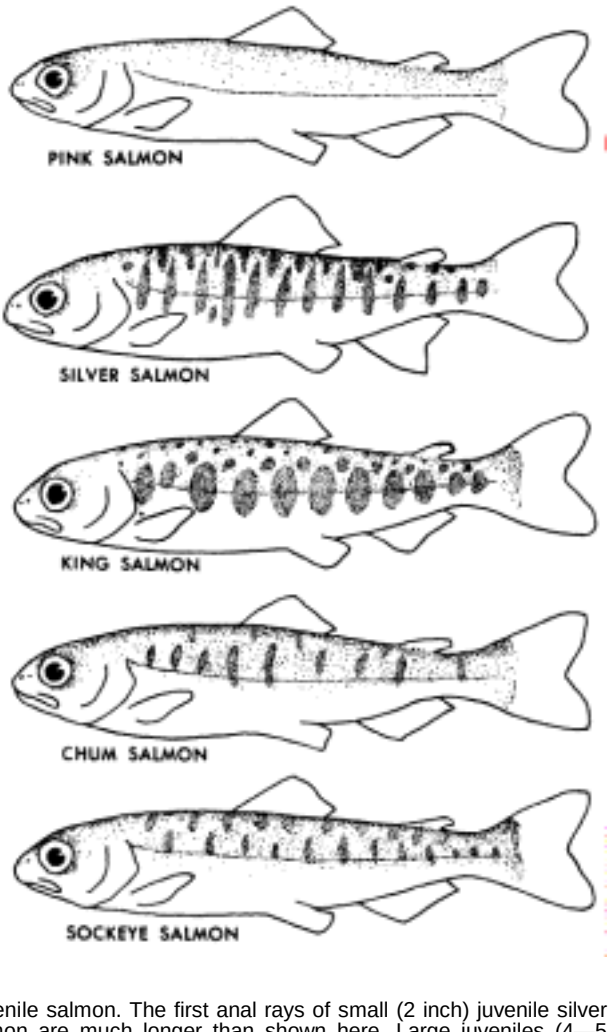
Characters being described	Alternate choice	Description
12	(13)	Teeth on tip *and* back of tongue. Yellow to red streak on underside of jaw (this may be absent in fresh sea-run individuals). Black spots large and numerous, without halos. No red spots. **Coastal cutthroat trout,** *Salmo clarkii clarkii*, page 62.
13	(12)	No teeth on back of tongue, no red streak on underside of jaw.
14	(15)	Black spots small, up to about ⅛-inch diameter, none with red or pink halos. No red spots. Lengthwise red stripe on side; this may be lacking on fresh sea-run individuals. **Steelhead rainbow trout,** *Salmo gairdnerii gairdnerii*, page 58.
15	(14)	Black spots on sides large, often with red, pink, or pale halos. Red spots sometimes present. No red stripe on side. **Brown trout,** *Salmo trutta*, page 56.
16	(11)	No black spots. Red or yellow spots sometimes present. White or yellowish white spots present. Scales small, over 185 in first row above lateral line. Teeth on tip of vomer but not on the shaft. **Chars,** genus *Salvelinus.*
17	(18)	Distinct wavy lines on back and dorsal fin. Red spots usually present, but may be indistinct on individuals from lakes. Yellowish white spots on sides. May be very brightly colored, especially at spawning time. **Brook trout,** *Salvelinus fontinalis*, page 65. Sometimes anadromous on the Atlantic Coast, but no sea-run individuals have been reported in California.
18	(17)	Back and sides olive green to muddy gray with no wavy lines or, at most, some very faint ones. Dorsal fin without spots or lines. Scattered white or pale yellowish spots on body. Some red or orange spots usually present on lower sides. **Dolly Varden,** *Salvelinus malma*, page 64. Never anadromous in California, but often anadromous farther north, especially in Alaska.

KEY
JUVENILE SALMONIDAE

Use this key for salmonids which are still in fresh water and which still retain distinct parr marks. Salmonids smaller than 2 inches will not always have developed enough to make this key usable. Few of the characters given here hold true in all fish from all areas. If in doubt, use several characters or examine several fish or both.

To use the key, read statement number 1 under "Character being described" (Anal fin with 13—19 rays). If the statement is true move to number 2. If the statement is nor true move to the alternate choice, in this instance number 10. Continue until the species is identified.

Characters being described	Alternate choice	Description
1	(10)	**Anal fin with 13-19 rays. PACIFIC SALMON** (genus *Oncorhynchus*). See drawings, page 47. On all species (silver salmon sometimes excepted) the anal fin base is distinctly longer than the longest rays of the anal fin. No spots on dorsal fin of salmon under 4 inches except that some kings may have a single small spot at the forward edge of the dorsal next to the body. Seven-inch kings and silvers usually have spotted dorsals.
2	(3)	No parr marks, no spots. **Pink salmon,** *Oncorhynchus gorbuscha*. Rare in California. Migrates to sea before or immediately after absorbing the yolk sac; i.e., when less than 2 inches long, page 67.
3	(2)	Parr marks present.
4	(7)	Parr marks large, tall, divided roughly in half by the lateral line.
5	(6)	Parr marks tall and usually narrower than the spaces between. Adipose fin finely speckled with gray, usually all parts are about equally dark, but a few individuals may have a darker margin or a clear area. The first 2 or 3 anal rays are usually longer than the others, giving the fin a concave edge (especially on smaller fingerlings). Lower fins usually tinged with orange Forward margin of the anal fin usually white. Pyloric caeca less than 90*. **Silver salmon,** *Oncorhynchus kisutch*. Abundant in many coastal streams from Santa Cruz County north, rare in the Central Valley, page 70.

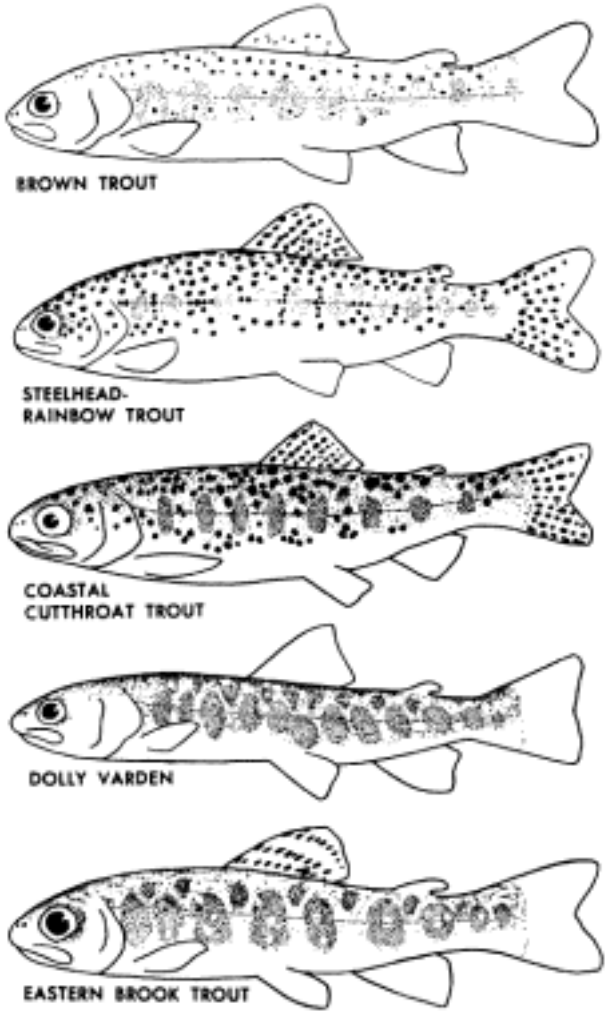


Juvenile salmon. The first anal rays of small (2 inch) juvenile silver salmon are much longer than shown here. Large juveniles (4—5 inches) are as shown.

Characters being described	Alternate choice	Description
6	(5)	Parr marks oval, usually wider than the spaces between. Adipose fin with dusky or black margin around tip; remainder of fin may be clear, finely speckled, or speckled with a clear area. Dorsal fin of fish under 4 inches unspotted or with a single small spot at forward edge of fin next to the body. A 7-inch fish will usually have a heavily spotted dorsal. Lower fins usually uncolored, first rays of anal fin not usually longer than those following Pyloric caeca more than 120*. **King salmon,** *Oncorhynchus tshawytscha.* Abundant in the Sacramento-San Joaquin River system and in some of the larger coastal streams. Occasionally found in some small coastal streams, page 74.
7	(4)	Parr marks smaller, mostly confined to the area above the lateral line.
8	(9)	A row of distinct dark spots on back. Back bluish or greenish. Gill rakers slender, 25 or more on first arch. **Sockeye salmon,** *Oncorhynchus nerka.* Very rare in California, except as **kokanee** (*O. nerka kennerlyi*), a landlocked form which has been introduced into lakes and reservoirs, page 82.
9	(8)	Parr marks similar to those of sockeye (above) but less distinct. Dark spots on back smaller, less regular, and may be absent. Back mottled green. Gill rakers thicker than on sockeye, fewer than 25 on first arch. **Chum salmon,** *Oncorhynchus keta.* Rare in California. Migrates to sea before or shortly after absorbing the yolk sac, i.e., when less than 2-inches long, page 80.
10	(1)	Anal fin with 9–12 rays. The fin base is shorter than the longest anal rays.
11	(16)	Sharply defined black or brown spots on back and dorsal fin. Teeth on tip and shaft of vomer. **TROUT,** genus *Salmo.* See drawings, page 49.
12	(15)	Small distinct black spots on dorsal fin. Adipose fin with black spots, black margin, or both. Never any red spots on body or fins.

* This gives a positive identification but counting caeca in small fish is very difficult and time consuming. Cut them off as you count them.

Characters being described	Alternate choice	Description
13	(14)	Teeth present on tip and base of tongue on fish over 4 inches. Parr marks tall, straight sided, and almost rectangular on fish under 4 inches, but may be small and round or oval on larger fish. Red or orange streaks usually present under jaw, except on smallest juveniles. **Coastal cutthroat trout,** *Salmo clarkii clarkii*, page 62.
14	(13)	No teeth on base of tongue. Parr marks oval or nearly round on all sizes of fingerlings. Usually no red or orange streaks under jaw. **Steelhead rainbow trout,** *Salmo gairdnerii gairdnerii*. Abundant. The most widespread sea-run salmonid in California, page 58.
15	(12)	Parr marks large, much wider than the space between. Sharply defined pale round spots near lateral line. On larger fingerlings some red spots and some black spots with halos. Black spots on sides fewer and more uniform in size than on steelhead or coastal cutthroat. **Brown trout,** *Salmo trutta*, page 56.
16	(11)	No small distinct black or brown spots. Teeth on tip, but not on shaft of vomer. **CHAR,** genus *Salvelinus*. See drawings, page 49.
17	(18)	No pale spots on back Vermiculations (wavy lines) on backs of large fingerlings. (These are present on many 3-inch fish.) Pale spots on sides near lateral line. These have appeared on many 2-inch fish. Parr marks large, some a little wider at bottom (pear shaped). **Eastern brook trout,** *Salvelinus fontinalis*. Introduced, widespread in California. Not common at lower elevations. Not known to be anadromous on the Pacific Coast, page 65.
18	(17)	No vermiculations. Pale spots on back as well as sides of larger fingerlings. Parr marks usually crowded, but quite variable in shape and in degree of crowding. **Dolly Varden,** *Salvelinus malma*. Native in California, but confined to the McCloud River, not anadromous in California, page 64.



Juvenile trout. Parr marks on small juvenile cutthroat (under 4 inches) are about as shown; on larger cutthroat they more nearly resemble those of rainbows. Technically Dolly Varden and Eastern brook trout are chars.

SEA-RUN BROWN TROUT

***Salmo trutta* Linnaeus, 1758**

OTHER NAMES

Brown trout, Loch Leven trout. (Ancestors of some of California's brown trout came from Loch Leven in Scotland, but the strain has been hybridized until no longer recognizable.) In Great Britain the quite appropriate term "sea trout" is used for the anadromous brown trout.

RELATIONSHIPS

The brown trout is of European origin and is most closely related to our rainbow and cutthroat and to the Atlantic salmon. To some extent the sea-run brown trout is the European equivalent of our steelhead.

DESCRIPTION

Anal rays 9 to 12 as in other trouts. Teeth on head and shaft of vomer well developed (more so than those of steelhead). Teeth on tip but not on base of tongue.

Color: Nonanadromous brown trout have large dark spots on the sides and head, smaller ones on the dorsal fin. Black spots on the opercle are larger and more conspicuous than on steelhead (which may have none). The spots on the sides have conspicuous pale halos. There are sometimes red spots with pale halos on the lower part of the sides. The sides have a yellow-brown cast which gives the species its common name. Sea-run browns turn pale and silvery and more nearly resemble steelhead. The *red* spots may disappear completely and the black spots become much less conspicuous. With the fish in some positions the silvery sheen may obscure many spots. If there are both black and red spots present, the fish is definitely a brown trout. There is *no* longitudinal red stripe on the sides (as in most steelhead), no red dash under the jaw (as in nearly all cutthroat), and *no* wavy lines on back or fins (as in the brook trout).

Size: In Europe sea trout of over 26 lb have been recorded, In California most of those examined have been from 1 to 4 lb, but larger browns have been taken in coastal drainages and may or may not have been anadromous.

Juveniles. Parr marks are large and are much wider than the space between. There is a row of pale round spots on the sides. There are few, if any, black spots on caudal and adipose fins and there is no black margin on the adipose. Adipose fin is tinged with orange. Black spots on back are fewer and more uniform in size than on rainbow or cutthroat. On larger fingerlings some black spots may have halos and there may be red spots, small fingerlings may lack the red. The sides and back are tinged yellowish or brownish.

DISTINGUISHING CHARACTERISTICS

Any California salmonid which has both black and red spots or black spots with conspicuous pale halos is this species. Fresh sea-run individuals may not show any red. Brown trout never have a red stripe on the side or a red dash under the jaw. No teeth on back of tongue. Fingerlings can be identified by a combination of black spots on the back and pale spots on the sides.

DISTRIBUTION

Sea-run brown trout have been reported from the Sacramento River system north to Vancouver Island, British Columbia. In California they have been reported in the Sacramento, Klamath, and Trinity Rivers in very small numbers. In addition to the above, one brown trout that was probably sea run was reported from Scott Greek and one from the San Lorenzo River, both in Santa Cruz County (Leo Shapovalov, personal communication). Nonanadromous browns are widely distributed in California.

HABITS

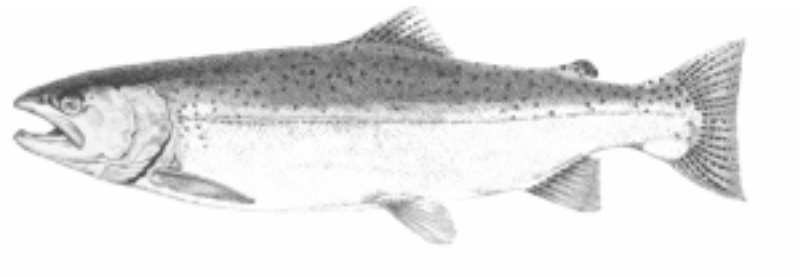
In America, young brown trout show less tendency to enter salt water than do the descendants of steelhead and apparently do not migrate as far at sea. Many browns remain in river estuaries or only go a short distance to sea. Like steelhead they usually spend one or two years in a stream before migrating to sea. Some return to fresh water before maturity. The age at maturity of sea-run browns in California is probably three or four years.

IMPORTANCE

Sea-run brown trout are too rare in California to be of importance to sportsmen. The habits and greater caution of brown trout make them harder to catch than our native trouts.

STEELHEAD RAINBOW TROUT

Salmo gairdnerii gairdnerii Richardson, 1836



OTHER NAMES

Usually called "steelhead" without any embellishments. Small immature sea-run individuals returning after less than a year in the ocean are commonly called "half-pounders". They usually weigh from ½ to 1½ lb. The American Fisheries Society Special Publication No. 6 (1970) ends the name *gairdnerii* with a single *i*.

RELATIONSHIPS

Belongs to the family **Salmonidae** which includes all salmon, trout, and chars. Most closely related to the other subspecies of rainbow and to the other species of trout.

DESCRIPTION

Anal rays 9—12 (rarely 13). Teeth on tip and shaft of vomer. Teeth on tip but not on base of tongue. Gill rakers on first arch 17—21. Scales in first row above lateral line 115—180.

Color. At sea, steelhead are steel blue above with bright silvery sides and belly. Sharply defined black spots on back, head, sides, dorsal, and caudal fins. The spots are small, rarely over ¼-inch diameter, and highly variable in number. After entering fresh water, steelhead develop a broad pink or red stripe on each side of the body. This stripe fades away at the edges rather than being sharply outlined. In fresh water steelhead gradually rake on more of the appearance of a stream rainbow; the back gradually becomes olive green and the sides and belly become less silvery. Steelhead lack the red streaks beneath the jaw which characterize the cutthroat. The mouth lining is white.

Size and **Age.** Most steelhead weigh less than 10 pounds, but a 23-lb 4-oz individual was recorded from the Smith River, California, on January 7, 1971, and a 42-lb fish was taken by an 8-year-old boy fishing alone in a rubber boat near Ketchikan, Alaska.

Fisheries workers in several areas have found fish seven years of age to be the oldest they have encountered, but two steelhead have been recorded which were older than this. The latest was netted at sea off Alaska in September, 1969. It was a 33.7-inch female that had spawned four times, had completed eight years of life and was well into her ninth.

Juveniles. Mouth moderate, the jaw bones not reaching past the rear of the eye. Teeth on tip and shaft of vomer. Teeth on tip *but not on base of* tongue. (Cutthroat over 4 inches have teeth on the base of the tongue but smaller individuals may not.)

Parr marks small and oval or nearly round on all sizes of juveniles. Back, sides, and dorsal fin with small black spots. Caudal fin sometimes spotted. No red or pale spots. Steelhead usually don't (and cutthroat usually do) have a pair of red or orange streaks on underside of jaw.

DISTINGUISHING CHARACTERISTICS

A broad red stripe on the side will identify the various subspecies of rainbow, but fresh sea-run individuals may lack the stripe. -Has no red dash under jaws, and no teeth on the base of the tongue. Black spots are small, usually up to ⅛-inch diameter. (Both cutthroat and brown have conspicuously larger spots.) This subspecies can best be separated from other rainbows by habitat. Coastal streams usually have pure or nearly pure steelhead. The Sacramento River system below the big storage reservoirs has steelhead with some minor dilution by other strains of rainbow.

DISTRIBUTION

At sea from northern Baja California to the Bering Sea and Japan. Still occasionally enters the Ventura River (which used to be a good steelhead stream). Regularly enters most suitable streams from San Luis Obispo County northward.

HABITS

The steelhead is a subspecies which has a bit more migratory urge than some other strains of rainbow. It does nor depend on an anadromous existence. Even in our coastal streams (where the migratory urge appears to be strongest) there are some individuals which mature without ever going to sea. Steelhead which are planted in a lake will grow to maturity and then spawn in streams tributary to that lake. So will other kinds of rainbow.

The great majority of steelhead are of a single type but are known as fall-run or winter-run steelhead, depending on when they enter the stream on their spawning run. Fish of this type enter the stream and spawn during the same season. The time of the migration varies from stream to stream. If a river is big enough and cool enough the fish may enter in late summer

or early fall. Runs start later in the many small coastal streams which have a sandbar across the mouth during the drier part of the year. No migratory fish can enter until the rains have increased the flow and the stream has broken through that sandbar. Whether the first steelhead start upstream in August or in January the run is apt to continue until March or April.

A basically different migration pattern is that of the spring-run steelhead (also called summer-run steelhead or summer steelhead). These fish differ from other steelhead in that they enter streams in the spring or summer and wait through the dry season and until the following spring before spawning. They move well toward the headwaters of the larger and cooler streams and wait in deep holes. Spring-run steelhead are found in only a few places and are not abundant anywhere in the State.

Steelhead spawning resembles that of salmon (pages 76 and 77). The urge to migrate seems to be size-related and in California young steehead most often migrate to the ocean after two seasons in fresh water. F aster growing fish migrate after one season and slow growers may not migrate until en in three, or sometimes four, seasons in fresh water.

After reaching salt water, steelhead grow rapidly and usually return to spawn in their home streams after one or two seasons in the ocean. Unlike salmon, steelhead do not necessarily die after spawning. The rigors of migration and spawning do cause many deaths, but fish that have spawned two and three times are not uncommon.

IMPORTANCE

Steelhead are the most widespread and one of the most important anadromous game fishes in California. They are probably the Klamath River's greatest attraction and are taken all the way from the mouth to Iron Gate Dam. The fall run starts entering the river in July and continues through September. Half-pounders and a few larger fish come first; the former seldom move more than a few miles above Happy Camp. Larger fall-run fish are not far behind and usually reach the upper river about October. Winter-run fish follow and fishing may remain good through the winter in the upper river. Spring-run fish are not abundant. They start entering in March and hole up by summer in some of the larger and cooler tributaries. One is Woolen Creek, a tributary of the Salmon River.

Smith River is known as a producer of exceptionally large fall and winter steelhead.

Mad River has fall, winter, and spring runs of steelhead but is often too muddy to be fishable.

The Eel River has a half-pounder run in the late summer and early fall. It gets about as far upstream as the mouth of the Van Duzen River. Bigger steelhead are available in the lower Eel in the fall, and throughout the river system in the winter. Spring- (summer-) run steelhead are found in parts of the Van Duzen, Middle Fork, and main Eel.

The Russian River is easily accessible from the San Francisco Bay area and is a very popular stream. About 100 miles of it is open to winter fishing. The steelhead enter from November through February. The stream is partly regulated by Coyote Dam on the East Fork near Ukiah. After the

first heavy rain the water behind this dam becomes very muddy, and stays that way for many weeks. When water released from Coyote Dam provides a large part of the flow, the river may be too muddy for fishing. When flows from other tributaries are adequate, the flow of muddy water is cut off to give a clear river on weekends.

The Sacramento River provides very good steelhead fishing in October and November. Except at the mouth of the American River, steelhead seldom take a hook until they are 30 miles or more upstream from Sacramento. Most steelhead fishing is done between the mouth of Deer Creek and Redding. Many steelhead enter Battle Creek and provide excellent fishing. By January (or sometimes earlier) most of the fish and fishermen have moved into tributaries such as Battle, Deer, and Mill Creeks. There is fair steelhead fishing in the Feather River. The American River is usually fair, but has short spells of really good fishing.

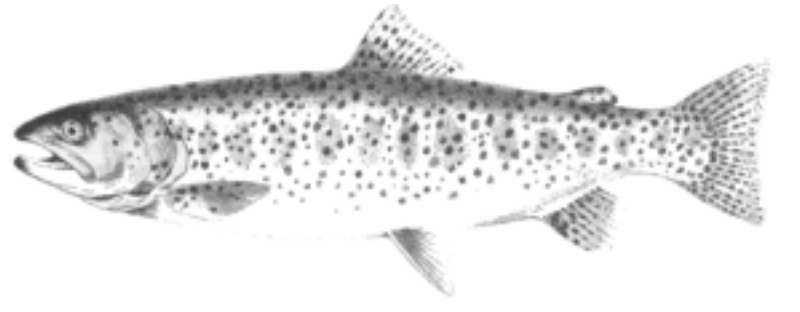
Steelhead do not enter the smaller coastal streams until after the first fall rains. Good fishing may only occur for short periods when water conditions are just right. Local fishermen do very well, but the visitor from a distant metropolitan area is all too apt to have difficulty timing his arrival with that of the fish.

Steelhead fishing is too involved an art to be described here in any detail and prevailing techniques differ from stream to stream. Bait fishing is popular and effective; salmon eggs or clusters of roe or nightcrawlers are drifted down riffles, pools, and especially where a tributary creek joins a larger stream. Spinners and other lures are popular. When the water is low and clear, flies can be very effective. Most steelhead fishing is done from the shore or when wading, but drifting in boats is quite popular in the larger streams.

Boats anchored at the mouth of the Smith River. The outgoing tide activates the anglers' lures.

COASTAL CUTTHROAT TROUT

***Salmo clarkii clarkii* Richardson, 1836**



RELATIONSHIPS

Belongs to the family Salmonidae, which includes all salmon, trout, and chars. Most closely related to the nonanadromous subspecies of cutthroat found in the Sierra and eastward. Closely related to the rainbow and other trout. The American Fisheries Society Special Publication No. 6 (1970) ends the name *clarkii* with a single *i.*

DESCRIPTION

Anal fin rays 8—12. Teeth on tip and shaft of vomer. Teeth on tip and base of tongue. Mouth large; jawbones reach past rear of eye even in juveniles. Scales in first row above lateral line about 120—180.

Color. Olive green on back, lighter on sides, and silvery on belly. Fresh sea-run individuals are more silvery on belly and sides, and more bluish on the back. Heavily spotted with black spots on head, back, sides, and unpaired fins. Spots are without halos. No red spots. There is usually a pair of red or orange streaks beneath the jaw (the cutthroat mark). On fresh sea-run individuals the cutthroat mark may be faint or absent and the black spots less conspicuous.

Size. Sea-run cutthroat to 17 lb have been taken but cutthroat usually average smaller than steelhead, relatively few being larger than three or four pounds.

Juveniles. Cutthroat juveniles less than 4 inches long may lack teeth on the base of the tongue or the teeth may be so small as to be undetectable.

On juveniles less than 4 inches, the parr marks are usually moderately tall and straight-sided and are almost rectangular; on larger juveniles they may become smaller and almost circular, resembling those of steelhead Cutthroat marks are usually present on all but the smallest juveniles.

DISTINGUISHING CHARACTERISTICS

Cutthroat are more variable in appearance than steelhead, and sea-run cutthroat often resemble steelhead. The pair of bright red or orange "cutthroat marks" beneath the jaw is the easiest and most commonly used character, but sea-run fish and some others may lack the mark. The presence of teeth on the base of the tongue is the most certain character for fish over 4 inches long [1]. Smaller fish may lack the teeth but can be identified by their straight-sided almost rectangular parr marks.

DISTRIBUTION

The coastal cutthroat is found from the Eel River north to southeastern Alaska. It is more common from the Mad River north. In California this subspecies is found in coastal streams and is usually quite close to the ocean, except in the Smith River where both anadromous and resident individuals are found throughout much of :he drainage.

HABITS

Optionally anadromous. Most individuals do go to sea, but many elect not to. Spawning is usually in small streams in late winter or spring. The young may move downstream to larger waters as they grow and usually migrate to sea when 2 to 4 years old. They actually return to the estuary within a few months and move upstream in late fall or winter. spawning is not necessarily fatal to this species and many fish spawn more than once. Many cutthroat spend much time in the estuaries and apparently the species does not migrate far at sea.

Food habits of cutthroat are similar to those of most trout. Insects are the principal item when they are small; later, fish become a part of their diet. Apparently cutthroat consume somewhat more fish than most trout.

IMPORTANCE

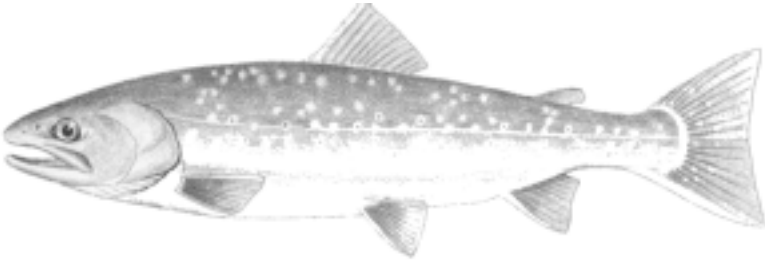
Coastal cutthroat trout are taken by relatively few sportsmen, but they are highly regarded by those that do fish for them. Like all California trout, they are fully protected from commercial fishing.

Fishing. Sea-run cutthroat are taken in Redwood Creek and in the Mad, Klamath, and Smith Rivers. There is good fishing in the fall, usually after the first heavy rain. Near the mouth of the Smith and Klamath Rivers fishing is often good as late as April.

[1] On fish over 6 inches run your little finger *gently* over the base of the tongue, and feel for the tee On fish small enough to crowd your finger in the slightest you may mistake gill rakers for teeth, or scrape off the teeth. The surest technique is to cut towards the tail from the angle of the jaw and remove the top of the head. Then feel gently with the tip of the little finger or use a hand lens.

DOLLY VARDEN [1]

Salvelinus malma **(Walbaum, 1792)**



OTHER NAMES
Dolly, bull trout.

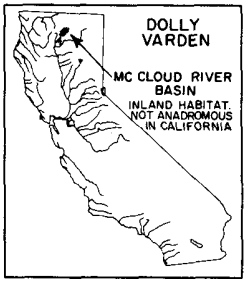
RELATIONSHIPS
A char, belongs to the salmon family, Salmonidae. It is most closely related to the other chars, less so to the trout.

DESCRIPTION
Anal rays about 9. Teeth on tip but not on shaft of vomer. Scales small, about 185—225 in first row above lateral line.

Color: Olive green to dark brownish gray. Scattered yellowish and pinkish yellow spots on back. Sides with small orange or red spots. No black spots. Fins without spots or bars except for some small pale spots near the base of the caudal (tail) fin. Sea-run individuals are silvery (but are not found in California).

Size: to 9 lb 1 oz in McCloud Reservoir and to 32 lb in Idaho.

Juveniles are slender, have large, crowded parr marks with narrow spaces between. No dark spots on fins. Larger juveniles have pale spots on sides.



DISTINGUISHING CHARACTERISTICS
This is the only char with no dark spots or marks on the fins. The presence of teeth on the tip but not on the shaft of the vomer will identify it as a char (genus *Salvelinus).*

DISTRIBUTION
Widely distributed from Oregon to Bering Sea, In California it is confined to the McCloud River system (above Shasta Dam).

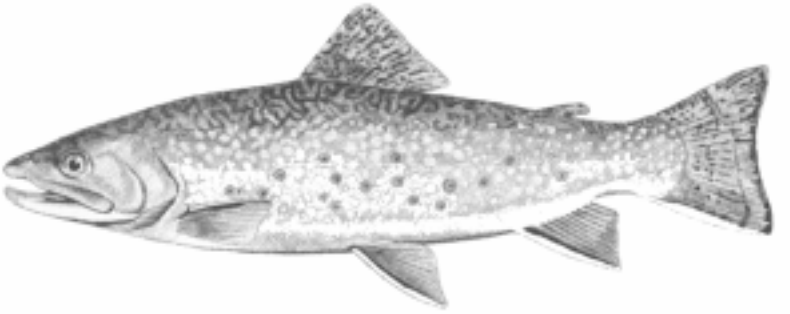
HABITS
Anadromous in the northern part of its range, but never in California. It was not anadromous here even before the construction of Shasta Dam.

[1] A 1978 revision to the taxonomy of the chars shows another species *(S. confluentus)* , the bull trout, also inhabited the McCloud River.

EASTERN BROOK TROUT

Salvelinus fontinalis **(Mitchill, 1815)**

(Introduced)



OTHER NAMES

Brook trout, speckled trout, speckled char.

RELATIONSHIPS

A char. Belongs to the salmon family, **Salmonidae.** It is most closely related to the other chars, less so to the trout.

DESCRIPTION

Anal rays about 9. Teeth on tip but not on shaft of vomer (page 49). Scales small, about 185—225 in first row above lateral line.

Color. Back is olive green, distinct wavy lines on back and dorsal fin. Yellowish white and usually red spots on sides. No black spots. Forward edges of anal and ventral fins are usually white. At spawning time there is a horizontal red-orange streak on the belly. A beautiful species. Males are the more brightly colored. Sea-run brook trout are silvery and tend to lose the red spots.

Size. The California record is 9 lb 12 oz, from Silver Lake, Mono County, on September 9, 1932. A 14½ fish was taken in Ontario, Canada, in 1916.

Juveniles have large parr marks, some of which may be a little wider toward the bottom (slightly pear-shaped). Two-inch fish have no wavy lines on the back and may have no pale spots on sides. By three inches they will have the spots and may have the wavy lines. At four inches they will usually have both.

DISTINGUISHING CHARACTERISTICS

Fish over 4 inches have distinct wavy lines on the back. Those over 2½ inches have pale spots on sides but not on back. No size has black spots.

DISTRIBUTION

Widely distributed in California but never anadromous here.

HABITS

In California it does best at altitudes above 5,000 ft. Sea-run strains are found only on the Atlantic Coast, where they are native.

King salmon climb the fishway from the American River into Nimbus Hatchery in front of an appreciative audience.

PINK SALMON

***Oncorhynchus* gorbuscha (Walbaum, 1792)**

SPAWNING MALE

SPAWNING FEMALE

OTHER NAMES

"Pink salmon" is a name used by canners to describe the flesh of this species. It is also called "humpback salmon", which aptly describes the spawning males.

RELATIONSHIPS

Belongs to the family **Salmonidae,** which also includes the trouts and chars. Its closest relatives are the other species of Pacific salmon.

DESCRIPTION

Anal rays 13—17. Gill rakers 24—35 on first arch. Scales smaller than in other salmon, 170—229 in first row above lateral line. Pyloric caeca 165—195.

Color. At sea the pink salmon is metallic blue above, silvery on sides and belly. It has large elongated black spots on tail and black blotches on body, the latter may disappear at spawning time. Males at spawning time develop an exaggerated hump between the head and the dorsal fin and

become reddish to yellowish on the sides. Females become olive green on the sides and do not develop the hump.

Size. Average weight at maturity is 3 to 5 lb but individuals up to 12 lb have been taken. This is the smallest of our salmon.

Juveniles. Pink salmon juveniles are the only salmonid juveniles which have no parr marks and no spots. They are deep blue to greenish on the back, and are noticeably more slender than trout juveniles. As on all juvenile salmonids the snout is rounded and slightly overhangs the lower jaw. Smelt also lack parr marks and have the adipose fin but the snout is more angular and does not overhang the lower jaw. Pink salmon migrate to sea at a very early age. At sea they soon develop scattered black spots on the upper half of the body.

DISTINGUISHING CHARACTERISTICS

The large, elongated black spots on the tail and the small scales (170— 229 in first row above lateral line) will identify this species. Fingerlings are easily distinguished by the absence of parr marks.

DISTRIBUTION

At sea, pink salmon have been taken from La Jolla, San Diego County, to northwestern Alaska and eastward along the Arctic coast to the Mackenzie River. The southernmost runs of any importance are in streams tributary to Puget Sound. There appear to be vestiges of runs in the Sacramento River and in the Russian River. Pinks have been recorded in several other California streams from Santa Cruz County north, but it is probable that these fish were strays.

HABITS

Pink and chum salmon are entirely dependent n an anadromous existence. There are no known landlocked strains of either. The eggs must be deposited where the water is fresh if they are to survive, and the growth must be in the ocean if the fish are to reproduce.

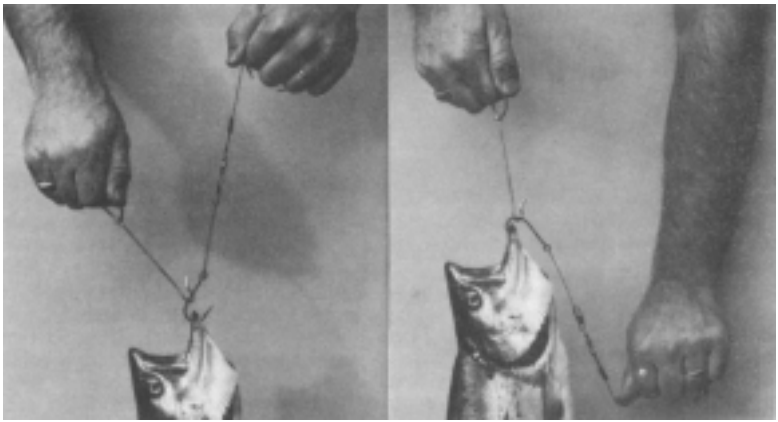
On the average, pink salmon probably migrate shorter distances into rivers than any other Pacific salmon. Some pinks even spawn in tidal areas of streams at low tide, where the gravel is covered by fresh water at low tide and by salt or brackish water at high tide. Nearly full strength ocean water (up to a salinity of about 30 parts per thousand) does reach the eggs, but is quickly washed away as the tide drops. Egg survival, at least in the upper half of the intertidal zone, appears to be fully as good as in fresh water. Although most pinks spawn within a few miles of salt water, there are some streams in which the travel considerable distances to reach spawning areas, such as those o[Babine Lake on

the upper Skeena River in British Columbia. In the Sacramento River system, pinks have been found in Battle Greek, which is over 200 miles from the ocean.

Pink salmon are unique in that all individuals mature at the end of their second year. It follows that any stream which supports an annual run thus supports two independent populations. In many streams, there is a large spawning run one year followed by a small one the next, and sometimes one run or the other is nonexistent. In North America the southernmost pink salmon fisheries of importance take these fish in large quantities only in odd-numbered years.

IMPORTANCE

The pink is the most abundant salmon in North America but in California it is of very minor importance. A few are taken by commercial fishermen and sportsmen, usually while they are looking for king or silver salmon. Most catches are made in odd-numbered years. By far the largest recorded catch in California was 30,000 in 1967. It can be assumed that the bulk of California's ocean-caught pinks come from farther north— our streams are not producing even the small numbers taken in our ocean catches.



You can make a hook releaser like this one out of coat hanger wire. When you wont to release an undersized salmon or some other fish:

1. Hook the releaser around the shank of the hook (left photo).
2. Pull down on the leader, thus turning the hook upside down (right photo).
3. Shake the fish off.

A gaff can be used to release fish this same way. Photos by author.

SILVER (COHO) SALMON

***Oncorhynchus kisutch* (Walbaum, 1792)**

OTHER NAMES

In California the "official" common name is "silver salmon". In the rest of the United States and in Canada it is "coho salmon". The California State Legislature had declared "silver" to be official before there was general agreement elsewhere, and that name appears in various Fish and Game Code sections.

RELATIONSHIPS

A member of the salmon family, **Salmonidae.** Most closely related to the other Pacific salmons, all of which are also in the genus *Oncorhynchus.* Less closely related to the genus *Salmo,* which includes trout and the Atlantic salmon.

DESCRIPTION

Anal rays 13—16. Gill rakers rough, 19—25 on first arch. Caudal peduncle averages a little thicker than in other salmon. Scales in first row above the lateral line 120—145. Pyloric caecae 45—83. At spawning time the upper jaw of the male becomes enlarged and distorted, often being curved under to form a hook.

Color. At sea it is metallic blue or blue green above, becoming silvery on sides and belly. There are small black spots on the back, dorsal fin, and the upper lobe of the tail. The lining of the mouth is dark (less so than in the king salmon), but the crown of the gums where the teeth project is much paler, thus forming a whitish strip through which the teeth project. At spawning time the mature males become brick red or even a brighter red and the females a dull bronze.

Size. The average weight at spawning time is *7* to 12 lb and individuals over 15 lb are uncommon. The record anadromous fish was one of 31 lb taken in Cowichan Bay, British Columbia, in October 1947. A 33-lb landlocked individual was taken in Michigan in October 1970. The largest recorded in a California stream was 22 lb and was taken in Papermill Creek, Marin County, in January 1959. Some salmon reported as "record-breaking silvers" have turned out to be kings.

Juveniles. Back brownish to brownish orange (bronzy). Sides and belly with a brassy sheen. Fins unspotted and usually tinged with orange. Parr marks high, narrow, and divided roughly in half by the lateral line. The space between parr marks is usually slightly wider than the marks themselves. The first three rays of the anal fin are usually longer than the remainder, especially on smaller juveniles. This gives the fin a concave rear edge. First anal ray is usually white. Adipose fin usually finely speckled to give it a uniform gray shading, rarely with a darker margin around the tip. Dorsal fin usually unspotted but 5-inch fish may show spots and 7-inch individuals usually will. Except for hatchery fish, 7-inch silvers are rare in fresh water. Yearlings (about 5 inches long) have usually lost much of the distinctive brown and orange coloration and some may be hard to distinguish from king salmon. As a last resort, count the pyloric caeca. Silvers have fewer than 90.

DISTINGUISHING CHARACTERISTICS

The presence of black spots on the back, dorsal fin, and upper lobe of tail will separate it from the chum and sockeye salmon; the low pyloric caeca count (45—83) will separate it from any salmon except the sockeye. The white gum line (through which the teeth project) will separate it from the king salmon. Small fingerlings can often be distinguished in the stream by their high, narrow parr marks, brownish or bronzy bodies, and orange-tinged fins. Yearlings (about 5 inches) have usually lost much of the coloring but retain the high, narrow parr marks.

DISTRIBUTION

Silver salmon have been taken in the ocean from about 100 nautical miles south of the Mexican line north to the Bering Sea and south along the Asiatic coast to Japan. The species is rare south of Monterey. It spawns in coastal streams from the northern part of Monterey Bay northward.

Before 1956, silver salmon were absent from the Sacramento-San Joaquin River system except as rare strays. Attempts to establish the species in the Sacramento drainage were started in 1956. Hatchery fish returned in large numbers and spawned naturally, but were not able to maintain a natural run, and the species is again rare in the Sacramento, though not as rare as formerly. They do not enter the San Joaquin system.

HABITS

Silver salmon very rarely establish landlocked populations but the ones in the Great Lakes have been such a resounding success that they disguise that fact. A far more typical result of planting silver salmon in reservoirs or landlocked lakes is to have the young grow, provide good fishing, then mature and spawn with a total lack of success.

The spawning habits of silvers are quite similar to those of king salmon (page 76). Silvers prefer somewhat smaller streams, but many areas are used by both species. Young silver salmon prefer small tributaries and in some places they will actively migrate upstream into such streams.

Young silvers usually enter the ocean when about 5 or 6 inches long and a little over a year old; a few wait another year but in general these are ones which had poor feeding and are about the size of a normal yearling.

Because silver salmon must stay at least a year in fresh water, they are unable to survive in waters which get too warm for them in the summer. Temperatures over 70 F are detrimental to salmon and 80 F is quickly lethal. Summer temperatures in most Sacramento and San Joaquin Valley streams used to be much too warm for salmonids. Since the construction of storage dams, cooler waters have been released into some streams during the summer. In spite of this apparent improvement in habitat, silver salmon have not been able to maintain their numbers in valley streams even though substantial numbers have been planted there (see **DISTRIBUTION**, above).

Silver salmon enter the streams in the fall and early winter, shortly before spawning. There are none which remain several months in fresh water before spawning. Migration into individual streams depends to a large extent on the time when fall rains make it possible for silvers to start their migration. Many small California coastal streams have a sandbar across the mouth until after the first fall rains. In general, the period from October into February covers the time of migration and spawning in most California streams.

Age at maturity. A number of male silver salmon mature at about two years (and at about 2 pounds). In California nearly all of the remainder mature at the end of their third year. The few four-year-olds are fish that spent their first two years in fresh water.

IMPORTANCE AND INTERESTING FACTS

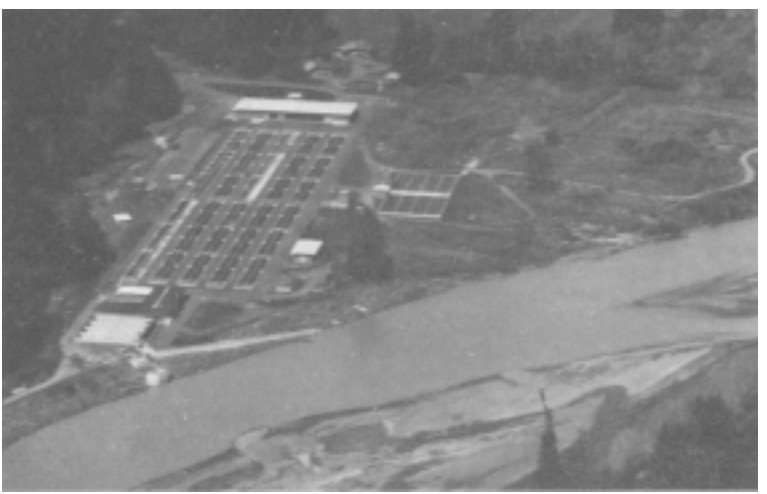
In California the silver salmon ranks second to the king but along the entire Pacific Coast it is taken in larger numbers than the king by both commercial fishermen and sportsmen. Coastwide it is probably first as a sport salmon, but commercially it is fourth, behind the pink, sockeye, and chum.

Before 1963, silver salmon usually made up 10% or less of the total California ocean salmon catch. Starring in 1963, there was a rapid increase in silver catches, which peaked in 1966 and 1967 and reached 50% of the catch; after that there was a decline, but in 1971 catches were back almost to the 1966—67 level. Much of the increase in silver salmon catches in California appears to be due to a large hatchery and management program in Oregon and Washington. Most silver salmon caught in California come from Oregon and Washington streams. This was true both before and after the increase started in 1963. The northern silvers are present in California waters in numbers in the spring and early summer. By August they are leaving and in September or later any silver salmon taken in California was probably born there.

A typical silver salmon grows very rapidly in its third and last year of life. In April and May there are few which measure more than 25 inches total length (the commercial size limit in California) but by July the average is up to 27 inches and very few are under 26 inches. Most of California's commercial silver salmon harvest is of necessity from mid June to early August. Before that period silvers are too small; after it, most of them have left the State.

The sport size limit is smaller than the commercial, so, in theory, sportsmen could take silvers earlier in the year. In practice there is not much sport salmon fishing before summer from Fort Bragg northward, and in most years there are not many silvers taken from San Francisco southward at any time. Sportsmen also have the opportunity to take silver salmon late in the season when the fish are entering the streams.

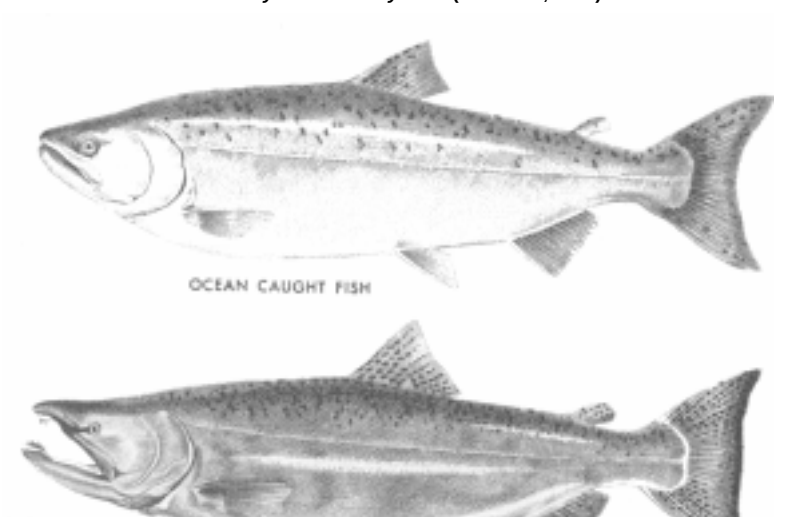
Silver salmon can be hatchery reared with good results. The young normally live about 14 months in a stream before migrating to sea. If this time is spent in a hatchery the losses are quite low. The fish can then be turned into the stream when they are ready to migrate. If this is done they quickly migrate to sea. If planted too soon they must feed for some time in the stream and may seriously overcrowd it. Such overcrowding can result in serious losses of both planted and wild fish.



Mad River Hatchery near Blue Lake, Humboldt County. Steelhead, coho salmon, and chinook salmon are raised here. *Photo by C.S. Kabel.*

KING (CHINOOK) SALMON

***Oncorhynchus tshawytscha* (Walbaum, 1792)**



SPAWNING MALE

OTHER NAMES

This species has a confusing number of common names. King salmon is official in California but chinook is official elsewhere in the United States and in Canada. Spring, tyee, blackmouth, and quinnat have all had wide use. Quinnat has general acceptance in New Zealand.

RELATIONSHIPS

Belongs to the salmon family, **Salmonidae,** which also includes the trouts and chars. Its closest relatives are the other species of Pacific salmon.

DESCRIPTION

Anal rays 13—19. Gill rakers on first arch 18—30, rough, and widely spaced. Scales in first row above lateral line 140—153. Pyloric caeca 140—185. Jaws and teeth of males become larger at spawning time and the jaws may be somewhat distorted (less so than the jaws of the silver salmon).

Color. At sea the king is bluish to gray on the back and silvery on the sides and belly. Numerous black spots on back and dorsal fin and usually on both lobes of the tail. The spots on the back are sharply

defined; the area under a scale is usually all black or contains no black at all. Characteristically a spot includes two to several scales in one diagonal line and may turn and include a scale or two on the other diagonal. The lining of the mouth is dark and there is no lighter area on the gums next to the teeth. When they enter fresh water, king salmon gradually lose their silvery color and turn darker. Females turn blackish. Males, especially the larger ones, often have blotchy, dull red sides. Smaller males tend toward dull yellow rather than red.

Size and **Age.** Average weight at spawning time is about 20 lb (less in the Klamath); some exceed 50 lb and the record is a 127-lb individual that was taken in a trap in Alaska. The California record is 85 lb, Feather River, October 1935. King salmon taken in the ocean are immature and average smaller than mature fish which have entered the rivers to spawn.

The greater part of California king salmon mature when three or four years old. Five-year-olds are much less common, sixes are rare, and sevens are almost unknown in California although they do occur farther north. Large numbers of precocious males (called "jacks", "chubs", or "grilse") mature at two years of age; these fish weigh about 3 lb. Relatively few females mature at this size and age. Male grilse of undetermined age and weighing less than a pound have been taken.

Juveniles. The back has little or none of the brownish color of silver salmon. Sides silvery. Fins clear or slightly greyish. Parr marks tall, oval, and approximately bisected by the lateral line. Parr marks usually wider than the spaces between. First 2 or 3 rays of anal fin *not* long enough to give the fin a strongly concave edge. Adipose fin usually with a dusky or black margin around the tip. The remainder of the fin may be clear (usually on the smallest fish), finely speckled with a clear area, or finely speckled throughout. On juveniles under 4 inches the dorsal fin may be shaded or may have some black on the margin. It is usually unspotted but may have a single small black spot at its forward edge next to the body. In fresh water juveniles of 5 inches may show a faint spotting and the relatively uncommon 7-inch individuals usually have heavily spotted dorsals. Pyloric caeca more than 100. (This count is difficult and usually unnecessary.)

King salmon in California usually migrate to sea when a few months old and under 4 inches long, In streams that remain cool all summer some kings may remain and migrate to sea in the fall or even in the following spring.

DISTINGUISHING CHARACTERISTICS

Numerous black spots on back, dorsal fin, and both lobes of the caudal fin plus a relatively low scale count (140—153 in first row above lateral line) will usually separate the king from any other salmon. If any doubt remains, the blackish pigment in the mouth extending clear to the bases of he teeth or the high pyloric caeca count (140—185) will separate it from he silver salmon. King salmon juveniles can usually be easily identified y the high, wide, and oval parr marks, plus the silvery color, and dark margin on the tip of the adipose fin.

DISTRIBUTION

In the ocean king salmon are found from San Diego north to the Bering Sea, and south on the Asiatic coast to Japan. Abundant from Monterey northward. Enters large streams and occasionally small ones from San Francisco northward. Once. in fresh water it may enter some astonishingly small tributaries.

California's largest spawning populations are in the Sacramento-San Joaquin River system. The species is also abundant in the Klamath, Smith, and Eel River systems. Smaller runs occur in Redwood Creek, Mad River, Mattole River, and some other coastal streams. This species avoids most of the smaller coastal streams. A small run in the Garcia River appears to be extinct and is not shown on the distribution map. Kings have been planted in the Russian River and good numbers of adults are returning but it is to soon to know whether natural reproduction will be able to maintain the run. The run into the San Joaquin River below Friant Dam has been reduced to near zero and occurs only in occasional wet years, when there is an adequate flow below Friant. It is not shown on the map.

HABITS

King salmon are very strongly anadromous.

Self maintaining landlocked populations arc very rare. When kings are planted in a lake or reservoir they sometimes survive and grow very well but usually fail to reproduce with enough success to maintain a population. There is no self-maintaining population of landlocked kings in California, but strangely there are at least two such populations in New Zealand lakes. New Zealand kings are descended from Sacramento River ancestors. The "landlocked" ones definitely have the opportunity to go to sea, but elect to remain in fresh water. These landlocked kings are much smaller than anadromous individuals—3 or 4 lb seems to be the usual size of a mature landlocked fish. To the best of our knowledge only one self-sustaining population of landlocked kings exists in North America. This is in Lake Cushman, a reservoir in Washington. Apparently these fish mature in the vicinity of 8-40 lb—larger than those in New Zealand but smaller than anadromous kings. After several earlier failures large numbers of kings were planted in streams tributary to the Great Lakes in 1967. They have matured at large sizes and in large numbers but it is too early to determine the success or failure of their reproduction.

Spawning. King salmon spawn in cool or cold streams where there is a gravel bottom. They prefer gravel in which most of the larger rocks are about 6 inches in diameter or a little smaller. The preferred spawning area is the lower end of a pool where the water is beginning to pick up speed, just above a riffle; riffles themselves and long glides are also used.

At spawning time a female selects a spot and digs a nest. To do this she rolls on her side on the bottom and with a swimming or pumping motion moves the gravel downstream, and leaves a pit in which she deposits some eggs which are immediately fertilized by a waiting male. The female then moves upstream a short distance and resumes her digging, thus covering her previously deposited eggs and extending the nest farther upstream. More eggs are deposited and the process repeated until she is spawned out. After spawning, all *adult* Pacific salmon die, whether they are male or female. A few may last a week, or even two, but none lives to spawn again. The only kings which survive spawning are a few precocious males which ripen and spawn at a length of a few inches, before they have gone to sea.

King salmon in California are all stream spawners, but lake spawning has been reported farther north. The fish are reported to select a gravel bottom and dig a nest as they do in the streams.

Eggs hatch in 50 to 60 days at California temperatures, and in the next 3 or 4 weeks the young wriggle up through the gravel to the water above. When newly hatched, the young have a large pinkish yolk sac which gives them a tadpole-like shape. They live off this yolk until it is absorbed and then start feeding on minute forms of life in the stream.

In California most young king salmon migrate to the ocean in their first few months of life. A small percentage wait in the stream till they are over a year old before migrating. Such fish are often taken by trout fishermen, many of whom assume the fish are trout. North of California somewhat more kings migrate as yearlings.

In the ocean, many king salmon apparently stay relatively close to the mouth of the river in which they were spawned, but many others migrate long distances. Salmon from the Sacramento River move down California's coast in quantity to Monterey Bay and smaller numbers will travel another hundred miles south. Good numbers move as far north as the northern part of the State of Washington, with relatively smaller numbers going clear to Vancouver Island, Canada. Of the salmon taken in the vicinity of the Golden Gate, over 90% are fish from the Sacramento-San Joaquin River system. Farther north the percentage drops off, but even in the northern part of California more than half of the kings taken in the commercial catch are Sacramento fish.

When a salmon approaches maturity, it returns to the stream from which it migrated to the ocean. Relatively few salmon will ascend any other river system. "Straying" into the wrong tributary is somewhat more common, and it has been demonstrated in the Central Valley of California that salmon which are bound for one tributary will ascend another if their home stream is not accessible to them.

In exceptionally wet years some kings will leave their regular spawning stream and enter small tributaries which are not ordinarily large enough to accommodate them. This habit leads to the appearance of kings in some strange places.

Most king salmon migrate into fresh water in the fall; the exact time varies from river to river. Fall-run salmon normally enter a stream late enough so that a suitable supply of cool water is available for spawning. Spawning is usually between October and January.

Some king salmon enter rivers in the spring. These spring-run fish move upstream until they find a cool area, where they remain throughout the summer to spawn in the fall. Time of the spring run corresponds with the snow melt and spring runoff, which provide fish an ample supply of cold water in which to reach the upper parts of a stream. In streams which are too warm for salmon during the summer there is no spring run, but there may be a good fall run of fish which enter after the water has cooled.

In the past, spring-run salmon were able to go far enough up their spawning streams to be assured of cool water during the summer. Dam construction has blocked many such streams and confined the spring-run salmon to the lower and warmer areas. If the summer flows are greatly reduced the water is apt to reach temperatures lethal to salmon. California has lost most of its runs of spring-run salmon through such chains of events.

In the Sacramento river system, in addition to fall- and spring-run fish, there are late-fall and winter runs of king salmon. Late-fall-run fish begin arriving in the upper river, near Red Bluff, during November and spawn from January through early April. Winter-run fish begin arriving in the upper river in January and spawn from the middle of April through early July.

Before the construction of Shasta Dam the winter run was very small and spawning appears to have been confined to the McCloud River. The dam cut these fish off from their ancestral home, but provided a large flow of cool water through the summer. Somehow a few winter-run salmon survived the period of dam construction and their descendants adapted to the downstream area. The run has increased from a few hundred fish to about 60,000 and provides excellent fishing.

IMPORTANCE AND INTERESTING FACTS

The king salmon is California's most important salmon to both the sportsman and the commercial fisherman, but on the entire Pacific Coast of North America it ranks last in commercial salmon landings and is probably second in sport catches.

Before 1963 the salmon catch of California was usually over 90% kings. Silver salmon are now taken in much larger numbers than formerly but kings still dominate the fishery.

All commercial salmon fishing in California is by trolling. A typical salmon boat is 30 to 45 ft long and fishes with six stainless steel lines, each weighted with up to 50 lb of lead and carrying four or more hooks. Spoons, plugs, or bait are used. Power gurdies arc used to pull the lines. Much smaller boats are fished commercially by men who are salmon fishing to help finance a vacation.

Formerly there was gill net fishing for salmon in several rivers. The last net fishery (in the Sacramento-San Joaquin River system) was closed by the Legislature in 1957.

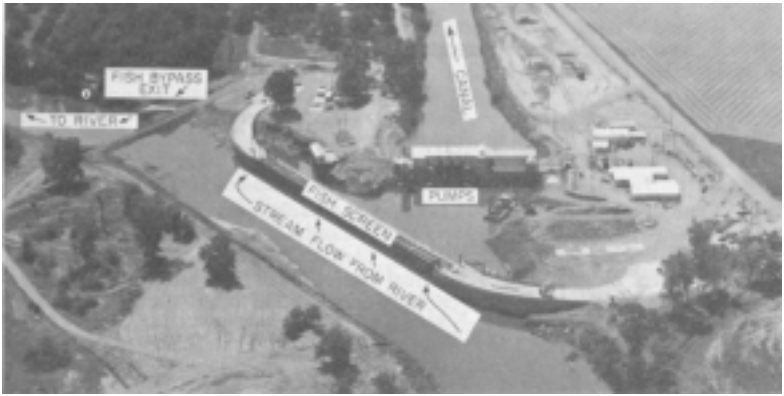
Sport fishing in the ocean is also by trolling. Sinkers of 1 to 3 lb or diving devices arc used to keep the bait or lure at the proper depth. A release mechanism drops the sinker when a heavy fish hits.

Both private boats and party boats are used for salmon fishing. The largest part of the salmon partyboat fleet fishes out of San Francisco Bay ports. The boats are operated by men who know their business and show their passengers how to catch salmon.

In the rivers when salmon are biting well they are pursued by hordes of anglers fishing from shore and boat. The latter are usually more successful. At the mouth of the Smith River the boats line up and anchor side by side in rows that extend almost across the river. Lures are kept in motion by the outgoing tide. Heavy tackle is a must but even when it is used a fish is apt to tangle several lines. The best fishing is for king salmon and is in late September and October.

Anchoring at the mouth of the Klamath used to be exceedingly popular but has been prohibited. Formerly an occasional boat was swept into the surf and its occupants drowned. The Coast Guard struggled with the problem for years and finally decided the best solution was a ban on all anchoring at the mouth. At present many anglers fish there by keeping the boat motor running just fast enough to hold a fixed position in the channel; many others troll in a more normal manner farther upstream. The best fishing is for king salmon and is in August and September.

In the Sacramento River system most salmon are taken above Sacramento and there are very few caught below the Delta. Fishing is best from October through March. There are numerous boat rentals in the upstream areas.



The 475-foot-long Glenn-Colusa Fish Screen at the entrance to the largest irrigation canal leading from the Sacramento River. Huge numbers of juvenile chinook salmon pass by here during the irrigation season. *Photo by C.S. Kabel.*

CHUM SALMON

***Oncorhynchus keta* (Walbaum, 1792)**

OTHER NAMES

The official common name, chum salmon, is well accepted but the species is also known as “dog salmon”. Two possible reasons for this name have been suggested. In some northern areas its chief use is as food for sled dogs. Males at spawning time develop large “dog-like” teeth (but so do males of some of the other species).

RELATIONSHIPS

Belongs to the family **Salmonidae,** which includes trouts, chars, and the other species of Pacific salmon.

DESCRIPTION

Anal rays 13—17. Scales in the first row above the lateral line 130—153. (This will not separate it from any salmon except the pink.) Gill rakers on first arch 18—26, short, smooth, and widely spaced. Pyloric caeca 140-186.

Color. Sea-run fish are metallic blue on the back, with fine black specklings but no black spots. Pectoral, anal, and caudal fins may be dusky at tip, especially on males. Fish in spawning condition are blackish on the back, and their sides have irregular vertical blotchy bars of reddish or blackish with paler dull greenish spaces between. Males have more contrasting colors and develop large canine teeth.

Size. Chums up to 33 lb have been taken, but 10—15 lb is typical.

Juveniles. Chum juveniles are quite slender. They migrate to sea at an early age, so large ones are not encountered in fresh water. Parr marks are largely confined to the area above the lateral line and some tend to have rather indistinct edges. Back dark mottled green, sides with a greenish sheen.

DISTINGUISHING CHARACTERISTICS

This species and the sockeye are the only two salmon which have no black spots other than fine specklings. The chum has 18—26 short, smooth, gill rakers while the sockeye has 28—40 long, slender, rough ones. At spawning time the blotchy vertical bars on the sides are characteristic. Fingerling chums can be identified by their mottled green backs, a greenish sheen on the sides, and parr marks almost entirely above the lateral line.

DISTRIBUTION

At sea, chum salmon have been taken from southern California (lower San Diego Bay near Chula Vista) to northwestern Alaska, and south on the Asiatic side to Kamchatka. They are rare off California and abundant off Canada and Alaska, In California they have been reported from as far south as the San Lorenzo River Santa Cruz County) but the only known regular spawning run is a very small one in the Sacramento River.

HABITS

All chum salmon are anadromous. There are no known landlocked populations anywhere. Most chum salmon spawn close to the ocean and some even spawn at the mouths of streams in gravel beds which are covered by fresh water at low tide and by salt water at high tide. The eggs are submerged in salt water for a part of the tidal cycle. Egg survival is good. By way of contrast, there are streams in which the chums migrate long distances from the ocean. Some chums in the Sacramento River go more than 200 miles upstream and some in the Yukon River go 2,000.

Most chum salmon start their seaward migration soon after emerging from the gravel. All have left by late spring or early summer. Chums travel long distances at sea and their food consists largely of free-swimming crustaceans. They usually mature in three or four years; some take five.

IMPORTANCE

In North America, the chum is usually the third most important species commercially; it ranks behind the pink and the sockeye. It is usually taken by purse seines or gill nets. It seldom takes a hook and is of little interest to the angler or the commercial troller. In California, they are so seldom seen that they are of no importance to sportsmen or commercial fishermen. When taken at sea, chums can be good quality fish, but they deteriorate rapidly as spawning time approaches.

SOCKEYE SALMON

***Oncorhynchus nerka* (Walbaum, 1792)**

OTHER NAMES

Throughout the Pacific Coast, sockeye salmon is the official common name of the anadromous form of this fish, hut "red salmon" and "blueback salmon" are often used. The landlocked subspecies, 0. *nerka kennerlyi*, is nearly always called "kokanee" in California but has additional names in more northern waters.

RELATIONSHIPS

Belongs to the family **Salmonidae,** which includes trouts, chars, and the other species of Pacific salmon.

DESCRIPTION

Anal rays 13—18. Spawning males have the teeth well enlarged and jaws strongly hooked. Scales in first row above lateral line 125—145. Gill rakers on first arch 28-40. Pyloric caecae 60—115 (fewer than in any salmon except the silver).

Color. Sea-run fish are a metallic blue-green on the back, and silvery on sides and belly. There are fine black specklings on the back, but no black spots on mature fish; partly grown individuals may have some. Spawning males have a green head and a bright red body. Spawning females are similar but the body is a darker blotched red.

Size: to about 15 lb but usually 5 to 8 lb.

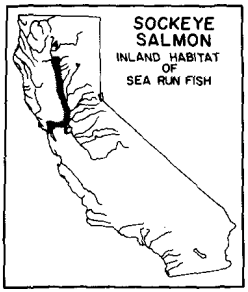
Juveniles. Parr marks are uniformly spaced, relatively small, and largely or entirely above the lateral line. Sides silvery, back olive to grassy green, not mottled. (Chum salmon juveniles are similar but are mottled on the back, and show a green sheen on the sides.)

DISTINGUISHING CHARACTERISTICS

Any salmon with 28 or more gill rakers on first arch is this species (Count the small rakers at each end of the arch). Juveniles with parr marks scarcely extending below the lateral line *and* with no mottling on the back are this species.

DISTRIBUTION

Sockeye salmon are found at sea from southern California (Los Angeles-Long Beach H arbor) to the northern part of the Bering Sea and south to the Kamchatka Peninsula on the Asiatic side. In North American streams they have been reported from the Sacramento River north to the Yukon, but are abundant only from the Columbia River to the southern part of the Bering Sea (Bristol Bay). They are tare in California. The only known anadromous "run" in the State is a minute one in the Sacramento River. Jordan and Evermann (1896—1900) mention the Klamath River as the southernmost stream used by the species, but since 1917 there has been only one sockeye recorded from the Klamath. Most sockeye ascend streams from which it is possible for them to enter lakes. Before the construction of Copco Dam in 1917, salmon could reach Klamath Lake (Oregon) via the Klamath River, and the river system may have supported a sockeye run.



HABITS

More than any other salmon the sockeyes have retained their ancestral trout-like ability to survive and reproduce without ever entering salt water, They are the only Pacific salmon with a large number of landlocked populations.

Although landlocked sockeye are far more numerous and widespread than any other landlocked Pacific salmon, they are far outnumbered by the sea-running individuals of their species.

Landlocked sockeye are of two types: the kokanee, which is regarded as a distinct subspecies, and the so-called residual sockeyes, at least some of which have anadromous parents, but remain in fresh water while their siblings migrate to sea.

When they leave the ocean on their spawning migration most mature sockeyes move upstream until they are close to a lake. Some swim through the lake and spawn in a tributary' stream above it, some spawn in the lake on gravel bottoms near shore, and some spawn in streams a short distance downstream from a lake. Relatively few spawn in streams such as the Sacramento River, where no lakes are available to them. A few of the young migrate to sea soon after emerging from the gravel, but the majority spend one to three years in a lake before starting on their seaward migration. Those which hatch upstream from a lake drop downstream into it, those which hatch in the lake remain there,

and those which hatch below the lake work their way upstream and into it.

When in the lake young sockeyes are plankton feeders; they subsist mainly on small free-swimming crustaceans. In British Columbia most of the young migrate to sea as yearlings averaging about 3¼ inches long. Farther north there is a higher proportion of 2- and 3-year-old migrants.

In the ocean, sockeye feed primarily on plankton (again free-swimming crustaceans are the most important items)but some squid, small fish, and other items are taken.

IMPORTANCE

In North America, sockeye are the second most abundant species. They are canned in huge quantities and make a very valuable pack because of the rich, red flesh. Most of the commercial catch is made with gill nets and purse seines. Commercial trollers and sportsmen take few. Because of their plankton feeding habits sockeye do not take a hook readily. In California, sea-run sockeye are so rare that they are of no importance whatever to either commercial fishermen or sportsmen, but kokanee do support sport fisheries in a good number of lakes and reservoirs.

Dipnetting eulachon on Redwood Creek, Humboldt County. Many fishermen use larger dipnets. *Photo by Don A. LaFaunce.*

THE SMELT FAMILY

Osmeridae

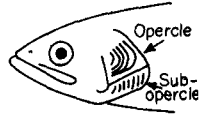
The smelts form a family of relatively small fishes which are related to the salmonids, and resemble them in enough ways so that at one time they were placed in the same family. Some of the most obvious resemblances are that both groups have thin cycloid [1] scales, an adipose fin, and no spines in the fins. Smelts differ from salmonids in having no fleshy appendage at the base of the ventral fin.

Smelts tend to gather in large schools, are relatively easily caught by larger fishes and human beings, and are excellent food fishes. Spawning is usually in relatively shallow water over fine gravel or coarse sand. The eggs sink to the bottom and adhere to pebbles or sand grains. Ten species are recognized (McAllister, 1963). They are found in arctic and subarctic waters of the Northern Hemisphere in lakes and streams, and in marine waters of the continental shelf (waters less than 600 feet deep). The southernmost forms reach southern California. Some are marine, some anadromous, and some freshwater. Of the 10 known species, 6 have been found in California, and of these 6, 3 are marine and 3 anadromous. One species is represented by 2 subspecies—one American and the other Japanese. The Japanese subspecies has been introduced into several inland waters in California, where it is now landlocked.

Four members of the silverside family **(Atherinidae)** occur in California and two are commonly called "smelt", although they are not closely related to the true smelts. These are the jacksmelt, *Atherinopsis californiensis,* and the topsmelt, *Atherinops affinis.* Both are native and marine. The other 2 members of the family are the California grunion, *Leuresthes tenuis* (native and marine) and the Mississippi silverside, *Menidia audens,* introduced and freshwater. Some obvious differences: silversides have much smaller mouths, they lack the adipose fin possessed by all true smelts, but they have 2 short dorsal fins, the first of weak spines, the second of rays. True smelt lack the spines.

[1] **Cycloid scales have concentric ridges (circuli) but do not have a cluster of small points ("teeth") near their posterior edge.**

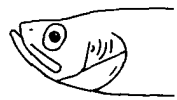
Characters being described	Alternate choice	Description
1	(8)	Mouth moderately large. Maxillary reaches to or beyond rear edge of pupil of eye (with mouth closed).
2	(3)	Strong concentric striae (fine lines) on opercle *and* subopercle. Gill rakers on upper half of first arch 4–6. **Eulachon,** *Thaleichthys pacificus.* Page 89.



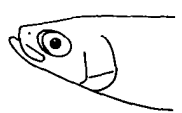
Eulachon

Large mouth, strong striae on opercle and subopercle.

Characters being described	Alternate choice	Description
3	(2)	Striae on opercle and subopercle few or none, weak. More than 6 gill rakers on upper half of first arch.
4	(5)	Vomer with an enlarged canine tooth on midline. Pyloric caeca 0–1. Pectoral fin short, extending half to ⅔ of the distance to the ventral fin base. **Whitebait smelt,** *Allosmerus elongatus,* a marine species, not described in this paper.
5	(4)	Vomer without enlarged canine tooth. Pyloric caeca 4–8. Pectoral fin reaches more than ⅔ of distance to anal fin base.
6	(7)	Pectoral fin long, measures 84 to 128% of the distance to ventral fin base. Longest rays of anal fin 45 to 70% of the distance to ventral fin base. **Longfin smelt,** *Spirinchus thaleichthys.* Page 87.
7	(6)	Pectoral fin intermediate in length, reaches 72–84% of the distance to ventral fin base. Longest rays of anal fin 32–40% of head length. **Night smelt,** *Spirinchus starksi,* a marine species, not described in this paper.
8	(1)	Mouth small. Maxillary does not reach past center of pupil.
9	(10)	Scales large, 41–48 along midline of side. Longest anal rays 29–39% of head length. **Surf smelt,** *Hypomesus pretiosus,* a marine species not described in this paper.
10	(9)	Scales smaller. 53–60 along midline. Longest anal rays 44–50% of head length. **Delta smelt,** *Hypomesus transpacificus transpacificus,* or **pond smelt,** *H. t. nipponensis.* Page 91.



Longfin Smelt
Large mouth, striae few and weak.



Delta Smelt
Small mouth, no striae.

LONGFIN SMELT
(Sacramento smelt)
***Spirinchus thaleichthys* (Ayres, 1860)**

OTHER NAMES
At one time this species was known as the Sacramento smelt in the Sacramento San Joaquin River system and as the longfln smelt in other areas. The Sacramento form was considered to be a different species. When it was concluded that only one species was involved, the name “Sacramento smelt” was dropped.

RELATIONSHIPS
Belongs to the smelt family, **Osmeridae.** Its closest relative is the night smelt, *Spirinchus starksi,* a marine species which spawns in the surf at night off sandy beaches from central California northward.

DESCRIPTION
See also under **SMELT FAMILY** (page 85).

Mouth large, maxillary reaches to rear edge of pupil or beyond. Maxillary and lower profile of head curve upward, giving the fish a blunt snout. Teeth small, none enlarged. Striae on subopercle 0—3, not concentric. Sometimes has weak concentric striae on opercle. Gill rakers on upper half of first arch 10-13. Pectoral fins measure 84—128% of the distance to the base of the ventral fins. Anal fins measure 45—70% of head length. Rays of dorsal and anal fins, and first rays of pectoral and ventral fins, are larger and stiffer in males. Scales along middle of side 54—63. Lateral line incomplete; only the first 14—21 lateral line scales have pores. This may be hard to determine if the fish has lost many scales. Pyloric caeca 4—6.

Color. Back light greenish brown with black speckling. Sides and belly silvery.

Length: to 6 or 7 inches.

DISTINGUISHING CHARACTERISTICS
Any California smelt with the pectoral fins reaching more than 84% of the way to the base of the ventral fins is this species. (Usually the pectorals reach past the base of the ventrals.) The mouth is large and the lower profile curves upward.

DISTRIBUTION

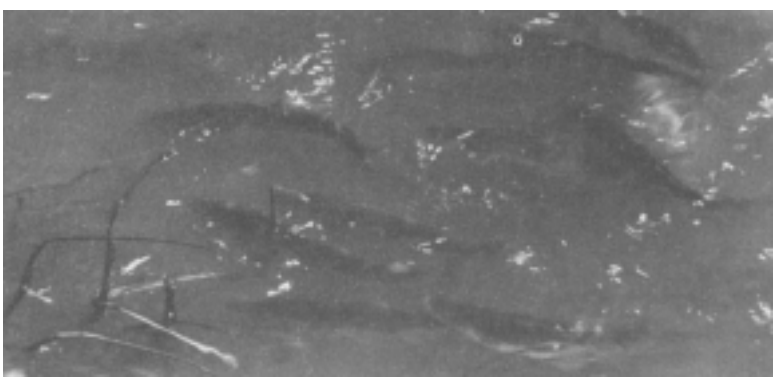
At sea from San Francisco north to Prince William Sound, Alaska. In California it has been reported in the San Francisco Bay complex and the Sacramento-San Joaquin Delta, in the lower Eel River, Humboldt Bay, and Smith River.

HABITS

The longfin smelt appears to be rather weakly anadromous. In the Sacramento-San Joaquin River system it migrates from the San Francisco Bay complex into the Delta during the winter and spawns in midwinter and early spring. It does not appear to move upstream above the Delta. Young longfin smelt averaging less than 1 inch nay be found in the western Delta in January and February. Generally, they occur downstream as far is Carquinez Strait by mid-May. By the following March, this same group is sexually mature and averages about 4 inches in length. At that time, no older group appears to be present. Hence, these fish apparently do not survive to spawn a second time.

IMPORTANCE AND INTERESTING FACTS

Occasionally marketed as "whitebait", but most of the whitebait catch is a related species. Of some importance as a forage species for larger game fishes. Some sportsmen fishing in the Eel River estuary found these fish could be taken in numbers by fly fishing with a minute trout fly.



Eulachon on a spawning migration in Redwood Creek. ***Photo by Don A. LaFaunce.***

EULACHON

***Thaleichthys pacificus* (Richardson, 1836)**

OTHER NAMES

Eulachon is now official wherever the species occurs. The name is of Indian origin and various other spellings have been used. “Candlefish” has also received wide use (see under **“IMPORTANCE AND INTERESTING FACTS”** below).

RELATIONSHIPS

Belongs to the smelt family, **Osmeridae,** along with the delta smelt, the longfin smelt, and three marine smelts found in California.

DESCRIPTION

See also under **"SMELT FAMILY"** (page 85).

Mouth moderately large; maxillary extends beyond rear edge of pupil. Maxillary and lower profile straight (not curved upwards). Teeth small and pointed; vomer with two moderate canines. Spawners, especially males, tend to lose their teeth. Strong striae in a concentric pattern on both opercle and subopercle. Gill rakers on upper half of first arch 4—6. Pectoral fin extends about ⅔ of distance to ventral fin base. Scales along lateral line 70-78. Lateral line complete; i.e., all lateral line scales have a pore. This may be hard to determine if the fish has lost many scales. Pyloric caecae 8—11.

Color: back blue gray with some fine black speckling; sides and belly silvery.

Size: to 12 inches, but anything over 8 inches in length is large.

DISTINGUISHING CHARACTERISTICS

Can be distinguished by the strong striae in concentric patterns on both the opercle and subopercle, or by the low number of gill rakers on the upper half of the first arch (4—6), or by the complete lateral line (all scales with pores).

DISTRIBUTION

Has been found at sea from off Bodega Bay, California, to the Bering Sea; in fresh water from the Gualala River: California, northward. The Klamath River has California's largest run.

HABITS

This species is strongly anadromous in that it goes from the ocean at least far enough upstream in fresh water to find clean bottoms of coarse sand. In the Columbia River system there is heavy spawning in the tributaries, much of it is more than 50 miles from the ocean. In the Klamath River, eulachon are known to go 25 miles upstream and may go farther. In California the spawning runs are mostly in March and April. The eggs are laid in flowing water over coarse sand. They have a double outer membrane, the outer layer of which ruptures and becomes partly detached. The torn edges of the outer layer are very adhesive, and stick to grains of sand or whatever else they may contact, thus anchoring the egg. The newly hatched young are about ¼ -inch long and are feeble swimmers. Apparently they are soon carried to sea by currents. In British Columbia most eulachon return to spawn when two years old; a few are three. Most die after spawning and few, if any, live to spawn a second time. The average female produces about 25,000 eggs. At sea, the little evidence available shows that eulachon feed on euphasiids; these are small, free-swimming, shrimp-like crustaceans. Presumably, other forms of animal plankton are taken at times.

IMPORTANCE AND INTERESTING FACTS

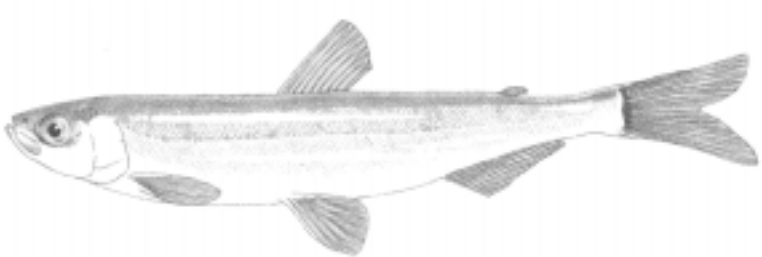
Eulachon are considered by many people to be one of the best eating of fishes. The flesh is exceedingly rich and oily and of excellent flavor. This species is of importance to Indians and local residents from the Klamath River north Alaska, and is used both as human and animal food. Indians fishing some of the more northern rivers dry many thousands of these fish on racks. Commercial fisheries for the species are of little importance. In California, eulachon support relatively minor sport fisheries near river mouths, the Klamath fishery being the largest. Dip nets are used.

As a forage fish, the eulachon is important to numerous larger animals. Sea lions take large numbers of them when they congregate off river mouths, and sturgeon in the river consume the spawned-out carcasses.

No discussion of this species can be complete without mentioning that at one time these fish were dried, wicks were inserted, and they were burned as candles. Quite logically, they were called "candlefish". Needless to say, technological improvements in methods of illumination have rendered this practice obsolete in most areas.

DELTA SMELT

***Hypomesus* transpacificus transpacificus McAllister, 1963**



OTHER NAMES

There are two subspecies of *Hypomesus transpacificus*: the anadromous **delta smelt,** *H. t. transpacificus*, which is found only in a small part of central California, and the **wakasagi**, *H. t. nipponensis*, which we (and some others) are calling the **pond smelt;** it is native only to Japan but has been introduced into a few freshwater areas in California. (A Russian author, V. A. Kljukanov, refers to these two forms as full species: *H. transpacificus* and *H. nipponensis.)*

RELATIONSHIPS

Belongs to the smelt family, **Osmeridae.** Its closest relatives in California are the pond smelt (introduced—see above) and the surf smelt, *Hypomesus pretiosus*, which spawns in the surf of sandy beaches from Monterey Bay north.

DESCRIPTION

See also under **SMELT FAMILY** (page *85).*

Mouth small; maxillary does not extend behind middle of pupil with mouth closed. Teeth small, pointed; none enlarged. No striae on opercle or subopercle. Gill takers on upper half of first arch 9—10. Pectoral fin extends half to 70% of the distance to the ventral fin base. Longest anal fin rays 43—50% of head length. Scales along middle of side 53—60. Lateral line incomplete; only the first 4—14 scales have pores. This may be hard to determine if the fish has lost many scales. Pyloric caecae 4—7.

Color: silvery.
Length: under 5 inches.

Separating the delta smelt from the pond smelt. In California the native and introduced forms can be separated easily and reliably on the basis of habitat (see **DISTRIBUTION).** McAllister demonstrates that anatomically they can usually be separated by fin ray counts (see below):

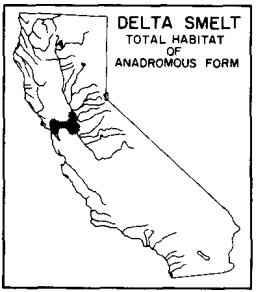
	Dorsal rays	Pectoral rays	Anal rays
Delta smelt (*H. t. transpacificus*)	9–10	10–12	15–17
Pond smelt (*H. t. nipponensis*)	7–9	12–14	13–15

DISTINGUISHING CHARACTERISTICS

The small mouth (maxillary not reaching beyond middle of pupil) will identify the genus *Hypomesus.* The relatively small scales (5 3—60 along midline of side) and the longer anal rays (longest 43—50% of head length) will separate it from *H. pretiosus.*

DISTRIBUTION

The species has a very unusual distribution. The American form (delta smelt, *H. t. transpacificus)* has been found only from San Francisco Bay upstream through the Sacramento-San Joaquin Delta to Stockton on the San Joaquin River and to within 10 miles of Sacramento on the Sacramento River. It has not been recorded from South San Francisco Bay. The Japanese form (the pond smelt, *H. t. nipponensis*) is native only in Japan but has been introduced in Freshwater Lagoon, Humboldt County; Dwinnell Reservoir, Siskiyou County; Spaulding Reservoir, Nevada County; Jenkinson Lake, El Dorado County; and some other inland waters. In Japan the pond smelt occurs as a freshwater form and as an anadromous form. It was the freshwater form which was introduced in California.



HABITS

The California form (delta smelt) appears to be rather weakly anadromous in that most of its migrations are between brackish and fresh water, but because these migrations do involve entering fresh water at spawning time it is being listed here as anadromous. McAllister lists it as euryhaline.

The delta smelt appears to move out of the San Francisco Bay complex and into the Delta during the winter, with a few moving up the Sacramento River at least as far as Freeport. Spawning seems to be in late winter and spring.

Length measurements made throughout the year first show the young in June at a length of a little over 1½ inches. By the time they are ready to spawn, 9—12 months later, they average a little over 3 inches. During the summer this age class disappears and does not reappear. This suggests that few, if any, delta smelt live to spawn a second time.

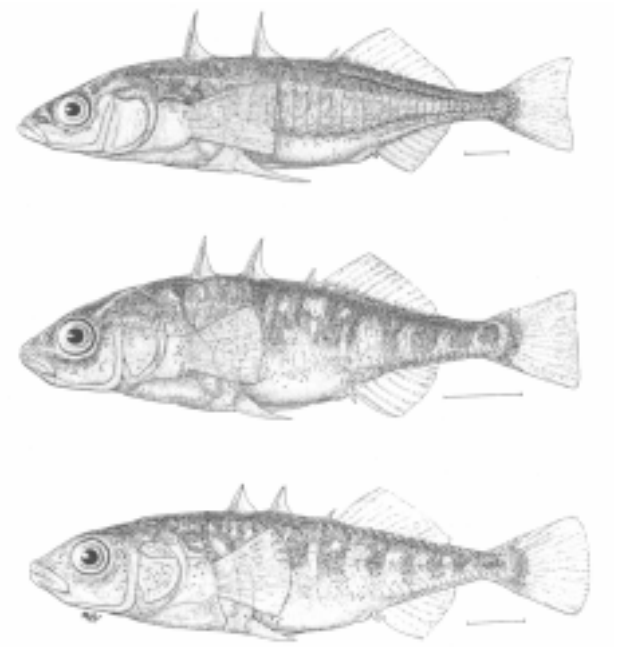
Young Delta smelt averaging less than 1 inch begin appearing at the western edge of the Delta in late March or early April. They remain as late as July when large concentrations of 1½—2-inch smelt often are found in the lower Sacramento River near Decker Island.

IMPORTANCE

Of some importance as a forage fish, but is seldom of direct use to man.

STICKLEBACK FAMILY (GASTEROSTEIDAE)
NORTHERN THREESPINE STICKLEBACK

Gasterosteus aculeatus aculeatus Linnaeus, 1758



Threespine sticklebacks, Gasterosteus aculeatus.
TOP: Northern threespine stickleback, G. a. aculeatus It is fully armored and often anadromous.
CENTER: West Coast threespine stickleback, G. a. microcephalus. It is partially armored and is not anadromous. It is widespread in California.
BOTTOM: Unarmored stickleback, G. a. williamsoni. Not anadromous. Found in southern California streams. It has been classed as rare and endangered.
Drawings by Martha B. Lackey, Museum artist, University of Michigan. First published in Copeia (1969) in an article by Robert R. Miller and Carl L Hubbs. (see REFERENCES).

RELATIONSHIPS

Belongs to the stickleback family, **Gasterosteidae.** There are 7 genera and about 12 species of sticklebacks. One species and 3 subspecies are found in California. Only one of the subspecies is anadromous. The nearest relatives of sticklebacks include tubesnouts, pipefishes, and seahorses.

DESCRIPTION

A small fish with somewhat flattened sides, a pointed snout, and a very thin caudal peduncle. Three strong serrated spines are forward of the soft dorsal fin. The first two are always isolated, the third sometimes is. The ventral fins each have a strong serrated spine. All of these spines are erectile and capable of being weakly locked in place.

Color: variable. In fresh water sticklebacks are usually mottled brown above, grading to silvery on the lower sides and belly, the young are more silvery. In salt water they are silvery green to bluish black. At spawning time the males have a scarlet throat and belly, the females a pinkish throat and belly.

Sticklebacks occur in three forms, referred to as "fully armored", "partially armored", and "unarmored". The "armor" consists of bony plates on the sides. These forms appear to be genetically distinct, although some hybrids do occur. They have been classed as subspecies.

The northern threespine stickleback, *G. a. aculeatus*, is fully armored. It has 28—35 bony plates on each side, from just behind the head to the forward edge of the tail. Those on the caudal peduncle form a lateral keel. Anadromous sticklebacks are of this subspecies, but not all individuals of the subspecies are anadromous.

The partially armored and unarmored subspecies found in California are freshwater forms. They are known as the West Coast threespine stickleback, *G. a. microcephalus* Girard, and the unarmored stickleback, *G. a. williamsoni* Girard. The west coast form may have 5 to 25 plates and has no keel or at most a very weak one. The unarmored form may have 2 or 3 anterior plates or none at all.

Size: length to about 4 inches, but a 3-inch stickleback is a big one.

DISTINGUISHING CHARACTERISTICS

This species can be distinguished by its three strong, serrated dorsal spines, the first two of which are always isolated; and by the strong single spine of each ventral fin. The anadromous subspecies is the only one which is "fully armored" and has its posterior plates ridged and forming a lateral keel.

DISTRIBUTION

The threespine stickleback is well distributed over the northern hemisphere from Mexico and North Africa northward. The armored form— the northern

threespine stickleback, *G. a. aculeatus*, is found at sea from Monterey Bay north to the Bering Sea and is also found in Lake Ontario, in parts of Europe, and in Japan. Individuals in fresh water close to the ocean are usually anadromous, but those found well inland are landlocked. In California it occurs in coastal streams from the San Lorenzo River, Santa Cruz County, northward, and there appear to be small, isolated populations in the Sacramento and San Joaquin Valleys. Along the coast it is usually anadromous, in the valley it apparently is not. The partially armored form is widespread in California, both in coastal and in inland streams. The unarmored form is found in southern California and is listed as a rare and endangered subspecies.

HABITS

Schools of anadromous sticklebacks are common in shallow bays, particularly where there is eel grass. They have also been found in the open ocean in large numbers. They enter streams and spawn, usually within a few miles of the ocean. Spawning in California is in the late spring and early summer. Grassy or weedy areas are normally chosen. The male builds a nest, usually of fragments of vegetation, which he fastens together with secretion from one of his kidneys. He forms a tunnel-like opening through the nest. When construction is completed he induces one or more females to lay eggs in the nest, then drives each one away and guards the eggs until they hatch. For a short period he will pick up any young that fall or swim out and spit them back into the nest. Quite soon they are on their own. Apparently most, if not all, adults die within the next two or three months. The life span of the anadromous form in the Netherlands was determined to be about 16 months.

Anadromous (fully armored) and freshwater (partially armored) stickle-backs are known to breed in some of the same small coastal streams with very little hybridization. In a carefully studied stream the anadromous form nearly always stayed close to salt water, and the freshwater form normally stayed well upstream. Few sticklebacks of either kind used the intermediate area and it was only there that crossing occurred. An additional mechanism that helped keep the two groups from mixing was a distinct difference in the type of nesting site chosen by each (Hagen, 1967).

IMPORTANCE AND INTERESTING FACTS

The stickleback is of no direct importance to the sportsman or commercial fisherman. It is probably of minor value as a forage fish (larger fish do eat them in quantity in spite of their needle-like spines). In California it is probably not abundant enough to be an important competitor

with the young of other fishes. Even in Alaska where it occurs in far larger numbers, the evidence on this point is not at all clear cut. In parts of Alaska it is used to a minor extent for dog food and even human food. In parts of northwestern Europe it has been used, to some extent, for human food and for preparation of fish meal.

Sticklebacks have been used for mosquito control but appear to be less satisfactory for this than the mosquitofish, *Gambusia.*

Some interesting information on stickleback behavior was the by-product of a salmon and steelhead study in Waddell Creek, Santa Cruz County. This stream is within the range of the fully armored anadromous sticklebacks but the partially armored freshwater form could also be expected there.

In 1933, a small dam was built across the creek about 1½ miles above the mouth. All fish using the fishway were counted until 1942. Sticklebacks could not climb the fishway so no anadromous individuals could reach the waters above the dam. Nevertheless each year numbers of sticklebacks moved downstream past the dam. It is interesting to conjecture whether they were on a definite seaward migration in spite of the fact that their parents had never been to sea or if they were merely moving downstream, possibly to escape overcrowded conditions above the dam. Unfortunately the fish were not examined to determine whether they were fully or partially armored (Leo Shapovalov personal communication).

THE TEMPERATE BASS FAMILY
Percichthyidae

There are only 6 North American species in this family. They occur in fresh or salt water in temperate climates. Three species are in California. One is the native giant sea bass, *Stereolepis gigas* which is strictly marine and will not be discussed here. The other two are introduced and both belong to the genus *Morone.* They can be separated as follows:

Body relatively slim, not noticeably compressed, depth less than ⅓ of length to base of tail fin; second anal spine about $^{1}/_{5}$ head length. **Striped bass,** *Morone saxatilis:* introduced, anadromous (page 98).

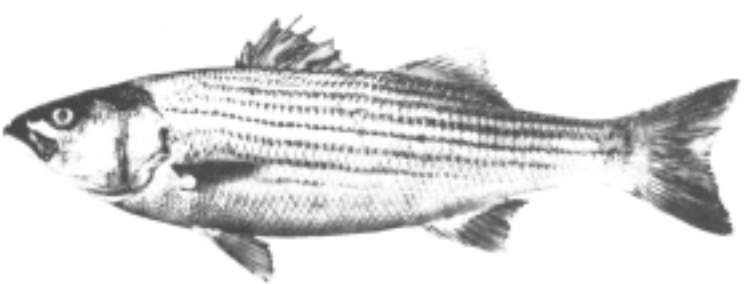
Body deeper, compressed; depth exceeds ⅓ of length to base of tail fin; second anal spine about ⅓ head length. **White bass,** *Morone chrysops:* introduced, freshwater, not included in text.

Returning a tagged striped bass to the water. *Photo by John E. Riggs*

STRIPED BASS

***Morone saxatilis* (Walbaum, 1792)**

(Introduced)



OTHER NAMES

Striper, rockfish. Some authors use the scientific name *Roccus saxatilis* for striped bass.

RELATIONSHIPS

The striped bass is a member of the temperate bass family (Percichthyidae). Its closest relatives in California are the introduced white bass, *Morone chrysops* (freshwater), and the native giant sea bass, *Stereolepis gigas* (marine).

DESCRIPTION

The striped bass has seven or eight conspicuous horizontal blackish stripes on the back and sides; the lateral line is in one of them. The eye is small, less than ¼ the length of the head. The pectoral fins are relatively short, not reaching past the tips of the ventrals. (In southern California the much smaller salema is sometimes mistaken for a young striped bass; it has orange-brown stripes, a much larger eye (roughly ⅓ head length), and a longer pectoral fin.) The ventral fins (of the striped bass) are inserted a little forward of the dorsal, and have 1 spine and 5 rays. There are 2 dorsal fins, the first with 9 spines, the second with 1 or 2 spines and 12 soft rays.

Size: Fish of 5 to 10 lb are typical. The California rod and reel record is 65 lb and one of 83 lb was netted in the Sacramento River in June 1949. The world record fish was 125 lb and was taken in North Carolina in 1891.

DISTINGUISHING CHARACTERISTICS

In the salt waters of central California or in the lowland parts of the Sacramento-San Joaquin River system any fish with 7 or 8 horizontal blackish stripes on the back is almost 100% sure to be this species. All

doubt is removed if the eye is conspicuously shorter than the snout, and the body is relatively slender (fork length 3½ times the body depth or more) and is not noticeably compressed (flattened side to side). The white bass, *Morone chrysops,* is a freshwater relative of the striped bass which has been introduced into (California and may spread through the Central Valley. It differs in being compressed, deeper bodied (fork length less than 3½ times body depth), and having the back conspicuously arched upward immediately behind the head.

DISTRIBUTION

Striped bass are native to the Atlantic Coast from the Gulf of St. Lawrence to the eastern part of the Gulf of Mexico. Since being introduced into the San Francisco Bay complex in the last century they have spread and have been taken from Vancouver Island, Canada, to 25 miles south of the Mexican border. They have established populations in Coos Bay, and in some Oregon streams. In California the great bulk of the striped bass population is in the Sacramento-San Joaquin River system, including the San Francisco Bay complex, the nearby ocean, the Sacramento-San Joaquin Delta, and the larger tributary rivers downstream from the impassable dams. Relatively small numbers are taken in Tomales Bay and the Russian River. Outside of the areas just named, sea-run striped bass are uncommon in California. At times they have entered most of the larger estuaries from Monterey Bay northward. Presumably the habitats have proved unsatisfactory because pop-ulations have not built up.

In the lower Klamath River small numbers of stripers are present in the spring. Few sportsmen fish the area at that time of year and their total striper catch is near zero, but the (legal) Indian gill net fishery below the mouth of the Trinity River does take a few. At one time there was a fishery in the estuary of the Salinas River, but the fish have abandoned that area, presumably because of a combination of reduced river flows, draining of some channels, pollution, and general habitat deterioration.

There are landlocked striped bass in Black Butte, Camp Far West, Millerton, Modesto, San Antonio, Santa Margarita, and Success Reservoirs, Lake Mendocino, and the Colorado River system. Stripers also are present in the federal Central Valley Project, State Water Project, and the Contra Costa County canals and reservoirs using the Sacramento-San Joaquin Delta as a source.

Introduction of Striped Bass. Two small plants of striped bass from the East Coast were made in California. The first release of 132 small fish was made near Martinez in 1879 and in 1882 an additional 300 were released in lower Suisun Bay. Within 10 years a commercial fishery had developed and did well until it was closed in 1935 in an effort to build up the sport fishery.

HABITS

Striped bass appear to depend rather strongly on an anadromous existence. Although planted fish will often grow well in fresh water most attempts to establish breeding landlocked populations have been failures. Landlocked striped bass succeed in breeding only in situations where there are rivers long enough and with sufficient flow to keep the eggs suspended until they hatch (about two days). An outstanding success has been in Santee - Cooper Reservoir in South Carolina. Other successes have been in Millerton Lake near Fresno and the Colorado River system in California. San Luis Reservoir in western Merced County has a large population of striped bass but there is no satisfactory way to determine if any of the young fish there were actually spawned in the lake. The water for the reservoir is pumped via canal from the San Joaquin Delta, and, every spawning season, large numbers of very small striped bass pass through the fish screens and pumps and arrive at the reservoir. The stripers in Lake Mendocino and San Antonio Reservoir were planted there and provide fishing, but have not shown any evidence of successful reproduction.

Reproduction. Striped bass begin spawning in the spring when the water temperature reaches 58 F. Most spawning occurs between 61 and 69 F, and the spawning period usually extends from April to mid June. They spawn in fresh water where there is moderate to swift current. The section of the San Joaquin River between the Antioch Bridge and the mouth of Middle River, together with the other channels in this area, is one very important spawning ground. Another is the Sacramento River from Courtland to Colusa.

Female striped bass usually spawn for the first time when they are about 5 years old and 24 inches long. Many males mature when two years old and only about 11 inches long. Most males are mature at age three. A 5-lb female spawns about 200,000 eggs in one season and a 12-lb fish is capable of producing up to about one million eggs. The eggs are quite small when in the fish—about 1/25 inch in diameter—but after being spawned they absorb water, triple their diameter, and become transparent and very hard to see. This is a good safety measure. That which is not seen is less likely to be eaten. The eggs are only slightly heavier than water. With moderate current they are held suspended while developing. Without any water movement they sink to the bottom and die. The larval bass are hatched in about two days, the length of time depending upon the temperature. Warmer water, causes faster development.

Survival of Young. The abundance of legal-sized striped bass in the Sacramento-San Joaquin Estuary appears to be largely determined by survival in the first months of life. Variation in survival of young bass (less than 1 ½ inches long) is affected by the magnitude of water diversion from the estuary and magnitude of river flows passing through the Delta. Diversions remove many young during the first few months of life (May, June and July) and river flow probably affects survival, at least in part by controlling the transport of young bass to suitable nursery areas. It takes stripers three years to reach legal length (18 inches) so good fishing depends upon precipitation and upon water management several years earlier.

Growth. Striped bass are only about 1/6 inch long at hatching and average about 4 inches at a year, 10 inches at two years, 16 inches at three, and 20 inches at four.
A 20-year-old striper will be about 48 inches long and weigh about 40 lb.

Food. Striped bass feed on many forms of animal matter. Crustaceans and fish make up the bulk of their diet. Small bass consume large quantities of *Neomysis,* a small opossum shrimp which is abundant throughout the Delta. As they grow the bass start adding larger items to their diet. Anchovies, shiner perch, shrimp, and herring are among the items taken in quantity. In the up-river areas the young of their own kind and threadfin shad are often taken.

IMPORTANCE

Striped bass support one of the most important sport fisheries in the State. In the San Francisco Bay region, the Delta, and the lower part of the Sacramento River it is definitely *the* most important.

Fishing methods. Because of strong currents and the need for heavy sinkers, a rod for striped bass fishing should be heavier than a typical bait casting rod, but aside from this restriction, almost any boat or surf rod will do. A good assortment of sinkers is needed. Most bass fishing is with bait. The use of hooks at least ½- inch from point to shank is advised. Small bass are apt to swallow smaller hooks and be killed in the unhooking process. Since bass under 18 inches total length may not be kept the use of small hooks can cause needless waste.

In the Delta and rivers, most bass fishing occurs from anchored boats and with a variety of baits. Usually, pieces of sardine, anchovies, threadfin shad, bloodworms, pile worms or ghost shrimp are used. The bait should be fished on the bottom. At times, trolling with plugs and jigs can be productive. In San Francisco and San Pablo bays, this is a common method. Drift fishing with live bait, particularly anchovies or shiner perch, is generally the best method in San Francisco Bay. Staghorn sculpins (bullheads) and yellow fin gobies (mudsuckers) are preferred baits in San Pablo and Suisun bays during the fall and winter.

Many boat operators in the Bay and a few in the Delta make a business of taking anglers striped bass fishing for a half day or day. A trip on one of these party boats is one of the best and quickest ways to learn the fundamentals of striped bass fishing.

Fishing season. Fishing for this species is legal all year. In the winter the fish are well scattered in both fresh and salt water but do not bite well until the water begins to warm up. By March the adult fish are moving into fresh water; fishing in the Delta and in the Sacramento River gets much better. By mid-June most of the legal-sized bass have spawned and are on their way back to salt water. During the summer, fishing is best in San Francisco Bay. Treasure Island, Alcatraz Island, and Raccoon Strait are often very good. A consistently good spot is the area around the south tower of the Golden Gate Bridge. For up-to-the-minute information, visit or phone a bait shop. They are found in the phone book.

LIFE HISTORY SUMMARY TABLE

Anadromous Fishes Found in California

	Pacific lamprey	River lamprey	White sturgeon	Green sturgeon	American shad	Brown trout
NATIVE (N) OR INTRODUCED (I) IN CALIFORNIA	N	N	N	N	I	I
IN CALIFORNIA ANADROMOUS INDIVIDUALS ARE: Common (C) uncommon (U) rare (R) or absent (A)	C	U	C	U	C	R
ANADROMOUS ADULTS COMMONLY SPAWN IN (a) Upstream areas of large river systems.	Yes	Yes	Yes	Yes	Yes	Yes
(b) Deltas or slower flowing parts of large rivers.	No	No	No	No	Yes	No
(c) Short coastal streams.	Yes	[4]	[4]	No	No	Yes[4]
SPAWNING HABITS Adults prepare nest or bury eggs in gravel.	Yes	Yes	No	No	No	Yes
Eggs sink, but are not buried.	No	No	Yes	Yes	No	No
Eggs adhesive, stick to sand, gravel, etc.	Yes	Yes	Yes	Yes	No	No
Eggs free-floating or sink very slowly.	No	No	No	No	Yes	No
Adults die from effects of spawning.	All	All	No	No	Many	Few
YOUNG MIGRATE TO SALT OR BRACKISH WATER: (a) Before or soon after egg yolk is absorbed.	No	No	Some	?	No	No
(b) Within a few months.	No	No	Some	?	Yes	Few
(c) After one or more years in fresh water.	All	All	?	?	Some	Most
OCEAN MIGRATIONS OFTEN EXCEED 500 MILES	Yes	?	Yes	Yes	Yes	No
SELF-MAINTAINING LANDLOCKED POPULATIONS ARE KNOWN: In California.	Yes	No	No	No	Yes	Yes
Anywhere.	Yes	No	No	No	Yes	Yes

[1] Not known to be anadromous on the Pacific Coast.
[2] *Landlocked* individuals are found far upstream in large river systems.
[3] Usually north of California in stream systems with lakes which are used as rearing areas by the young.
[4] Not in California.
[5] California's native subspecies is anadromous. An introduced (Japanese) subspecies is landlocked.
[6] Eggs placed in a nest of plant fragments.

Steelhead rainbow trout	Coastal cutthroat trout	Brook trout	Dolly Varden	Pink salmon	Silver salmon	King salmon	Chum salmon	Sockeye salmon	Eulachon	Longfin smelt	Delta smelt	Threespine stickleback, northern	Striped bass
N	N	I	N	N	N	N	N	N	N	N	N	N	I
C	C	A	A	U	C	C	R	R	C	C	C	C	C
Yes	No	[1]	[2]	Some	Some	Yes	Some	Yes[3]	No	No	No	No[2]	Some
No	No	No	No	No	No	No	No	No	Yes	Most	Yes	?	Yes
Yes	Yes	[1]	Yes[4]	Yes	Yes	Some	Yes	Yes[3]	No	Some	No	Yes	No
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No
No	No	No	No	No	No	No	No	No	?	Yes	--	--	No
No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	[6]	No
No	No	No	No	No	No	No	No	No	?	No	--	--	Yes
Many	Few	Few	Few	All	All	All	All	All	Many	All?	Many	Most	Few
No	No	No	No	Yes	No	No	Most	No	?	Yes	?	No	Some
Few	Few	No	No	No	Few	Most	Few	Few	Yes	No	Yes	Yes	Most
Most	Most	Yes	Yes	No	Yes	Many	No	Most	No	No	No	No	Some
Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	?	?	No	?	Yes
Yes	Yes	Yes	Yes	No	No	No	No	Yes	No	No	Yes[5]	Yes	Yes
Yes	Yes	Yes	Yes	No	Few	Few	No	Yes	No	No	Yes	Yes	Yes

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GLOSSARY

ADIPOSE FIN—small fleshy fin on the back between dorsal and tail fins.
AMMOCOETES—blind larval stage of lampreys.
ANADROMOUS—up running, refers to fish which migrate from salt or brackish water to spawn in fresh water.
ANAL FIN—unpaired fin on the underside of a fish between anus and tail.
ANNULUS—mark or zone formed once each year on the scales or other hard parts of fish or other animals.
BARBEL—a slender spaghetti-like organ near the mouth. It is capable of detecting odor or taste.
CANINE TEETH—large pointed teeth.
CATADROMOUS—down running, refers to fish which migrate from fresh water to spawn in brackish or salt water.
CAUDAL FIN—tail fin.
CAUDAL PEDUNCLE—narrow part of the body just forward of the tail fin.
CIRCULI—concentric rings on fish scales.
COMPRESSED—flattened from side-to-side, deeper than broad.
CTENOID—scales with small sharp spines.
CYCLOID—scales without spines.
DEPRESSED—flattened from top to bottom, wider than deep.
DORSAL FIN—un p aired fin (or fins) on the midline of the back. Exclude the adipose fin—if present.
ESTUARINE—refers to fish or other forms of life which live chiefly in estuaries.
EURYHALINE—tolerant of a wide range of salinity *(eury* = broadly, *haline* = salty).
GILL ARCH—bony support to which gill filaments and gill rakers are attached.
GILL FILAMENTS—delicate red parts of the gills which absorb oxygen from the water.
GILL RAKERS—rod-like structures opposite the gill filaments. Rakers serve to retain food which would otherwise be lost through the gills.
HETEROCERCAL—refers to a tail fin in which the backbone ends in the upper (and usually longer) lobe.
HOMOCERCAL—refers to a tail fin with backbone ending at the base of the tail and usually with the two lobes of roughly equal length.
(EEL—lengthwise ridge, usually on the side of the caudal peduncle or tail.
LARVA (AE)—immature stages which differ greatly from the adult.
LATERAL LINE—a lengthwise row of sensory pores which form a line on the side of the fish.

MANDIBLE—lower jawbone.
MAXILLARY—the hindmost and usually largest of the upper jawbones.
METAMORPHOSE—change from lanai to adult form.
NOTOCHORD—a longitudinal elastic rod which forms a body support in the lampreys and other prevertebrates. Sturgeons have both notochord and vertebral column.
OPERCLE—gill cover.
ORIGIN OF A FIN—farthest forward point at which a fin is attached to the body.
PARR MARKS—high oval or oblong blotches on the sides of young salmonids.
PECTORAL FINS—fins on the sides, just behind the head; they correspond to the arms in humans.
PELAGIC—free-swimming in open waters.
PLANKTON—very small plants or animals which drift with the currents of lake or ocean.
PREMAXILLARY—farthest forward of the upper jawbones.
PROTRUSILE—capable of being extended.
PYLORIC CAECA—blind tubes which open into the alimentary canal at the junction of the stomach and intestine.
RAY—bony supports in the fins of fishes. Soft rays are jointed and not sharp at the tip. See "SPINE".
REDDS—a nest excavated in the stream or lake bed in which eggs are deposited.
RESIDUAL—when anadromous fishes migrate to sea those that remain behind in fresh water are referred to as residuals.
SCUTE—a horny or bony plate which is often spiny or keeled.
SERRATED—saw toothed.
SPINE—(or spiny ray) a bony support in the fins of some fishes, it is unjointed, stiff, and usually sharp pointed.
STENOHALINE—tolerating only a narrow range of salinity *(sten* = narrow, *haline* = salty).
STRIAE—fine lines or ridges, as on the gill covers of fishes.
SUCKING DISK—the lamprey's jawless mouth, surrounding lip-like muscle and leathery appendages. With its sucking disk the lamprey is able to attach to prey or to rocks, etc.
VENTRAL FINS—the paired fins nearest the mid-line of the belly or thorax (chest) of most fishes; they correspond to the rear legs of land dwelling vertebrates.
VERMICULATING—wormlike markings.
VOMER—a bone on the forward part of the roof of the mouth; in some species it carries teeth.

INDEX OF COMMON AND SCIENTIFIC NAMES OF FISHES

Major references in bold face.

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