

Curtis (1942)

California Fish & Game 28, 2-8

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(1942)

## THE GENERAL SITUATION AND THE BIOLOGICAL EFFECTS OF THE INTRODUCTION OF ALIEN FISHES INTO CALIFORNIA WATERS<sup>1</sup>

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The introduction of exotic species into any area is an abrupt and artificial extension of a natural process. All animals are continually trying to expand their range. They are constantly pressing against the limits of their habitat, moving outward slowly or swiftly according to their nature from their centers of origin until they meet an impassable barrier. Without the interposition of such barriers all species would eventually be of worldwide distribution.

Man alone is capable of transporting animals across almost any distance and over practically all barriers. What are his reasons for bringing species into areas where they do not naturally exist? Various as they may be, they all have one common objective—to provide him with some form of satisfaction which the indigenous species do not. Utilitarian satisfactions come first to mind but esthetic and sensory satisfactions are also important. Commercial fishes belong in the first category; they provide the necessities of life. Game fishes belong in the second category; they provide pleasure, and without some form of pleasure most men do not find life worth living.

Aside from the two foregoing, a third incentive plays a part in almost all of man's efforts to transplant species—his immense and unquenchable curiosity, his uncontrollable desire to "see if it will work." This phenomenon has manifested itself in waves of varying intensity throughout the history of the subject under discussion, and one of its modes, if not indeed its all-time high, occurred in the last half of the last century. At the same time the exploitation of California was at its zenith, and the pull of these two forces coincided to bring a veritable tidal wave of exotic fishes flowing into the State. In 1874 alone, according to Evermann and Clark (1931), seven different species were brought in, and from 1871 to 1894 at least 25. The total number of attempted introductions given in their paper is 32, and Smith (1896) lists three which they do not include. Of these fishes, four came to us from other continents—the Loch Leven or brown trout, the carp, the goldfish and the tench. The remainder came from our Atlantic seaboard and middle western states.

<sup>1</sup>This paper was presented at the symposium, "Introduced fishes in waters of the Pacific Coast," at the meetings of the Western Division, American Society of Ichthyologists and Herpetologists, held in Pasadena, California, June 18, 1941.

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In this epidemic of transplantations, there seems to have been little realization of the possible attendant dangers. The unfortunate lessons of the rabbit in Australia and the mongoose in Haiti had not yet been learned, and the only effort appears to have been to increase the number of species, to find a place where the exotic would prosper, regardless of the effect.

A great many of these strangers failed to establish themselves. In some cases ignorance of natural history was to blame—some unrecognized condition essential to the completion of the life-history was wanting. No one at present would make repeated attempts to introduce the Atlantic eel to the Pacific Coast, but in 1874 Johannes Schmidt had not yet shown that this eel must get to the Sargasso Sea in order to reproduce. In some cases no unoccupied niche existed to which the exotic was adapted. This may account for the failure of the Atlantic salmon; all suitable waters were so filled and overflowing with Pacific species that there was no room for the newcomer.

Another outstanding failure was the Great Lakes whitefish, *Coregonus clupeaformis*. The desire to establish them in Tulare Lake and in Clear Lake, where a total of 45,000 was planted to no avail in the early '70's, is not incomprehensible. But what they were expected to contribute to Lake Tahoe and Donner Lake, where 250,000 were planted in 1877, is a mystery, in view of the large population of the Rocky Mountain whitefish (*Prosopium williamsoni*) at that time present in those waters.

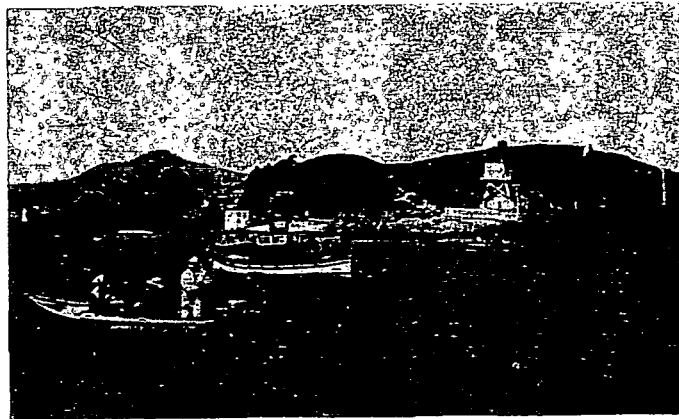


FIG. 1. Striped bass fishing on San Francisco Bay. The introduced striped bass furnishes sport for many thousands of enthusiastic anglers in central California. San Quentin Point, July, 1938.

Let us turn now to the biological effects of these aliens. By this we mean the effect upon other forms of life already in the region, and it may be said at the start that few transplantations of species have ever actually increased the welfare of the native fauna, however much they may have increased the welfare of human beings. For every introduced species, if it is to establish itself, must either find an empty

ecological niche or shoulder its way into the niche already occupied by some other animal. In the first case it may do no direct harm but may, freed from the natural controls which kept it in check in its own land, overrun the new territory to the detriment of other animals. In the second case, the infringement of the alien upon the native may be considered under two headings:

1. The direct effect, either as predator or competitor.
2. The indirect effects—introduction of parasites; alteration of the habitat; modification of the life-history of the introduced fish or the native.

Obviously the aliens which failed to establish themselves in our waters had no permanent direct effect. As to their indirect effect, it is conceivable that they might have introduced some parasite before perishing, but no case of this kind has been reported.

That the fishes which did succeed in establishing themselves have all had at least some effect upon the natives is probable. In some cases it has been so trifling as to be negligible; in others the native affected has not been of interest to man; and in others the introduced population is still too small to have had any noticeable influence. The following species, however, seem to demand consideration in detail:

1. The shad (*Alosa sapidissima*). No detrimental effects are reported for this fish, in spite of the great abundance which it has at times attained in the Sacramento River system. It seems to be possible to point to this species as the one case of an introduction which has caused no complaint from any quarter. It has apparently found an ecological niche which was not only completely unoccupied but also large enough to accommodate an enormous population.

2. Striped bass (*Roccus saxatilis*). For many years this was thought to be a purely beneficial introduction, but in 1936 Shapovalov found young salmon and steelhead in striped bass stomachs in the lagoon mouth of Waddell Creek, a small coastal stream in Santa Cruz County. In an effort to throw light on the part played by striped bass in the depletion of salmon, Hatton (1940) examined 224 striped bass stomachs in 1939 in the Sacramento River near Pittsburg when the young salmon were descending to the sea and found not one single identifiable salmon. This is not proof, however, that in the clearer, shallower waters farther up the river the striped bass does not feed on both salmon and trout. The striped bass is known to feed upon the bay smelt.

3. Small-mouthed black bass (*Micropterus dolomieu*) and large-mouthed black bass (*Huro salmoides*): California authorities, aware of the incompatibility of black bass and trout, have endeavored to confine the former to waters unsuitable to the latter. For that reason detrimental effects have been limited. Partly through unauthorized transplantations, black bass have gained access to some trout waters with bad results. Notable is Lake Britton in the Pit River drainage. Conditions here are in many ways excellent for trout; but the large-mouthed bass have taken over the lake, and although they furnish good fishing trout are rarely caught any more. It appears that where conditions are more or less equally suitable to both fish, the bass dominate the trout through greater adaptability, predaciousness, and all-around

hardiness. It is only where conditions definitely favor the trout that it seems able to prevail over the spiny-rayed intruder.

The black bass has been found to feed on down-stream salmon migrants (Hatton, 1940). From its habits it may be guessed that it is at least a competitor with, if not also a predator on, its near relative, the native Sacramento perch (*Archoplites interruptus*).

4. Sunfish. Two species are known to be well established in California, the bluegill (*Lepomis macrochirus*) and the green (*Lepomis cyanellus*). In some parts of the State they are called fresh-water perch. They furnish much excellent minor fishing but their biological



FIG. 2. A typical scene on a southern California lake. Many municipal and private reservoirs and flood control lakes have been stocked with black bass, sunfish and crappie and furnish excellent sport to throngs of fishermen. Lake Wohlford, May, 1939.

effect seems to be largely limited to their relationship with another introduced fish, the black bass, on whose eggs they prey to some extent and for whom their young furnish an abundant food supply.

5. Crappie, white and black (*Pomoxis annularis* and *P. nigromaculatus*). Both species have been introduced. They are known to prey upon the young of the black bass, sometimes to the extent of

greatly decreasing their numbers. They are not known to have detrimental effect upon any of our native fishes of value.

6. Catfish, fork-tail (*Ictalurus catus*) and square-tail (*Ameiurus nebulosus*). These are scavengers and to some extent predators upon the eggs and young of many other fish. They are believed by some people to be responsible for the decrease in number of the native Sacramento perch. They have been introduced to some extent by unauthorized and uninformed persons to high mountain waters, where they become so stunted as to be of no value to man, and where they none the less sometimes become so numerous that they inhibit the trout populations through competition and sheer force of numbers.

7. Carp (*Cyprinus carpio*). This has become the most unpopular fish ever brought into California. It stands as Public Enemy No. 1 on the fisherman's books. It is accused of preying on the spawn of other species, including the Sacramento perch; of making the water it inhabits muddy; of digging up plant life; and of being a general nuisance to fishermen. The last three points are undoubtedly true. In competing with game fish its rapid growth, its high fertility, its adaptiveness and its hardiness give it the advantage. Its young, on the other hand, undoubtedly furnish food for valued fishes. Sentence seems to have been passed upon it for determined efforts are being made to control or eradicate it in all parts of the United States.

8. Loch Leven or brown trout (*Salmo trutta*). There is a feeling among some fishermen that this trout is more cannibalistic than the other members of the genus, but no evidence exists to support the theory. It is true, however, that this species is more difficult to catch than the others, especially in lakes; that, therefore, individuals survive to a greater size and age; and that large trout, regardless of species, are more apt to be fish eaters than small ones through sheer force of necessity, the smaller forms of food being insufficient to sustain them.

As biological credit for this trout must be placed the fact that it lives contentedly in the slower, weedier portions of trout streams not favored by rainbow and thus brings about a more complete realization of the biological potentialities of the habitat.

9. Eastern brook trout (*Salvelinus fontinalis*). Little can be said against this trout on the purely biological side. In its favor—it seems to do well in high mountain lakes with very cold water and short summers, and it is able to spawn more successfully than rainbow trout in spring seepages in the bottoms of such lakes, thus maintaining itself naturally where the rainbow has difficulty. Like the Loch Leven, therefore, it utilizes a portion of the trout habitat which would otherwise be wasted.

10. Mackinaw trout (*Cristivomer namaycush*). This species is a center of controversy. It has reached its greatest abundance in Lake Tahoe where it is now maintaining itself without any artificial aid. Since the practical disappearance of the native cut-throat it has become the mainstay of the Lake Tahoe fishery. Many anglers look upon it as a great asset; many others have no use for it and blame its depredations for the depletion of the native trout. The mackinaw undoubtedly subsists largely on fish. Examinations of several hundred Lake Tahoe mackinaw stomachs over the past three years have

catfish

carp

trout

trout

trout

shown remains of many suckers, minnows and sculpins, but only a single identifiable trout. This is not conclusive proof that mackinaw do not prey upon trout but its deep water habits would not tend to bring it into contact with the young of the other trouts in Lake Tahoe, and it is entirely possible that the rise of the mackinaw population, at the same time that the native trout were decreasing in number, is not a case of cause and effect but of coincidence.

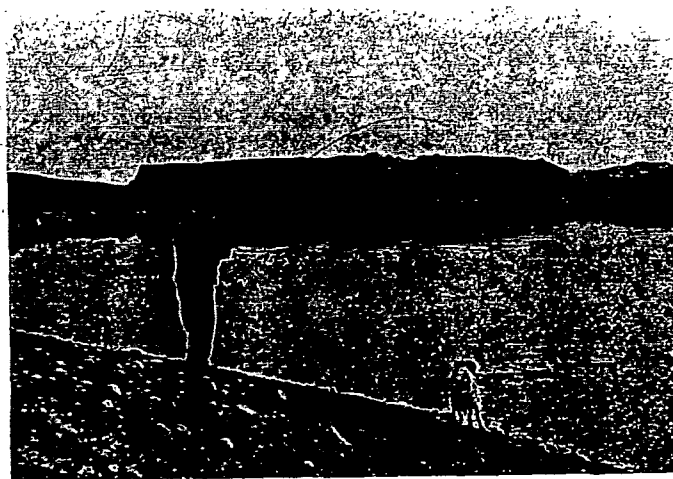


FIG. 3. Black bass fishing on Havasu Lake, formed by Parker Dam on the Colorado River between Arizona and California. Introduced fishes, particularly black bass, catfish, sunfish and crappie furnish practically all the fishing in the lakes of Arizona, Nevada and southern California. Photographed January, 1941.

From the foregoing pages it can be seen that the introduced species may be arranged in three general groups by biological effect:

A. Those entirely harmless, at least in so far as we now know, to the native fishes. The only eligibles for this category are the shad and perhaps the sunfish.

B. Those accused—although by no means always convicted—of offenses of varying degrees of importance. The following are ranked in increasing order of criminality, that is, with the least guilty at the top:

Eastern brook trout  
Crappie  
Loch Leven or brown trout  
Mackinaw trout  
Striped bass  
Black bass  
Catfish

C. Criminals of the deepest hue. Some people would include catfish in this group but the only unanimous choice would be the carp.

shad  
sunfishtrout  
striped bass  
crappie  
black bass  
catfish

carp

This grouping appears to emphasize the debit side of the biological ledger, with the threatened extinction of the Sacramento perch the most serious crime on the docket. However, it must be remembered that the evidence is by no means conclusive and that evils of various kinds are blamed on introduced exotics which are really due to quite different causes. Draining of the tule fields and overfishing may have as much to do with depletion of our native perch as alien depredations. Also, it must be remembered that this appraisal has deliberately excluded, because of their assignment to a later place on the program, the compensating circumstances—the increases in human welfare brought about by those same exotics which are accused of decreasing the welfare of our native fishes.

The fact is that Nature left a real scarcity of game fishes in the warmer fresh waters of California. Man has done away with this scarcity. Entirely aside from the catfish, much sought after in some parts of the state, our latest data show that over 35 per cent of all our licensed anglers fish for species which were brought into our waters from outside our boundaries.

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## ALIEN FISHES IN THE WATERS OF THE PACIFIC NORTHWEST<sup>1</sup>

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The present report is a list of the species of fishes which have been introduced into the fresh and marine waters of the Pacific Northwest, the history of their introduction where known, the manner in which each species has been acclimated in the new habitat, the present distribution as far as known, and the relative importance of the various species in the sport and commercial fish catches at the present time. The data for British Columbia are fragmentary and are not intended to be complete. Such data as are available have been furnished by Dr. Ferris Neave, Fisheries Board of Canada, and Dr. W. A. Clemens, University of British Columbia. The Province of British Columbia has regulations against the introduction and dispersion of spiny-rayed fishes. The data for Oregon are felt to be complete as far as known for the presence of the various species, but information on the relative abundance and dispersion within the State is fragmentary.

Through the kindness of Mr. Clarence Pautzke, Chief Biologist, Washington Department of Game, the statistics of the game catch of fish in Washington have been made available and most of the notes on the present distribution of alien game fish in Washington are traceable to him. Because of the active research of Pautzke and his associates in recent years, the notes on the alien fishes in Washington are felt to be fairly complete, although it will probably be found when the fish fauna of Washington becomes fully known, that other species of centrarchid fishes than those mentioned will be found. The figures which are cited on the relative abundance of the various species in the sport catch of Washington are taken from the state-wide creel census of the Washington Department of Game. Since this census is more complete for the lake fisheries than the stream fisheries and does not include the considerable marine sport fisheries of the State, the figures are skewed to the lake-dwelling species in an amount not known.

What little is known of the history of the introduction of the various species in the northwest is taken from H. M. Smith's (1896) report. Until 1933 the game fishes of the State of Washington were under the regulation of county game commissions. Little is known of the activities of these independently operated bodies. The policy on introducing new fishes varied from county to county and was undertaken by the county commissions, the United States Bureau of Fisheries, sportsmens' organizations, and often independently interested sportsmen.

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