

Geographical Distribution
of Fish Species Found in
Putah Creek

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INTRODUCTION

Existing records indicate that over forty species of fishes have been noted or collected within the Putah Creek basin (Thomas R. Payne and Associates 1992). Thomas R. Payne and Associates was contracted to document the extent of the these species' occurrence within the basin, as well their regional distributions outside of Putah Creek basin. The aim of this report is to provide information to help evaluate the relative status and importance (based on limited distributions or abundance) of the fishery resources of lower Putah Creek.

All but two of the figures used for this report were taken from Lee et al. (1980), with several of the maps modified using data from other sources as noted. The map showing the global distribution of brown trout (Figure 25) was copied from MacCrimmon et al. (1970). The map showing the known ranges of bigscale logperch and inland silverside in California (Figure 38) was derived from Moyle et al. (1974).

California Native Species

Lamprey (*Lampetra* sp.). Most of the reports of lampreys in Putah Creek do not identify the species present since only immature ammocoetes or nests were noted. Though Shapovalov (1947) lists Pacific lamprey as present in the basin, Putah Creek falls within the range of several lamprey species. These have been included in the discussion as well.

Pacific lamprey (*Lampetra tridentata*). Distribution: This widely distributed parasitic anadromous lamprey is found throughout the northern Pacific basin (Figure 1). Most coastal streams and large rivers from Southern California to the Aleutian Islands and Seward Peninsula in Alaska, and down the eastern coast of Asia to Japan, serve as its spawning and

nursery grounds (Lee et al. 1980). Dwarf landlocked forms exist in the upper Klamath River, Klamath Lake, and Goose Lake (Moyle 1976; Hocutt and Wiley 1986).

River lamprey (*Lampetra ayresi*). Distribution: The anadromous river lamprey occurs in Pacific coast rivers and streams from San Francisco Bay to Tee Harbor, Alaska (Lee et al. 1980; Figure 2). Though not particularly abundant anywhere in this range (Morrow 1980), in California they appear to be most abundant in the lower Sacramento-San Joaquin River system (Moyle 1976).

Pacific brook lamprey (*Lampetra pacifica*). Distribution: This anadromous, but nonparasitic species, is found in the lower elevation portions of the Sacramento and San Joaquin rivers and their tributaries, streams tributary to San Francisco Bay, northern California coastal streams, and in the lower Columbia River basin (Moyle 1976; Lee et al. 1980; Hocutt and Wiley 1986; Figure 3).

Lamprey nests were noted in upper Putah prior to the Solano Project and ammocoetes have been collected in lower Putah Creek since the project's completion.

Chinook salmon (*Oncorhynchus tshawytscha*). Distribution: Originally native to the Pacific basin rivers and tributary drainages from Ventura River in southern California, north around Aleutian Islands to Point Hope, Alaska. Although migrants may be caught in the ocean as far south as San Diego (Miller and Lea 1972), chinook salmon populations south of San Francisco Bay now appear to be extinct (Moyle 1976). In Asia chinook salmon are found in coastal streams and rivers from northern Japan and Peter the Great Bay near Vladivostok north to the Anadyr River (Moyle 1976; Lee et al. 1980). Lee et al. (1980) presented a map that suggests an even wider dis-

tribution that includes the Arctic coasts of the Soviet Union along the east Siberian and Laptev seas, as well as the Arctic coast of Alaska, and the Yukon Territory to the mouth of the McKenzie River (Figure 4). Chinook salmon have been successfully transplanted into Great Lakes region of Minnesota, Wisconsin, Illinois, Indiana, Michigan and New York. Also successful introductions have been made in coastal waters of New Zealand (Lee et al. 1980). Prior to construction of the Shasta Dam and the Central Valley project, runs of chinook salmon ascended the upper Sacramento, McCloud and Pit rivers. Today they spawn only in the Sacramento river and tributaries below Keswick Dam. In the San Joaquin, hatchery supported runs still exist below Friant Dam and in the lowermost portions of the Stanislaus, Tuolumne, Mokelumne, and Cosumnes rivers. In northern California runs occur in the Eel, Mattole, Mad, Redwood, Klamath, Trinity, and Smith river drainages (Moyle 1976).

Though the completion of the Solano Project eliminated the small runs of chinook salmon that migrated into the upper Putah Creek watershed, periodic captures of juvenile chinook salmon in lower basin suggest that adults are occasionally successful at accessing and spawning within lower Putah Creek.

Coho salmon (*Oncorhynchus kisutch*). Distribution: This anadromous species spawns in coastal stream throughout the Pacific rim from northern Japan to the Anadyr River in Russia, and from Point Hope Alaska south to Monterey Bay (Moyle 1976; Figure 5). Coho salmon have been reported at sea as far south as Baja California (Miller and Lea 1972). Coho salmon have been stocked in several freshwater lakes in the western United States and Canada, as well as Argentina and Chile (Lee et al. 1980). Most transplants have been unsuccessful at establishing reproducing populations and must be maintained by repeated stocking (McGinnis 1984). Successful introductions

of reproducing populations were made into the Great Lakes basin in 1966 (Stephenson 1968). Coho have also been planted in several east coast basins from Maine to Maryland, with little success at establishing permanent populations (Morrow 1980). In California small runs of coho salmon are found in most coastal rivers and streams north of Monterey Bay (Lee et al. 1980). They rarely enter the Sacramento-San Joaquin basin despite efforts to establish a run in the late 1950's, although they may spawn in small Marin County streams tributary to San Francisco Bay (Hallock and Fry 1967).

Though coho salmon are considered a California native species, they are not native to the Putah Creek basin. Prior to 1970 when the Department of Fish Game first introduced coho salmon into Lake Berryessa, this species was not present in the Putah Creek basin. From 1970 through 1976, an annual plant of approximately 19,000 coho salmon was made into Lake Berryessa. Though coho salmon grew well in the reservoir, stocking was discontinued due to a lack of a coho egg source and fears that silver salmon were severely impacting the threadfin shad population during the winter. The absence of any coho from creel censuses and fish surveys conducted in Berryessa (or elsewhere in the basin) since the cessation of stocking indicate that viable populations were never established in the basin, and this species is no longer present in Putah Creek.

Rainbow trout (*Oncorhynchus mykiss*). Distribution: Occurs throughout the northeastern Pacific rim. In Asia, north from Amur River in Othotsk Sea basin, and on Kamchatka and Commander Islands. In North America this species ranges from Kuskokwim River basin in Alaska to Rio del Presidio, Durango, Mexico (Figure 6). Interior distribution includes headwaters of the Mackenzie, Fraser, and Columbia rivers. Resident stocks have been widely distributed into suitable cold-water habitats throughout the world including South America, India, Africa,

southern Asia, Japan, Europe, New Zealand, Australia, Tasmania, Hawaii, as well as various regions throughout the United States and Canada (Moyle 1976; Lee et al. 1980). In California rainbow trout are native to coastal streams and rivers from the Los Angeles and Ventura river basins north to the Klamath River. They are native to most of the Sacramento-San Joaquin basin Moyle (1976). Today rainbow trout can be found in most major freshwater habitats throughout California (McGinnis 1984).

Resident and anadromous forms of rainbow trout have been documented from Putah Creek in the past. The completion of the Solano Project blocked the anadromous forms from the upper watershed, though large rainbow trout resident in Lake Berryessa now appear to migrate into the upper basin to spawn. Prior to the project rainbow trout were restricted the upper basin and headwaters of tributaries. Today the existence of suitable habitat created by the project, combined with supplemental stocking, has resulted in the distribution of viable rainbow trout populations in Putah Creek from below Solano Diversion Dam upstream to Lake Berryessa, as well as the upper basin.

Thicktail chub (*Gila crassicauda*). Distribution: This species was formerly abundant and widespread in lakes and sloughs of the Sacramento-San Joaquin Valley, Clear Lake, and streams tributary to San Francisco Bay (Snyder 1905; Lee et al. 1980; Figure 7). There are unconfirmed records of thicktail chub from the Salinas and Pajaro basins (Moyle 1976), and Miller (1963) examined specimens reputedly collected from Soap Lake, San Benito County. The last known specimens were collected from Cache Slough, near Rio Vista in 1958. Thicktail chub are now presumed to be extinct, though relict populations may be extant within former range (Miller 1963; Moyle 1976).

Though Shapovalov (1947) listed thicktail chub among his species

list for Putah Creek basin, he admitted uncertainty over their actual occurrence in the basin. A survey of lower Wragg Creek by the Department of Fish and Game in 1940 noted the presence of "suckers and chubs", but no identification was provided, and it is unclear whether the report is referring to thicktail chubs in particular, or small minnows in general. The only two documented records for species in Putah Creek were found in a list of specimens examined by Miller (1963) as part of his taxonomic study. Both records of its collection from Putah Creek were prior to 1943 (Dave Catagna, personal communication). Despite the numerous fish collections that have been made in lower Putah Creek since this time, thicktail chub have never been reported among the samples. This suggests that thicktail chub are either now extinct from the basin, or so rare as to escape detection.

Hitch (*Lavinia exilicauda*). Distribution: This cyprinid is native to warm, low elevation lakes, sloughs and tributaries of the Sacramento-San Joaquin basin, including Clear Lake (Lee et al. 1980; Hocutt and Wiley 1986); Coyote and Alameda creeks (tributary streams of San Francisco Bay - Snyder 1905); and ponds and slow-moving waters of some coastal streams such as Russian, Pajaro and Salinas Rivers (Moyle 1976; Lee et al. 1980; Hocutt and Wiley 1986; Figure 8). Though Pintler and Johnson (1958) list this species among the fishes of the Russian River, the population may not be endemic to the basin. Snyder (1908) did not include this species among his list of Russian River fauna earlier in the century.

Hitch have been collected on numerous occasions from the lower portions of Putah Creek, and Department of Fish and Game records indicate that viable populations of this species exist in Lake Berryessa.

California roach (*Hesperoleucus symmetricus*). Distribution: This species was originally distributed in small streams throughout Sacramento-San Joaquin system, including Pit River and tributaries to Goose Lake (Lee et al. 1980; Hocutt and Wiley 1986; Figure 9). Roach are also native in the small streams draining the southern portion of San Francisco Bay (Snyder 1905). This species is also found in a number of small coastal streams of California, from the Eel River south to the Cuyama River (Lee et al. 1980). The latter population may be a result of introduction by bait fisherman (Moyle 1976). Pintler and Johnson (1958) reported capturing roach in the Russian River basin.

Roach have been collected on numerous occasions throughout the Putah Creek watershed from the headwaters downstream to Mace Boulevard. According to the Department of Fish and Game records, viable populations of roach exist in Lake Berryessa.

Sacramento blackfish (*Orthodon microlepidotus*). Distribution: Blackfish were originally native only to the warm, eutrophic backwaters, sloughs and lakes of the Sacramento-San Joaquin basin (including Clear Lake), San Francisco Bay tributaries, and the Pajaro and Salinas rivers (Snyder 1905; Murphy 1950; Moyle 1976; Lee et al. 1980; Figure 10). This species can now be found among the man-made reservoirs within these systems, as well as in suitable waters of the Russian and Carmel Rivers into which it was introduced (Murphy 1950; Moyle 1976). Distribution maps in Lee et al. (1980) and Audubon Society (1983) show blackfish in coastal streams ranging as far south as Cuyama River in Santa Barbara County. Murphy (1950) mentions that blackfish were introduced as a forage fish into Lake Hughes and nearby waters in Los Angeles County; this planted population was reportedly eradicated via chemical treatment in 1949. Remnants of a population introduced into the Truckee Meadows area of western Nevada may

still be extant in irrigation and drain systems of that area (La Rivers 1962).

Sacramento blackfish were noted from Putah Creek prior to the construction of the Solano Project (Shapovalov 1947; Kimsey 1956). Department of Fish and Game records indicate that viable populations of this species exist in Lake Berryessa. Sacramento blackfish have been collected on numerous occasions from the lower portions of Putah Creek below Solano Diversion Dam.

Sacramento splittail (*Pogonichthys macrolepidotus*). Distribution:

This species was formerly abundant and widespread throughout lakes and rivers of Sacramento-San Joaquin basin, including Suisun Bay, and the streams tributary to San Francisco Bay (Snyder 1905; Rutter 1908; Figure 11). Information concerning its presence in the Russian River drainage is confused. Snyder (1908) does not list this species among the fish fauna, while Pintler and Johnson (1958) did report collecting this species from the basin. Moyle (1976) suspects the reported occurrence in the Russian River to be an error. The range of the Sacramento splittail now appears to be limited to the Delta area and the lower Sacramento River below Red Bluff Diversion Dam (Moyle 1976; Lee et al. 1980; McGinnis 1984).

Sacramento splittail were formerly distributed in the lower Putah Basin. Specimens collected from Putah Creek near Monticello, Napa County, by Charles Gilbert in 1897 reside in the California Academy of Science fish collection (Dave Catagna, personal communication). This is the only documentation that could be found for splittail within the Putah Creek basin. Shapovalov (1947) did not include Sacramento splittail among his species list for Putah Creek. The numerous recent collections that have been made in the lower basin have never yielded this species. Based upon this information it would seem that Sacra-

mento splittail were extirpated from the basin years ago, or have been rare enough to have escaped notice.

Hardhead (*Mylopharodon conocephalus*). Distribution: This species is native to the larger low and mid-elevation streams of Sacramento-San Joaquin basin, including the Pit River system (though it is absent from Goose Lake and the Kern River; Figure 12). Hardhead are indigenous to the Russian River system, but are not found in other coastal drainages (Snyder 1908; Moyle 1976; Lee et al. 1980; Hocutt and Wiley 1986).

Hardhead have reported in the past as occurring in the middle portions of Putah Creek, but not since 1957. Johnson (1957) also reported that some of the numerous farmponds within the Putah Creek basin contained hardhead. There is no documentation for the occurrence of this species in the lower basin.

Sacramento squawfish (*Ptychocheilus grandis*). Distribution: Squawfish are found in larger and clearer intermittent and permanent streams of the Sacramento-San Joaquin basin (including upper Pit River), but is absent from Goose Lake and the Kern River (Hocutt and Wiley 1986; Figure 13). Squawfish are also native to the Pajaro, Salinas, and Russian rivers, streams of Clear Lake system, and tributaries of the San Francisco Bay (Snyder 1905, 1908; Murphy 1950; Moyle 1976; Lee et al. 1980). The large stable squawfish populations that have recently been found in Eel River drainage (Steiner Environmental Consulting 1991) probably represent a relatively recent introduction.

Records indicate this species has been common throughout Putah Creek basin in the past and that it is still found throughout the watershed.

Speckled dace (*Rhinichthys osculus*). Distribution: Speckled dace are native to all major western U.S. drainages from Columbia River to Colorado River, and south into Sonora, Mexico (Figure 14). Dace are also present in interior drainages and are considered the most ubiquitous freshwater fish of western U.S. (Moyle 1976; Lee et al. 1980). Speckled dace are found throughout California, although they are absent or uncommon from most coastal streams (Moyle 1976; McGinnis 1984). Populations in San Luis Obispo Creek seem to have originated from an early bait-bucket introduction (Moyle 1976).

Distributional records of this species in Putah Creek indicate that it is restricted to the upper and middle portions of the basin. It has never been observed in Putah Creek below Monticello Dam.

Sacramento sucker (*Catostomus occidentalis*). Distribution: Suckers are widespread and abundant in streams and reservoirs of the Sacramento-San Joaquin drainage, including the upper Pit River (including Goose Lake and tributaries), and tributaries of San Francisco Bay (Figure 15). This species is also found in the Clear Lake basin and coastal rivers from Morro Bay north to Redwood Creek, California (Snyder 1905; Moyle 1976; Lee et al. 1980; McGinnis 1984; Hocutt and Wiley 1986; Salamunovich 1987).

Past and present records indicate that suckers are widely distributed throughout the Putah Creek basin.

Threespine stickleback (*Gasterosteus aculeatus*). Distribution: This fish is nearly circumpolar and widely distributed in northern hemisphere in marine and fresh waters (Figure 16). It is native to the Mediterranean coast of Europe (including Black

Sea), as well as the Atlantic coast from Portugal north to Russian coast of Barents Sea (including British Isles and Iceland). It is also native to eastern coast of Asia from Japan and Korea north to Siberia. In North America threespine stickleback range along the Atlantic coast from Chesapeake Bay north to the Arctic Circle at Baffin Island and west into Hudson Bay drainage; and along the Pacific coast from Rio Rosario, Baja California to Seward Peninsula and Aleutian Islands, Alaska (Figure 17). Freshwater populations are found far inland along Atlantic coast (especially in Maine and New Brunswick), and have been recorded throughout Lake Ontario, and the Ottawa and St. Lawrence rivers (Lee et al. 1980). In California they can be found in most coastal streams from tidewater upstream to major fish barriers. They are widely distributed throughout the Sacramento-San Joaquin basin and have been transplanted into the Mojave River, as well as many reservoirs throughout the state (Moyle 1976).

Threespine stickleback in Putah Creek have almost exclusively been recorded below Lake Berryessa, however their presence in Swartz Creek may suggest a wider distribution in the basin.

Sacramento perch (*Archoplites interruptus*). Distribution: This species is the only native centrachid west of the Rocky Mountains. Sacramento perch were originally widely distributed in the sloughs and lakes of the Sacramento-San Joaquin drainage (including the Clear Lake basin), as well as the Pajaro and Salinas River basins (Figure 18). Sacramento perch have been rare or absent within this original range since the turn of the century. Their extirpation has generally been attributed to the introduction of exotic species (Jordan and Gilbert 1895; Aceituno and Nicola 1976) and the reclamation of wetlands (Rutter 1908), though Smith (1982) suggests their elimination from the Pajaro River was not due

to competition or habitat loss, but rather a massive pesticide-caused fish kill in 1968. Cook et al. (1966) noted the rapid decline of populations in Clear Lake, Lake County, since the mid-1950's. McGinnis (1984) reported that since 1974 the Sacramento perch population native to Lake Greenhaven, Sacramento County, has virtually disappeared. Sacramento perch have been widely introduced into alkaline lakes and reservoirs of California, Nevada (including Pyramid and Walter lakes), Utah, Colorado, Nebraska, North Dakota, and South Dakota (Lee et al. 1980). Though once widely distributed in California, populations are now found only in scattered localities, principally farm ponds and reservoirs into which they have been introduced (Aceituno and Nicola 1976). The population in the Russian River is also presumably derived from introductions made into the basin. Large populations have become established in San Luis Reservoir and Ruth Lake, Merced County; Clear Lake Reservoir, Modoc County; Crowley Lake, Inyo County; Lake Almanor, Plumas County; and Blue Lake, Lake County (Aceituno and Nicola 1976; Moyle 1976).

The only mention of Sacramento perch in relation to Putah Creek is a reference to a single adult released in the lower basin by the Department of Fish and Game in 1939. No other accounts of the presence of this fish species in the basin have been found, suggesting that Sacramento perch were not native to the basin, or were extirpated prior to fish surveys that would have detected their presence, or are extremely rare and have escaped detection.

Tule perch (*Hysterocarpus traski*). Distribution: This live-bearing species is native to low elevation sections of the Sacramento-San Joaquin River and the larger tributaries (including the Pit River up to Pit Falls), the Clear Lake basin, tributaries of the San Francisco Bay, as well as central Cal-

ifornia coastal streams from Russian River south to Salinas River (Figure 19). Tule perch now appear to be extinct from Pajaro-Salinas systems and the San Joaquin basin (Snyder 1905; Moyle 1976; Lee et al. 1980; Smith 1982). This embiotocid species now appear to be limited to the lower Delta region and its reservoirs, the Sacramento River and its tributaries (including Pit River below Lake Britton), Clear Lake, and the Russian River (McGinnis 1984). Populations have been established in O'Neill Forebay of San Luis Reservoir, Merced County, and in a nearby reservoir on Los Banos Creek (Moyle 1976).

Despite the numerous fish surveys that have been conducted throughout the basin, the first documented record of tule perch in Putah Creek was made in the lower basin in 1990 (Trinity Fisheries Consulting 1991). Moyle (1992) indicated that spawning populations of tule perch were known to exist in beaver ponds above the town of Winters prior to 1990.

Riffle sculpin (*Cottus gulosus*). Distribution: These cottids have a disjunct distribution, occurring from Morro Bay north to Noyo River, California, are absent from the Trinity, Klamath, and Rogue rivers, and are present again from the Coquille River, Oregon north to Puget Sound, Washington (Figure 20). In California riffle sculpin are found throughout most of the Sacramento-San Joaquin basin (except the upper Pit River) including tributaries to San Francisco Bay, and in coastal streams from Morro Bay north to the Noyo River in Mendocino County (Snyder 1905; Moyle 1976; Lee et al. 1980; McGinnis 1984). Hocutt and Wiley (1986) reported their occurrence from streams along the southern California coast, but do not identify any detailed distributional pattern.

Past and present records indicate that riffle sculpin are widely distributed throughout the Putah Creek basin.

Introduced Species

American shad (*Alosa sapidissima*). Distribution: American shad, an anadromous species, are native to the Atlantic coast from New Foundland south to the St. John's River, Florida (Moyle 1976; Lee et al. 1980; Figures 21 and 22). American shad were introduced along the western coast of the United States in the later part of the nineteenth century (Sacramento River in 1871; Colorado River in 1884; Columbia River in 1885). As a result of these introductions, they now spawn in most major rivers from Todos Santos Bay, Baja California to southeastern Alaska (Miller and Lea 1972; Moyle 1976), with strays ranging north and west to Cook Inlet and Kamchatka (Morrow 1980). The first American shad introduced into California, consisted of about 10,000 fry which were imported from the Hudson River, New York and released into the Sacramento River near Tehama in 1871. A second plant of approximately 35,000 fry were released at the same location in 1873 (Smith 1896). Between 1876 and 1880 another 574,000 fry were introduced into California (Moyle 1976) and by 1877 returning spawners had become quite numerous in the Sacramento basin (California State Board of Fish Commissioners 1877). In California the main shad runs occur in the lower Sacramento River below Red Bluff and the lower portions of the major tributaries including the American, Feather, and Yuba rivers. Shad also migrate into the lower San Joaquin basin as well as the Mokelumne and Stanislaus rivers. Small runs also occur in the sloughs of the southern Delta, the Russian, Eel and Klamath rivers (Moyle 1976). Moyle (1976) reported a land-locked population in Millerton Lake, Fresno-Madera counties.

American shad were reported to have migrated into Putah Creek prior to construction of Solano Project (Shapovalov 1940, 1947). Apparently this anadromous species can still migrate into lower

Putah Creek during high flow events, since it was collected in this area during mid 1970's.

Threadfin shad (*Dorosoma petenense*). Distribution: Threadfin shad are native to the Mississippi basin, from the Ohio River in Illinois, Indiana and Kentucky south to Oklahoma, Texas and Florida. They are also found along the Gulf coast of Mexico to the Yucatan peninsula and into northern Guatemala and Belize (Figure 23). Threadfin shad have been transplanted throughout the southeastern United States including Alabama, Georgia, South Carolina, North Carolina, Virginia and Tennessee. This clupeid was also introduced as a forage fish into the western United States including Arizona, Nevada, California, and Hawaii. Since its introduction in the western United States threadfin shad have subsequently migrated into the lower Yaquina River, Oregon (Lee et al. 1980). A stock of threadfin shad obtained from the Tennessee River was introduced to brood ponds in San Diego County in 1953 (Kimsey 1954). The following year fish were released into Lake Havasu on the Colorado River by the Department of Fish and Game (Shapovalov et al. 1959). Within the next ten years they had been introduced to lakes, ponds, and reservoirs throughout the state (Burns 1966). From these transplants threadfin shad have spread and become established in the Sacramento-San Joaquin River basin and its Delta, the lower Colorado River, and the Salton Sea (Moyle 1976). This species can now be found in most low and middle elevation freshwater habitats throughout the state (McGinnis 1984). Threadfin shad are occasionally taken in salt water from Long Beach to Humboldt Bay (Miller and Lea 1972).

Threadfin shad have established a viable population in Lake Berryessa since their original introduction into the Putah basin in 1963. They have also been collected in the lower portions of the creek below Solano Lake.

Kokanee (Sockeye salmon) (*Oncorhynchus nerka*). Distribution: Kokanee are the nonanadromous form of sockeye salmon. Sockeye are native to rivers of the northern Pacific rim from northern Japan to the Anadyr River in Russia, and from the Yukon River in Alaska south to the Sacramento River (Moyle 1976; Lee et al. 1980; Figure 24), though large spawning runs are generally restricted to the Columbia River northward (Hallock and Fry 1967). Sockeye are particularly abundant off British Columbia and Alaska and they are the second most abundant salmon in North America (Hallock and Fry 1967). No anadromous runs of sockeye remain in California. Prior to the construction of Copco Dam in 1917 small runs of sockeye may have migrated up the Klamath River to into the Klamath Lake basin (Moyle 1976). The infrequent sockeye that have been reported in the Sacramento basin are probably strays from more northern runs (Hallock and Fry 1967). Kokanee occur naturally through the range of the anadromous form (Lee et al. 1980). They have been successfully introduced into coldwater lakes throughout Canada and the northern and western United States. Kokanee are not native to California and have been established through introductions from different origins. Kokanee from Idaho were first introduced into California in 1941 with plants into the Salt Springs Reservoir on the Mokelumne River, which were subsequently released into Lake Tahoe and nearby lakes. In 1951 kokanee from British Columbia were planted into Lake Shasta. Subsequent stocking into other California lakes and reservoir has occurred with varying degrees of success (Seeley and McCammon 1966; Moyle 1976).

Prior to the early 1960's kokanee salmon were not present in the Putah Creek basin. From 1964 through 1966 the Department of Fish and Game planted approximately 1.5 million kokanee fry into Lake Berryessa. The program was discontinued when investigations into the possibility of starting a trophy trout fishery

suggested that kokanee, a planktivore, might compete for food resources with the trout forage species, such as threadfin shad. Despite observations in 1968 of kokanee spawning in areas of the reservoir, they were unable to maintain viable populations and appear to be no longer present in the basin.

Brown trout (*Salmo trutta*). Distribution: Brown trout are originally native to Europe and western Asia from the Ural Mountains south to the Aral sea and Afghanistan west through continental Europe, the British Isles and Iceland (Moyle 1976; Lee et al. 1980; Figure 25). They are also native to the Atlas Mountain region of Africa in Morocco, Algeria, and Tunisia (MacCrimmon et al. 1970). Brown trout have been successfully introduced into much of the United States and Canada (Figure 26) as well as some parts of South America, Africa, India, Australia, New Guinea, and New Zealand (MacCrimmon et al. 1970). It was first introduced into North America in 1883. In 1892 eggs of the Von Behr (German) strain of brown trout were successfully reared in California and the progeny were released the following year into the Trinity and Redwood basins of Humboldt County (Smith 1896). In 1894 eggs of the Loch Leven (Scotland) strain of brown trout were successfully reared in California. Since this time the Department has reared and distributed millions of brown trout throughout the state, so that today this fish is now present in trout waters throughout the state, including streams, lakes and reservoirs (Staley 1966).

It is not known when the first brown trout were imported into the Putah Creek basin. The earliest documented records of fish stocking within the basin are from 1931 when the Department of Fish and Game planted 20,000 brown trout in upper Putah Creek. After the completion of the Solano Project the Department began making annual plants of brown trout into Lake Berryessa and Solano Lake, as well as Putah Creek between the two impound-

ments. The Department apparently discontinued its annual stocking of brown trout into Lake Berryessa in the early 1980's, but continued stocking below Monticello Dam and in Solano Lake. Today wild and planted populations of brown trout exist in Putah Creek below Monticello Dam downstream to Solano Lake. No observations of brown trout have been documented for the upper or lower Putah Creek basin.

Brook trout (*Salvelinus fontinalis*). Distribution: Brook trout were originally native to northeastern North America from Hudson Bay drainages south through New England and west through Great Lakes and upper Mississippi basins (Figure 27). This salmonid is also native to western Appalachian Mountain streams to Georgia. Brook trout have been introduced into higher elevation streams throughout the western United States and Canada as well as South America, Asia, New Zealand, and Europe (Moyle 1976; Lee et al. 1980). Brook trout were among the earliest fishes introduced into California. As early as 1872 the California Fish Commission released some 6,000 fish into the North Fork American River, the headwaters of Alameda Creek, and San Andreas Reservoir (Smith 1896). Subsequent introductions have resulted in the establishment of brook trout populations in high elevation (>4,000 feet) lakes and streams from the San Bernardino Mountains in southern California to the Oregon border (California Department of Fish and Game 1969).

Department of Fish and Game records suggest that brook trout were first imported into the Putah Creek in 1966, with a second and final plant in 1968. Both release sites were located below Monticello Dam. Despite observations of brook trout in this section of Putah Creek and in Solano Lake as late as 1970, it appears that these fish were unable to successfully establish populations and are no longer present in the basin.

Golden shiner (*Notemigonus crysoleucas*). Distribution: This species is native to the rivers of North America from the Maritime Provinces of Canada southward to Florida, and west along the Gulf coast to Texas and north into Saskatchewan, including the Mississippi and Great Lakes basins (Figure 28). It has been widely introduced within and outside of this range for use as a bait fish and as an ornamental (Lee et al. 1980). Golden shiners were first introduced into southern California in 1891, and their wide use as a bait fish has resulted in their spread to most suitable waters in California, including the Sacramento-San Joaquin basin and the Colorado River. They are one of the most abundant fishes in the Big Valley area of the upper Pit River (Moyle 1976).

The first documentation of this species in the Putah basin was in Lake Berryessa in 1958. The source of its introduction is unknown but probably due to the release of live bait by fishermen. Golden shiners are now found in Lake Berryessa and lower portions of its tributaries as well as Solano Lake and lower Putah Creek.

Fathead minnow (*Pimephales promelas*). Distribution: The native range of this cyprinid includes much of North America from Chihuahua, Mexico, north to Great Slave Lake drainage, east to New Brunswick and west to Alberta (Figure 29). These minnows have been transplanted east into the Atlantic slope states, and west into the Colorado and Sacramento River basins (Lee et al. 1980). In California fathead minnows can be found in the lower Colorado River (Lee et al. 1980) and in small streams of the Central Valley (McGinnis 1984). Fathead minnows were introduced into California as bait fish. The first known record of fathead minnows in California is from a bait tank near the Colorado River in 1950 (Shapovalov et al. 1959). Fathead minnows were introduced into the northern

part of the state in 1953 by the Department of Fish and Game (Reiner 1955). Since their introduction they have spread (as a forage fish) throughout the state mostly in the Colorado and Sacramento-San Joaquin river basins, with breeding populations established in many waters (Shapovalov et al. 1959). Moyle (1976), however suggests that successful reproducing populations have actually been established at few localities. They are found in large numbers in some small streams of the San Joaquin Valley, such as Los Banos and Ulati creeks (Moyle 1976).

Fathead minnows have been collected on numerous occasions from the lower portions of Putah Creek. Department of Fish and Game records indicate that viable populations of this species exist in Lake Berryessa.

Goldfish (*Carassius auratus*). Distribution: This cyprinid is native to streams and rivers from eastern Europe to China, Korea, and Amur River in Russia (Figure 30). Its native distribution also includes Taiwan, Japan, and Sakhalin Island (Courtenay and Stauffer 1984). Goldfish have been introduced into western Europe, North America, and suitable waters throughout the world. This species was the first exotic introduced into North America, the first releases being made in the seventeenth century (Courtenay and Stauffer 1984). Introductions into the United States have been over such a broad geographical scale that this species may now be found in every state (except Alaska) and three Canadian provinces (Moyle 1976; Lee et al. 1980). Cortenay and Stauffer (1984) reported that though specimens are collected periodically, viable breeding populations appear to be lacking in Florida, Maine, Utah, Vermont, and West Virginia. In California large self-sustaining populations are present in some southland reservoirs and in the canals and sloughs of the Sacramento-San Joaquin basin. Goldfish are likely to be found in almost

any aquatic environment of the state where the water is sufficiently warm (Moyle 1976).

Goldfish have been collected on numerous occasions from the lower portions of Putah Creek, and the Department of Fish and Game records indicate that viable populations of this species exist in Lake Berryessa.

Carp (*Cyprinus carpio*). Distribution: Introductions of this species into European waters as early as during the Roman Empire, have confused the original native distribution of the common carp. One theory described its native range as the basins of the Black, Caspian, and Aral seas, perhaps western Europe, the Volga River, and the Pacific coast drainages from the Amur River in Russia south to Burma. The theory given most credence at this time purports that carp were originally native to Asia Minor and the basins of the Black (including Danube River) and Caspian seas, from which they were spread westward into Europe and eastward into China (Courtenay and Stauffer 1984; Figure 31). Carp were first introduced into North America in the Hudson River in New York in 1831 by a private citizen (Courtenay and Stauffer 1984). In 1872 five carp imported from Germany were stocked in a pond in Sonoma County in California (Moyle 1976). In 1877 the U.S. Fish Commission began culture operations with some 338 carp imported from Germany, while the California Fish Commission embarked on a similar program with a brood of 88 carp brought from Japan. From these sources carp were distributed to applicants for planting as a food and sport fish throughout California, as well as the United States and Canada (Shebley 1917; Moyle 1976; Courtenay and Stauffer 1984). Self-sustaining populations of carp exist in the forty-eight contiguous states and carp may be found in most rivers and reservoirs throughout the United States. Though less common in the western states, carp reach their greatest population

densities in the waters of the midwestern states (Courtenay and Stauffer 1984). In California carp can be found in virtually every drainage except the Klamath River system (Moyle 1976; Lee et al. 1980; McGinnis 1984).

Past and present records indicate that carp are widely distributed throughout the Putah Creek basin.

Black bullhead (*Ictalurus melas*). Distribution: This ictalurid is native to central United States and Canada from southern Saskatchewan, Great Lakes and St. Lawrence basins, south to Gulf of Mexico and northern Mexico, and from western Appalachian streams west to rivers draining eastern slopes of the Rocky Mountains (Figure 32). Black bullhead have been introduced outside this native range so that they can now be found in most of western United States (Lee et al. 1980). Black bullheads were presumably imported into California with a shipment of other ictalurids in 1874 (Curtis 1949) and may be the species Shebley (1917) referred to as the "Mississippi Valley catfish" introduced into the San Joaquin River near Stockton with a group of white catfish. Black bullhead are now found in most major rivers and some low and middle elevation lakes and reservoirs in the state (Moyle 1976; McGinnis 1984).

Fish distribution records for Putah Creek indicate this species may be restricted to the lower portion of the basin, below Solano Diversion Dam.

Brown bullhead (*Ictalurus nebulosus*). Distribution: Brown bullhead are native throughout the eastern half of United States and in southern Canada, from Saskatchewan to Nova Scotia (Figure 33). They have been widely introduced outside their native range (Lee et al. 1980). Shebley (1917) reported that this

species was first introduced into California from a plant of seventy fish from Lake Champlain, Vermont, that was made into ponds and sloughs near Sacramento in 1874; Curtis (1949) claimed brown bullheads were first planted into the San Joaquin River in California in 1874. Despite this confusion over the site of their original introduction, brown bullhead are now present in most warm water habitats throughout the state, and are the most common bullhead in California (Moyle 1976; McGinnis 1984).

Brown bullheads have been collected from middle and lower Putah Creek basin. Large populations of this species exist in Lake Berryessa.

White catfish (*Ictalurus catus*). Distribution: This catfish is native to the Atlantic coastal states from New York south to Florida and around the Gulf coast to Alabama (Lee et al. 1980; Figure 34). White catfish have been successfully introduced into many parts of the middle and western United States, especially California (La Rivers 1962). California populations are apparently all derived from a single introduction of about fifty-four fish imported from the Raritan River, New Jersey and released into the San Joaquin River near Stockton in 1874 (Shebley 1917). White catfish can be found in every major drainage system of the state except the Klamath and Colorado basins (Moyle 1976). Pintler and Johnson (1958) reported their presence in the Russian River.

It is not known when white catfish were first introduced into the Putah Creek basin. This ictalurid has periodically been stocked in various portions of the watershed and has been observed throughout the middle and lower Putah Creek basin. Large populations of this species exist in Lake Berryessa.

Channel catfish (*Ictalurus punctatus*). Distribution: Channel catfish are native to the central drainages of the United States (including the Mississippi-Missouri and Rio Grande systems) from southern Canada south to southeastern Mexico, as well as the south Atlantic coastal drainages in Georgia and Florida (Lee et al. 1980; Figure 35). Their range has been expanded through introductions to almost all parts of North America where there are suitable waters (Moyle 1976; Lee et al. 1980). This catfish has been introduced into the southwestern United States via the Sacramento-San Joaquin, Colorado, and Gila river basins in California and Arizona, and reservoirs in Truckee, Carson, and lower Humboldt River basins in Nevada (La Rivers 1962; Lee et al. 1980). Evermann and Clark (1931) and Curtis (1949) reported that the first introductions of channel catfish into the Sacramento River system were made in 1891 and 1895. Moyle (1976) claimed they were stocked into the Sacramento-San Joaquin basin earlier, in 1874. Perhaps channel catfish were the species Shebley (1917) referred to as the "Mississippi Valley catfish" introduced into the San Joaquin River near Stockton with a group of white catfish in 1874. Despite the uncertainty of their original introduction into northern waters of the state, successful stocking of this species in the Sacramento basin did not apparently occur until after 1940. It is unknown exactly when channel catfish were introduced into the Colorado River basin of California. La Rivers (1962) reported that Arizona planted this species as early as 1892. They had become well established in the California portion of this basin since 1920 (Miller 1966). Channel catfish have been introduced into most lower elevation reservoirs and can now be found in suitable waters in almost every major drainage of California (Moyle 1976; McGinnis 1984).

Channel catfish were introduced into Putah Creek basin with the release of some 12,000 fingerlings in 1962. Since this time channel catfish have been recorded from Lake Berryessa and the lower basin.

Mosquitofish (*Gambusia affinis*). Distribution: Mosquitofish were originally native to the Mississippi basin south from Illinois and southern Indiana, as well as rivers of Mid-Atlantic United States coast and rivers throughout Gulf Coast south to Vera Cruz Mexico (Lee et al. 1980; Figure 36). Because of their reputation as mosquito-control agents mosquitofish have been introduced into suitable waters throughout the world. They were introduced into California in 1922 and have since been spread throughout the state into most low and middle elevation freshwater habitats (Moyle 1976; McGinnis 1984).

Mosquitofish have been recorded from the middle and lower Putah Creek basin. Large populations of this species exist in Lake Berryessa.

Inland silverside (*Menidia beryllina*). Distribution: The native distribution of this atherinid includes coastal and freshwater habitats from Massachusetts to southwestern Gulf of Mexico, and in Mexico south to Vera Cruz. Silverside are also native to the lower Mississippi basin below the Missouri River and the Rio Grande (Lee et al. 1980; Figure 37). In 1967 the first introductions of this species in California were made into the Blue Lakes and Clear Lake, Lake County (Cook and Moore 1970). From the Clear Lake basin they have spread into Cache and Putah creeks (Moyle et al. 1974). Experimental plants into some small ponds in Santa Clara County in 1968 have also lead to illegal introductions to larger reservoirs in this county as well as in Alameda County (Moyle et al.

1974; Figure 38). Silversides are also found in the Sacramento-San Joaquin Delta and tributary rivers of the San Joaquin Valley and associated reservoirs (McGinnis 1984).

Inland silversides have been observed upstream and downstream of Lake Berryessa and are quite common in the lower basin (Jones 1974). This information, along with their success in nearby Clear Lake, suggests that they are probably present in Lake Berryessa as well.

Striped bass (*Morone saxatilis*). Distribution: The native range of this anadromous species consists of Atlantic coastal plain drainages from St. Lawrence River, New Brunswick, south to St. Johns River, Florida, and Gulf Coast drainages from Suwannee River Florida to Lake Ponchartrain, Louisiana (Lee et al. 1980; Figure 39). Striped bass have been widely introduced into rivers and lakes in much of the Mississippi River system (Audubon Society 1983). In 1879 striped bass were introduced to the west coast from New Jersey when approximately 135 juveniles were released into the Sacramento-San Joaquin estuary, near Martinez. A second shipment of juvenile striped bass imported from New Jersey were planted in Suisun Bay, near Suisun in 1882 (Shebley 1917; Curtis 1949). The introductions were so successful that within a few years a viable commercial fishery had become established. From these original importations, striped bass distribution has since expanded. They have been captured in marine waters from just south of the Mexican border to Barkely Sound, British Columbia (Miller and Lea 1972) and have established breeding populations in coastal streams in California, Oregon, and Washington (Audubon Society 1983). In California the main population is that of the Sacramento-San Joaquin basin; small runs may also exist in the Russian, Klamath, and Colorado systems. A viable land-locked population lives in Millerton Lake on the upper San Joaquin River. Populations

maintained by artificial means can be found in San Luis Reservoir, Madera County (through replenishment via California Aqueduct), San Antonio Reservoir, Monterey County (through stocking), Millerton Lake, Madera County (through stocking), and Lake Mendocino, Mendocino County (through stocking) (Moyle 1976; McGinnis 1984). Attempts to establish this species in the Salton Sea have failed (Curtis 1949).

There is no documentation for the existence of anadromous runs of striped bass in Putah Creek prior to the completion of the Solano Project. Since the early 1970's periodic captures of juvenile striped bass suggest that either adults are occasionally successful at accessing and spawning within the lower Putah basin or juveniles are entering the basin from other source waters via irrigation canals.

Bluegill (*Lepomis macrochirus*). Distribution: Originally restricted to southern and central North America, this species ranged from coastal Virginia to Florida, west to Texas and northern Mexico, and north from western Minnesota to western New York (Figure 40). It has been widely transplanted into other portions of the United States (Figure 41), as well as Mexico, Canada, Europe, and South Africa (Moyle 1976; Lee et al. 1980; Audubon Society 1983). Evermann and Clark (1931) stated that the exact date of their introduction into California is uncertain, but suggest that members of this species (as well as others) were introduced merely as "sunfishes" in 1890 or 1891. The first known introduction of bluegill into California was in 1908 at which time they were distributed at various sites from Lassen County in the north to Orange County in the south (Shebley 1917). They can now be found throughout the state in almost all lakes and slow-flowing streams with warm summer temperatures (Curtis 1949; Moyle 1976).

Past and present records indicate that bluegill are widely distributed throughout the Putah Creek basin.

Redear sunfish (*Lepomis microlophus*). Distribution: This centrarchid is native to peninsular Florida, lower Atlantic slope and Gulf slope drainages, west to Texas and north to southern Indiana (Lee et al. 1980; Figure 42). They have subsequently been introduced into warm water habitats throughout the United States. After first appearing in California in the Lower Colorado River about 1948, they have since been introduced to variety of waters in southern California and the Central Valley (Moyle 1976).

Redear sunfish were introduced into Putah Creek basin in 1957. Since this time redear sunfish have been recorded from Lake Berryessa and the lower basin.

Green sunfish (*Lepomis cyanellus*). Distribution: Originally the native range of this species was east-central North America from Ontario and New York south to Texas and northeastern Mexico, and from the western Appalachian drainages to eastern North Dakota and the foothills of the Rocky Mountains in the west (Figure 43). Subsequently it has been widely introduced elsewhere throughout the United States (Figure 44), northern Mexico and in Germany (Lee et al. 1980; Audubon Society 1983). Green sunfish were first introduced into California from Illinois in 1891 by accident, being mixed among a shipment of other sunfishes that were planted in Lake Cuyamaca, San Diego County (Shebley 1917; Evermann and Clark 1931; Curtis 1949). They have since been planted throughout the state (in many cases by people who thought they were bluegill) and now appear to be absent from only the Klamath River basin (Moyle 1976); although Curtis (1949) suggested

that green sunfish have been found in the Klamath basin in association with trout.

Past and present records indicate that green sunfish are widely distributed throughout the Putah Creek basin.

White crappie (*Pomoxis annularis*). Distribution: The original range of white crappie included freshwater habitats of east-central North America from southern Ontario and southwestern New York west of Appalachians, south to Gulf coast and throughout Mississippi basin into South Dakota and southern Minnesota (Lee et al. 1980; Figures 45 and 46). Moyle (1976) reports they were originally native Atlantic coast states north to North Carolina. They are now distributed within this original range east through middle Atlantic States, west through Nebraska, Kansas, and entire southwestern United States into California and Oregon. There are isolated distributions in Montana, Wyoming, and eastern New York/Massachusetts (Lee et al. 1980). White crappie were first introduced into California from Illinois in 1891 to Lake Cuyamaca, San Diego County (Curtis 1949), but the early introductions did not appear to be successful (Shebley (1917)). Moyle (1976) claims the first successful introduction did not occur until 1917 when sixteen fish were planted in a pond in San Diego County. White crappie from this population were planted throughout southern California, but were not transplanted north of the Tehachapi Mountains until 1951. They are now also present in many reservoirs and sloughs of the Sacramento-San Joaquin basin (Moyle 1976).

This species was first noted within the basin in Lake Berryessa in the early 1960's. Its origin is unknown, but emigration from local farmponds was suspected. It has established viable populations in the reservoir and has been collected in lower Putah Creek below Solano Diversion Dam.

Black crappie (*Pomoxis nigromaculatus*). Distribution: The native range for this sunfish was most likely rivers of the lower Atlantic slope from Virginia to Florida, along Gulf coast states to central Texas and north into southern Canadian provinces of Manitoba, Ontario and Quebec, and east to Appalachians (Figures 47 and 48). Black crappie have been widely transplanted in United States so that its current distribution also includes the middle and upper Atlantic States, west into the upper Missouri River basin, and throughout the entire southwest into California, Oregon, and Washington, including the Snake River drainages of Idaho (Moyle 1976; Lee et al. 1980). Black crappie were first introduced into California from Illinois in 1891 to Lake Cuyamaca, San Diego County (Curtis 1949). Moyle (1976) however said they were not successfully introduced into California until 1908. Black crappie can now be expected to have colonized almost all freshwater habitats in the state where there is warm, quiet water (Moyle 1976).

Like white crappie, black crappie were first noted within the basin in Lake Berryessa in the early 1960's. Its origin is unknown, but emigration from local farmponds was suspected. It

has established viable populations in the reservoir and has been collected in lower Putah Creek below Solano Diversion Dam.

Largemouth bass (*Micropterus salmoides*). Distribution: Although the precise native range is unclear due to numerous undocumented transplants, it is thought to be from northeastern Mexico to Florida and throughout the Mississippi basin north to Great Lakes States into southern Quebec and Ontario, and from lower Atlantic states from Florida to South Carolina (Figure 49). Largemouth bass have been transplanted virtually worldwide (Moyle 1976; Lee et al. 1980). Evermann and Clark (1931) and Curtis (1949) claimed largemouth bass were first introduced into California in 1874 (along with smallmouth bass) with releases into Napa and Alameda creeks. However Shebley (1917) indicated that this centrarchid was introduced into the state at two sites - Lake Cuyamaca, San Diego County, and the Feather River, near Gridley - by the U.S. Fish Commission in 1891. Regardless of the circumstances of their importation, largemouth bass are now distributed throughout the state into most warm, freshwater habitats (Moyle 1976; McGinnis 1984).

Records indicate that largemouth bass were present in the middle basin (at least in private farmponds) prior to the Solano Project. The the completion of Lake Berryessa and large plants of largemouth bass have lead to an increased abundance of this species in the reservoir and the lower portion of the basin.

Smallmouth bass (*Micropterus dolomieu*). Distribution: The original range for smallmouth bass included freshwater habitats from Minnesota to southern Quebec south to the Tennessee River system in Alabama and west to eastern Oklahoma (Figure 50). Smallmouth bass have been widely transplanted in the United States and elsewhere (Lee et al. 1980). They were first in-

troduced into California in 1874 via releases of seventy-five adults from Lake Champlain, Vermont into Napa Creek, and twelve juveniles from St. Joseph River, Michigan into Alameda Creek (Shebley 1917; Curtis 1949). In 1895 some 25,000 fry were rescued from overflow ponds in the Russian River and distributed throughout several counties in the state (Evermann and Clark 1931). They have since been planted in most of the larger streams, and lower and middle elevation lakes, throughout the Sacramento-San Joaquin system, the Russian River, and southern California (Curtis 1949; Moyle 1976; McGinnis 1984).

Past and present records indicate that smallmouth bass are widely distributed throughout the Putah Creek basin. In the 1930's Putah Creek was renowned for its smallmouth bass fishery and portions of the middle basin still support a substantial fishery. Large populations of this species are present in Lake Berryessa, and smallmouth bass have also been collected in the lower basin.

Spotted bass (*Micropterus punctulatus*). Distribution: Spotted bass were originally distributed in the Gulf coast basins from Texas to northwestern Florida, and the lower and central Mississippi basin (including the Ohio River - Moyle 1976; Lee et al. 1980; Figure 51). This centrarchid has been introduced into several Atlantic coast basins in North Carolina and Virginia, as well as selected waters in California (Lee et al. 1980). The northern strain of spotted bass was first introduced into California from Ohio in 1933, where it propagated at Central Valleys Hatchery and subsequently stocked into the Tuolumne, Kern, San Joaquin, Cosumnes and Feather rivers. Only the later two sites developed viable populations (McKechnie 1966). The Alabama strain was imported into California in 1973 and planted into Perris Reservoir in San Bernardino County (Moyle 1976). Viable populations were es-

established from subsequent stocking into Millerton Lake, Fresno-Madera County, and Lake Berryessa, Napa County.

From initial plants of about 115 adults in 1981 and 124 adults in 1983 a viable population of Alabama spotted bass has been established in Lake Berryessa. There has been no documentation to date of the occurrence of spotted bass in the lower basin. However, given the habitat present in lower Putah Creek, the apparent success of the other black basses in this area, and the success of this species in moderate sized, low gradient sections of streams, it should not be surprising to find them in the lower basin sometime in the future.

Bigscale logperch (*Percina macrolepida*). Distribution: Bigscale logperch are native to the Sabine River in eastern Texas and western Louisiana, northwest into Red and Washita rivers in Oklahoma, south to periphery of Edwards Plateau of central Texas, and west into Devil's River in Texas and Rio San Carlos in northern Coahuila, Mexico and the middle and upper Pecos River in New Mexico (Lee et al. 1980; Figure 52). They were accidentally introduced into California in 1953 by the Fish and Wildlife Service when they were mixed in with a shipment of largemouth bass and bluegill planted into three small lakes on Beale Air Force Base in Yuba County. By the mid 1970's logperch had spread via the Bear River basin into other parts of the Sacramento-San Joaquin basin as far north as Wilson Landing, northwest of Chico (Boles 1976) and as far south as the Mendota Wildlife Area near Fresno (Farley 1972). Logperch can now be found in the Feather, Yuba, Dry Creek, and Butte Creek basins and are probably extending their distribution into suitable drainages throughout the Central Valley (Boles 1976; Moyle 1976; Figure 38). Logperch are especially abundant in sloughs and backwaters of the Delta and lower Sacramento-San Joaquin river, as well as associated low elevation reservoirs (Moyle 1976; McGinnis 1984). Moyle et

al. (1974) also collected this species from Del Valle Reservoir, which drains into South San Francisco Bay.

Logperch were first observed in lower Putah Creek in 1973 (Moyle et al. 1974) and have since established viable populations in the lower basin below Solano Diversion Dam. A Department survey of Lake Berryessa in 1991 documented the first record of this species from Lake Berryessa.

CONCLUSION

More than forty species of fishes have been listed as occurring in Putah Creek, with most having distributions that include other drainages both within and outside of California. Only three species may be considered to be restricted in their distribution: the thicktail chub, the Sacramento splittail, and the Sacramento perch. None of these native California fishes appears to be present within Putah Creek basin at this time. Thicktail chub were included in a species list published by Shapovalov (1947) and he admitted uncertainty of their actual presence in the basin. The last known collection of thicktail chub in Putah Creek occurred prior to the early 1940's. Sacramento splittail and Sacramento perch were not included in the Shapovalov faunal list. The only record for splittail in Putah Creek was prior to 1900. No record for the collection of Sacramento perch in the Putah Creek basin could be found, and the only evidence documenting its presence in the watershed was a reference to the release of a single individual below Winters in 1939. The failure to collect thicktail chub, Sacramento splittail, and Sacramento perch in any of the numerous fish surveys that have been conducted within the basin since the 1940's suggest that either these members of the Sacramento-San Joaquin fish fauna are extremely rare and have managed to avoid detection, or more plausibly, that they are no longer present in the basin.

All of the remaining species, whose presence in Putah Creek has been recently documented, maintain populations elsewhere in California, with most having distributions outside of the state as well. None of these fish species is dependent on the populations in Putah Creek for their continued existence. Thirty-three fish species are known to occur in the lower basin below Solano Diversion Dam (Table 1). Among this group, twenty-six are known to maintain viable populations in the Putah basin upstream of the Solano Diversion Dam (Table 2). These upstream populations are significant since they could serve as a source for recolonizing downstream areas should lower basin populations become depleted.

Of the seven remaining species that appear to be found only in the lower basin of Putah Creek (Table 3), four are anadromous fishes (lamprey, American shad, chinook salmon, and striped bass). Recent fish surveys suggest that except for the lamprey, these anadromous fishes are currently quite rare in the Putah Basin; however, all of them are common or abundant in waters throughout their range of distribution. These anadromous fish are able to migrate up into Putah Creek only during periods of extremely high discharge. Since their access to Putah Creek is uncertain and random (in that it depends on adequately high flows that occur simultaneous with their spawning migrations) these fish, when they are present in Putah Creek cannot truly be considered endemic populations, but are more probably strays from other Sacramento River basin populations. This means that flow conditions in Putah Creek between the high flow events that provide these species access to Putah Creek have little to do with the continued maintenance of spawning populations within Putah Creek.

This leaves three species (black bullhead, bigscale logperch, and tule perch) that could potentially be considered dependent on water quality and quantity conditions in the lower basin for the maintenance of their populations in Putah Creek. Logperch and black bullhead are both introduced species that some consider nuisances and potential hazards to the native fauna (Moyle 1976; McGinnis 1984). Black bullhead are widely distributed throughout the central and

western United States, and logperch are currently expanding their populations in California (Moyle 1976). Tule perch, a member of the Sacramento-Jan Joaquin native fauna, are currently considered abundant in the Russian, Clear Lake and Sacramento basins. The logperch (specimens of which have recently been found in Lake Berryessa) and tule perch are commonly found in Putah Creek between the Solano Diversion Dam and the Interstate 505 Bridge. This reach is considered to be within the "living" continuous stream even at the minimum 15 cubic foot per second release required during critically dry years (Trinity Fisheries Consulting 1991). Their presence in this area minimizes the danger of their extirpation from the lower Putah Creek basin. This leaves black bullhead as the only species remaining whose only known distribution in the basin is in the intermittent flow area of lower Putah Creek. Black bullhead are quite successful in surviving in intermittent streams with high water temperatures (Moyle 1976) and thus seem quite suited to sustaining viable populations despite periods of little or no flow in sections of the lower Putah Creek basin.

Table 1. Fishes Collected From Lower Putah Creek Since Completion of Solano Project

California Native Species

- 1) lamprey
- 2) chinook salmon
- 3) rainbow trout
- 4) hitch
- 5) California roach
- 6) blackfish
- 7) speckled dace
- 8) Sacramento squawfish
- 9) Sacramento sucker
- 10) threespine stickleback
- 11) tule perch
- 12) riffle sculpin

Introduced Species

- 13) American shad
- 14) threadfin shad
- 15) carp
- 16) goldfish
- 17) golden shiner
- 18) fathead minnow
- 19) brown bullhead
- 20) black bullhead
- 21) channel catfish
- 22) white catfish
- 23) mosquitofish
- 24) inland silverside
- 25) striped bass
- 26) bluegill
- 27) green sunfish
- 28) redear sunfish
- 29) black crappie
- 30) white crappie
- 31) largemouth bass
- 32) smallmouth bass
- 33) bigscale logperch

Table 2. List of Fish Populations Supported in Putah Creek Upstream of Solano Diversion Dam (Includes Upper Basin and Tributaries, Lake Berryessa, Putah Creek Below Monticello Dam, and Solano Lake)

California Native Species

- 1) rainbow trout
- 2) hitch
- 3) California roach
- 4) blackfish
- 5) hardhead
- 6) speckled dace
- 7) Sacramento squawfish
- 8) Sacramento sucker
- 9) threespine stickleback
- 10) riffle sculpin

Introduced Species

- 11) threadfin shad
- 12) brown trout
- 13) carp
- 14) goldfish
- 15) golden shiner
- 16) fathead minnow
- 17) brown bullhead
- 18) channel catfish
- 19) white catfish
- 20) mosquitofish
- 21) inland silverside
- 22) bluegill
- 23) green sunfish
- 24) redear sunfish
- 25) black crappie
- 26) white crappie
- 27) largemouth bass
- 28) smallmouth bass
- 29) spotted bass
- 30) bigscale logperch? - found in Lake Berryessa during 1991 survey;
not known if exist in numbers large enough
to support a viable population

Table 3. Fishes Noted from Lower Putah Creek That Are Not Found in Putah Creek Upstream of Solano Lake

California Native Species

- 1) lamprey
- 2) chinook salmon
- 3) tule perch

Introduced Species

- 4) American shad
- 5) black bullhead
- 6) striped bass
- 7) bigscale logperch ?

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Personal Communication

Dave Catagna, Collection Manager, Ichthyology Section of California
Academy of Science, San Francisco. 10 March 1992.

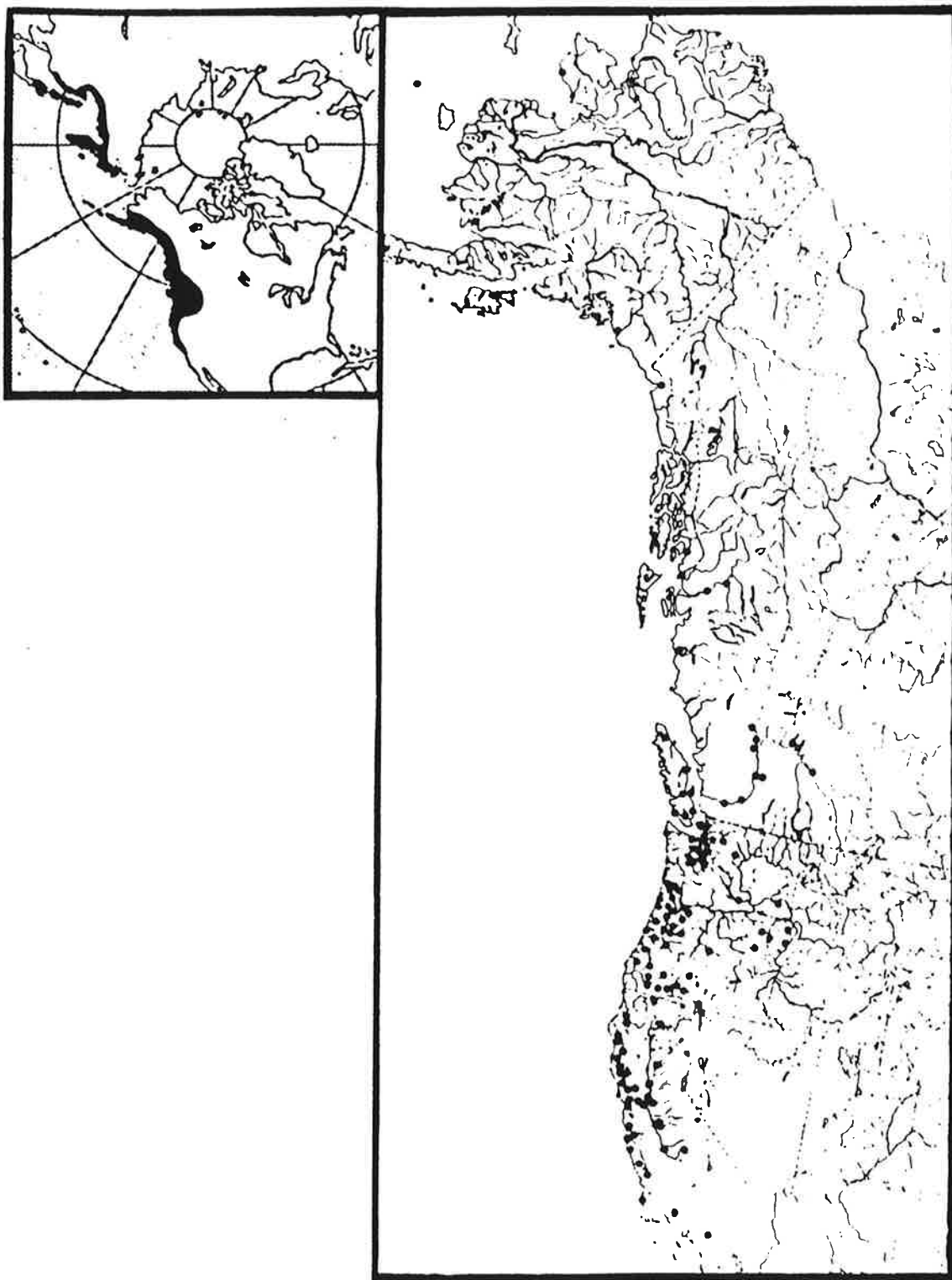


Figure 1. Range of Pacific lamprey.

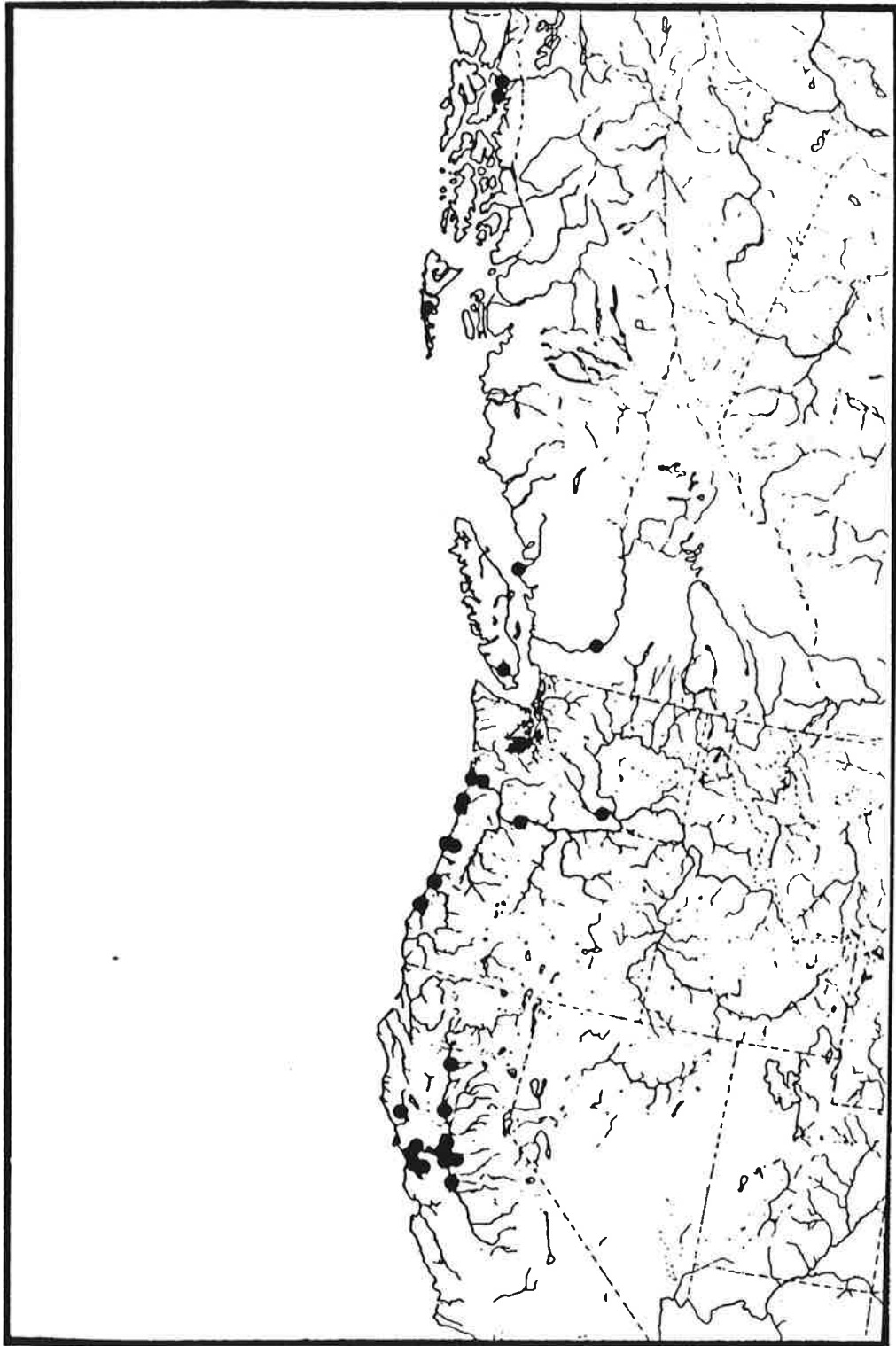


Figure 2. Range of river lamprey.

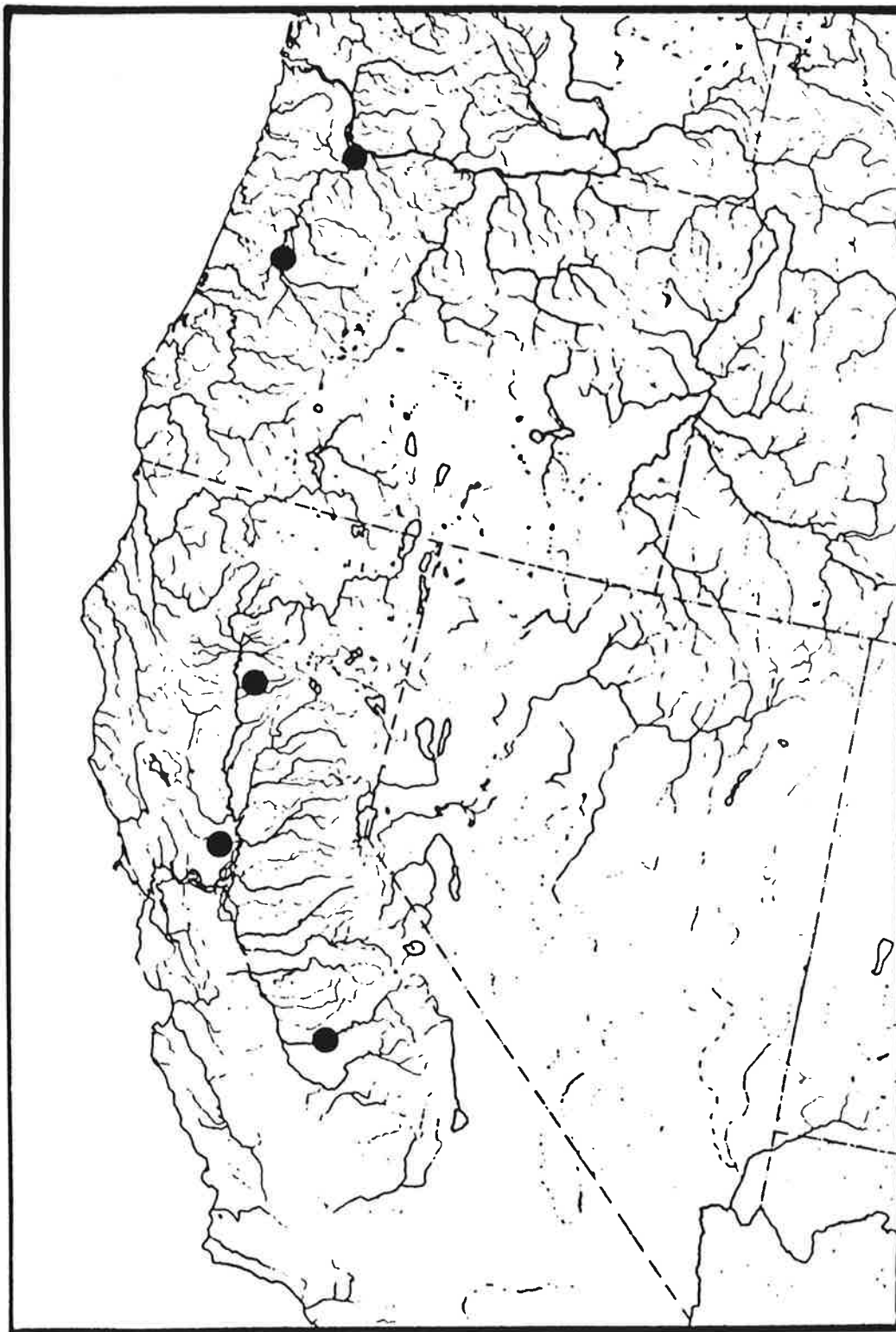
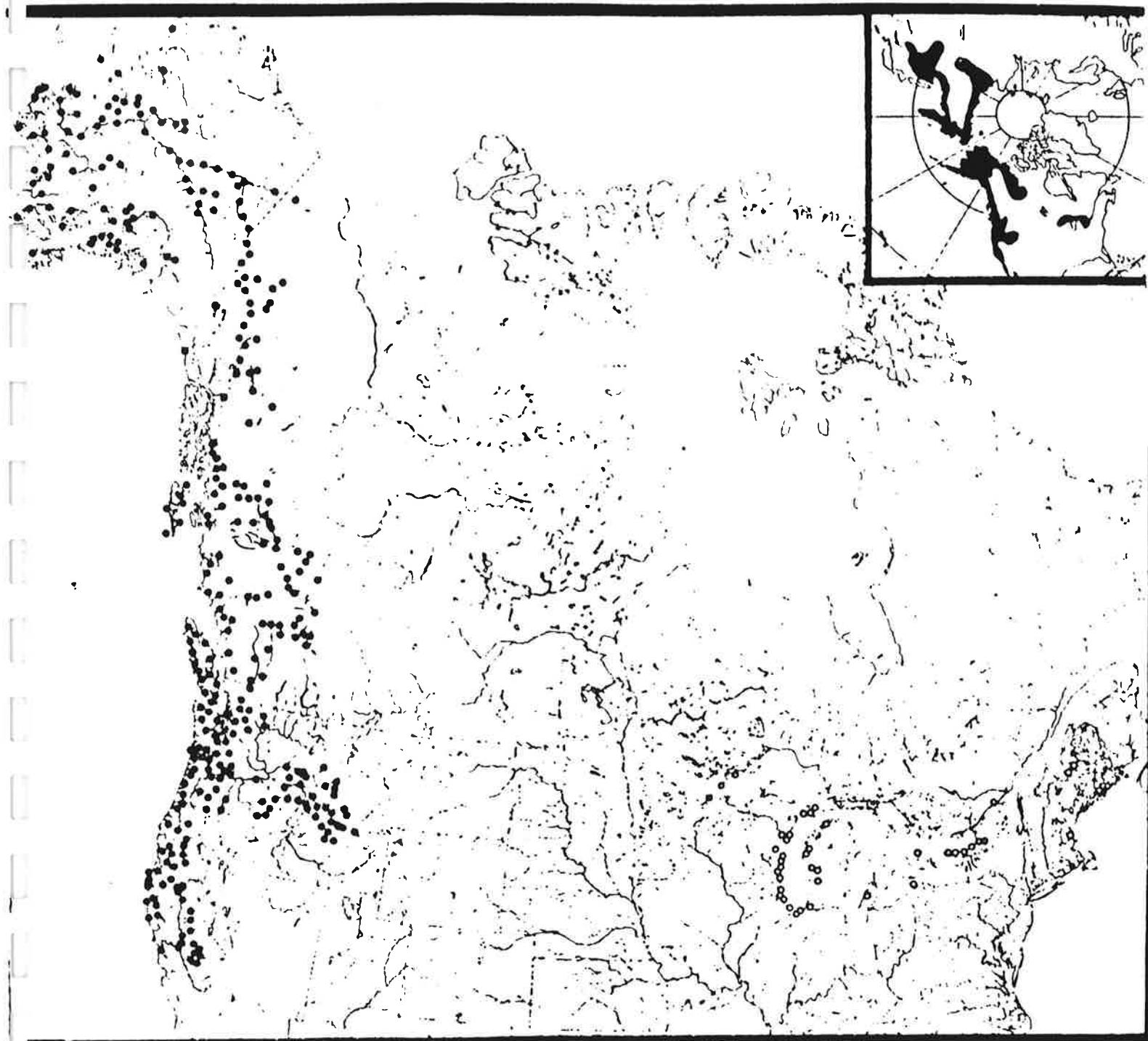


Figure 3. Range of Pacific brook lamprey.



Open circles transplanted populations

Figure 4. Range of chinook salmon.

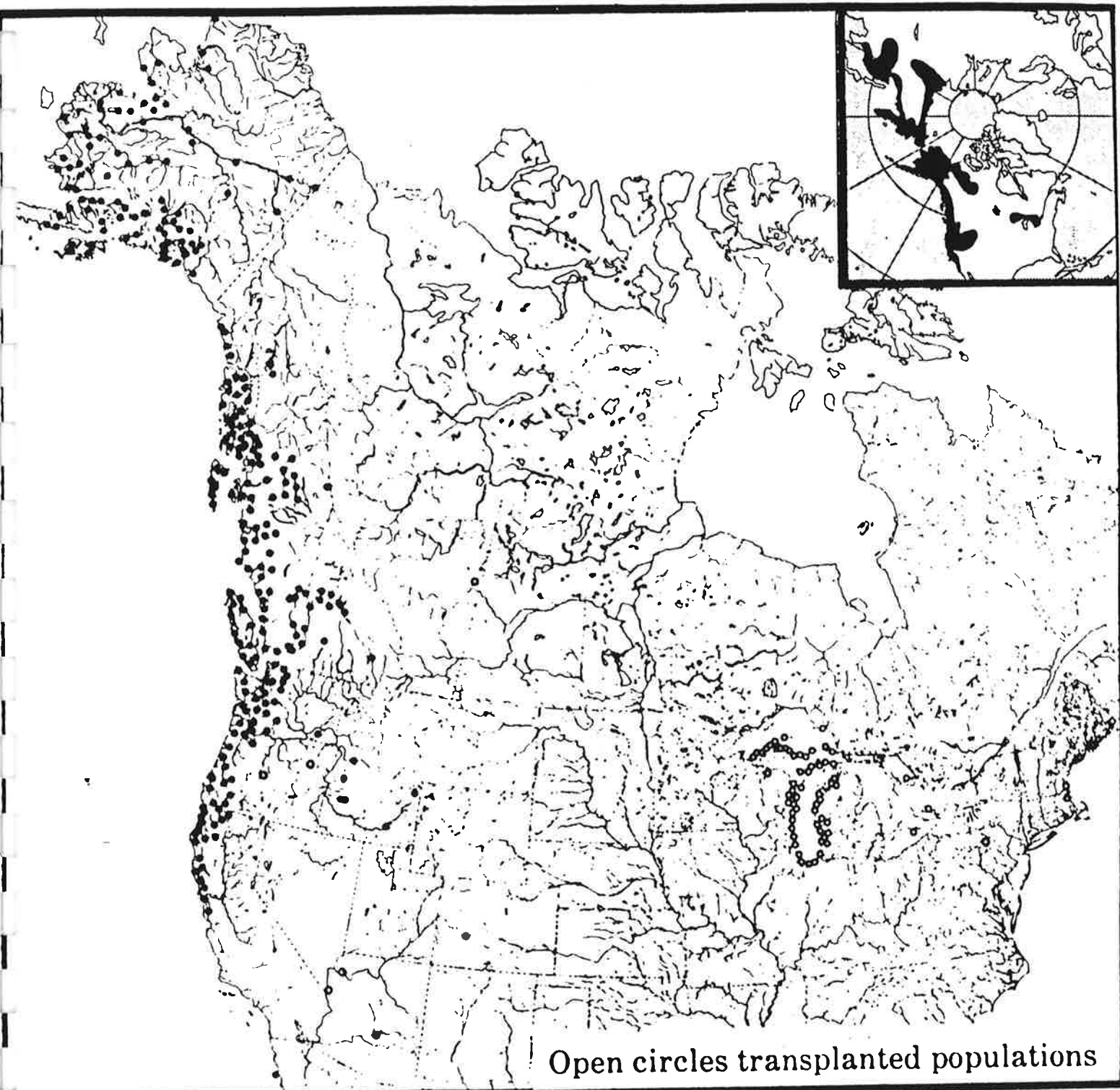
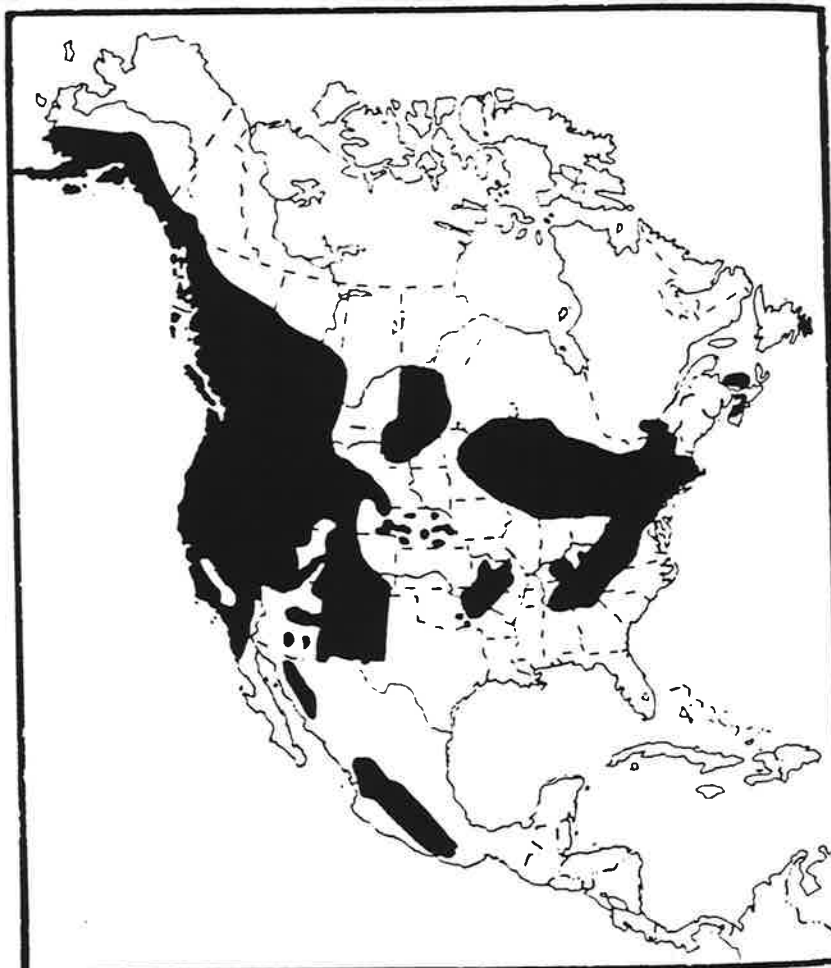


Figure 5. Range of coho salmon.



Former Distribution



Present Distribution

Figure 6. Range of rainbow trout
in North America.

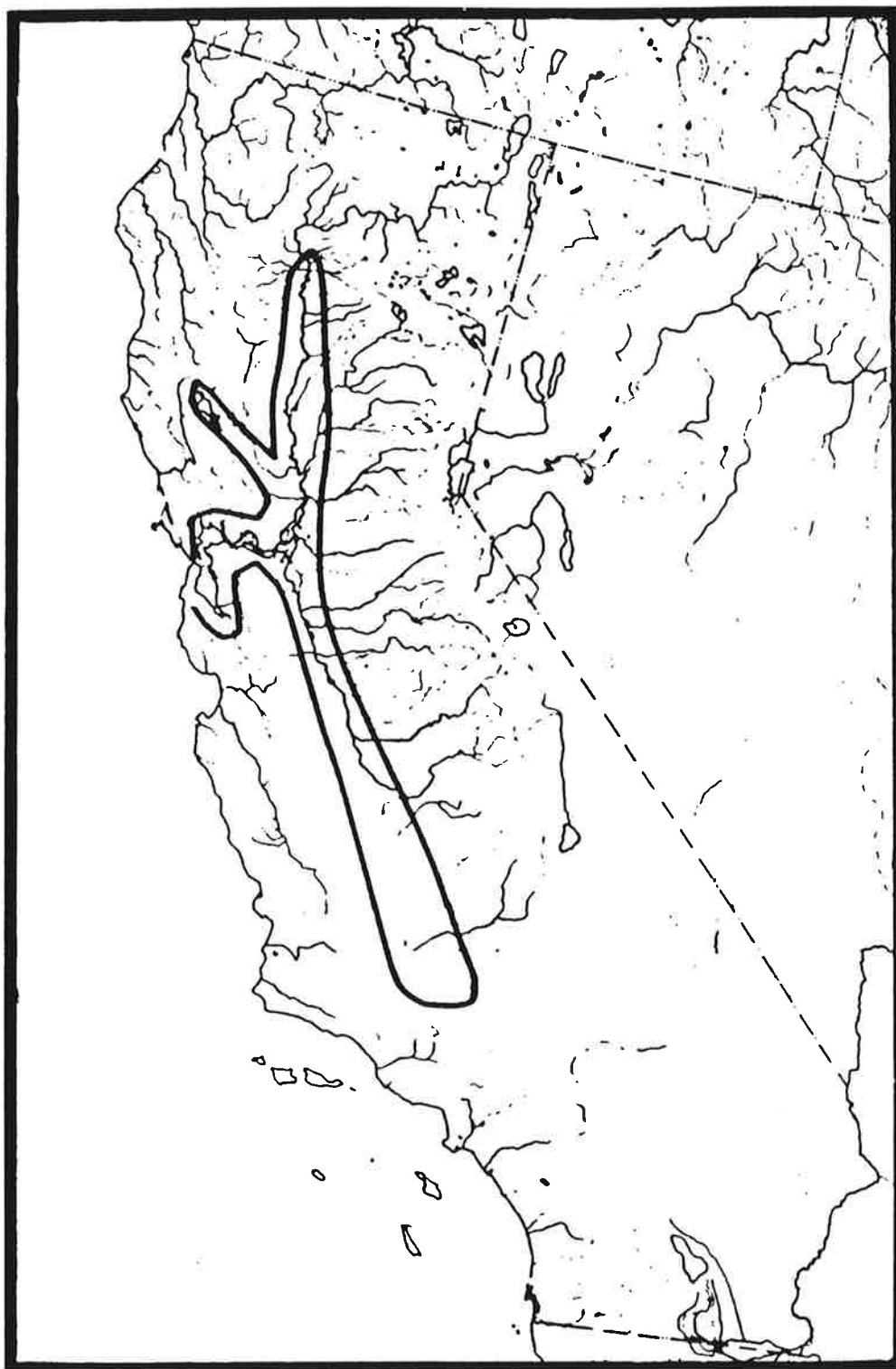


Figure 7. Former range of
thicktail chub.

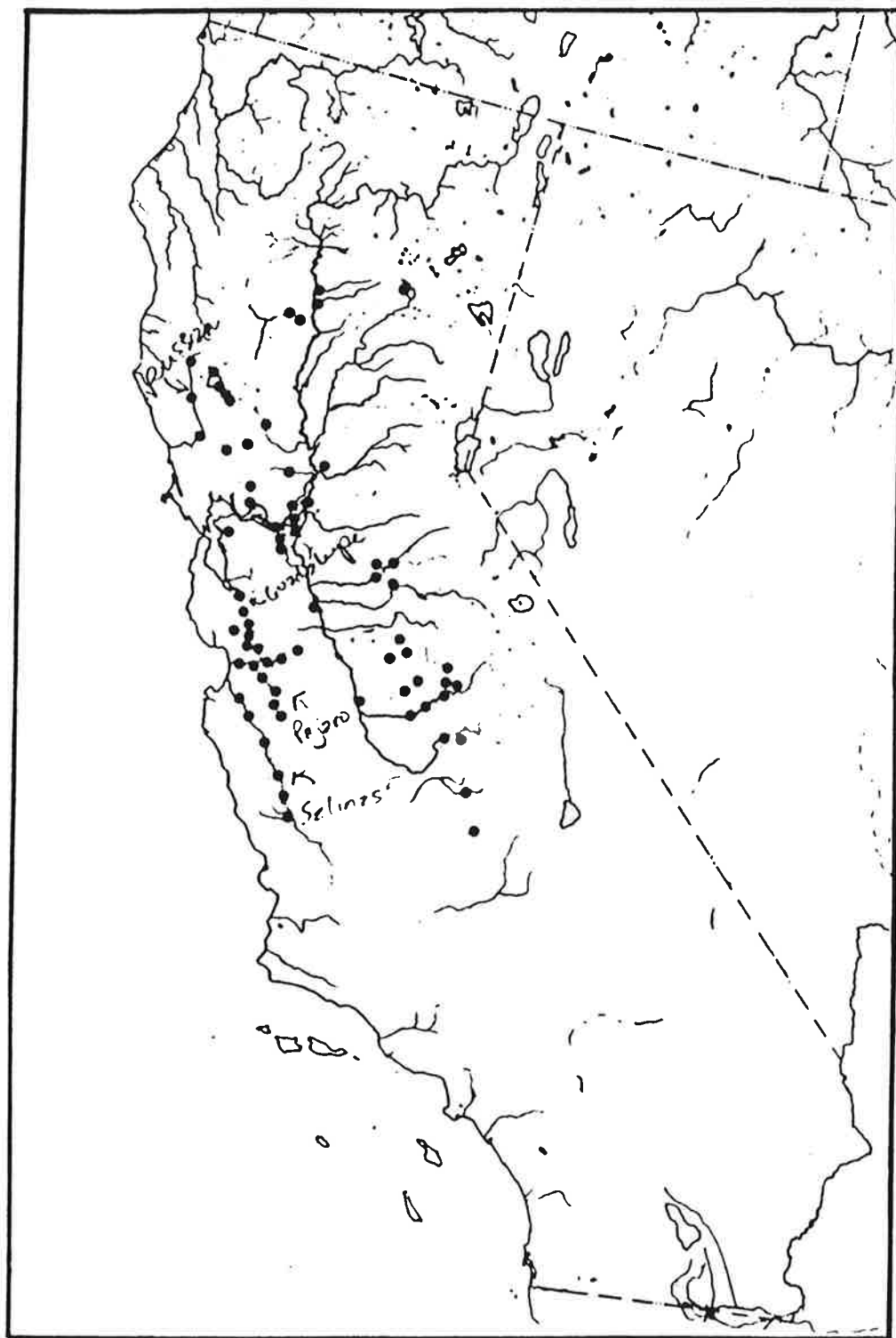


Figure 8. Range of hitch.

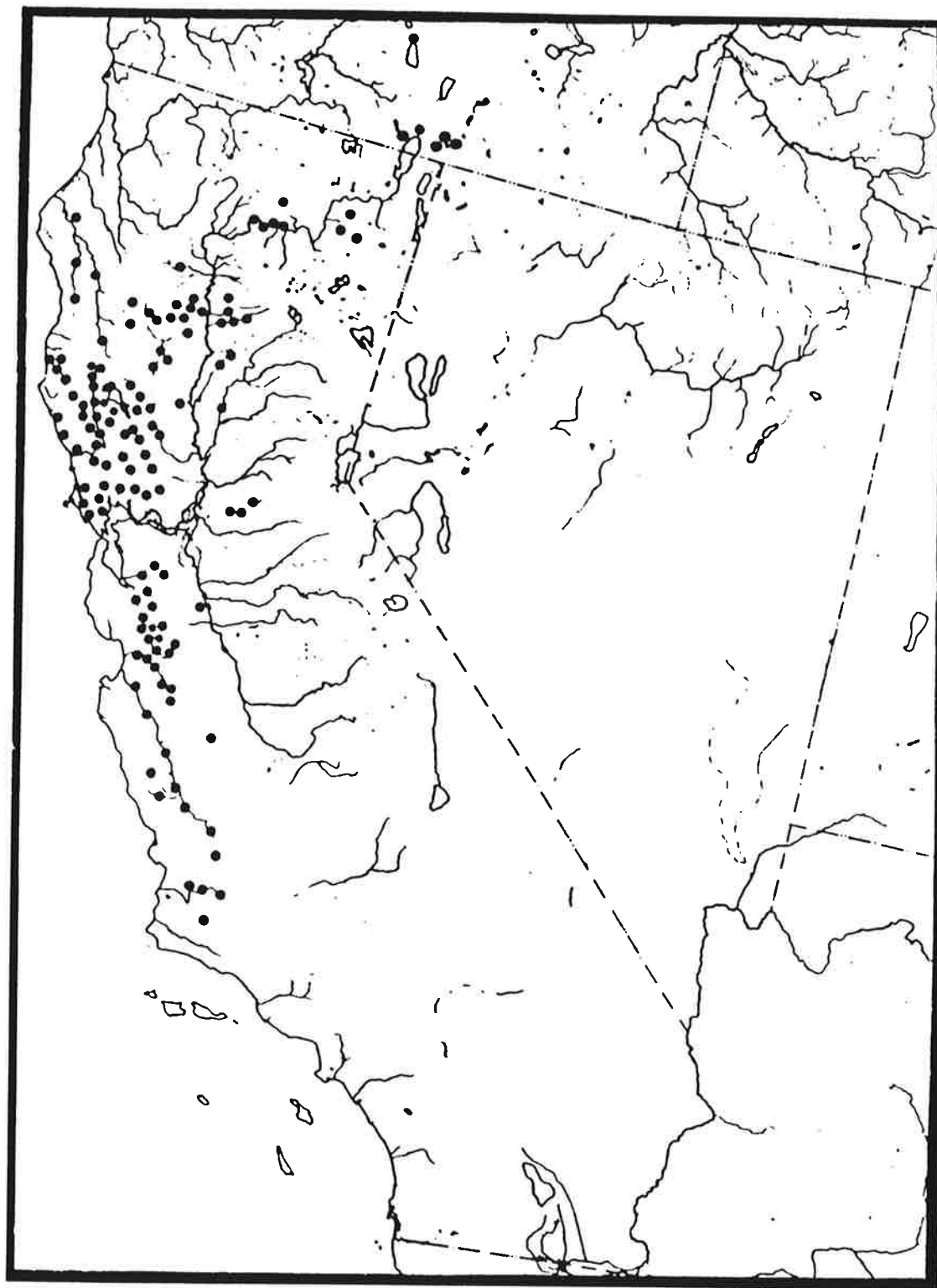


Figure 9. Range of California roach.

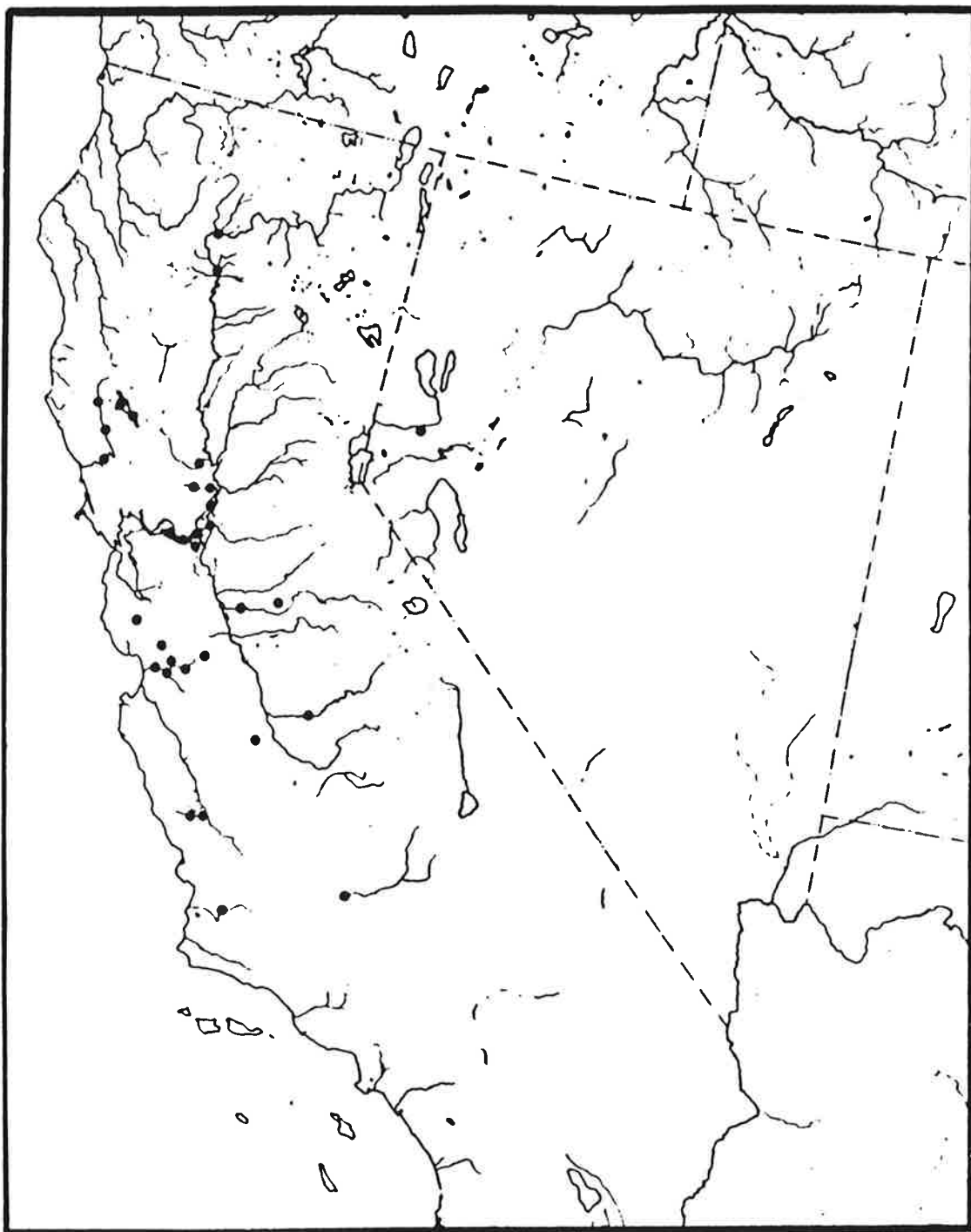


Figure 10. Range of Sacramento blackfish.

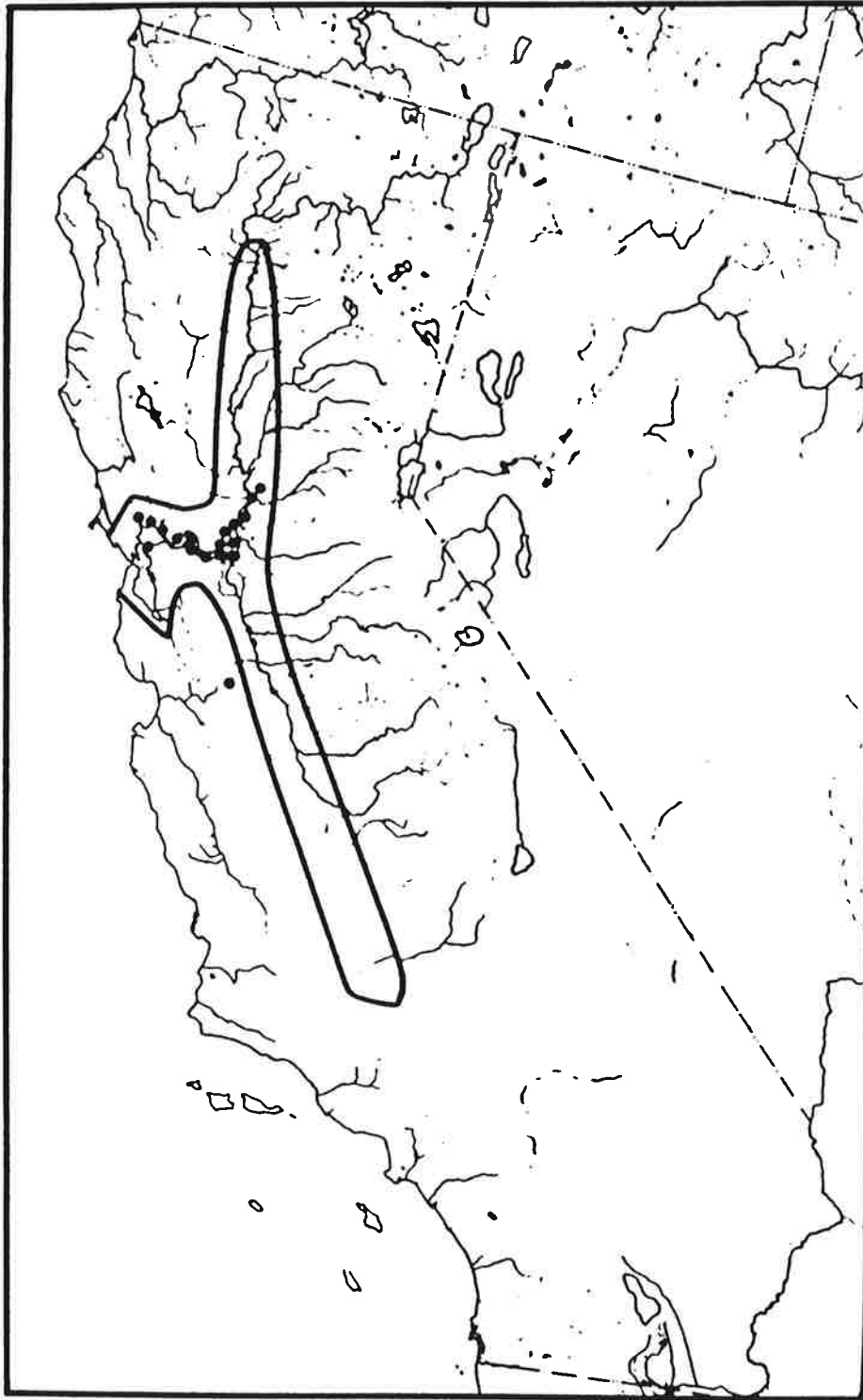


Figure 11. Former and current range
of Sacramento splittail.

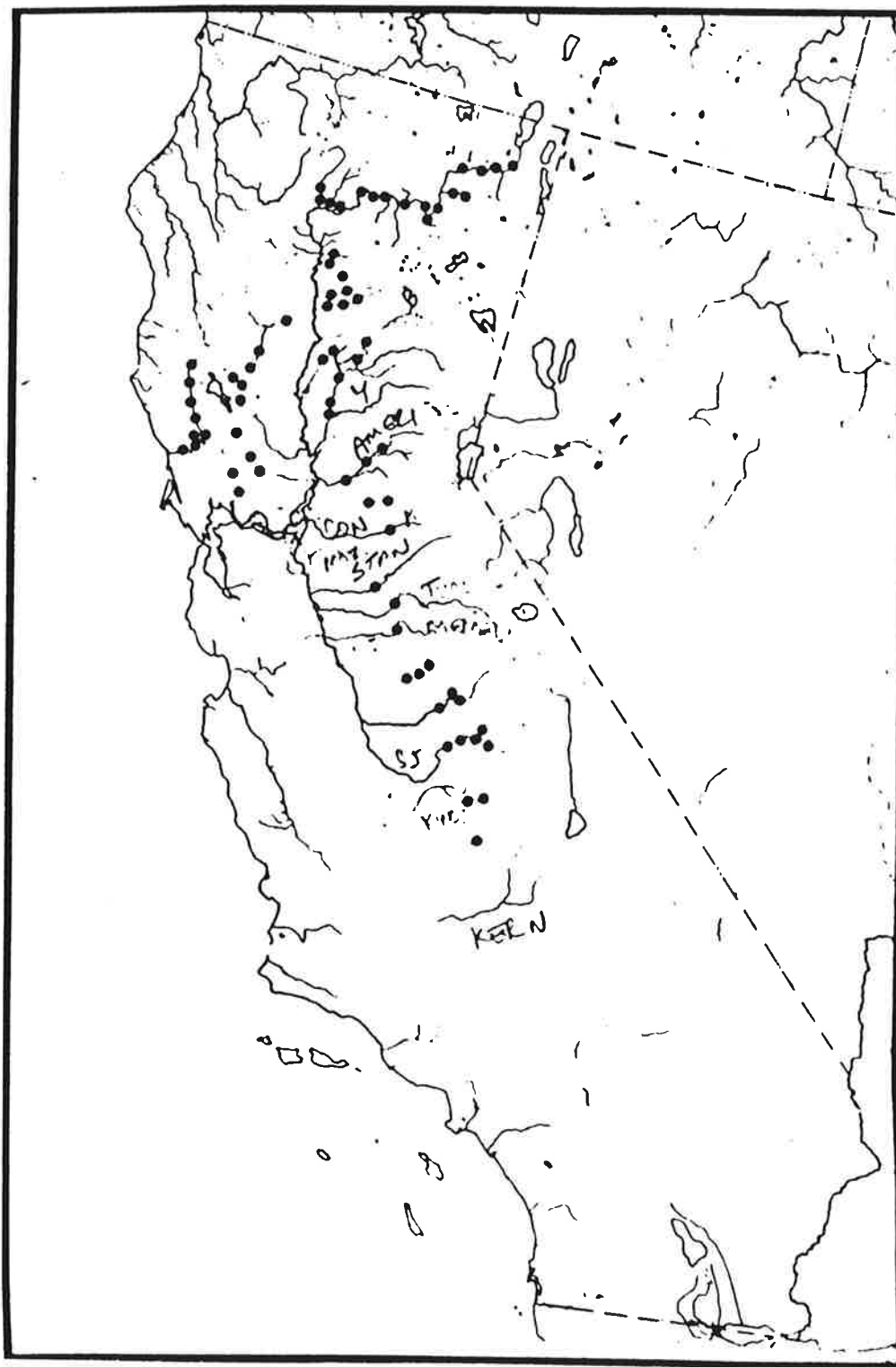


Figure 12. Range of hardhead.

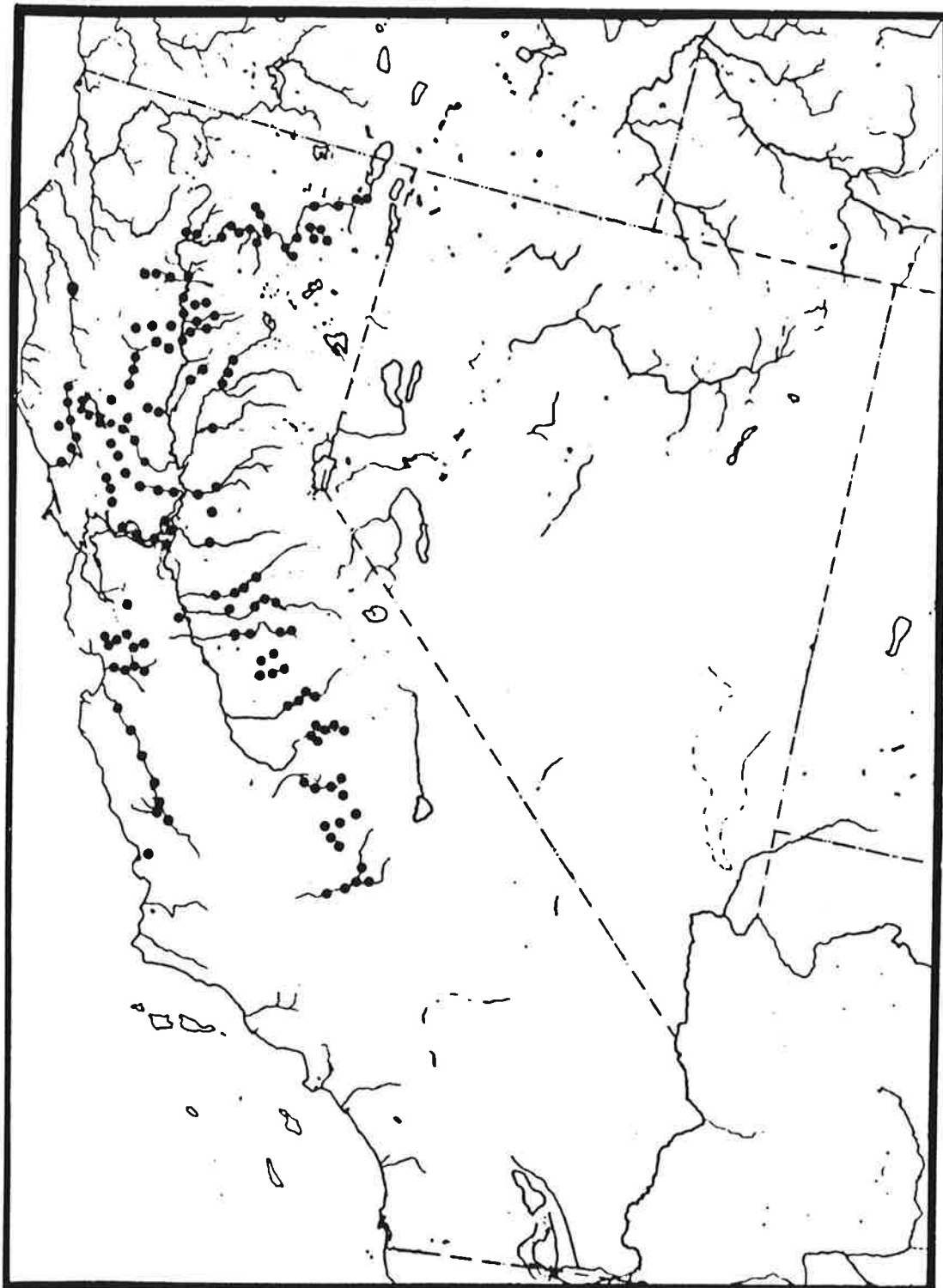


Figure 13. Range of Sacramento squawfish. Modified from Steiner Environmental Consulting 1991.

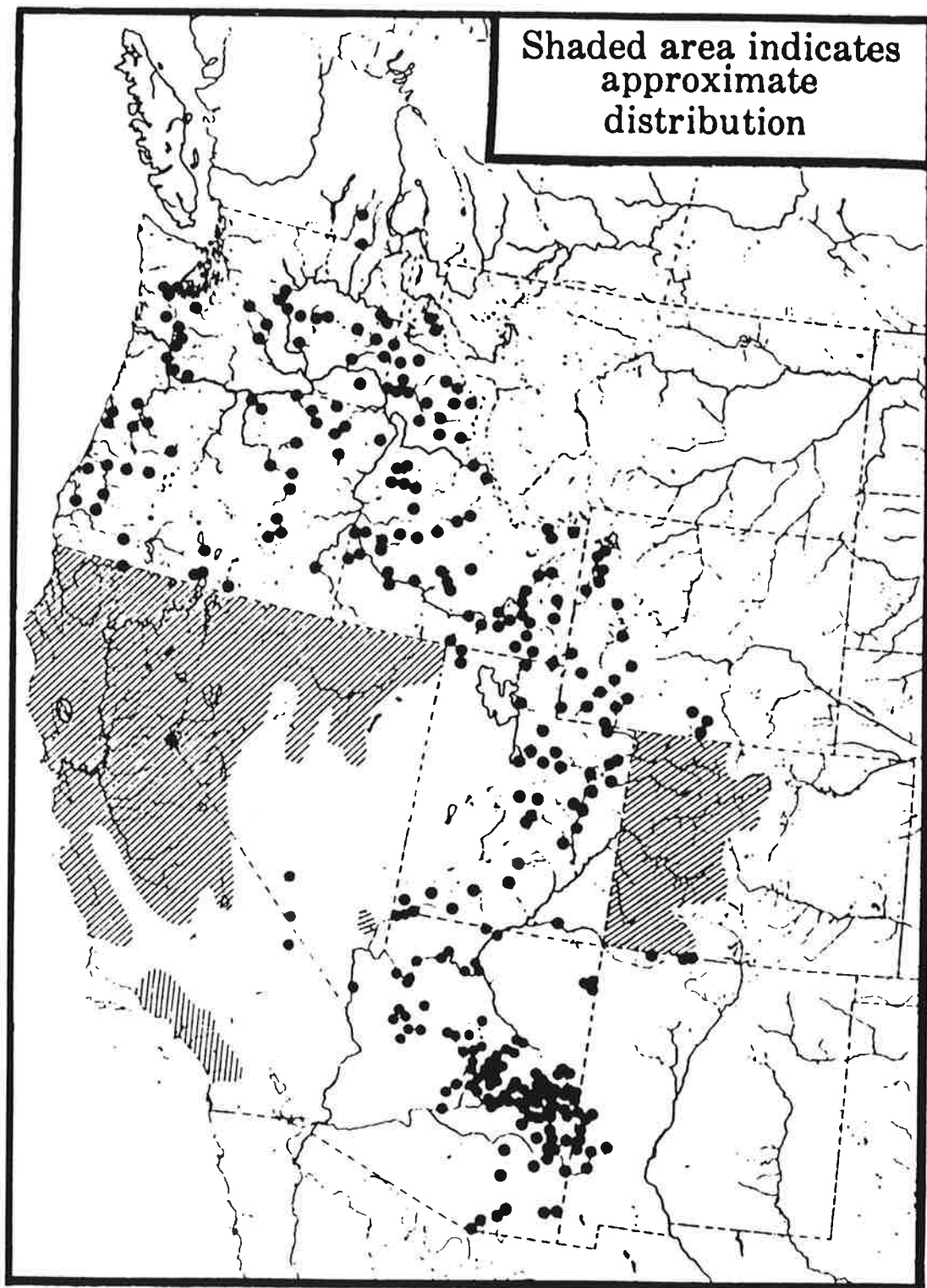


Figure 14. Range of speckled dace.

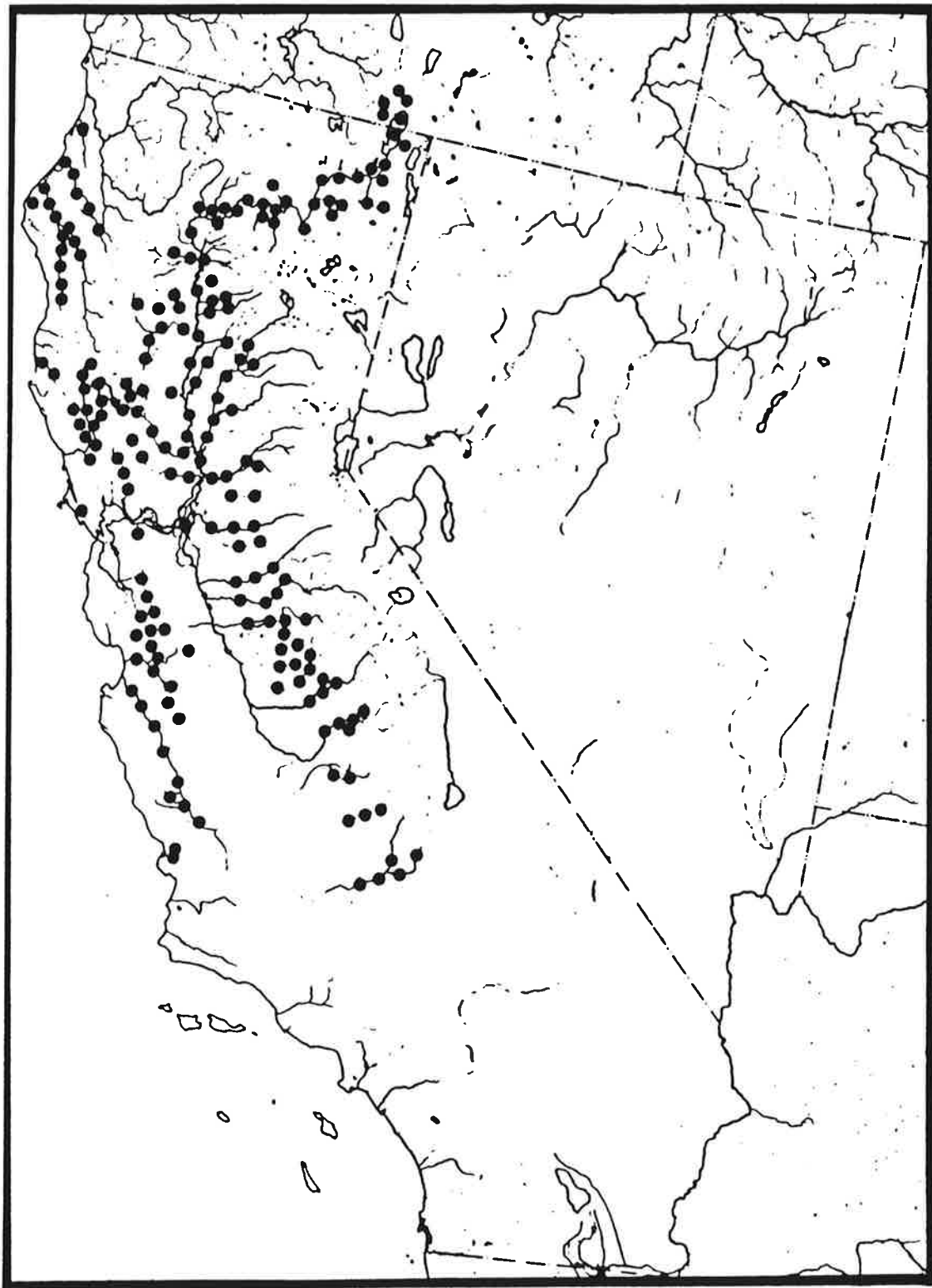


Figure 15. Range of Sacramento sucker.

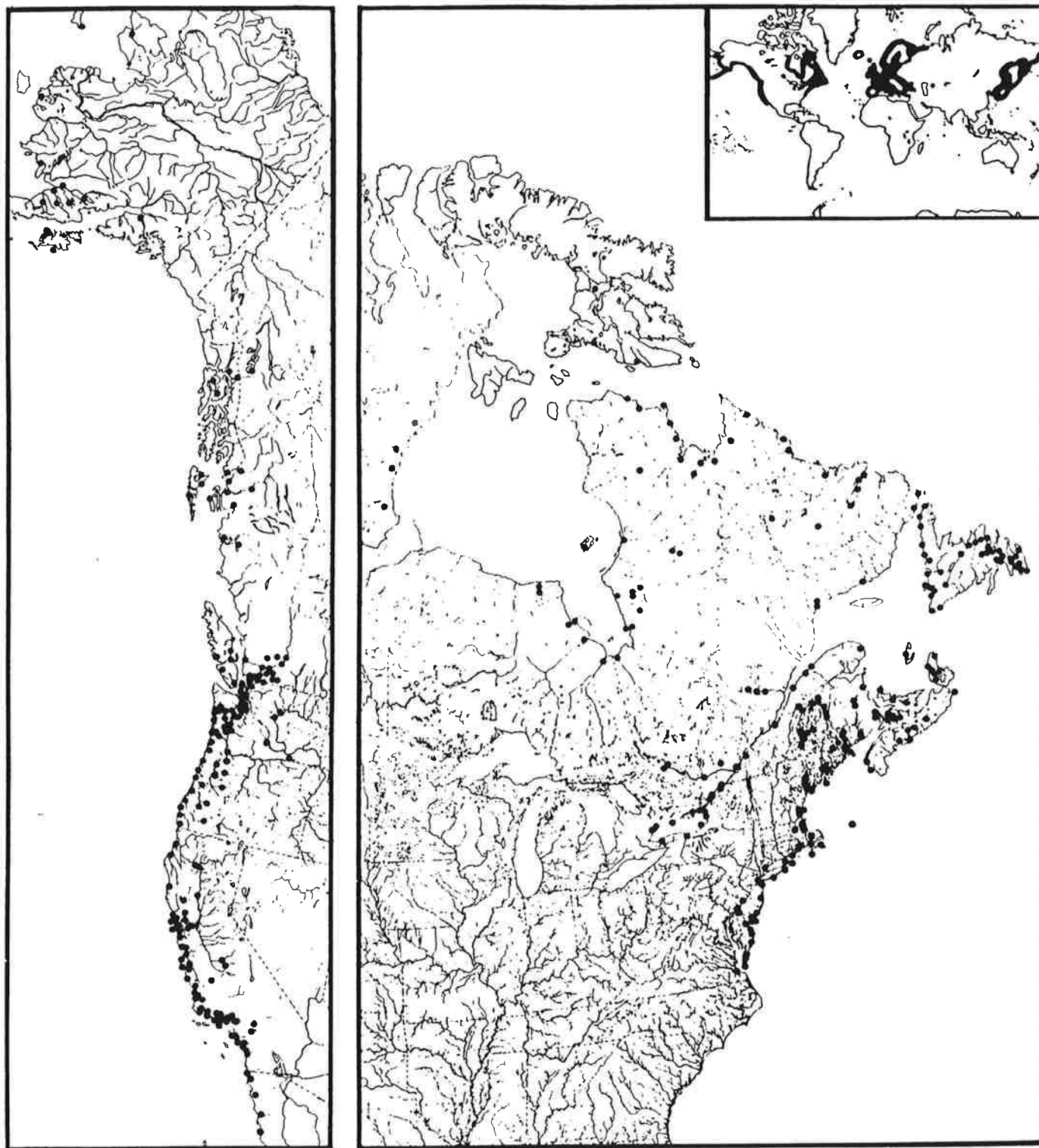


Figure 16. Range of threespine stickleback.



Figure 17. Range of threespine stickleback in North America.

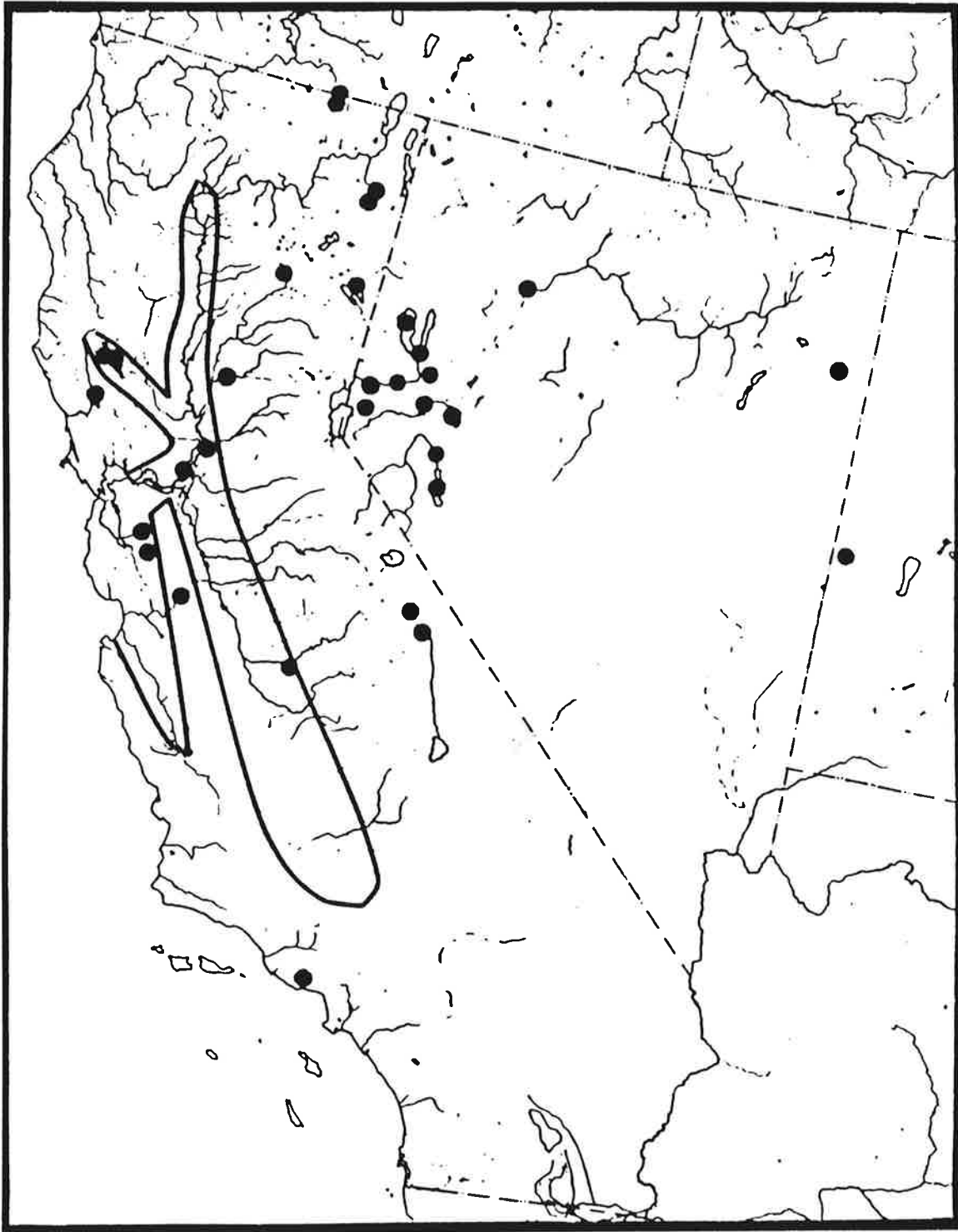


Figure 18. Former and current range of Sacramento perch.

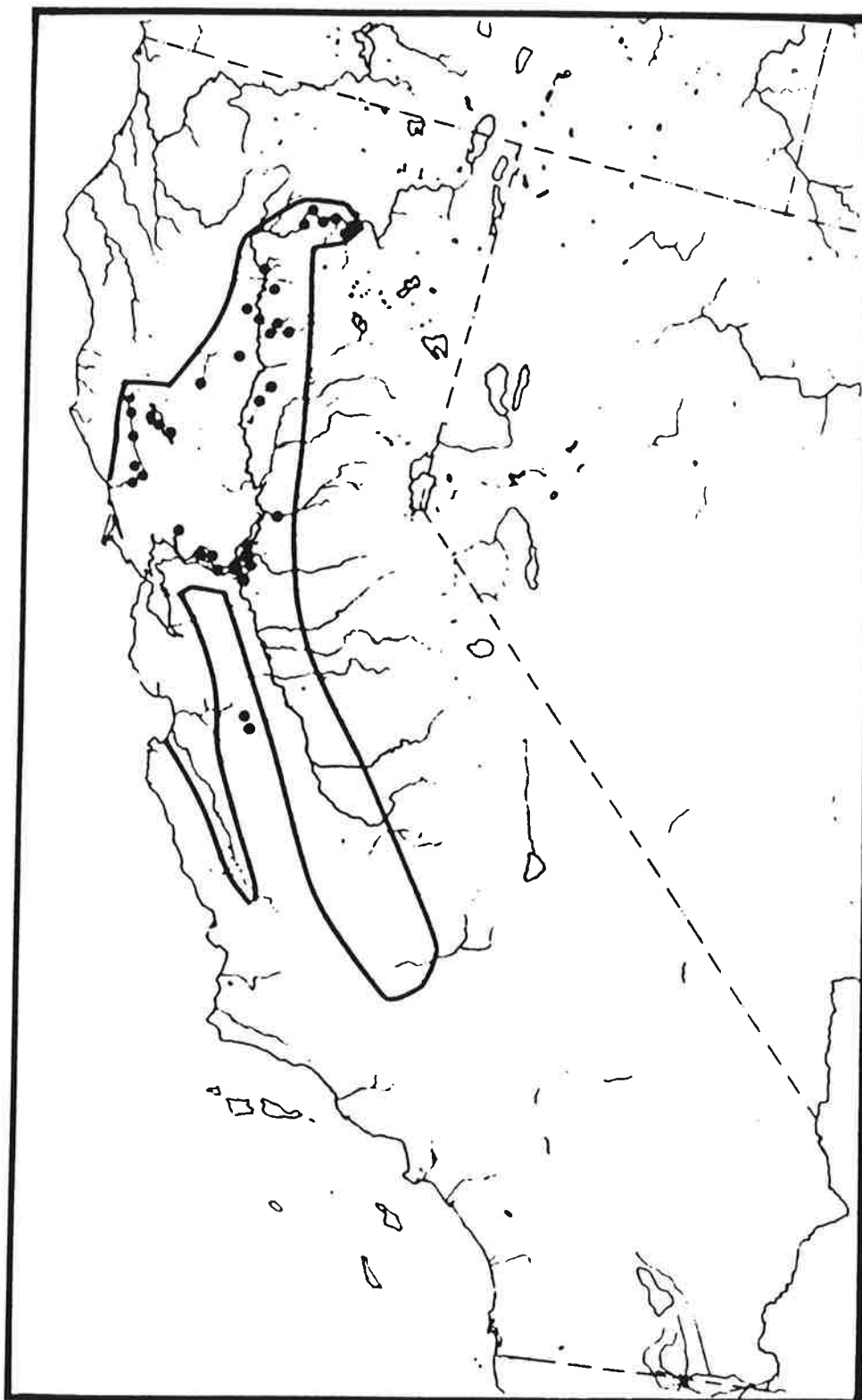


Figure 19. Former and current range of tule perch.

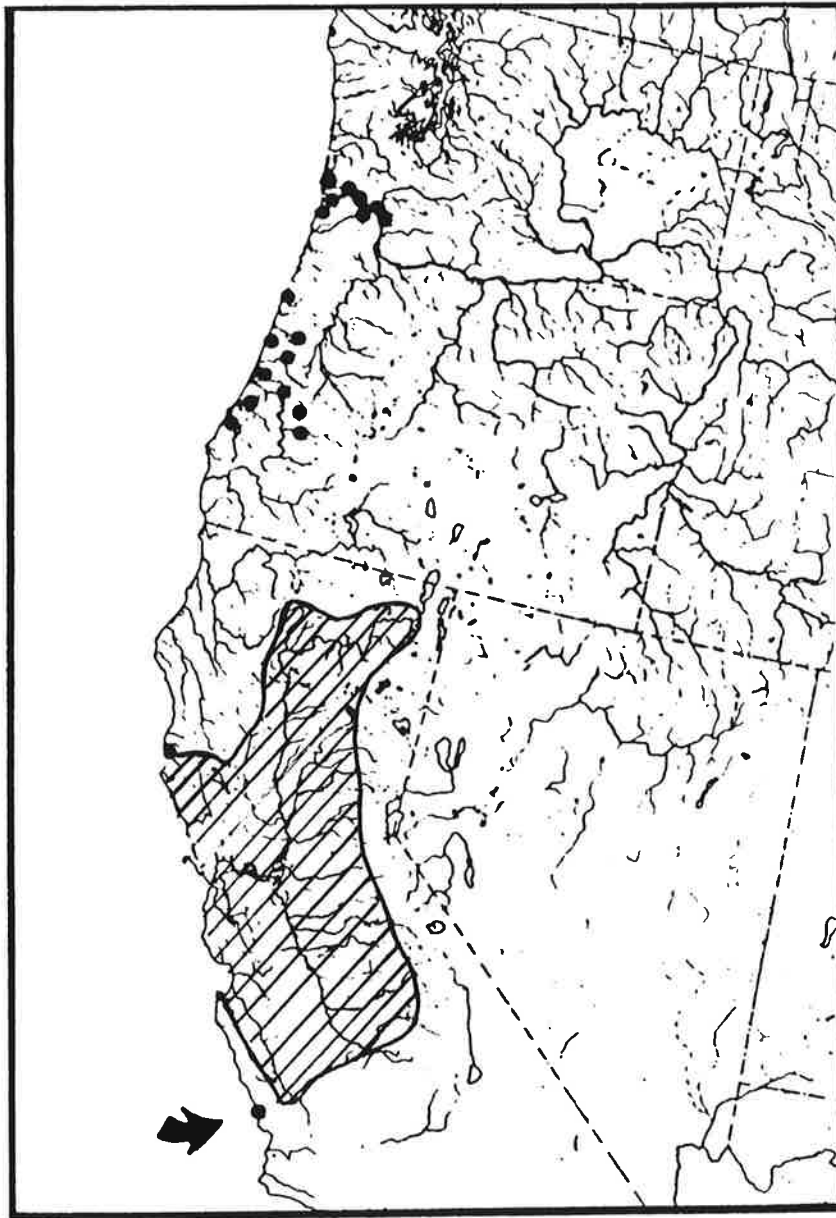


Figure 20. Range of riffle sculpin.
Modified from Lee et al.
1980.

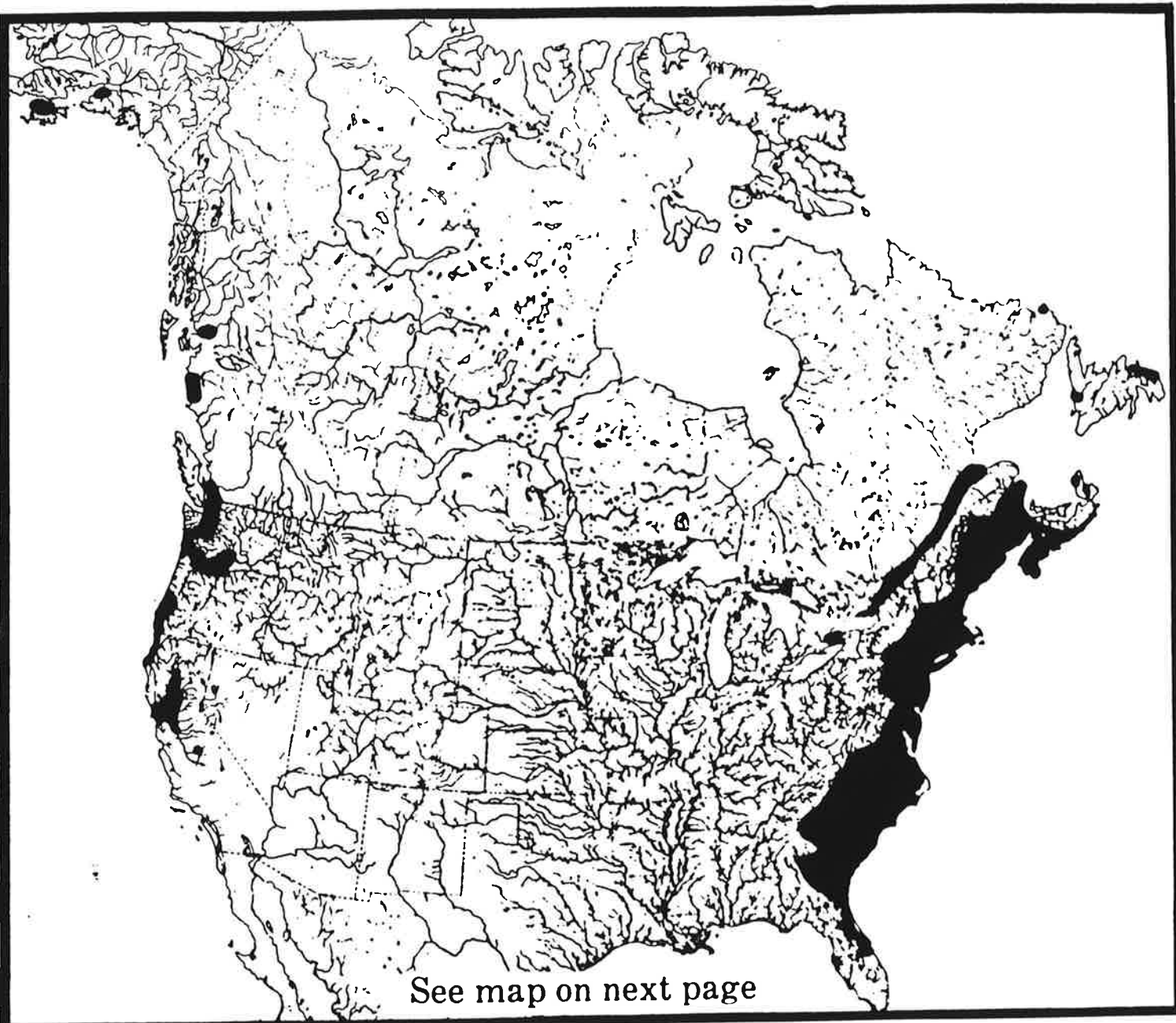


Figure 21. Range of American shad.

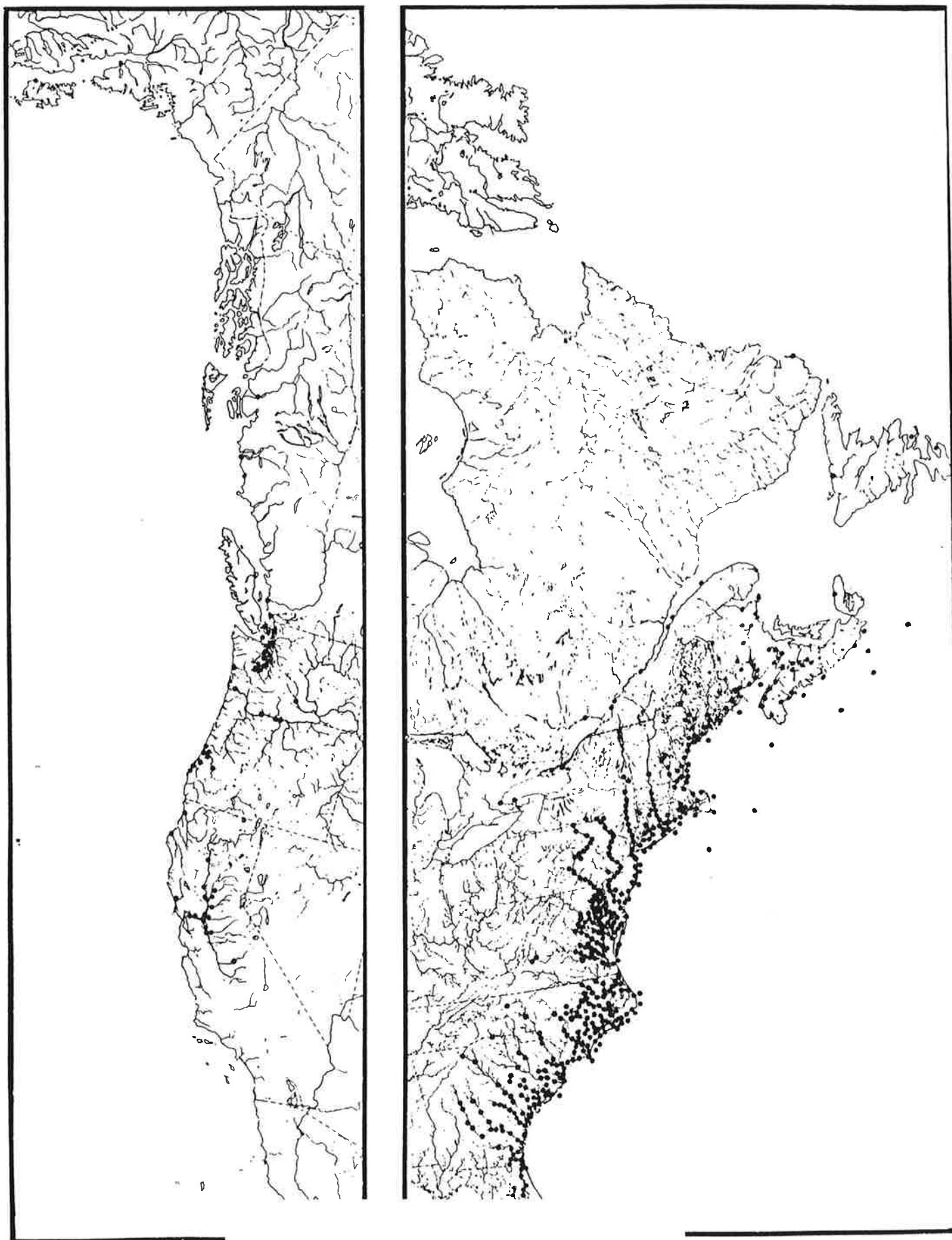


Figure 22. Range of American shad.

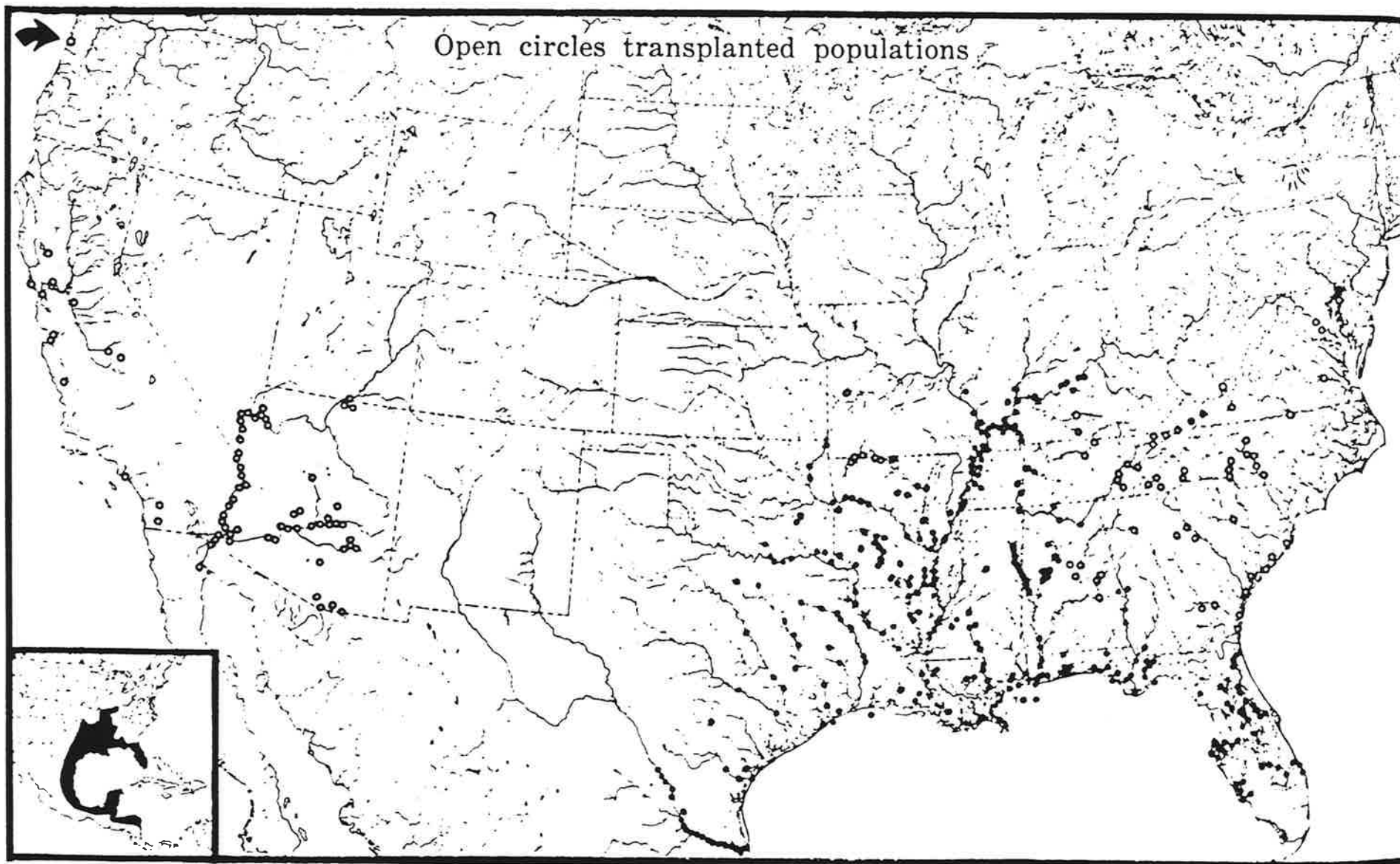


Figure 23. Range of threadfin shad.

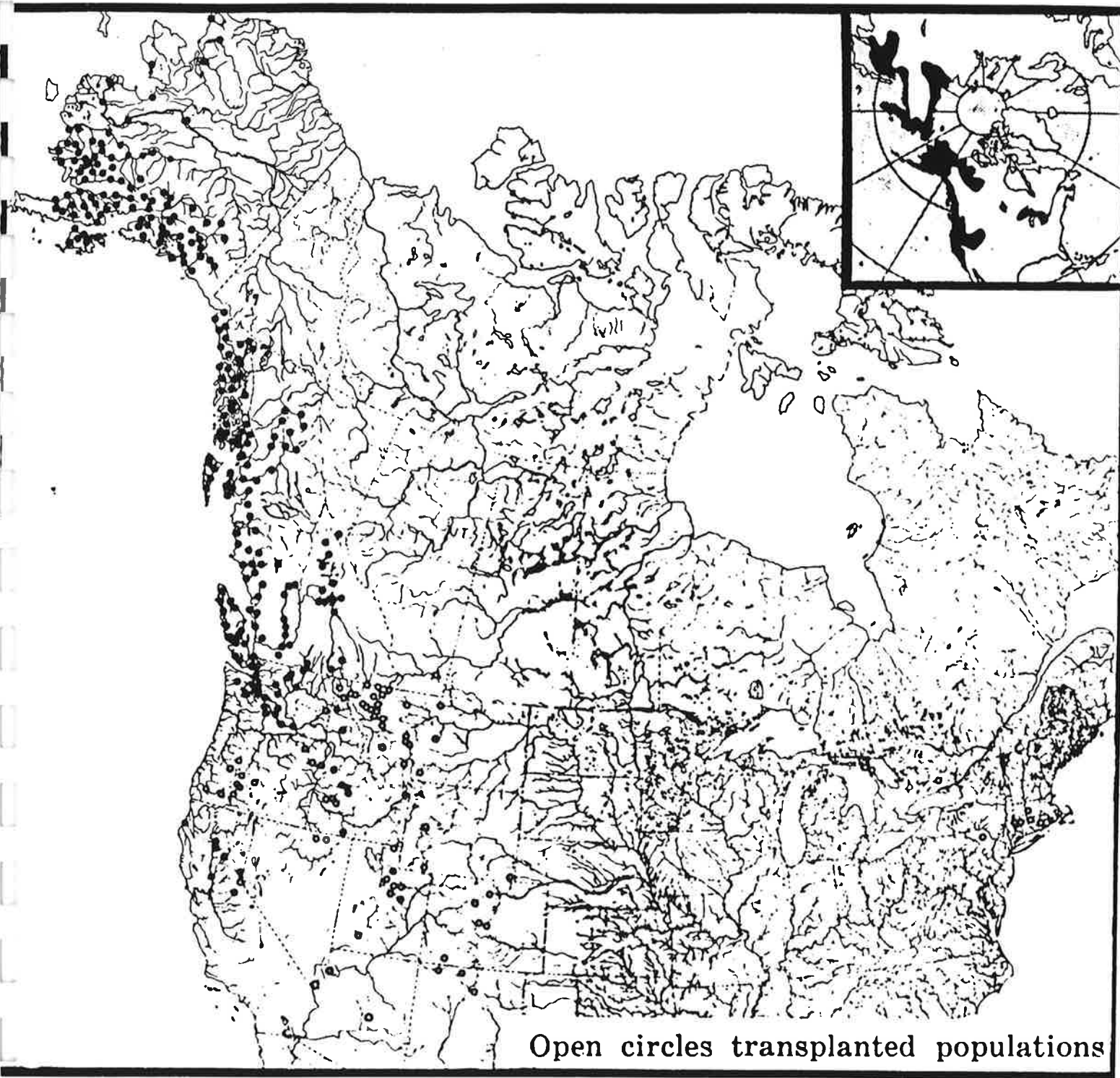


Figure 24. Range of sockeye salmon and kokanee.

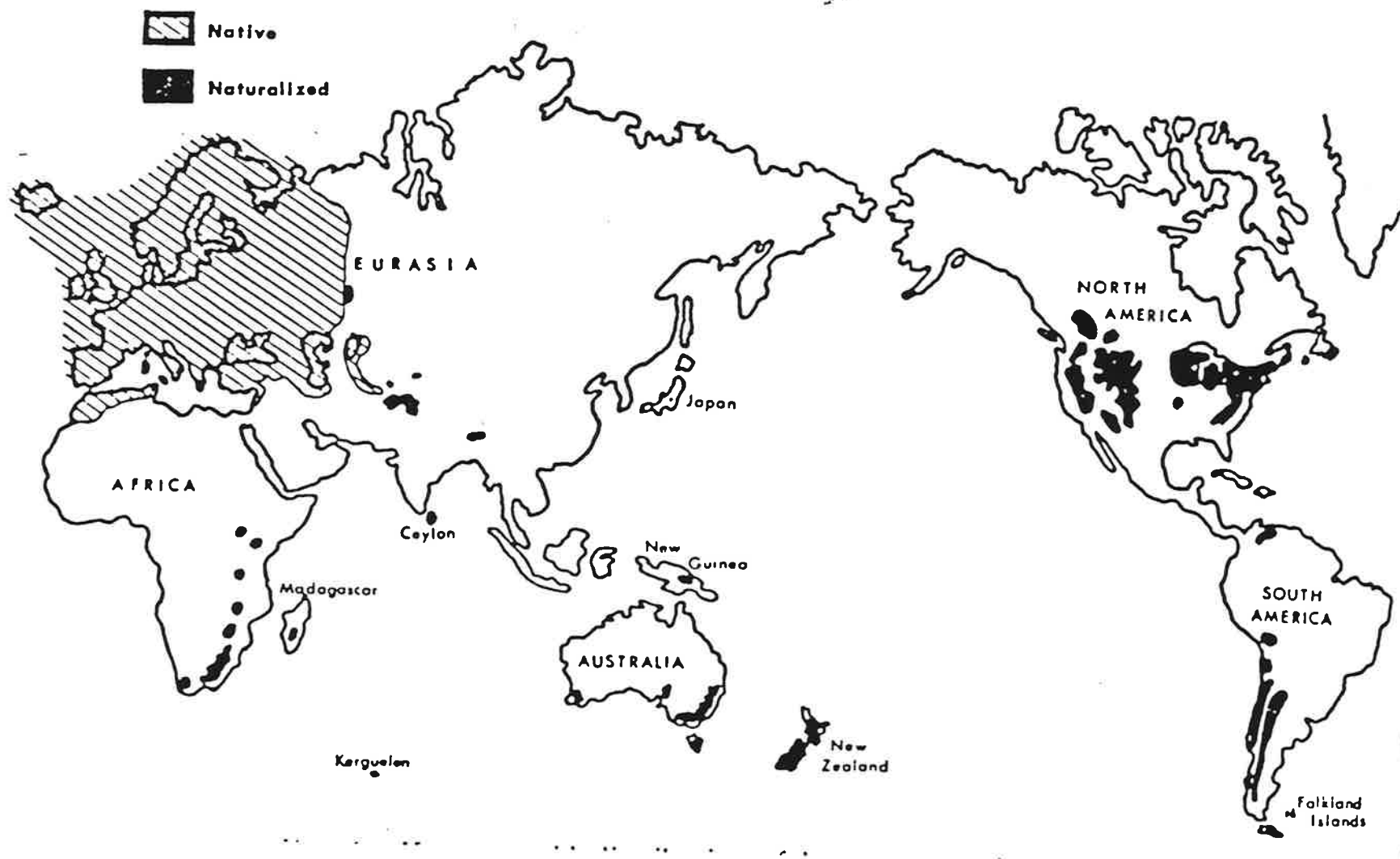


Figure 25. Range of brown trout.

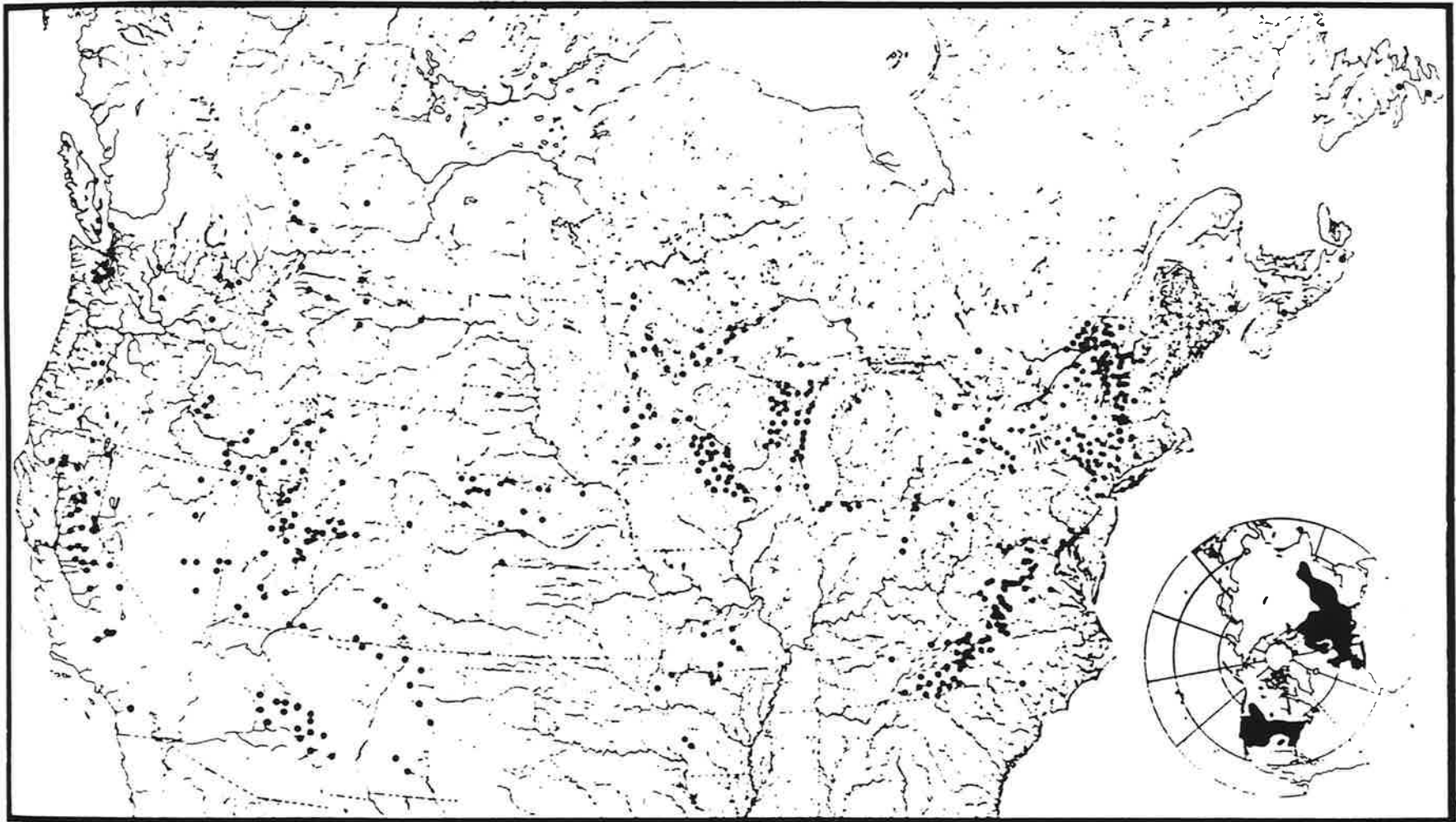


Figure 26. Range of brown trout.



Former Distribution



Present Distribution

Figure 27. Native and current range of brook trout in North America.

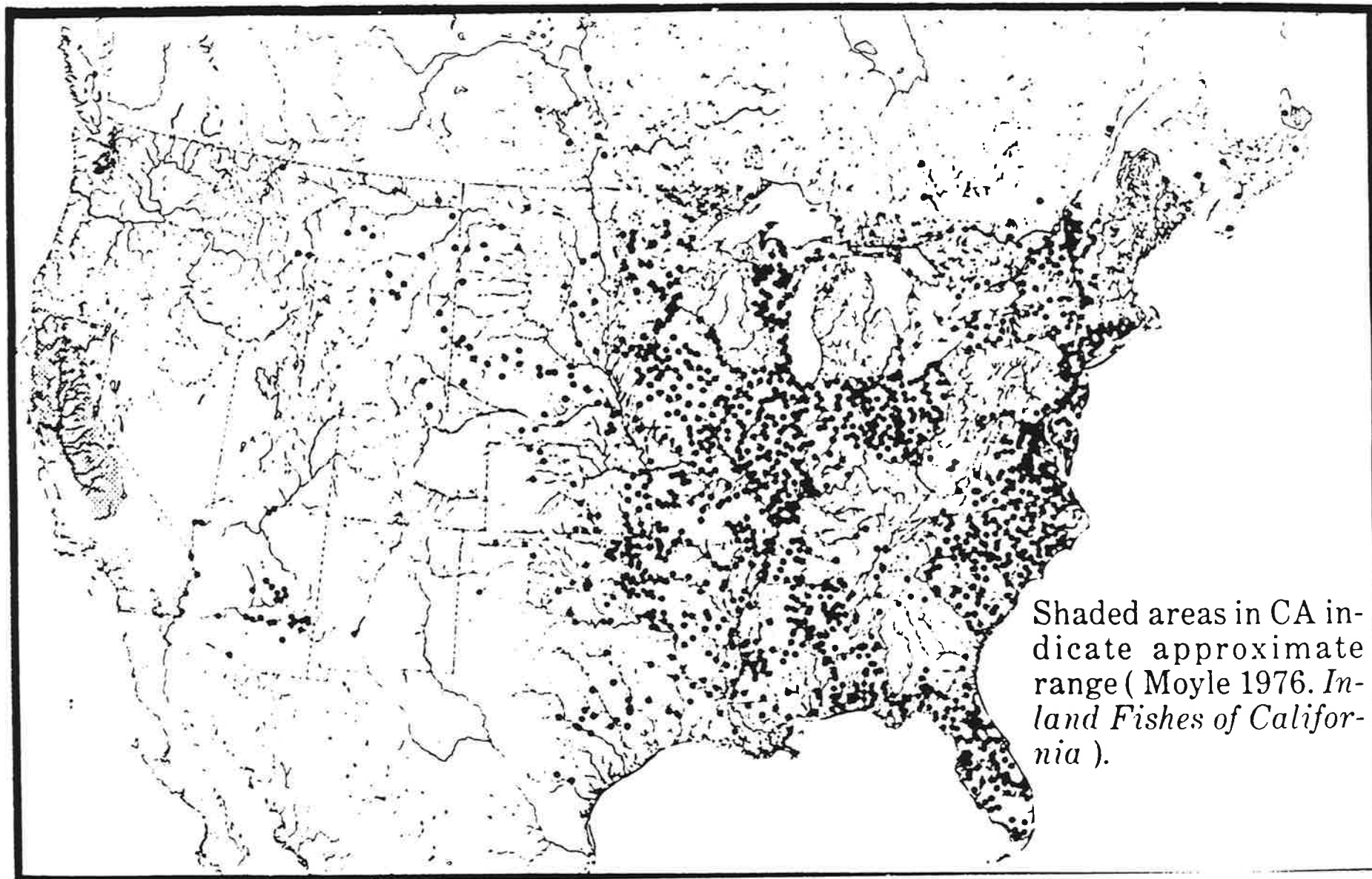
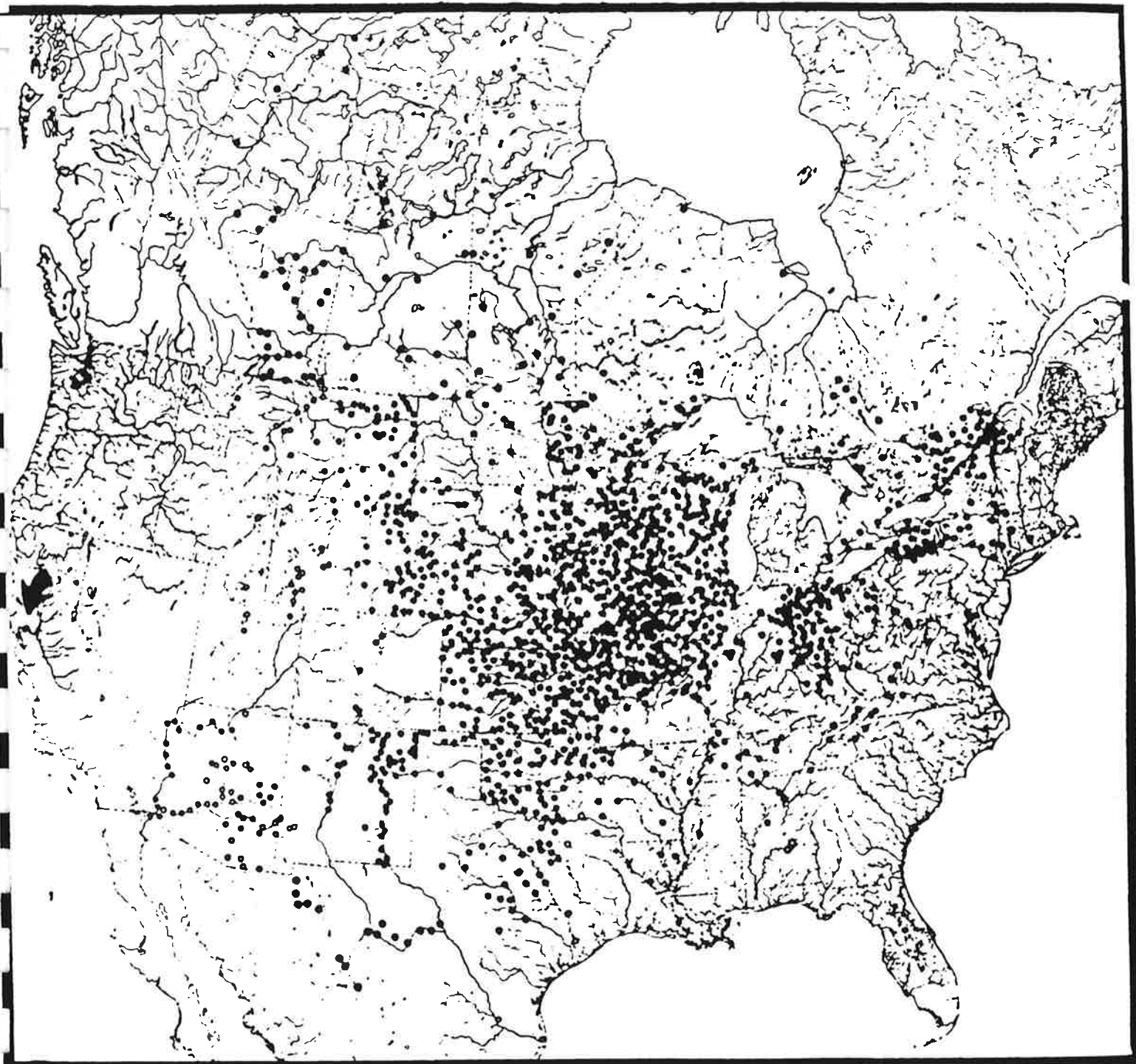


Figure 28. Range of golden shiner.



Open circles transplanted populations

Figure 29. Range of fathead minnow.

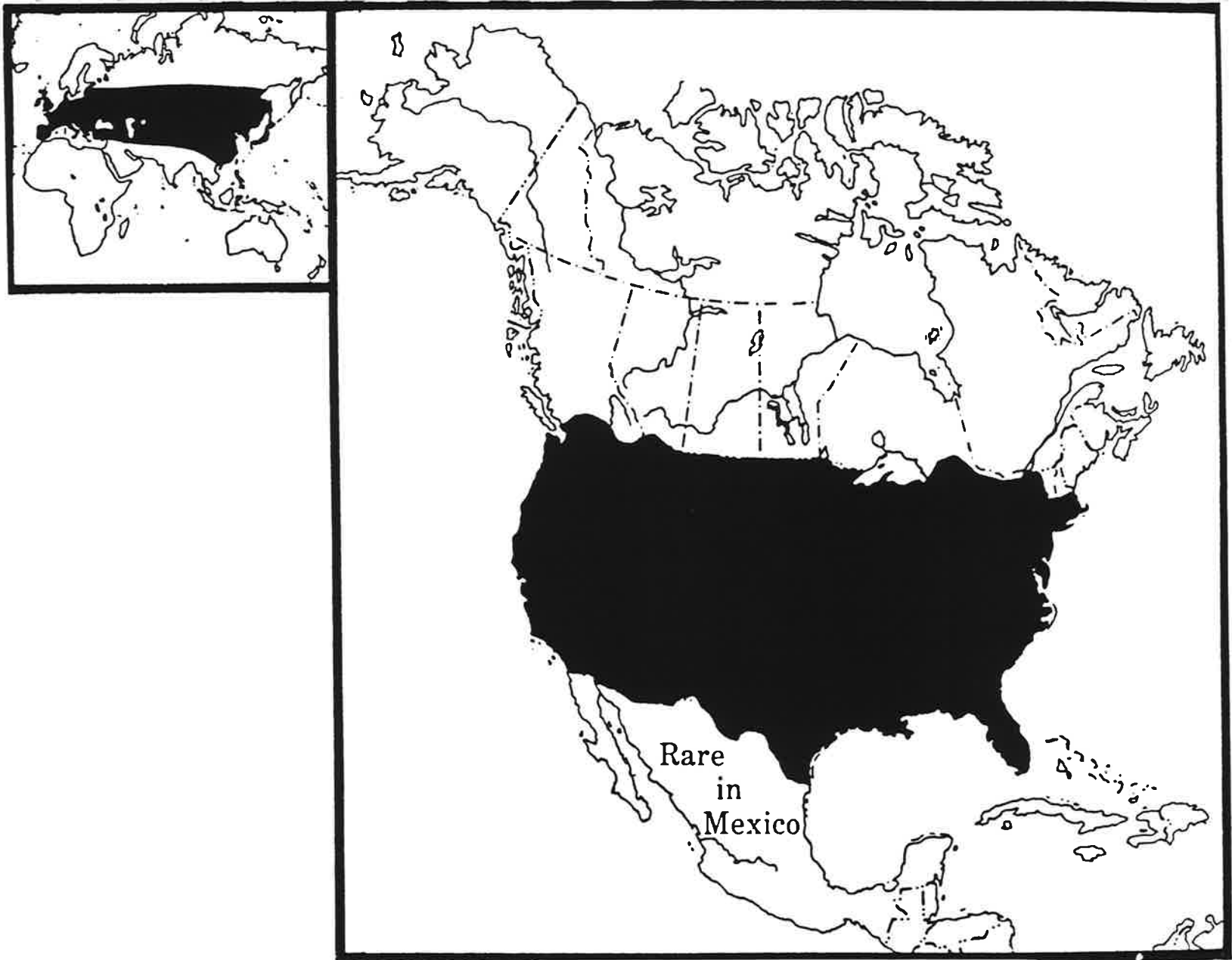


Figure 30. Range of goldfish.

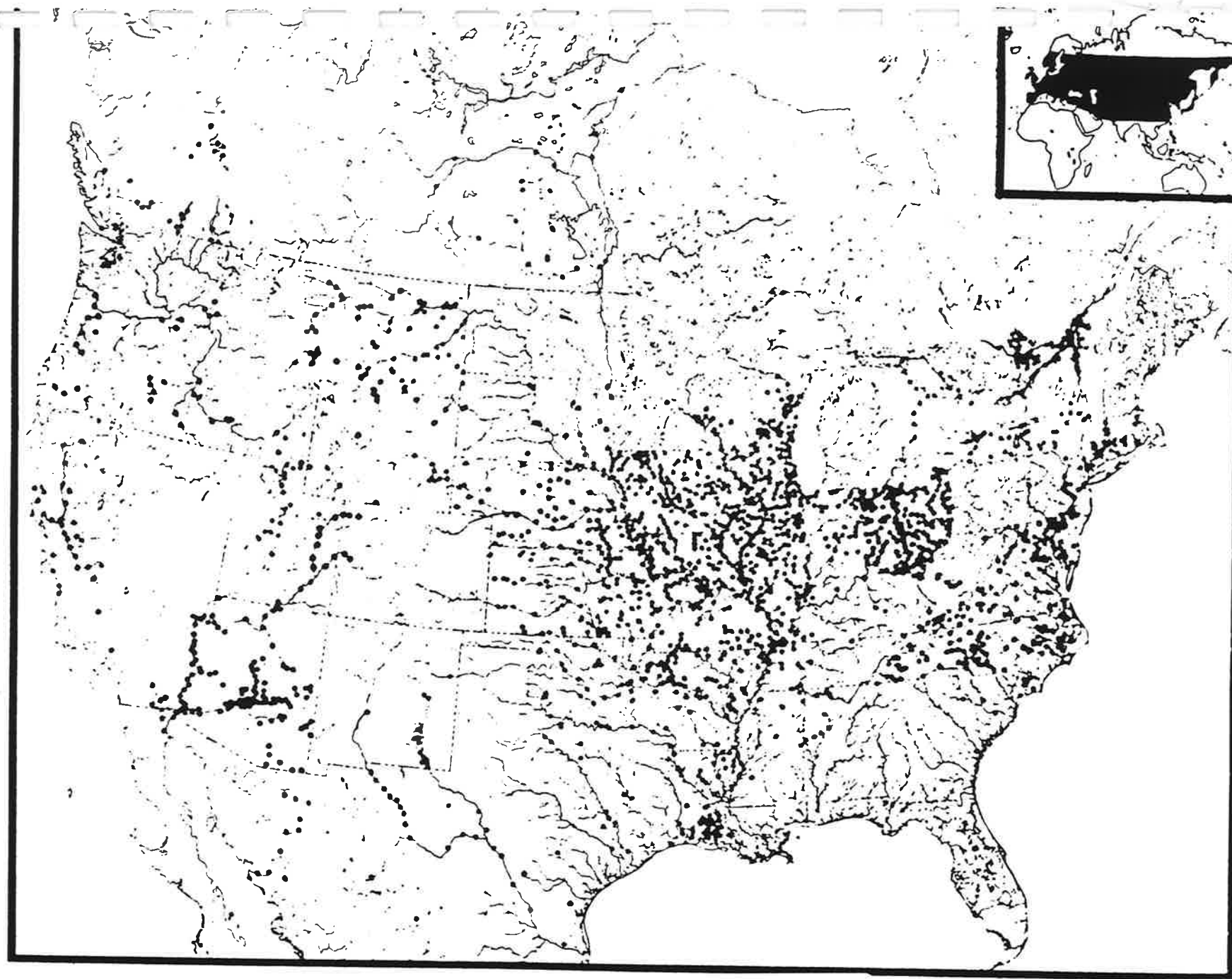
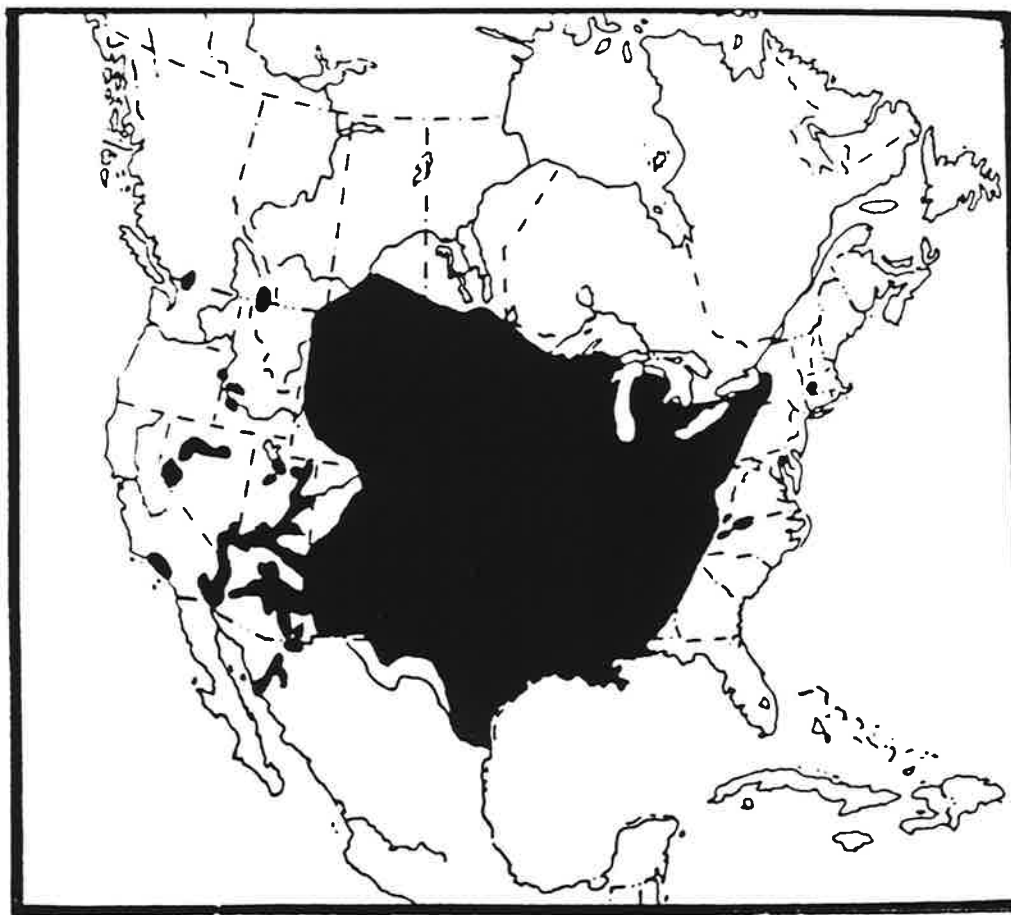


Figure 31. Range of carp.



Former Distribution



Present Distribution

Figure 32. Range of black bullhead.

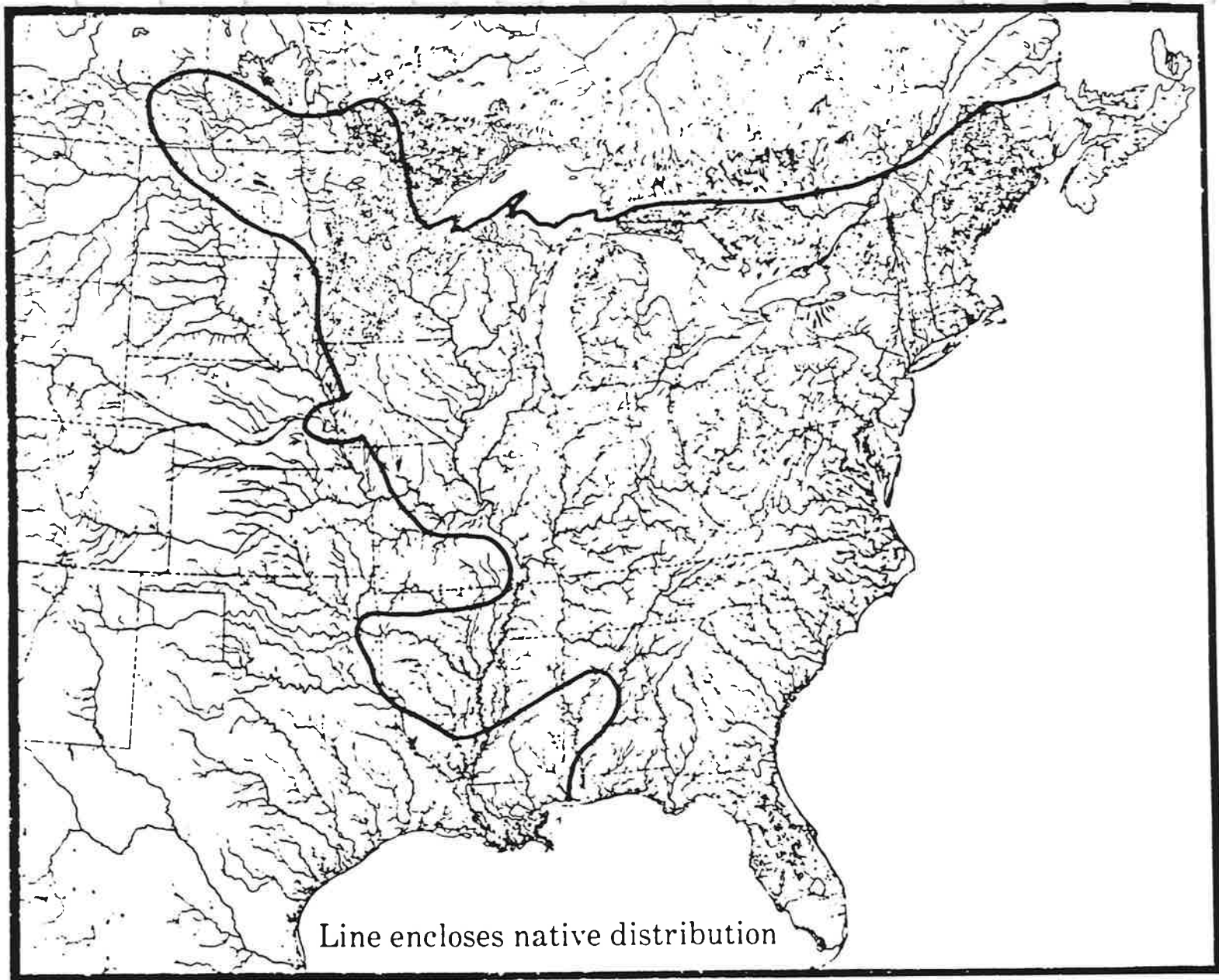
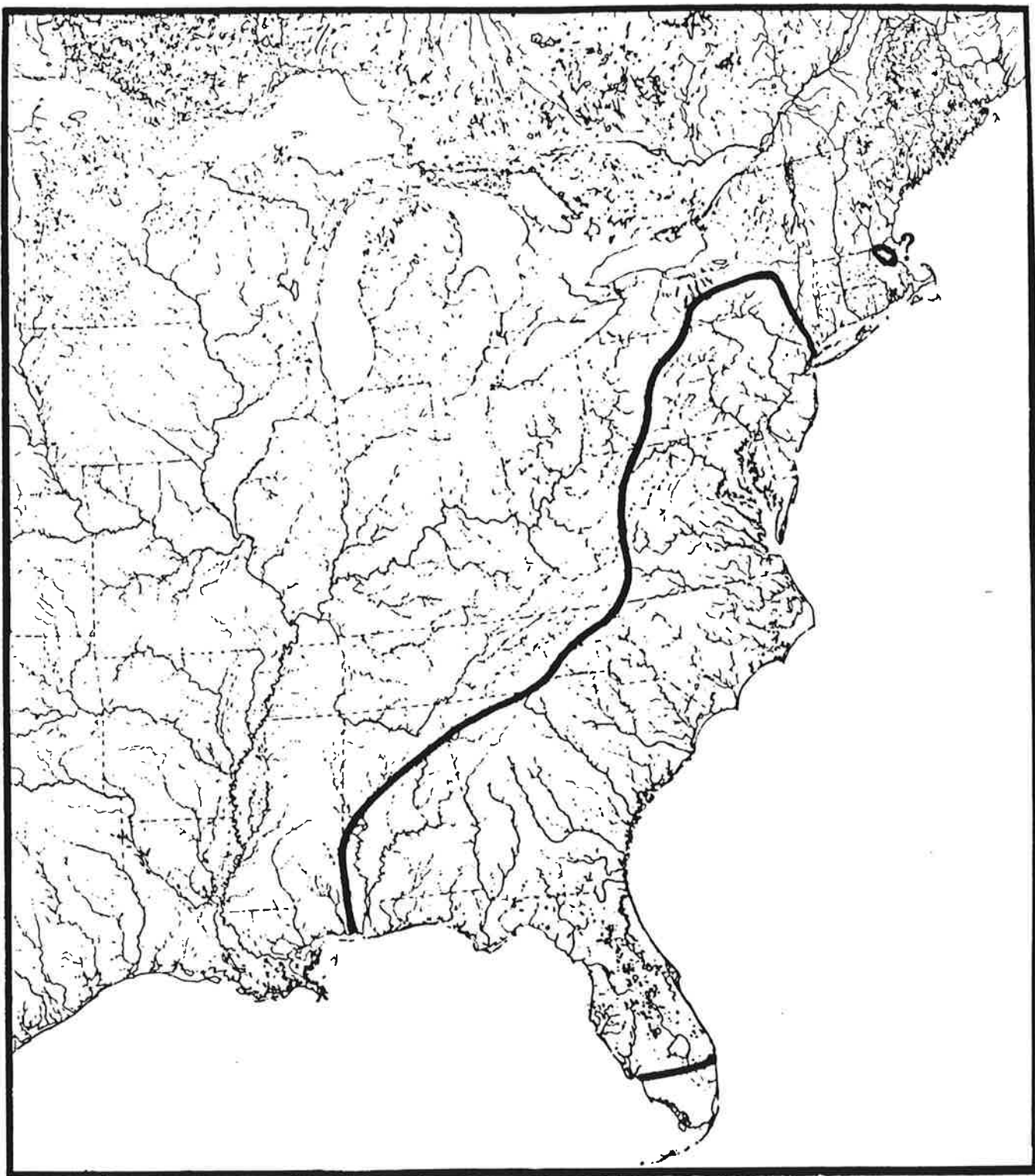
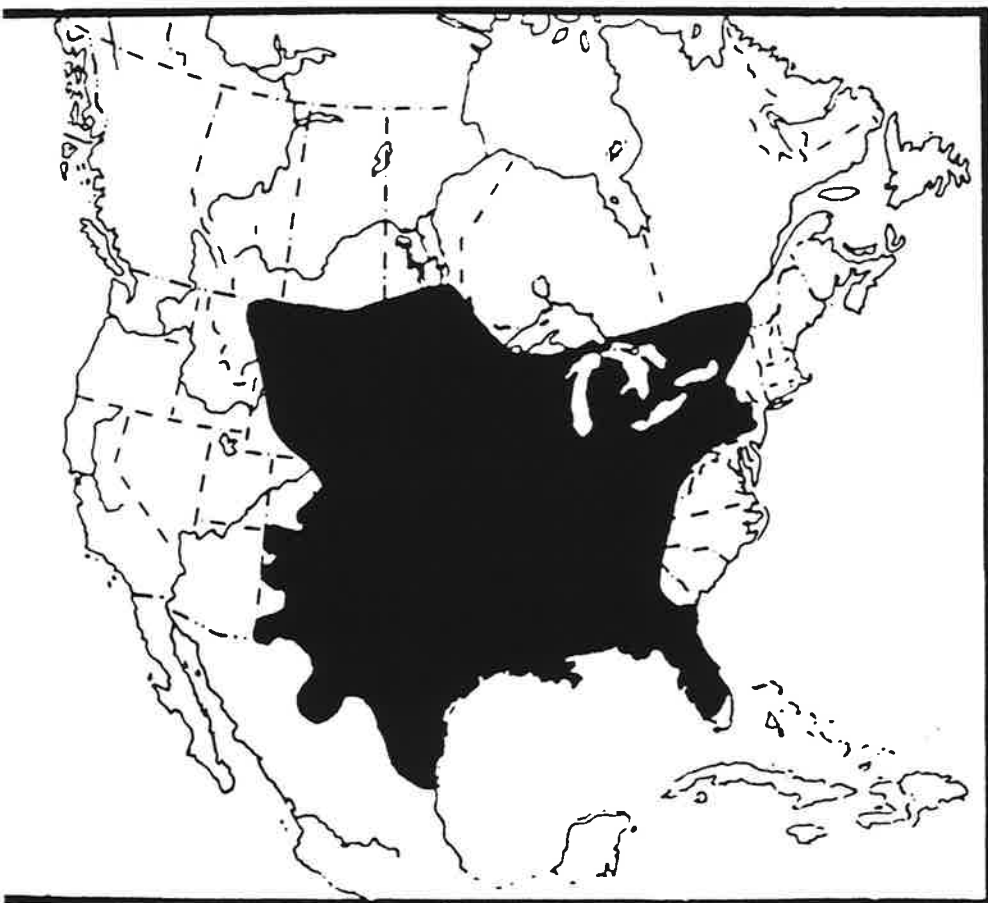


Figure 33. Native range of brown bullhead.

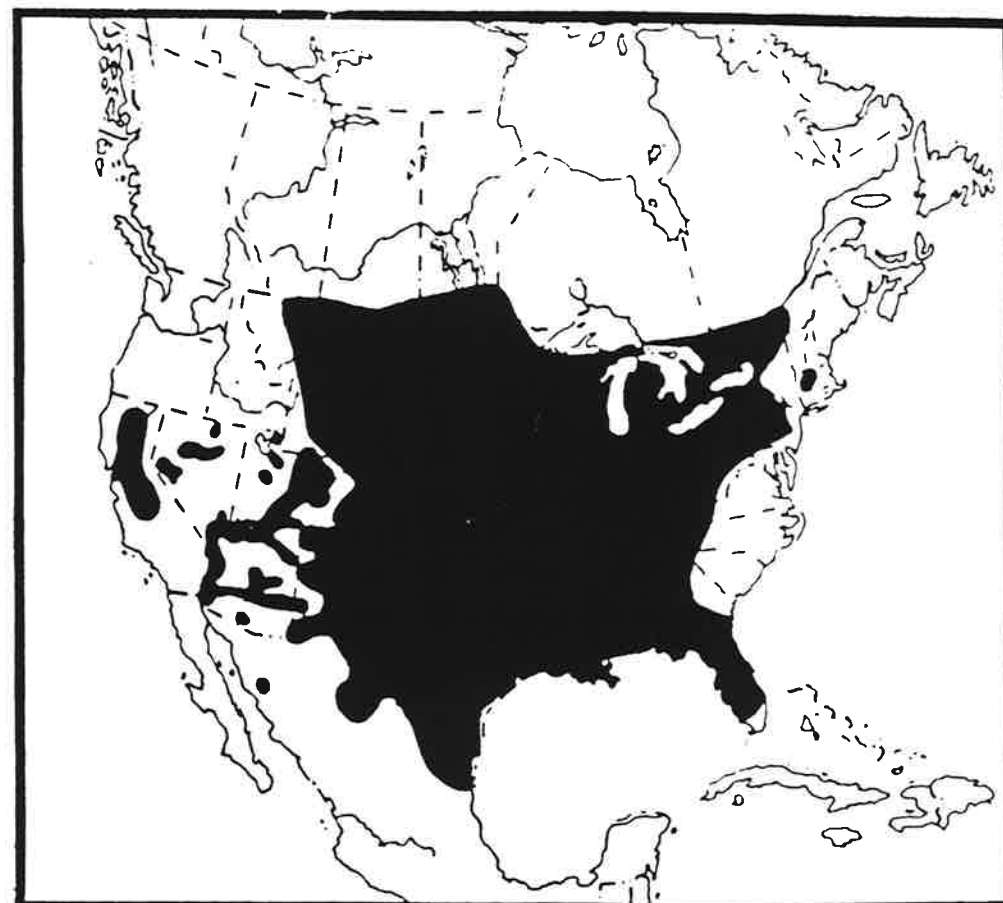


Line encloses native distribution

Figure 34. Native range of white catfish.



Former Distribution



Present Distribution

Figure 35. Native and current range of channel catfish.

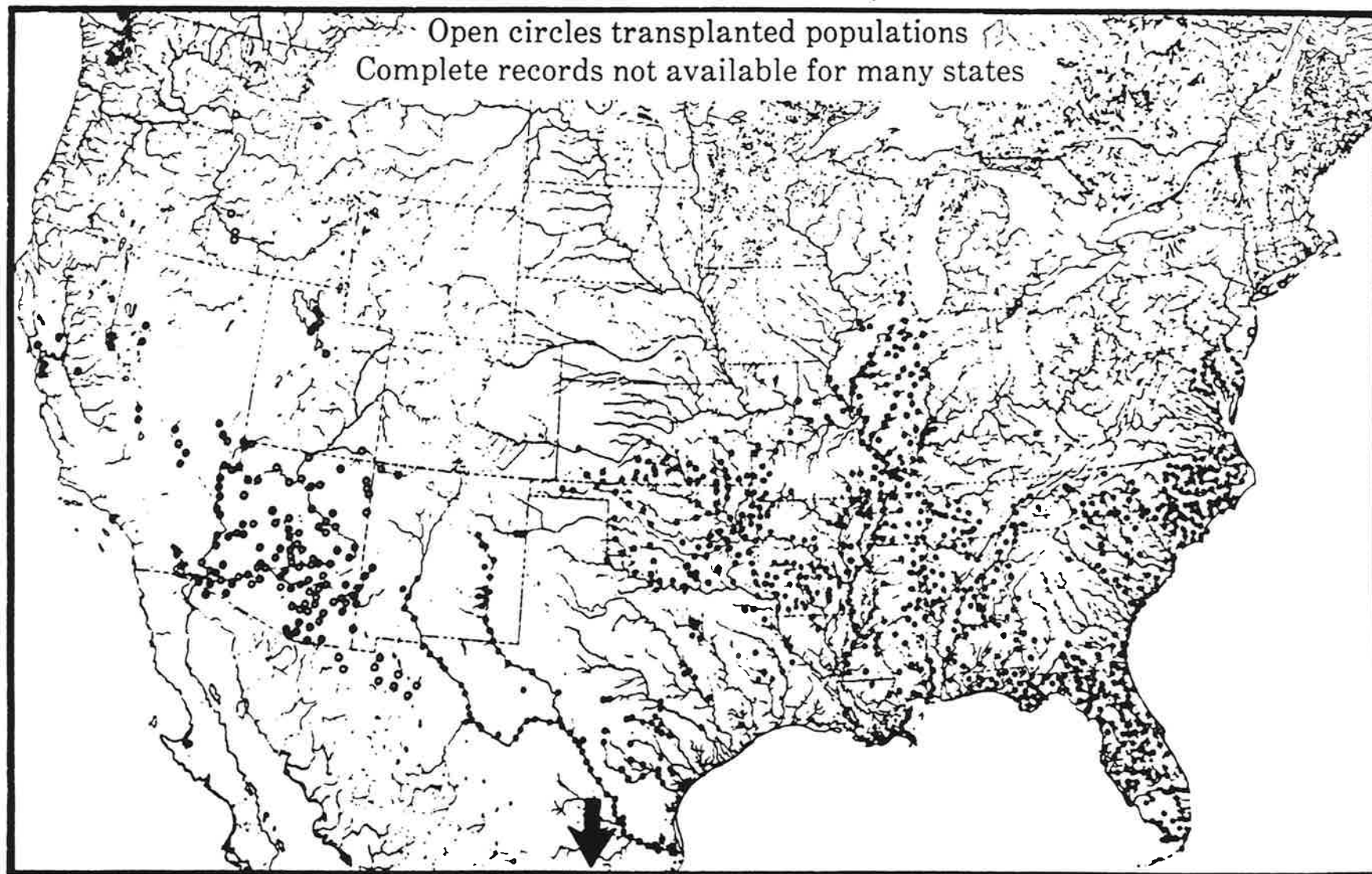


Figure 36. Known range of
mosquitofish in the
United States.

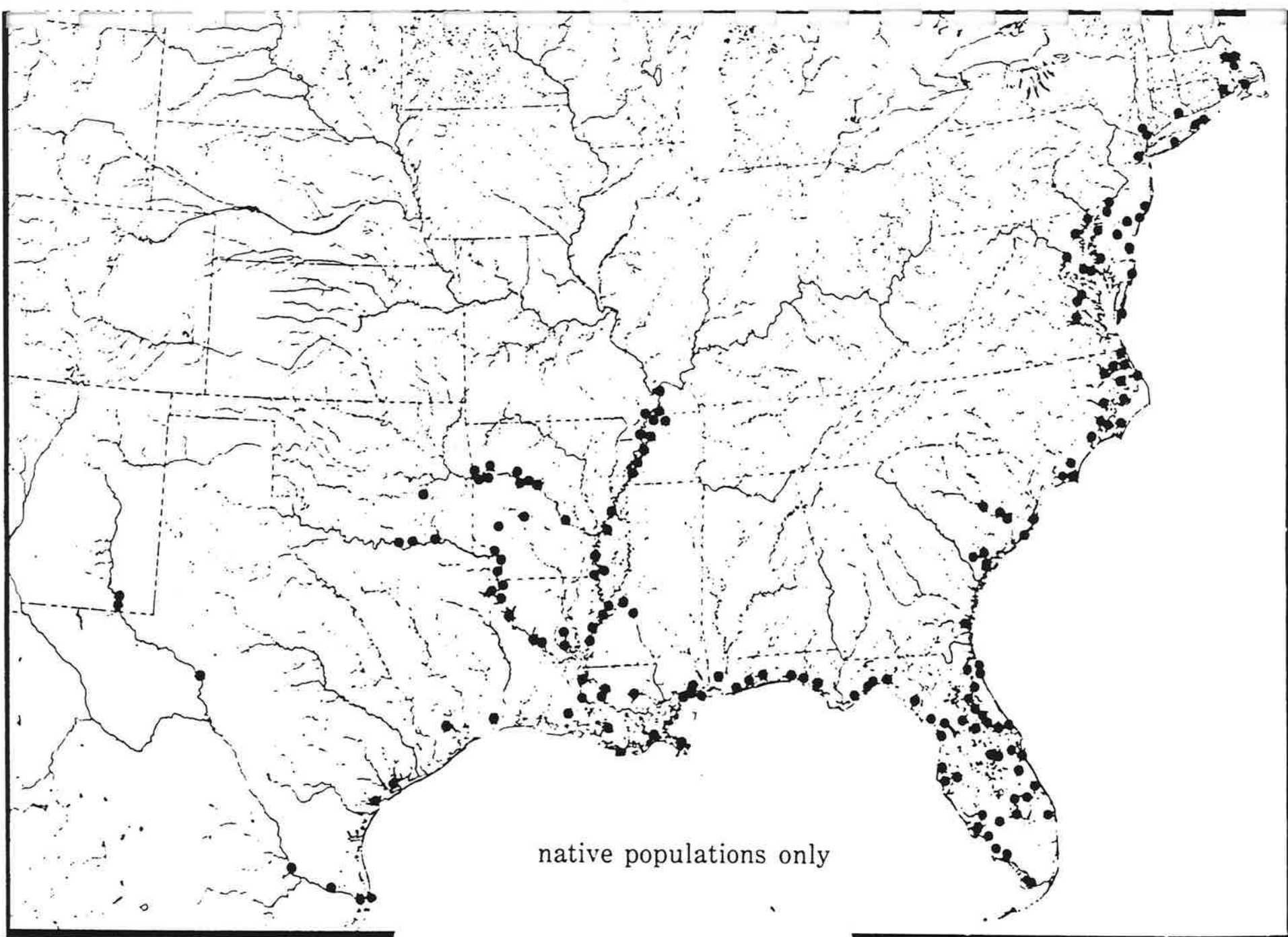
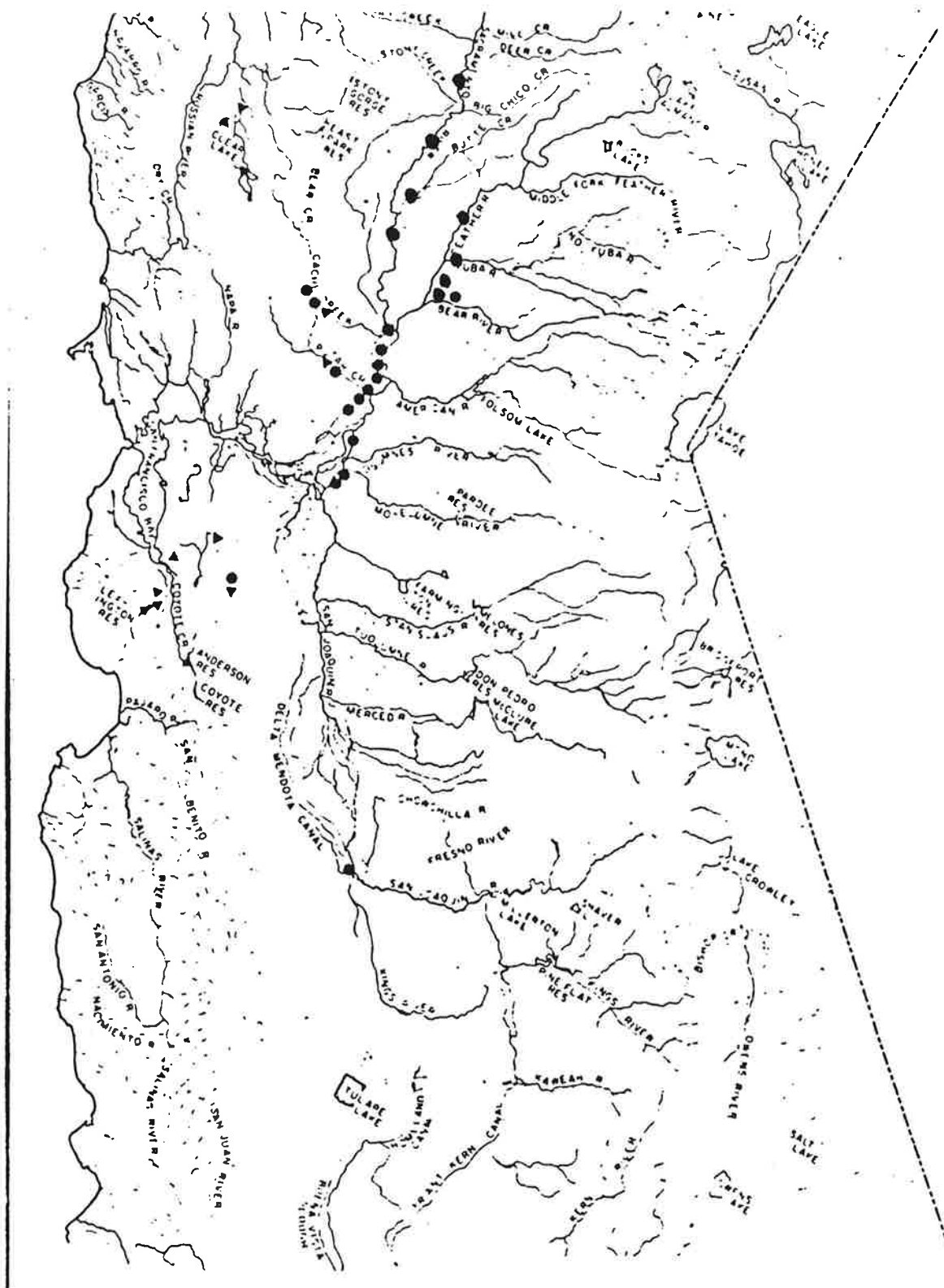


Figure 37. Native range of inland silverside.



Recent records of Mississippi silversides (triangles) and logperch (circles) in California.

Figure 38. Known ranges within California for inland silverside (as of 1974) and bigscale logperch (as of 1976, modified from Boles 1976).

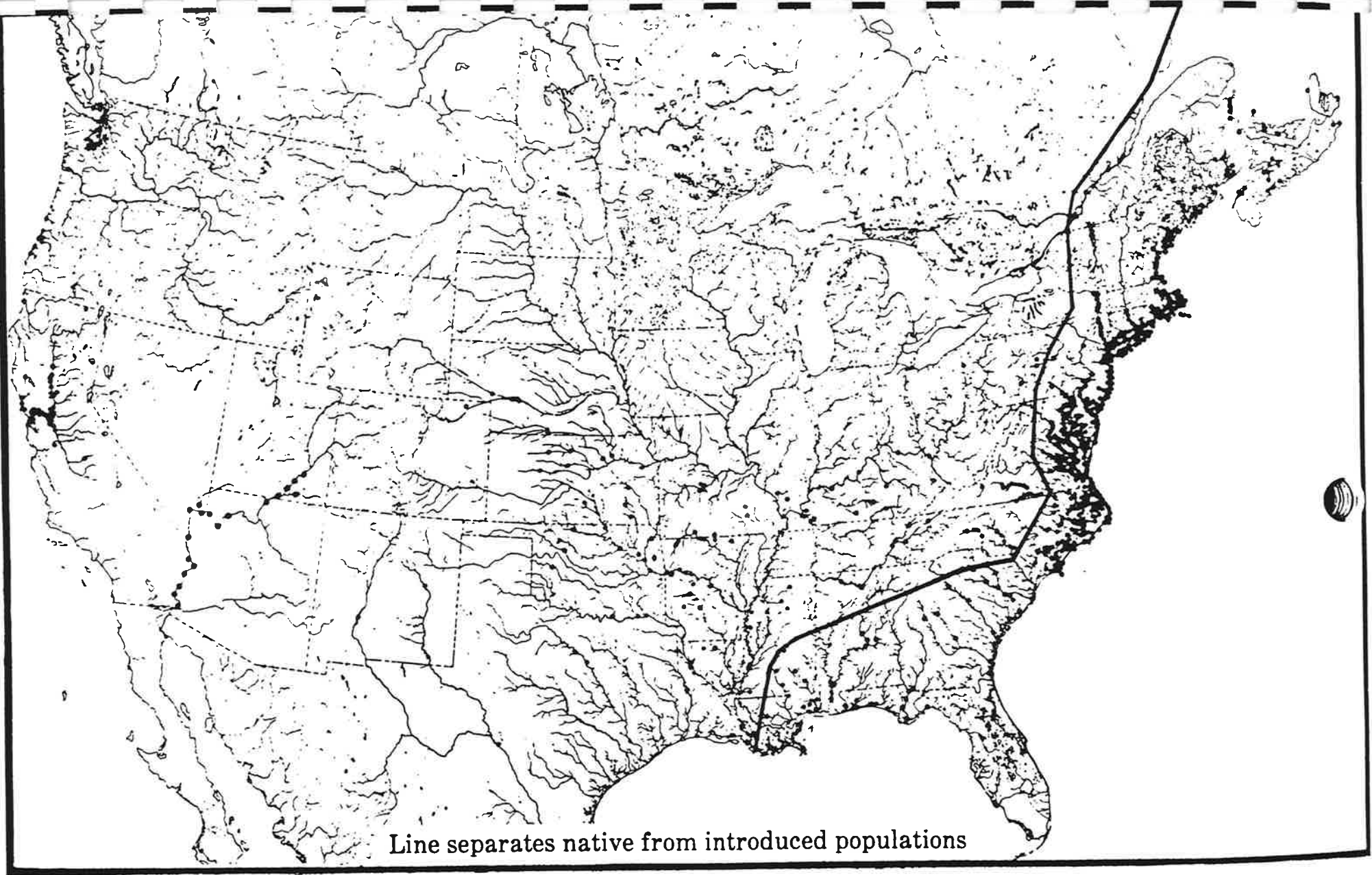


Figure 39. Range of striped bass.



Former Distribution



Present Distribution

Figure 40. Former and current range of bluegill in North America.

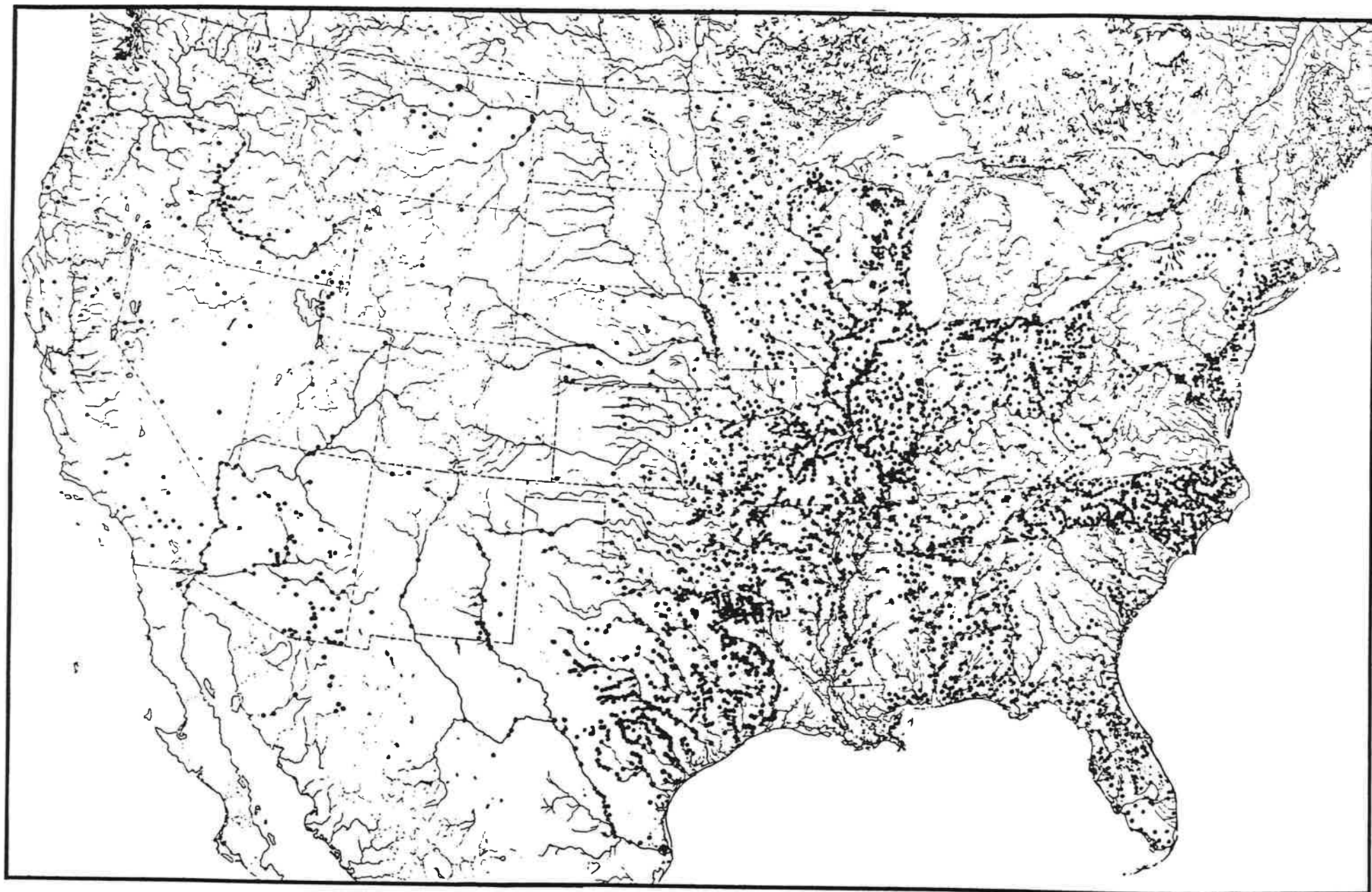
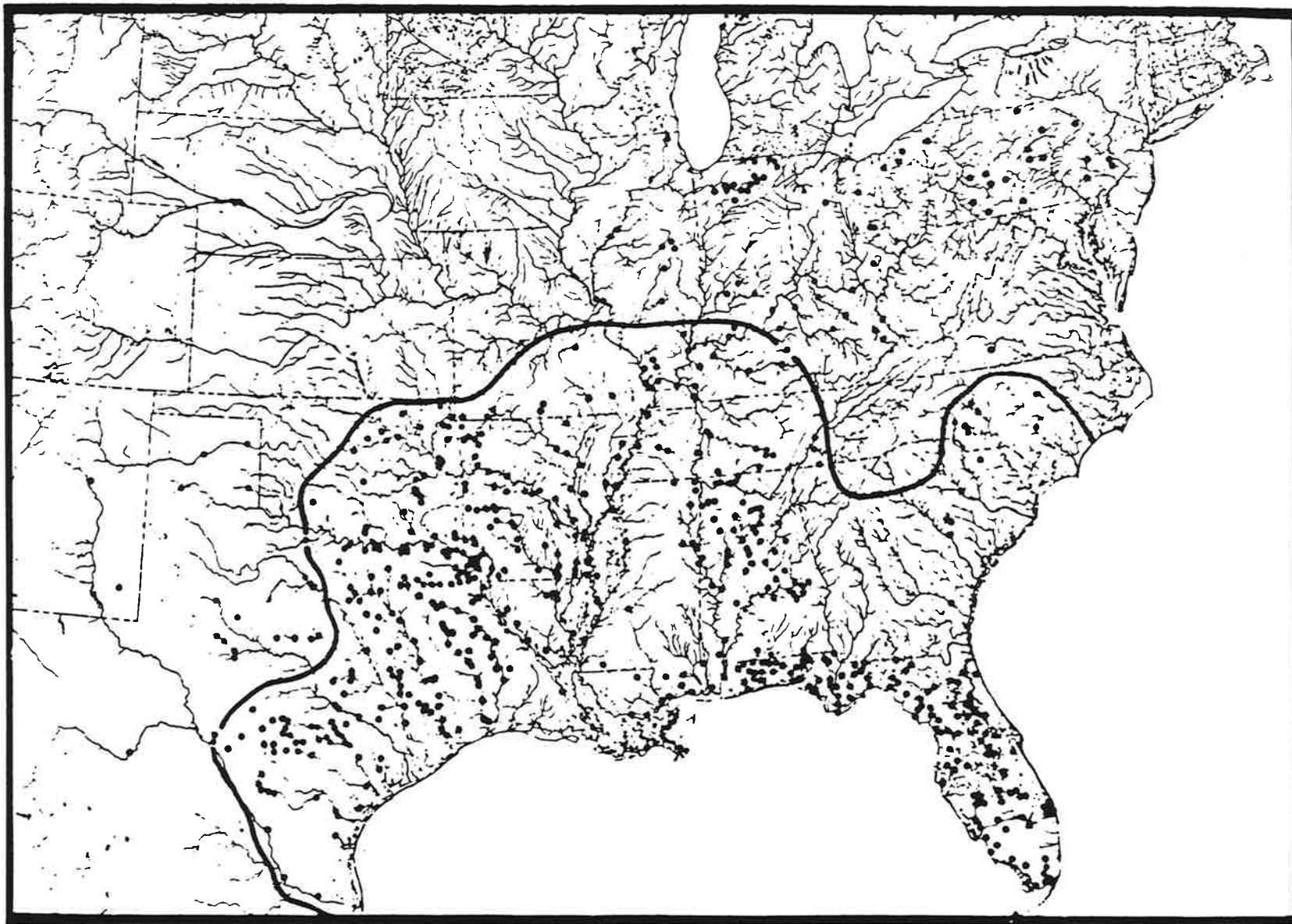


Figure 41. Range of bluegill in North America.



Line encloses native distribution

Figure 42. Range of redear sunfish
in central and eastern
United States.



Former Distribution



Present Distribution

Figure 43. Former and current range of green sunfish in North America.



Figure 44. Range of green sunfish
in the United States and
Mexico.



Former Distribution



Present Distribution

Figure 45. Former and current range of white crappie in the United States and Mexico.

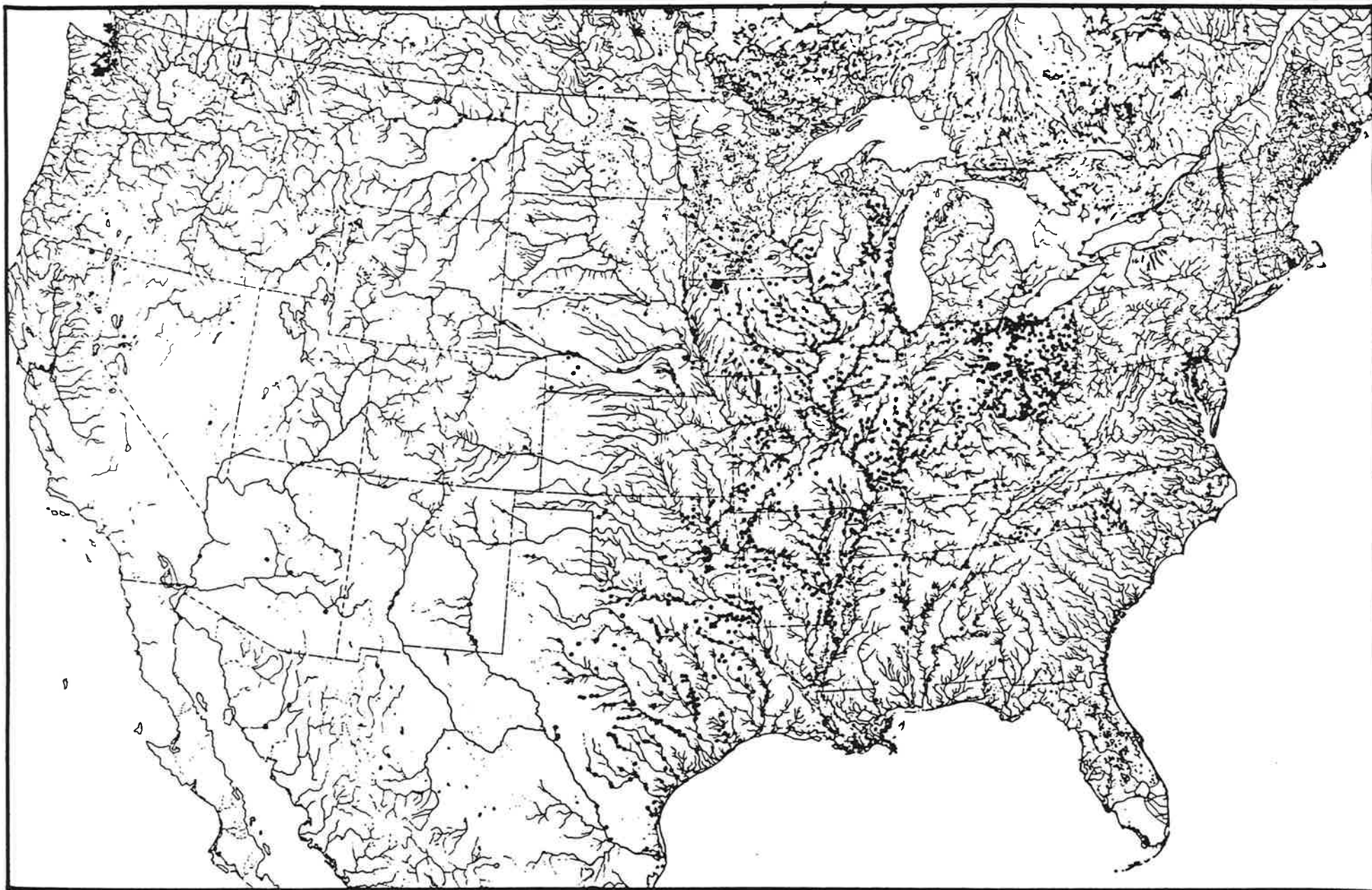


Figure 46. Range of white crappie
in the United States and
Mexico.



Former Distribution



Present Distribution

Figure 47. Former and current range of black crappie in the United States and Canada.

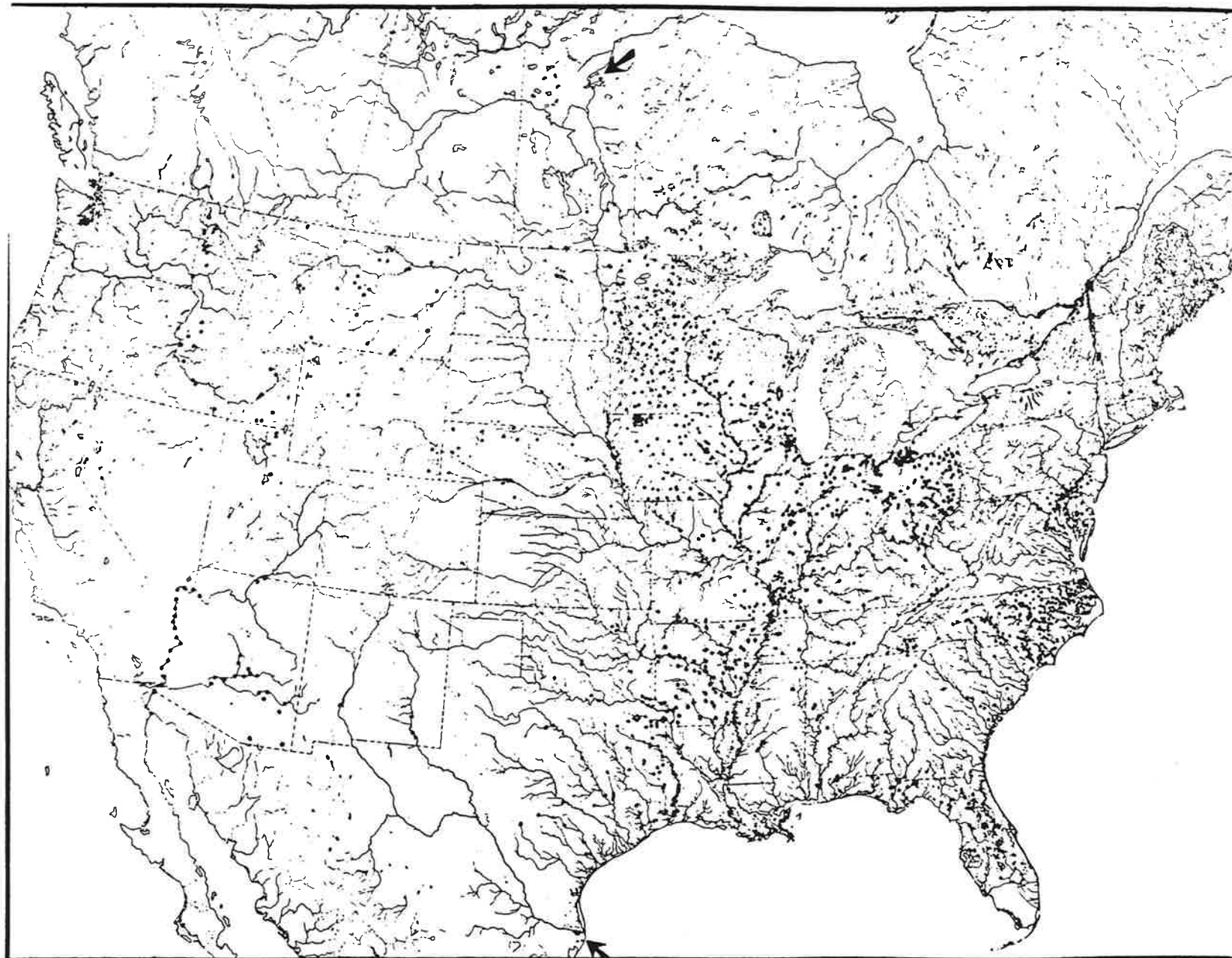


Figure 48. Range of black crappie
in the United States and
Canada.



Former Distribution

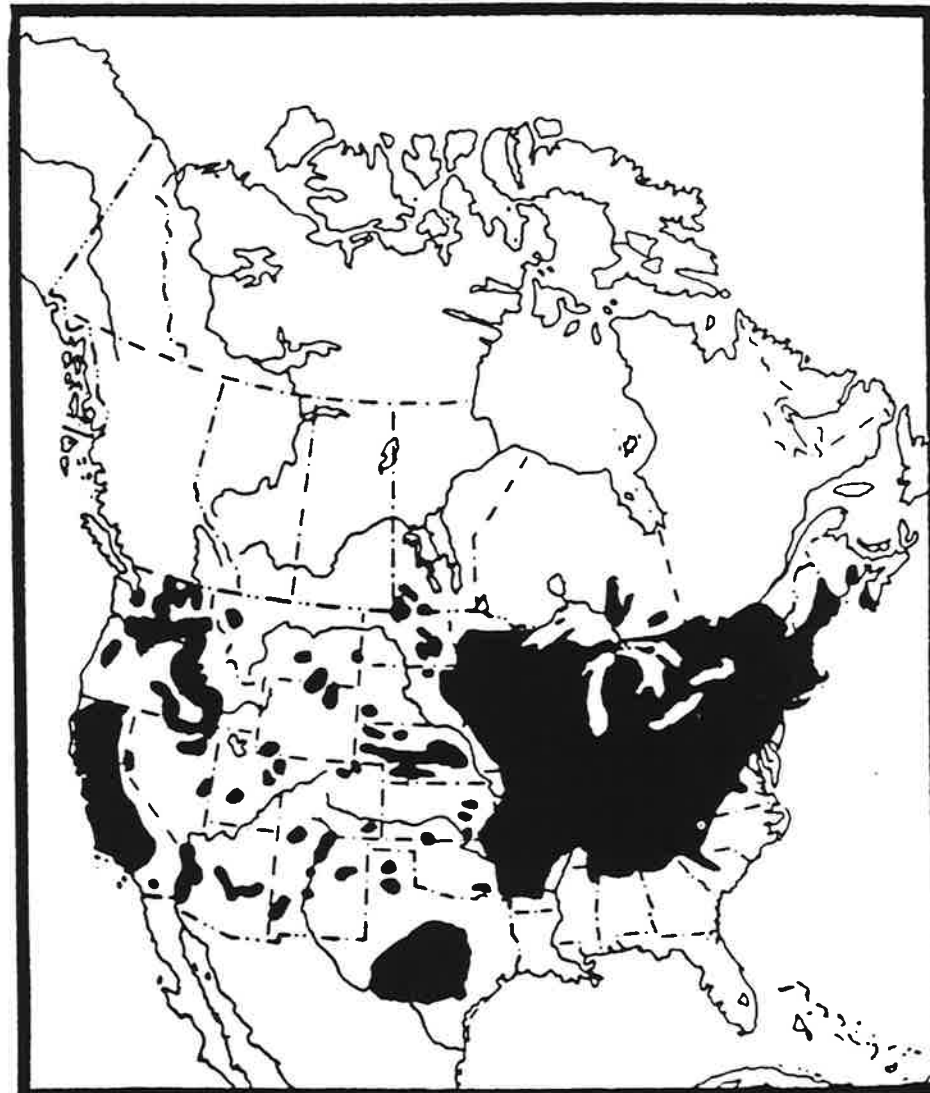


Present Distribution

Figure 49. Former and current range of largemouth bass in North America.



Former Distribution



Present Distribution

Figure 50. Former and current range of smallmouth bass in the United States and Canada.

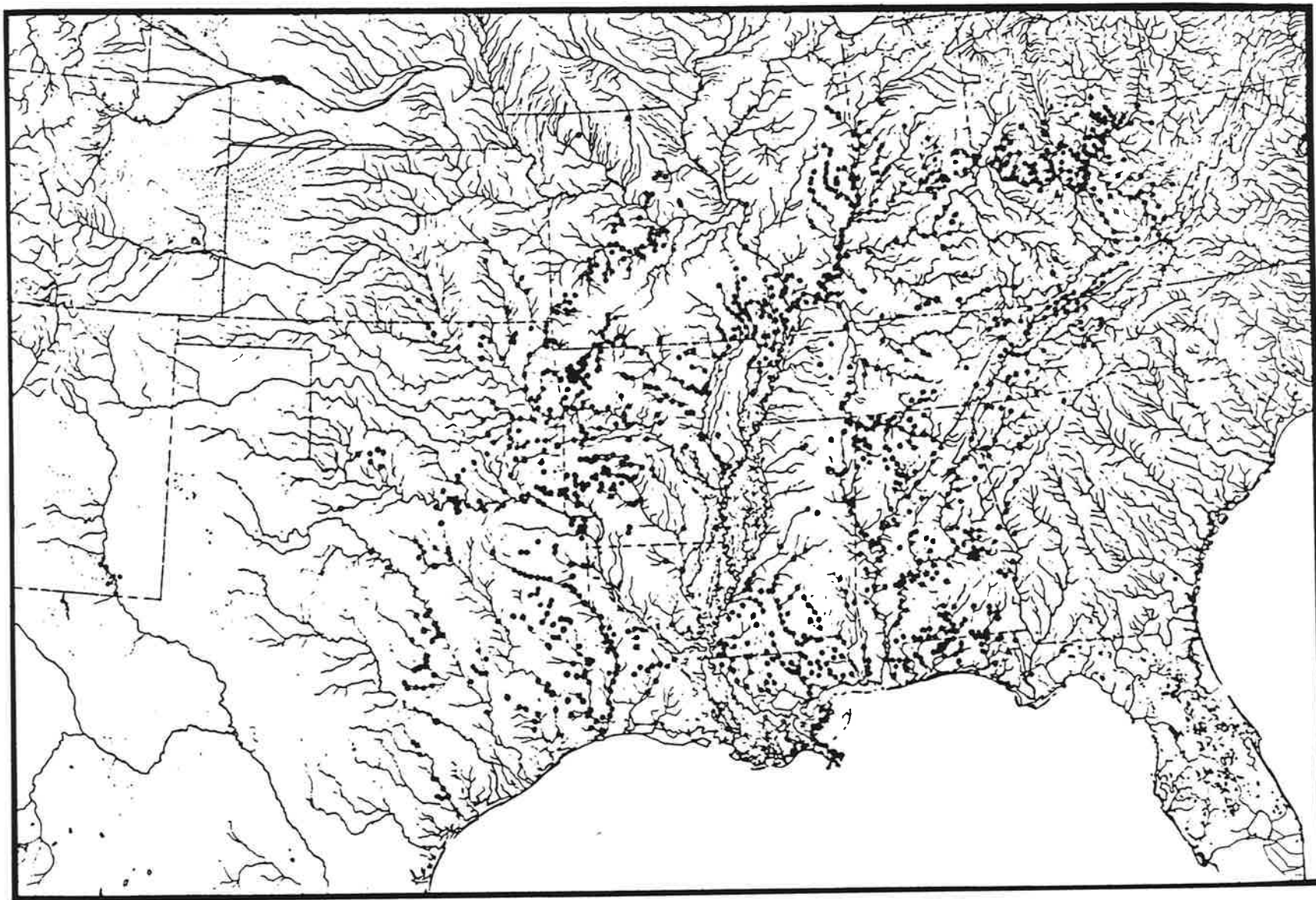


Figure 51. Native range of spotted bass.

Map modified from Stevenson (1971), Moyle
et al. (1974 Calif. Fish Game 60:144-149).

Open circles transplanted populations

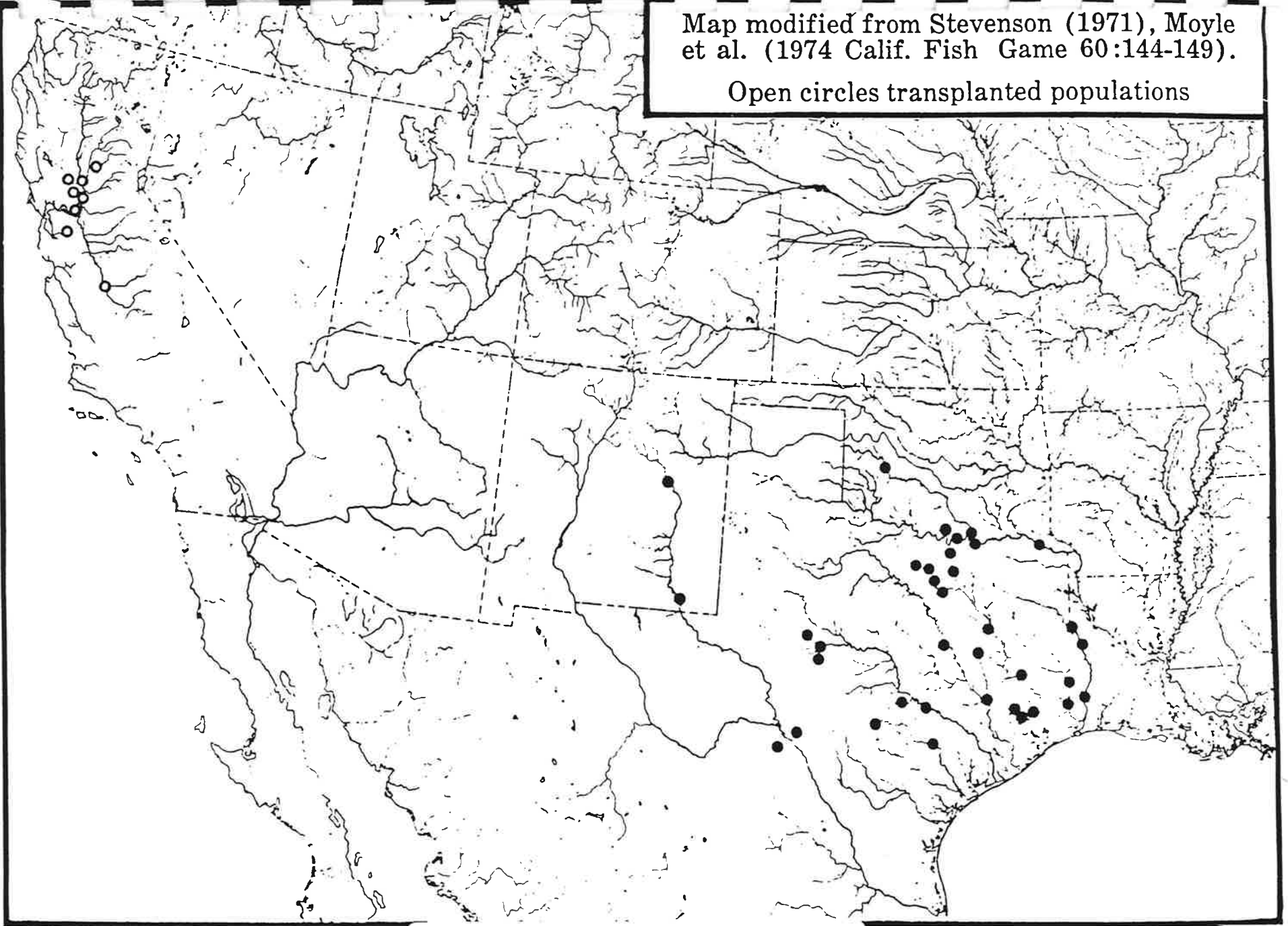


Figure 52. Known range of bigscale
logperch in the United
as of 1974.