Chapter 1. The Problem: Fewer Salmon and Steelhead in the Central Valley and San Francisco Bay Area

Today, there are fewer salmon and steelhead in the watersheds of California's Central Valley and the San Francisco Bay Area. Federal and state governments have recognized and called attention to the problem by putting the fish on threatened or endangered lists.

This chapter describes the historical and current distribution of salmon and steelhead listed as threatened or endangered and their critical habitat in the Central Valley and Bay Area. The chapter also shows the distribution of evolutionarily significant units (ESUs) of salmon and steelhead in the Central Valley and Bay Area, the distribution of critical habitat for endangered or threatened Chinook salmon and steelhead, and the distribution of essential fish habitat for four Chinook salmon runs (Figures 2-10). More information about these designations are in Appendix D.

Chinook Salmon in the Central Valley

There are four runs of Chinook salmon in the Central Valley, with each run named according to the season when adult fish migrate upstream and spawn, and the periods of juvenile residency and smolt migration (Vogel and Marine 1991, Fisher 1994).

Spring runs

Figures 11 and 12 show the historical and current distribution of spring-run Chinook salmon (DFG 1998). Spring-run salmon require adequate summer flows and summer holding habitat — cold pools. Streams suitable for the spring run have higher elevation reaches of at least 1,500 feet in the Sacramento River drainage and higher in the San Joaquin River drainage (Yoshiyama and others 1996). Streams originating at high elevations or receiving substantial water from cold springs have cooler summer water, adequate summer flows, and pools for over-summering. According to the National Marine Fisheries Service (NMFS 1999), the five-year average in the late 1990s was 8,500 fish, compared with 40,000 fish in the 1940s. Between 70 percent and 90 percent of the spring-run Chinook's spawning and rearing habitat has been lost due to water system developments. Water diversion and hydroelectric dams have limited or prevented access to up reiver summer holding habitat historically utilized by spring-run. As a result, spring-run and fall-run are no longer separated spatially and temporally in a river, increasing hybridization potential.

Winter runs

Winter-run salmon were in the upper Sacramento River system, including the Little Sacramento, Pit, McCloud, and Fall rivers, and Battle Creek, ascending far up the drainages to the headwaters (California State Board of Fish Commissioners 1890; Hallock and Rectenwald 1990; Fisher, unpublished data referenced in Yoshiyama and others 1996). Winter-run streams are fed by cool, constant springs that provide the flows and low temperatures required for spawning, incubation, and rearing in summer (Slater 1963). Figures 13 and 14 show the historical and current distribution of winter-run Chinook salmon based on Yoshiyama and others (1996). From 1974 to 1984, winter-run salmon were occasionally documented on the Calaveras River, east of Stockton (DFG 1993). There is considerable debate whether the river, with its headwaters at a relatively low elevation, once had a winter run or whether recent sightings of winter-run fish were strays. Thus, Figure 4 does not include the Calaveras River.

Battle Creek is the only remaining tributary stream having accessible winter-run habitat and supporting a small winter run.

Figure 2. Steelhead trout ESU

Figure 3. Chinook salmon ESU

Figure 4. Critical Habitat for Spring-run Chinook Salmon

Figure 5. Critical Habitat for Winter-run Chinook Salmon

Figure 6. Critical Habitat for Central Valley and Cental California Coast Steelhead ESUs

Figure 7. Essential Fish Habitat for Spring-run Chinook Salmon in the Central Valley

Figure 8. Essential Fish Habitat for Winter-run Chinook Salmon in the Central Valley

Figure 9. Essential Fish Habitat for Fall-run Chinook Salmon in the Central Valley

Figure 10. Essential Fish Habitat for Late-fall run Chinook Salmon in the Central Valley

Figure 11. Spring-run Chinook Salmon in the Central Valley of California: Historical Range and Distribution

Figure 12. Spring-run Chinook Salmon in the Central Valley of California: Present Range and Distribution

Figure 13. Winter-run Chinook Salmon in the Central Valley of California Historical Range and Distribution

Figure 14. Winter-run Chinook Salmon in the Central Valley of California: Present Range and Distribution

Figure 15. Fall-run Chinook Salmon in the Central Valley of California Historical Range and Distribution

Figure 16. Fall-run Chinook Salmon in the Central Valley of California Present Range and Distribution

Fall and late-fall runs

Figures 15 and 16 show the historical and current distribution of fall-run Chinook salmon based on Yoshiyama and others (1996). Fall-run salmon were in all Central Valley streams that had enough water during the fall, even if the streams were intermittent during other times of the year. The fall-run salmon generally spawned in streams on the Valley floor and in foothill reaches below 500 feet elevation (Rutter 1904; Yoshiyama and others 1996).

Figure 17. Late-fall Run Chinook Salmon in the Central Valley of California Historical Range and Distribution

Figure 18. Late-fall Run Chinook Salmon in the Central Valley of California Present Range and Distribution

Late-fall run fish require similar conditions to those of the winter run in which juveniles, rearing in freshwater, require cold water in summer (Fisher 1994) from either springs or late snowmelt. Figures 17 and 18 show the historical and current distribution of late-fall run Chinook salmon based on Yoshiyama and others (1996).

There is still suitable habitat for fall-run and late-fall run Chinook salmon spawning and rearing in lower foothill and Central Valley streams that had historical runs or host these runs today. There are many man-made barriers in these reaches that can delay spawning or prevent access.

Figure 17. Late-fall Run Chinook Salmon In the Central Valley of California: Historical Range and Distribution

Declining habitat

All four runs today are restricted to lower foothill and Central Valley stream reaches primarily due to construction of flood control and water storage reservoirs on rivers such as the Feather, Mokelumne, Yuba, and American, on Stony Creek, and on tributaries of the upper Sacramento River. Spring-run salmon have been extirpated from the San Joaquin River drainage.

Based on large streams in the Central Valley and excluding the Sacramento-San Joaquin Delta, Yoshiyama and others (1996) estimated that 1,014 miles of Central Valley streams remain available to Chinook salmon compared to the 2,113 miles that were available historically (a 48 percent loss). This includes lengths of streams available to salmon as migration corridors, such as the lower Sacramento and San Joaquin rivers, as well as upstream holding and spawning habitat. Further, when excluding stream lengths used strictly as migration corridors, Yoshiyama and others (1996) estimated that 82 percent of original spawning and holding habitat for all salmon runs in the Central Valley was no longer available.

In 1996, Yoshiyama and others reported the loss of spawning habitat was a larger portion of the total loss because it lies in stream reaches now cut off by dams. Of the total length of stream courses accessible today, less than a third in the San Joaquin River drainage and less than half in the Sacramento River drainage are suitable as spawning habitat. Using a 1929 figure by Clark of 6,000 miles of historical habitat (Yoshiyama and others 1996), DFG estimated that less than 300 miles of spawning habitat was available for salmon and steelhead in the Central Valley, a 95 percent loss, which is similar to the estimate made by Yoshiyama and others (1996).

Steelhead in the Central Valley and Bay Area

Before intensive water development last century, steelhead were more common in the Central Valley than they are today. Steelhead in the Central Valley are all winter steelhead. Adult steelhead normally migrate during high flows between September and March (DFG 1996). In July, adults generally begin moving upstream through the mainstem of the Sacramento River. Upstream movement peaks in September but continues though February and March (Hallock and others 1961). Most spawning occurs from December to April. Summer steelhead may have been present in the Sacramento River system, but not today. Little historical documentation exists for San Joaquin River steelhead. Figure 19 shows the historical and current distribution of rainbow trout (both oceangoing and inland forms of *Oncorhynchus mykiss*) and steelhead (oceangoing only) in drainages flowing into the Central Valley.

Figure 19. Steelhead Trout *Oncorhynchus mykiss* California Central Valley

Both natural and hatchery-maintained steelhead have declined in the Sacramento River system. In 1996, about 10 percent to 30 percent of adults returning to spawn were of natural origin (referenced in DFG 1996) down from an average of 88 percent for the 1953-1954 and 1958-1959 seasons (Hallock and others 1961). The size of the steelhead run in the American River in the 1971-1972 and 1973-1974 seasons was 19,583 and 12,274, respectively (Staley 1976). Run sizes of 300, 1,500, and 250 were estimated for the 1990-1991 through 1992-1993 seasons, respectively (DFG 1996).

Dams and other structures have blocked steelhead access to miles of spawning and rearing habitat. Low-elevation stream reaches below dams typically do not provide suitable habitat conditions for steelhead, particularly because summer rearing temperatures are too high. Mill Creek and Deer Creek, tributaries of the Sacramento River, represent probably the best spawning and rearing habitat available to steelhead in the Central Valley. In addition, Cow, Battle, Clear, and Cottonwood creeks have incidental reports of steelhead, but offer good opportunities for restoration of native steelhead populations for the Upper Sacramento River.

DFG (1996) identified several Central Valley streams with steelhead habitat and has recommended ways to improve fish access to upstream reaches or provide adequate flows for steelhead spawning and rearing. The streams with potential for self-sustaining wild runs are Clear, Big Chico, Cow, Cottonwood, Battle, Mill, Deer, Antelope, and Butte Creeks, and the Yuba River.

There is little history regarding steelhead distribution in the San Joaquin River system. Based on historical documentation of known Chinook salmon distribution in the drainage, there were steelhead from at least the Kings River headwaters north. (McEwan 2001). Today, a small but active steelhead sport fishery exists on the Tuolumne River, according to a 2000 communication with Dennis McEwan, a steelhead specialist with the DFG.

Steelhead numbers in many streams emptying into San Francisco Bay have declined. Most of those streams flow through heavily urbanized areas, so the streams have been modified into flood control channels. They have lost their riparian vegetation and water quality has deteriorated. The headwaters also have been affected by erosion and siltation from housing development and grazing cattle (Leidy 1984).

Figure 20. Steelhead, Historical and Current Distribution San Francisco Bay Area *Oncorhynchus mykiss*

Figure 20 shows the historical and 1984 distribution of steelhead in the San Francisco Bay Area based on Leidy (1984). Steelhead are documented in a variety of watersheds around the bay including San Pablo Creek in Contra Costa County; San Francisquito, Corte Madera, San Antonio, Campbell, Guadalupe, Coyote, Arroyo Honda, Smith, and Isabel creeks in Santa Clara County; San Leandro and Alameda Creeks in Alameda County; creeks and rivers of the Napa River and Sonoma Creek drainages in Napa and Sonoma counties; and Corte Madera and Miller creeks in Marin County (Leidy 1984).

How Structures in Rivers and Streams Contribute to the Problem

Since the 19th century when the first dams were built in California's Central Valley, salmon and steelhead habitat has declined from 6,000 miles of rivers and streams to 300 miles — a 95 percent loss (California Department of Fish and Game 1993). This decline in habitat relates to a corresponding decline in salmon and steelhead.

Salmon and steelhead were not only abundant in these stream communities but they also provided food and energy for other native fishes (Moyle and Randall 1998). Populations of bald eagles and other animals that depend on migrating salmon for food may decrease dramatically if the salmon are eliminated (Spencer and others 1991). And water quality and nutrient cycling can also be impacted by loss of key faunal components. Salmon release nutrients when they die after spawning, affecting algal biomass and primary production (Kline and others 1990) as well as secondary insect consumers (Schuldt and Hershey 1995). This nutrient release is considered essential for maintaining productivity of nursery areas for future salmon stocks (Mathisen 1972). When dams or other obstructions block salmonid

migration routes, patterns of nutrient cycling in entire river and stream ecosystems can be altered.

In California, as in most temperate and arid regions of the world, aquatic biodiversity is being lost rapidly because aquatic ecosystems have been severely altered by human activity (Moyle and Williams 1990; Moyle and Leidy 1992; Jensen and others 1993; Leidy and Moyle 1998). A well established body of literature documents the widespread occurrence of dams and their profound physical, chemical, and biological effects on riverine ecosystems (Baxter 1977; Petts 1984; Dynesius and Nilsson 1994; Collier and others 2000; Graf 1999; Rosenberg and others 2000).

Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead rainbow trout (*O. mykiss*) were once important parts of aquatic ecosystems at low to middle elevation in western Sierra Nevada streams from the Kings River north. However, dams and other obstructions have excluded these species from much of their former habitat. Migratory fish, particularly salmon, are frequently the species most impacted by dams (Shuman 1995. The exclusion has significantly altered the stream communities of which salmon and steelhead were once part (Moyle and Randall 1998).

Stream ecosystems evolved as continuous features of the landscape. Man-made structures can fragment streams and their ecosystems. Road crossings, dams, diversions, severe pollution, or land management practices alter physiography or hydrologic regime or hydrologic connectivity of streams. Fragmentation of aquatic ecosystems results in altered nutrient cycling patterns, streamflow, sediment transport, channel morphology, species composition, and genetic diversity. The fragmentation and alteration of streams by humans can have dramatic effects on ecosystem integrity and biological diversity (Holden 1979; Petts 1979; Krapu and others 1984; Sullivan and others 1987; Grams 1991; Stevens and Ayers 1993; Bauer and others 1994; Middleton and Liittschwager 1994; Pringle 1997; Levin and Schiewe 2001).

Some aquatic ecologists believe that environmental degradation, including fragmentation of streams and rivers by dams and other structures, underlies the demise of the 106 salmon populations now considered extinct along the west coast of North America, resulting in the loss of the unique genes of the lost populations (Levin and Schiewe 2001). Bank erosion is the most important source of spawning gravel in the Sacramento River; riprap bank stabilization reduces the amount of gravel that is available for salmon spawning habitat in this system (Shields 1991). Also, Buer and others (1984) identified riprap bank stabilization as a contributing cause of declining salmon populations in the Sacramento River.

Over the past 75 years, on stream dams in Southern California have caused considerable loss of steelhead freshwater habitat (McEwan and Jackson 1996). Habitat fragmentation and population decline increases the chances for inbreeding, loss of rare alleles, and genetic drift, impacting species' ability to respond to environmental changes over the long-term and remain viable. Research to determine the level of genetic diversity of rainbow trout populations from Big Pico Creek south to Pauma Creek in Southern California was conducted to determine levels of genetic diversity (Nielsen and others 1997). It was determined that rainbow trout that retained access to the ocean had significantly higher levels of genetic diversity than those whose migrations were blocked by dams.

Sustained unnatural flows below dams cause loss of breeding and rearing habitat for amphibians, such as the arroyo southwestern toad of southern California (Sweet 1991, USFWS 1994), and other aquatic fauna. Habitat loss affects larval, newly metamorphosed and adult life stages of aquatic fauna, causing high mortality (Sweet 1992). Extreme alterations in habitat conditions have been documented below large dams such as Glenn Canyon Dam on the Colorado River. Cold water releases from the dam and trapped sediments have altered downstream habitat conditions and have been related to declining populations of endangered Humpback Chub, a native minnow of the lower Colorado River (Coggins and Walters 2001). For more information see www.gcmrc.gov/bio/bio.htm.

Types of Structural Fish Passage Barriers

Obstructions to fish passage include dams, culverts, bridges, flood control channels, erosion control structures, canal and pipeline crossings, and gravel mining pits, as well as natural features such as beaver dams and log jams, and geomorphic features such as waterfalls. Dams, however, are the most obvious and visible of these obstructions.

Dams

Dams provide water storage for flood control and navigation; debris containment; electrical power generation, recreation, fish and wildlife habitat, and improve water quality (Collier and others 2000). In the early years of dam building, their environmental effects were largely, not considered. Since, however, impacts of dams on migrating fish, natural geomorphic processes in streams such as sediment transport, and flows and temperatures of river systems have become evident. With declines of many fish populations in California and listing of some salmonids under the federal Endangered Species Act, all dams and other structures are being considered in restoration and recovery efforts.

Migratory blockage at large dams is due primarily to the height limitations for fishways and the ability of fish to climb or swim past extreme elevations and loss of downstream migrants in large reservoirs and through turbines (Bell 1990). To the fish accustomed to rivers, a lack of current in reservoirs causes them to wander upstream and downstream in search of an exit from the reservoir. Wandering can be fatal to fish because of the energy they expend and their susceptibility to predation (Bell 1990). Dams as small as a foot high can prevent passage if there is not enough streamflow, or if the downstream face or footing of the dam is too long or shallow for fish to overcome. Downstream-migrating juvenile salmonids face stress, injury, and death by passing over the tops of dams and landing on concrete or rocks below, becoming caught in recirculating hydraulics at the base of dams, or becoming prey to piscivorous fish that congregate at dams or ladders.

In addition, sustained unatural flows and flow manipulations below dams confuse fish when high flow releases occur at non-migratory periods, attracting fish at the wrong times or into channels where flows are not sustained, stranding or killing fish as a result.

Gravel Pits

Instream gravel pits and associated large ponds provide habitat for warm water, or slack water, predatory fish that prey on juvenile salmonids. These predators include non-native striped bass, largemouth and smallmouth bass, or natives such as the northern pike minnow. Juvenile salmonids migrating downstream can become disoriented in the slow waters of a pond and become more vulnerable to predation. Many of these ponds lack adequate cover for juvenile salmonids trying to avoid predators. Demko (1998) noted the occurrence of predation on juvenile salmonids by bass in instream gravel pit ponds at the Oakdale Recreation Area on the Stanislaus River. The warm water in the ponds can be deadly for juvenile salmonids that are acclimated to the colder water of their spawning areas. Warm-water stress also makes them susceptible to predators. Instream ponds trap large quantities of sand and silt that high flows mobilize and carry downstream, potentially covering downstream spawning areas. In addition, when high river flows spill over into offstream ponds close to river fish can be trapped and stranded once flows recede. Many of these problems have been observed anecdotally by biologists and anglers but await further study to describe the extent of these impacts (pers. Comm.Mesick 2002).

Roads and Infrastructure

Depending on streamflow, horizontal distance, and depth of water over the structure, roads and other infrastructure built across streams have been recognized (Robison and others 2000) as potential barriers to fish migration (e.g. fords, pipelines, bridge footings, and energy dissipaters). Recent surveys and investigations have documented the significance of road

construction impacts to migratory paths of anadromous salmonids in the Pacific Northwest alone (GAO 2001; R. Taylor 2000, 2001; NMFS 2002 in prep.). Culverts may become perched by downstream scouring or erosion making them too high for adult or juvenile fish to access under low streamflow. Fish can become injured from landing on rip-rap or concrete placed below an outlet to control erosion. At high flows, the force of the water flowing through a culvert may create velocity barriers that can overwhelm migrating fish. As part of the effort to recover declining populations of listed salmonids and other fishes, culverts at stream road crossings have come under intense scrutiny nationwide. These effort have received significant state and federal funding.

Channel modifications for flood control include clearing vegetation, riprapping, widening, deepening, realignment, and lining. These modifications remove ecologically valuable features such as stream meanders, oxbows and sloughs, spawning substrate, streamside riparian cover, and instream vegetation, decrease stream length, increase gradient and velocity, dewater adjacent lands, change basic physicochemical regime, and alter nutrient inputs (USFWS 1982). Flood control structures such as concrete-lined or riprapped stream channels can impede upstream migration if there are no places for fish to rest as they work against a flow of high velocity water. Drop structures also impede fish migration if fish cannot move past them. Channelized or de-watered stream reaches create adverse habitat conditions, such as warm water that exceeds tolerance limits, or lack of cover that limits shading, food production, predator avoidance capacity and ultimately survival and growth of migrating juveniles. Areas downstream of channelized reaches can experience adverse streamflow and stream quality.

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Figure 2

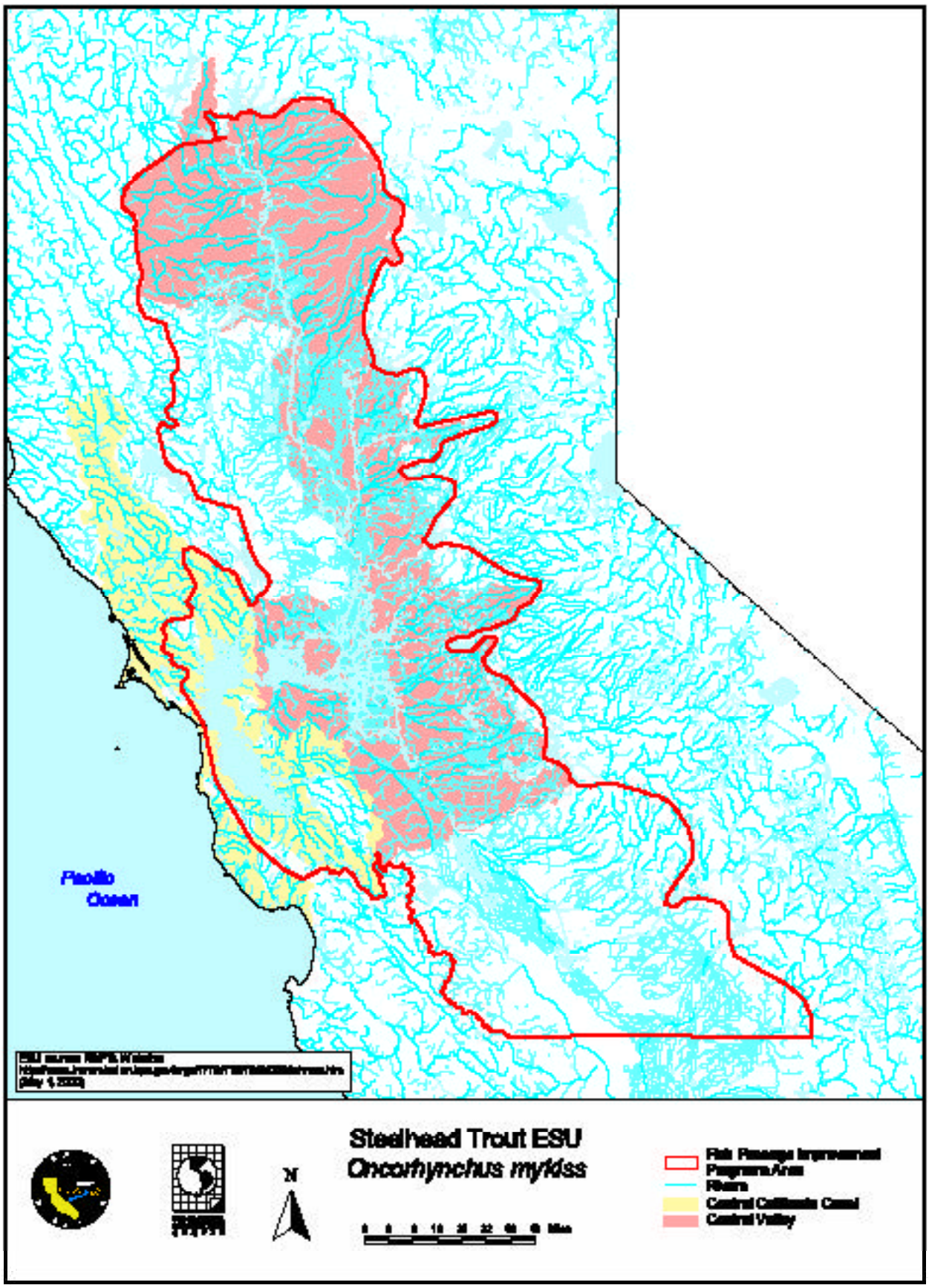
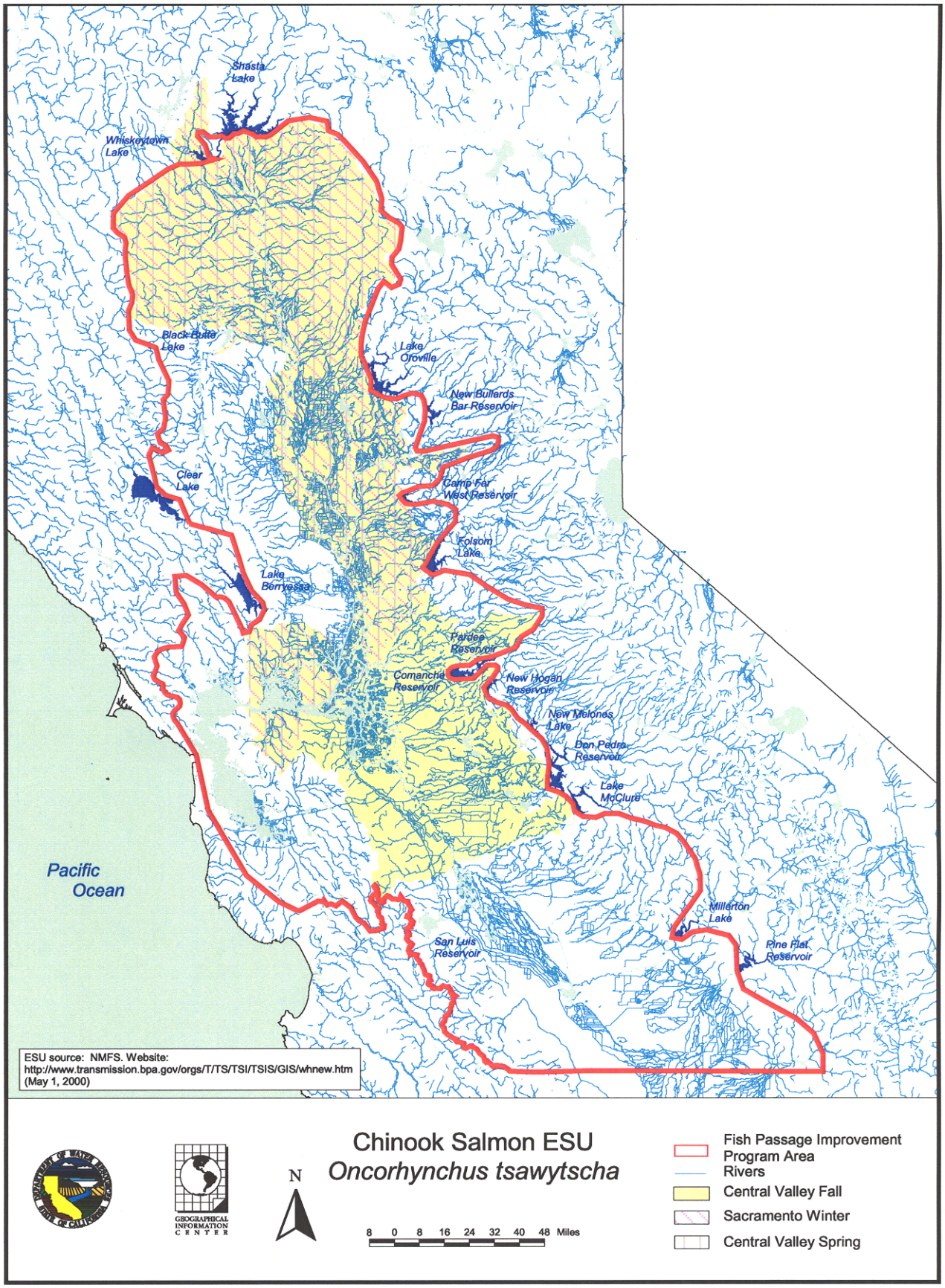

Pacific
Ocean
Steelhead Trout ESU
Oncorhynchus mykiss
N
Fish Passage Improvement
Program Area
Rivers
Central California Coast
Central Valley

Figure 3



Chinook Salmon ESU
Oncorhynchus tsawytscha

Figure 4

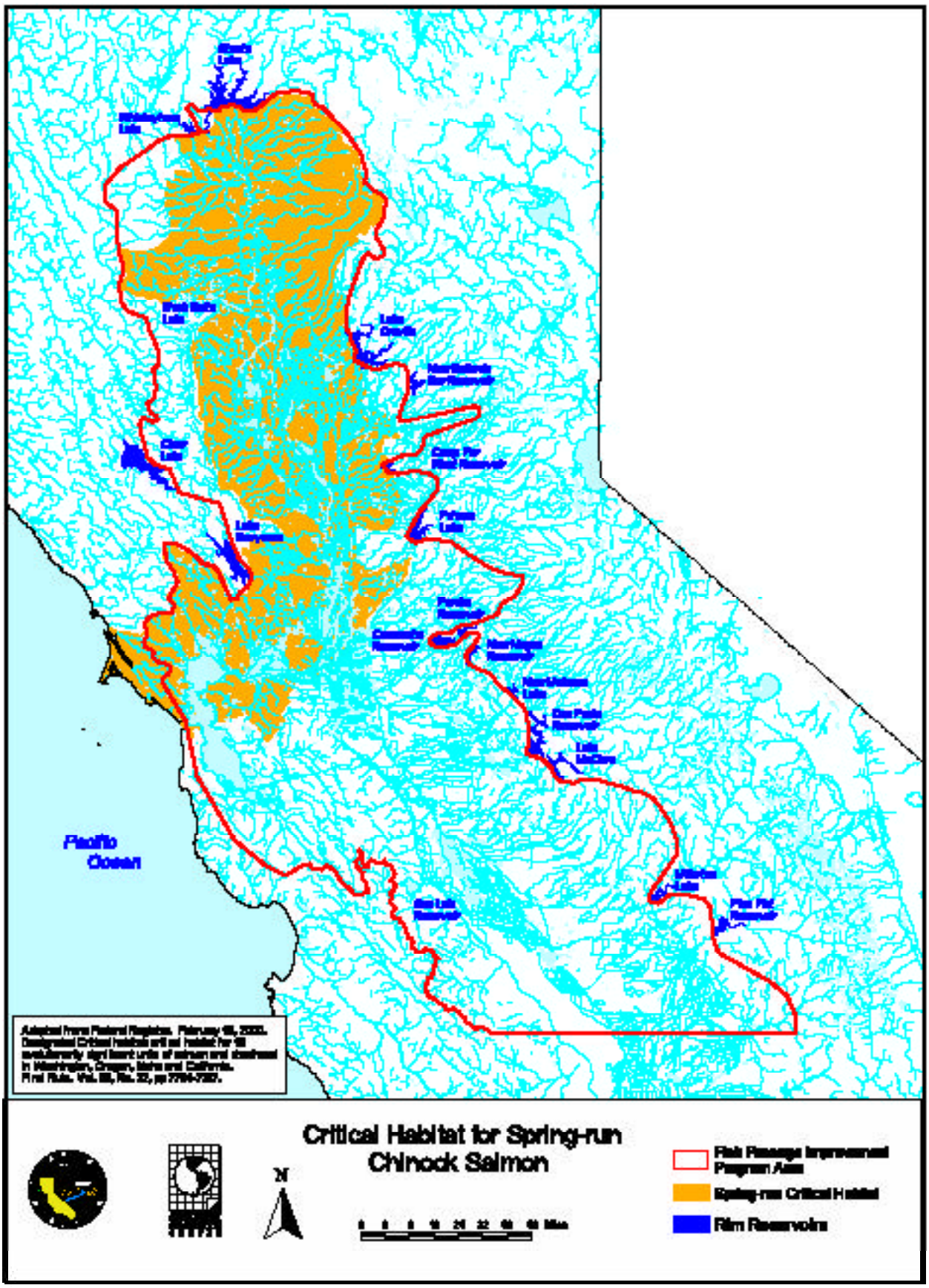

Pacific Ocean
Critical Habitat for Spring-run Chinook Salmon
N
Fish Passage Improvement Program Area
Spring-run Critical Habitat
Rim Reservoirs

Figure 5

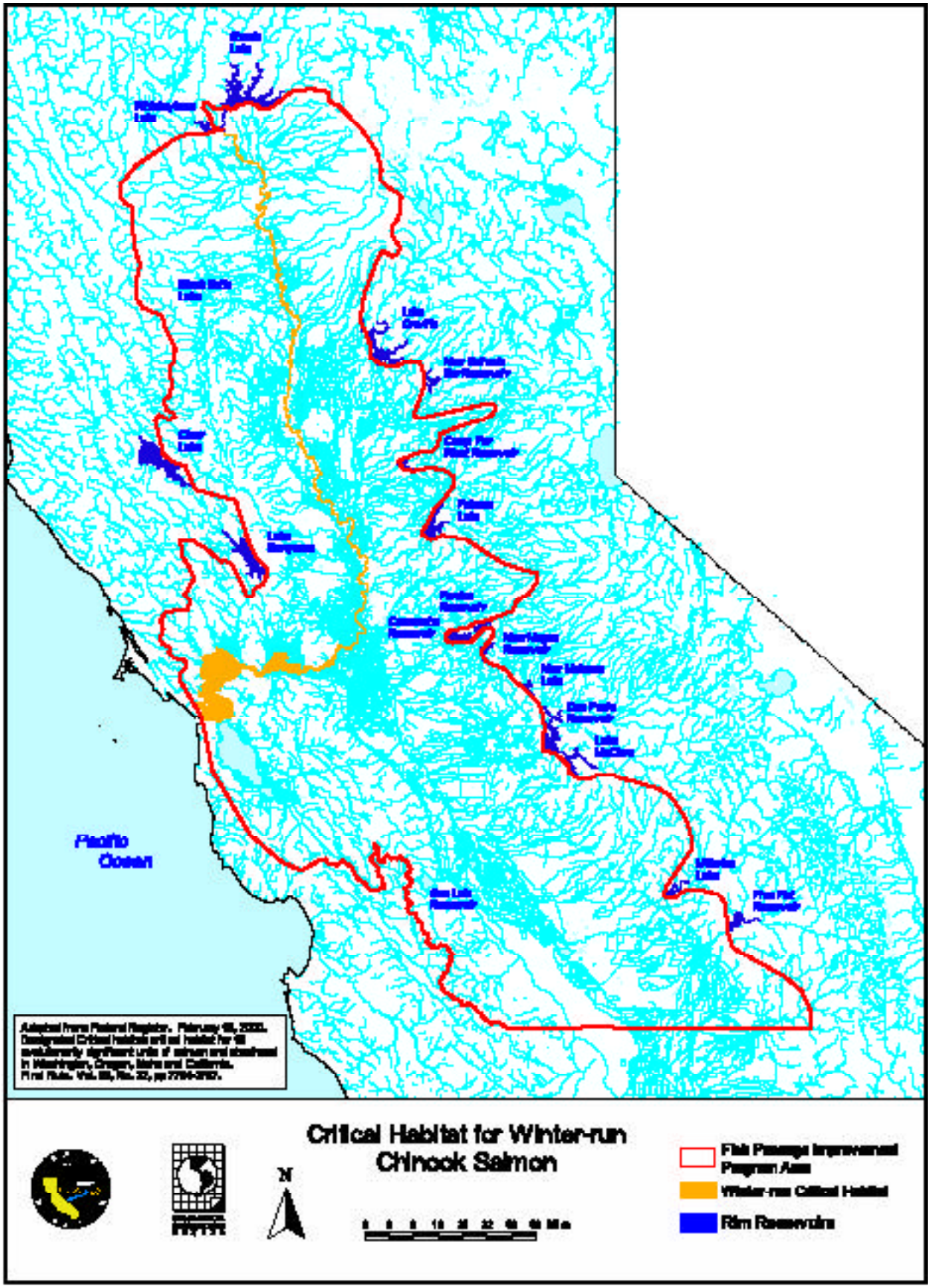

Pacific Ocean
Critical Habitat for Winter-run Chinook Salmon
N
Fish Passage Improvement Program Area
Winter-run Critical Habitat
Rim Reservoirs

Figure 6

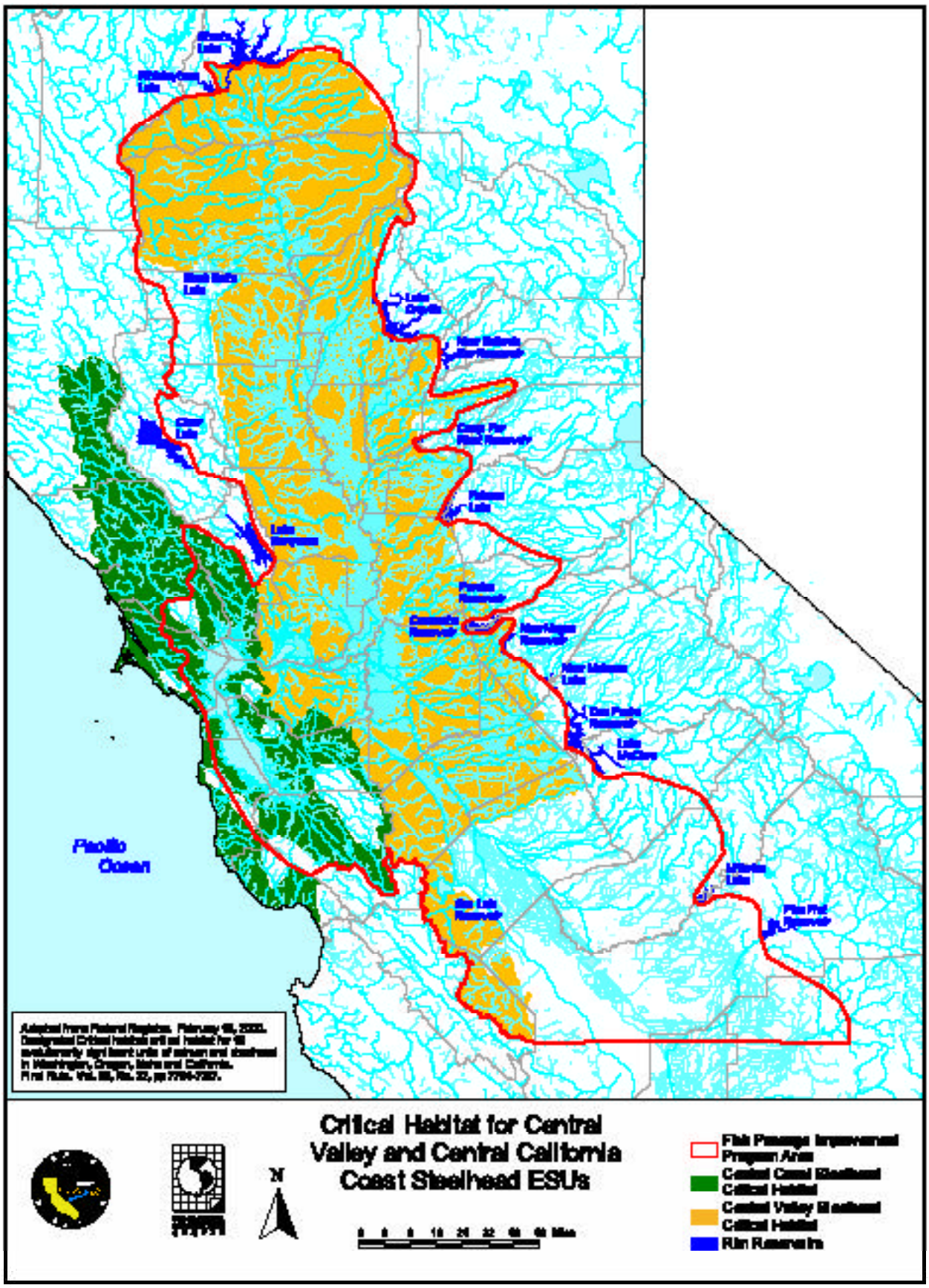

Pacific Ocean
Critical Habitat for Central Valley and Central California Coast Steelhead ESUs
N
Fish Passage Improvement Program Area
Central Coast Steelhead Critical Habitat
Central Valley Steelhead Critical Habitat
Rim Reservoirs

Figure 7

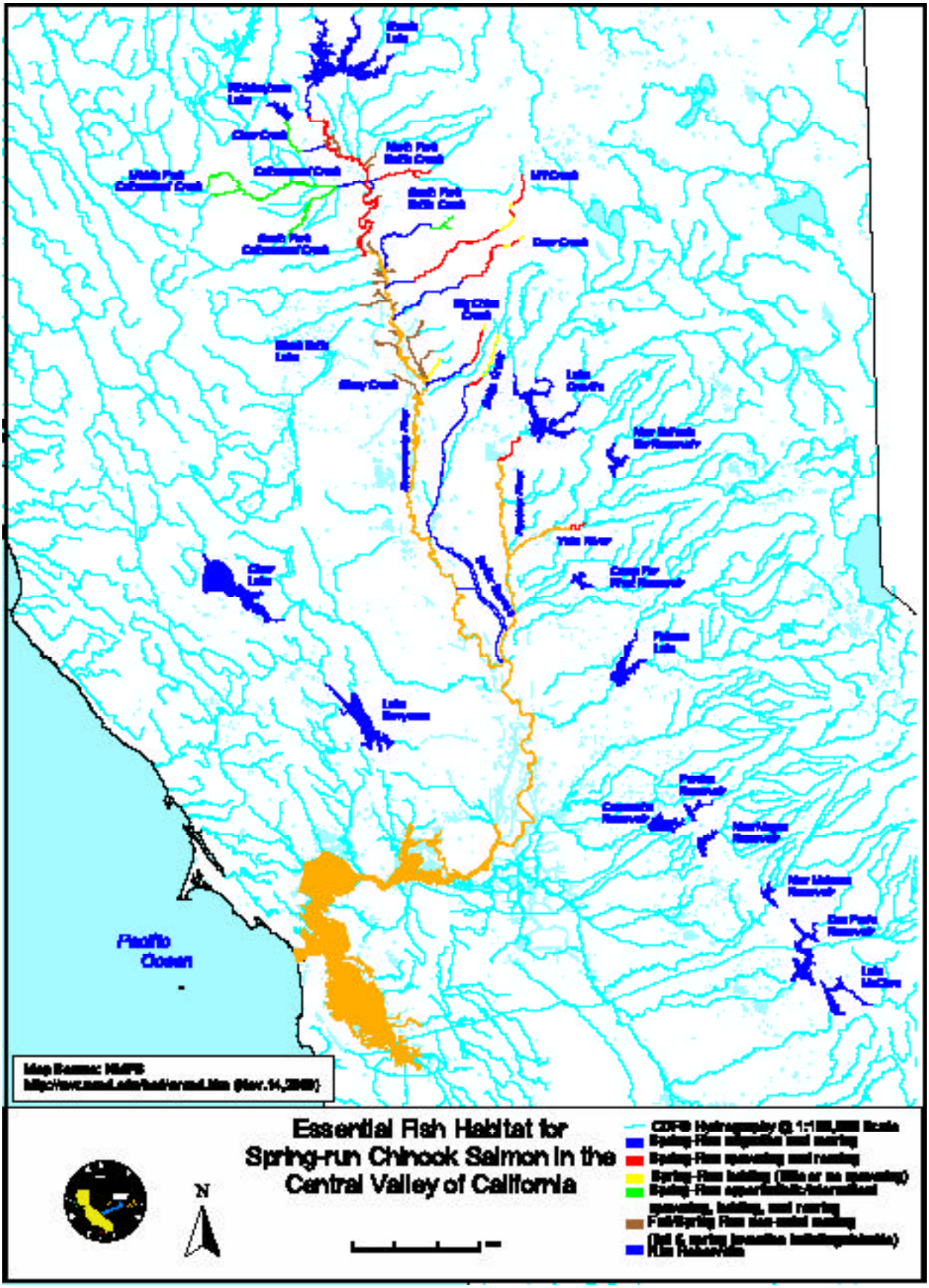

Pacific Ocean
Essential Fish Habitat for
Spring-run Chinook Salmon in the
Central Valley of California
N

Figure 8

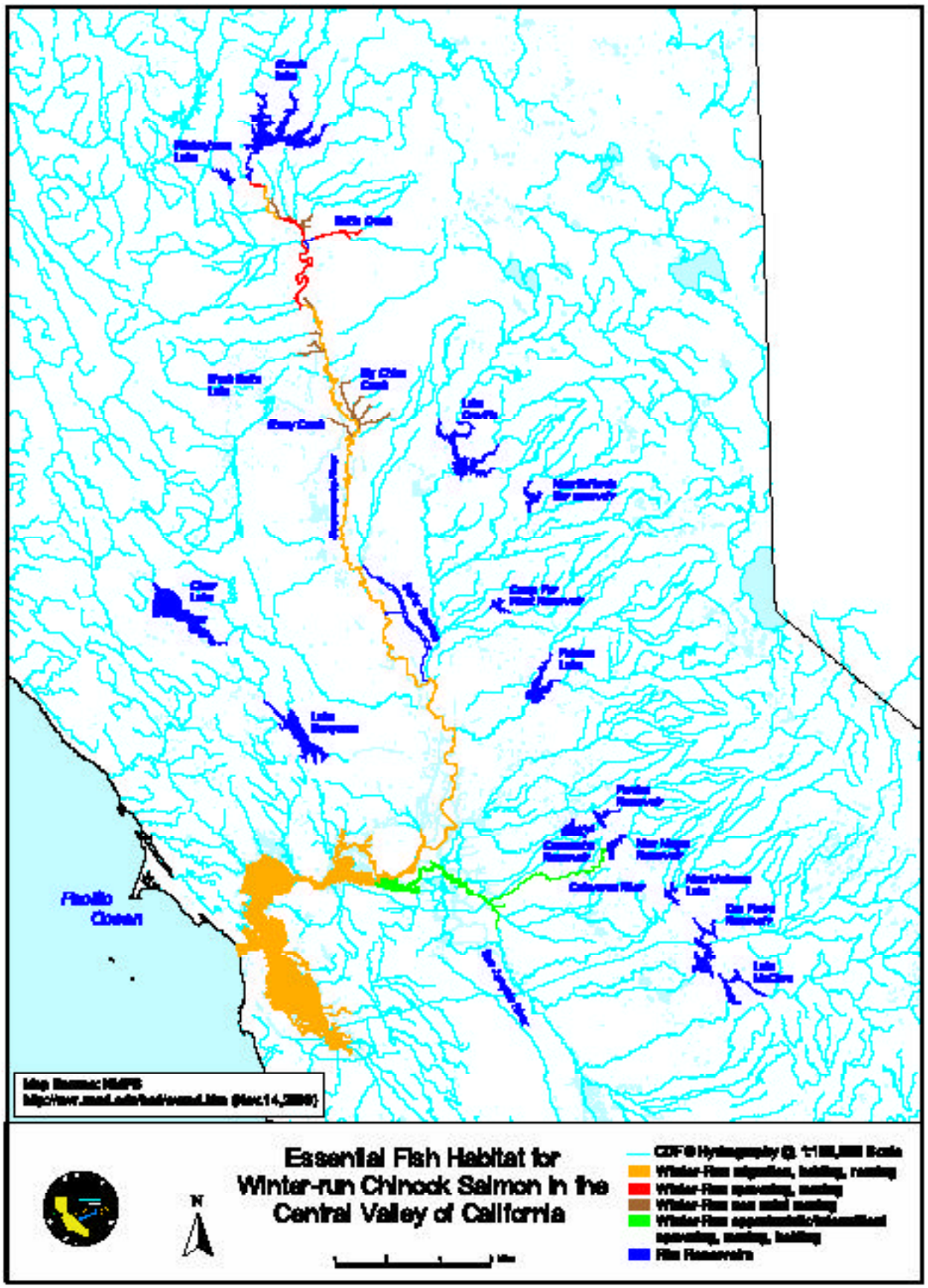

Pacific Ocean
Essential Fish Habitat for
Winter-run Chinook Salmon in the
Central Valley of California
N

Figure 9

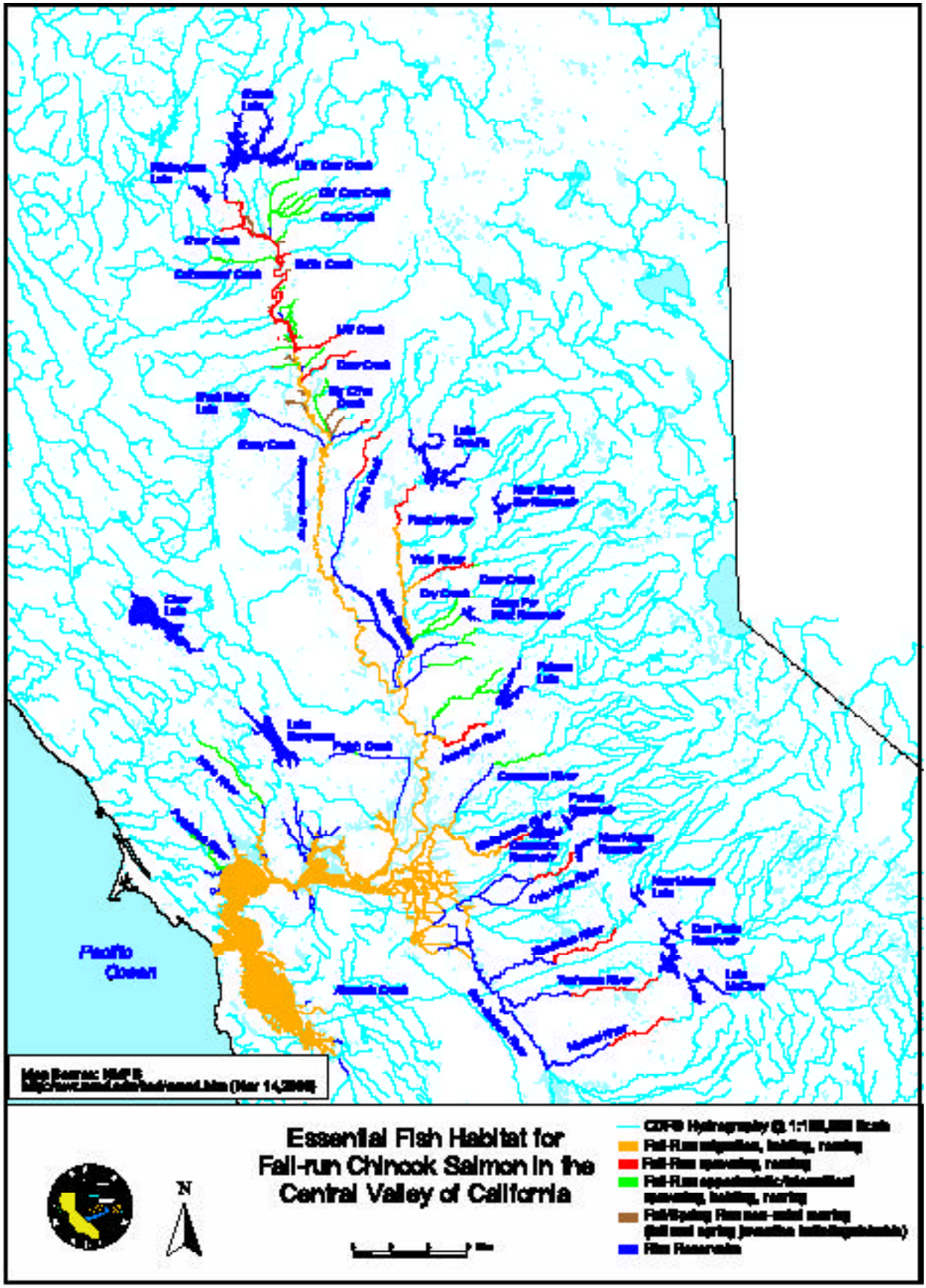

Pacific Ocean
Essential Fish Habitat for
Fall-run Chinook Salmon in the
Central Valley of California
N

Figure 10

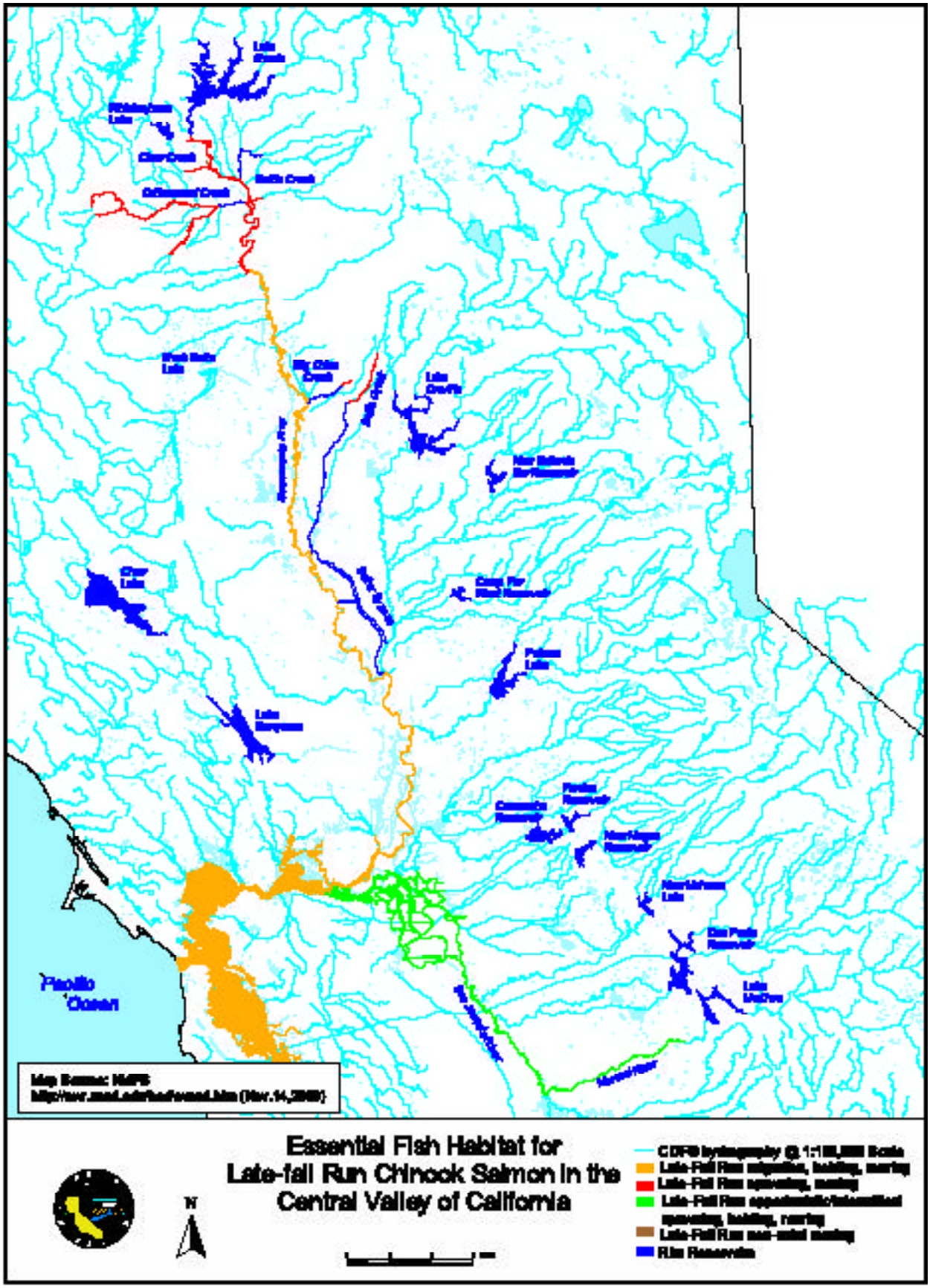

Pacific Ocean
Essential Fish Habitat for
Late-fall Run Chinook Salmon in the
Central Valley of California
N

Figure 11

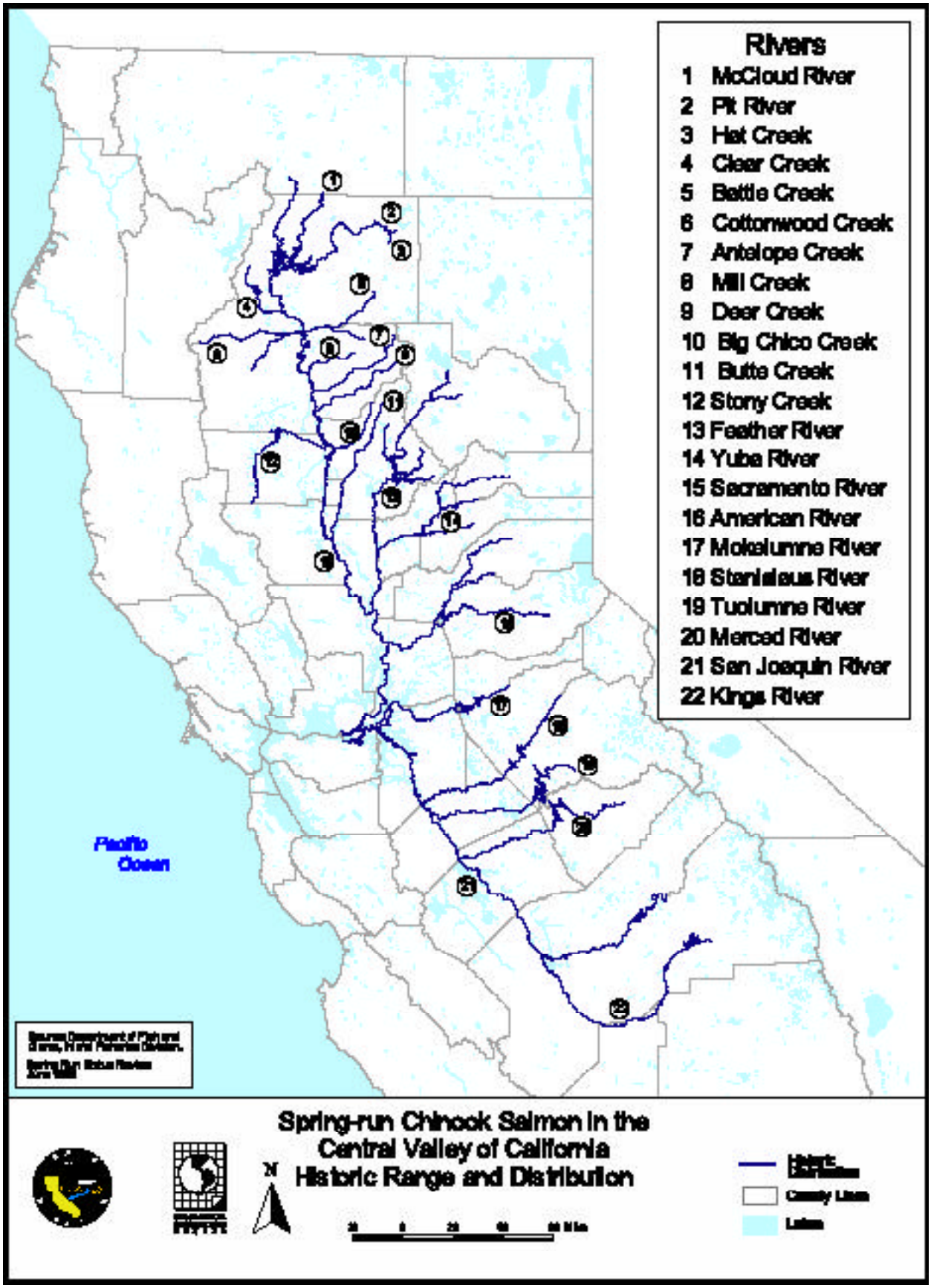

Rivers
1 McCloud River
2 Pit River
3 Hat Creek
4 Clear Creek
5 Battle Creek
6 Cottonwood Creek
7 Antelope Creek
8 Mill Creek
9 Deer Creek
10 Big Chico Creek
11 Butte Creek
12 Stony Creek
13 Feather River
14 Yuba River
15 Sacramento River
16 American River
17 Mokelumne River
18 Stanislaus River
19 Tuolumne River
20 Merced River
21 San Joaquin River
22 Kings River
Pacific Ocean
Spring-run Chinook Salmon in the Central Valley of California Historic Range and Distribution
N

Figure 12

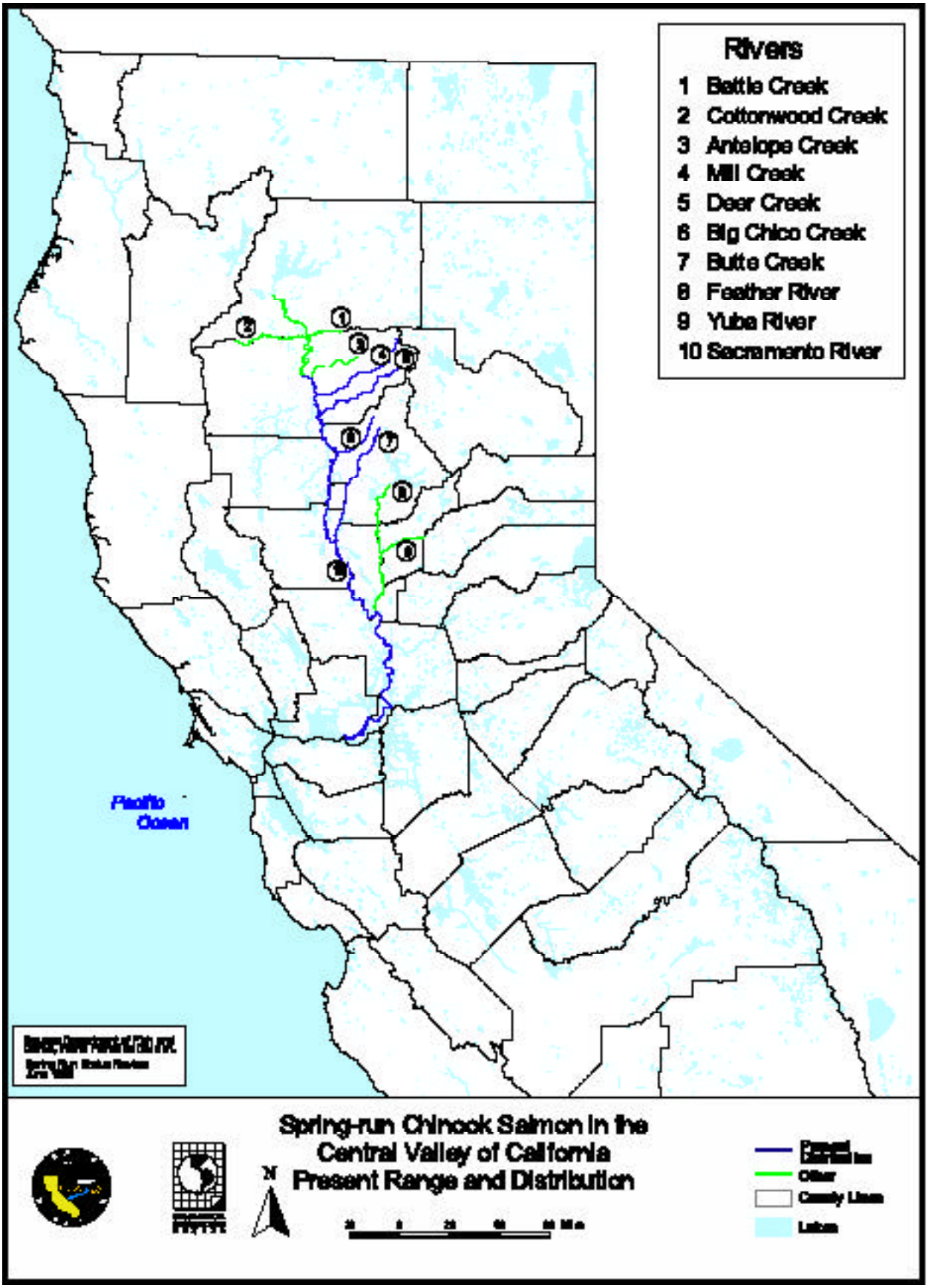

Rivers
1 Battle Creek
2 Cottonwood Creek
3 Antelope Creek
4 Mill Creek
5 Deer Creek
6 Big Chico Creek
7 Butte Creek
8 Feather River
9 Yuba River
10 Sacramento River
Pacific Ocean
Spring-run Chinook Salmon in the Central Valley of California Present Range and Distribution
N
Other
County Lines
Lakes

Figure 13

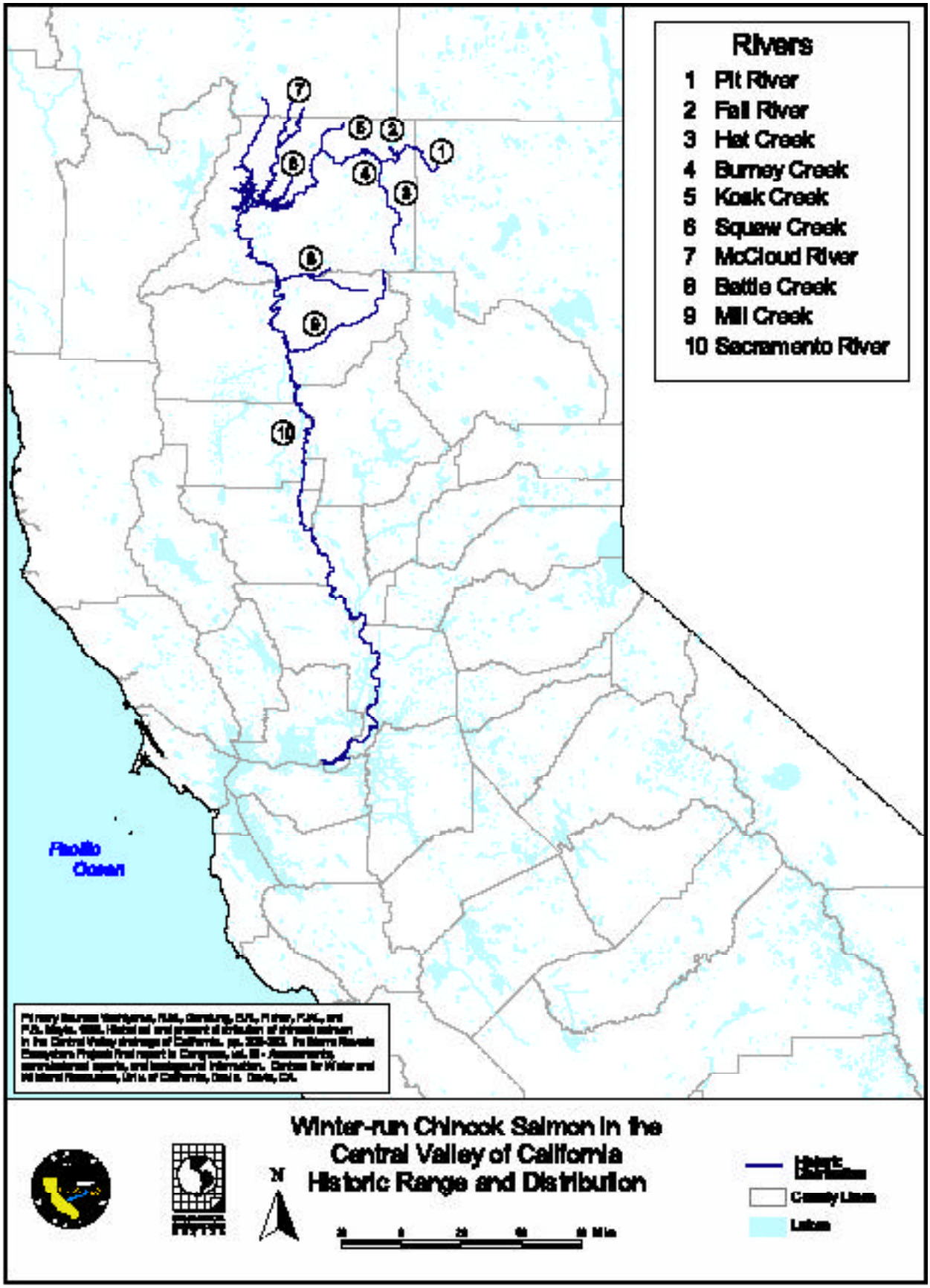

Rivers
1 Pit River
2 Fall River
3 Hat Creek
4 Burney Creek
5 Kosk Creek
6 Squaw Creek
7 McCloud River
8 Battle Creek
9 Mill Creek
10 Sacramento River
Pacific Ocean
Winter-run Chinook Salmon in the
Central Valley of California
Historic Range and Distribution
N
County Lines
Lakes

Figure 14

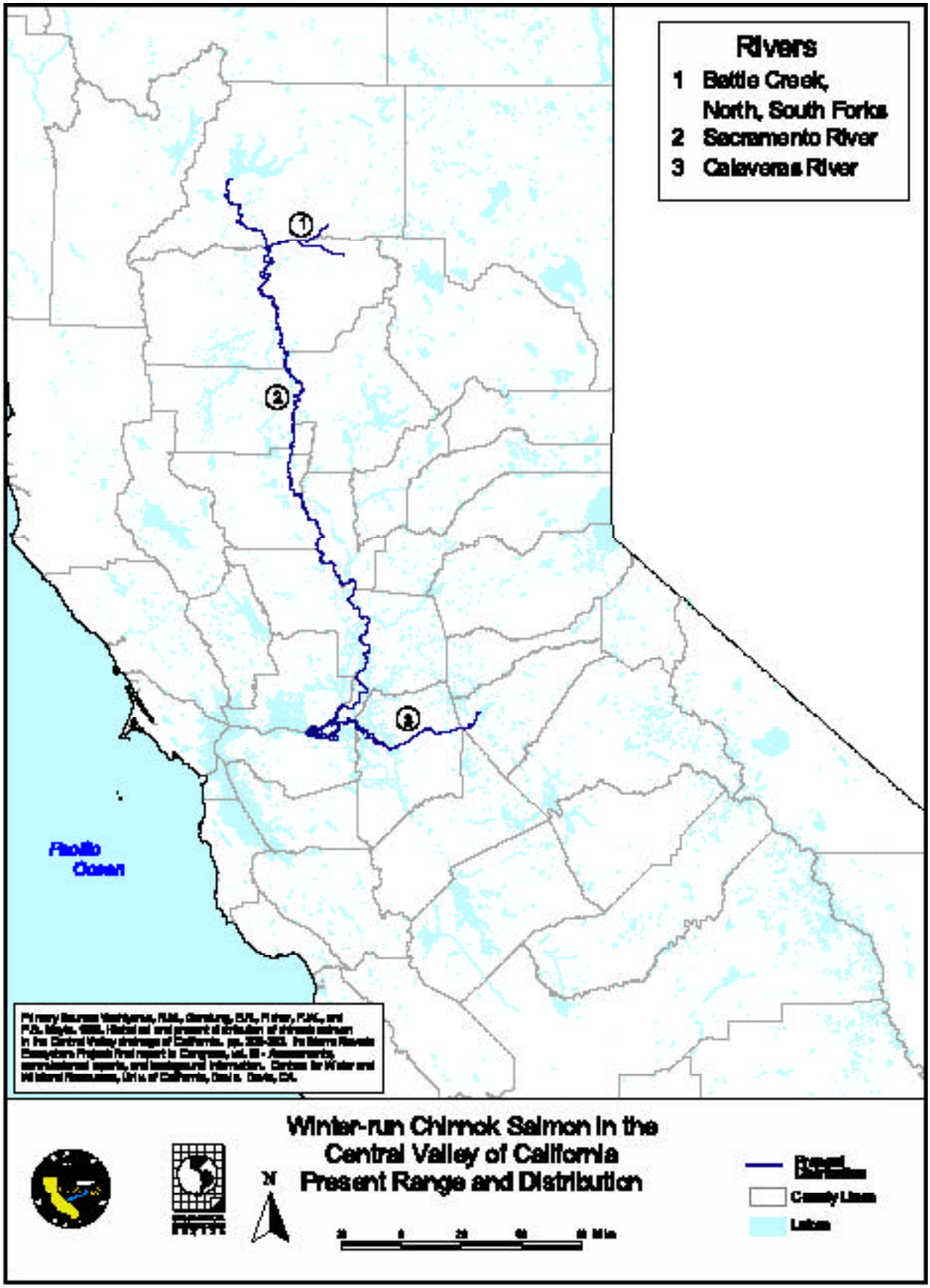

Rivers
1 Battle Creek, North, South Forks
2 Sacramento River
3 Calaveras River
Pacific Ocean
Winter-run Chinook Salmon in the Central Valley of California Present Range and Distribution
N
County Lines
Lakes

Figure 15

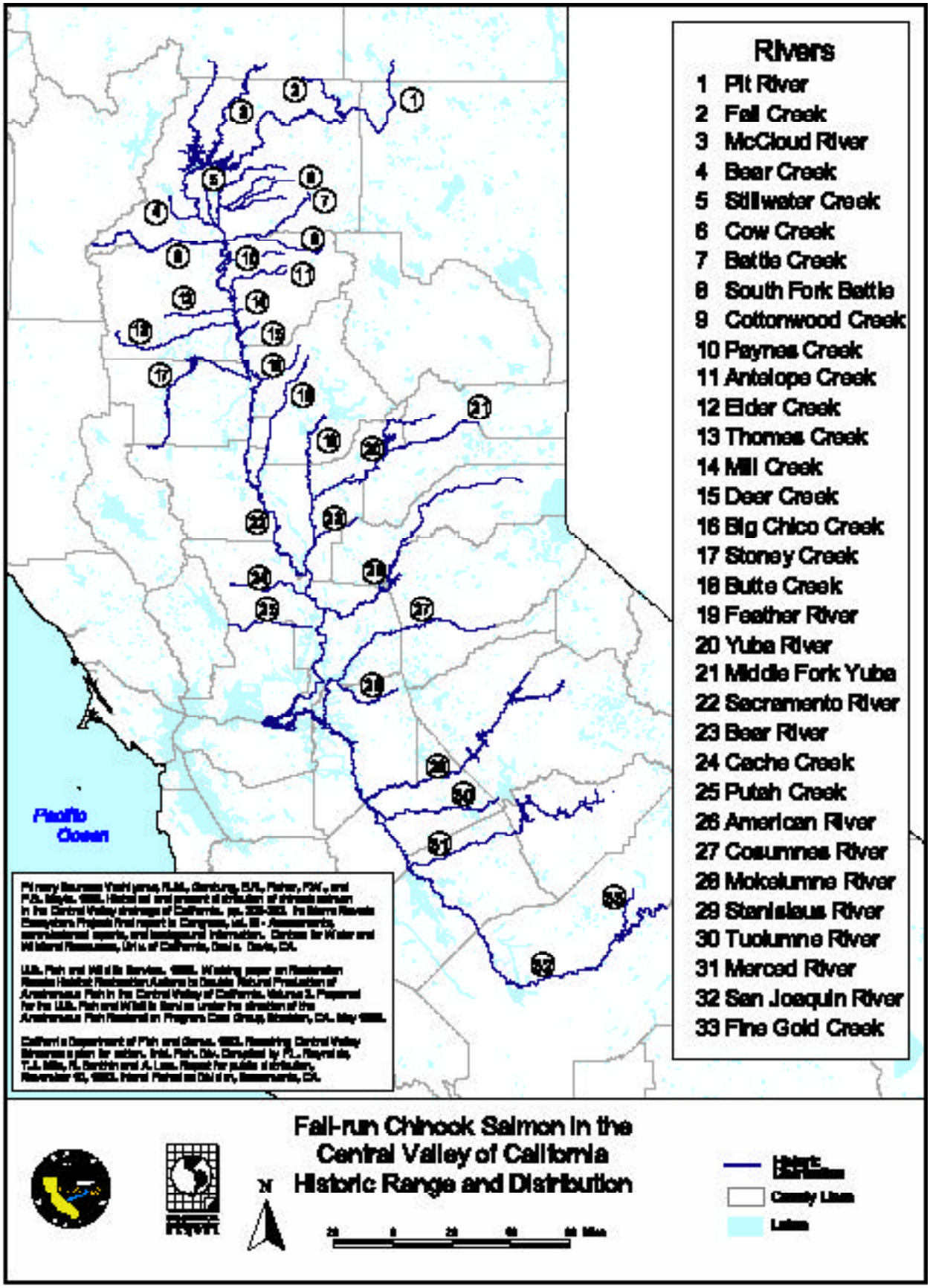

Rivers
1 Pit River
2 Fall Creek
3 McCloud River
4 Bear Creek
5 Stillwater Creek
6 Cow Creek
7 Battle Creek
8 South Fork Battle
9 Cottonwood Creek
10 Paynes Creek
11 Antelope Creek
12 Elder Creek
13 Thomes Creek
14 Mill Creek
15 Deer Creek
16 Big Chico Creek
17 Stoney Creek
18 Butte Creek
19 Feather River
20 Yuba River
21 Middle Fork Yuba
22 Sacramento River
23 Bear River
24 Cache Creek
25 Putah Creek
26 American River
27 Cosumnes River
28 Mokelumne River
29 Stanislaus River
30 Tuolumne River
31 Merced River
32 San Joaquin River
33 Fine Gold Creek
Pacific Ocean
Fall-run Chinook Salmon in the
Central Valley of California
Historic Range and Distribution
N
County Lines
Lakes

Figure 16

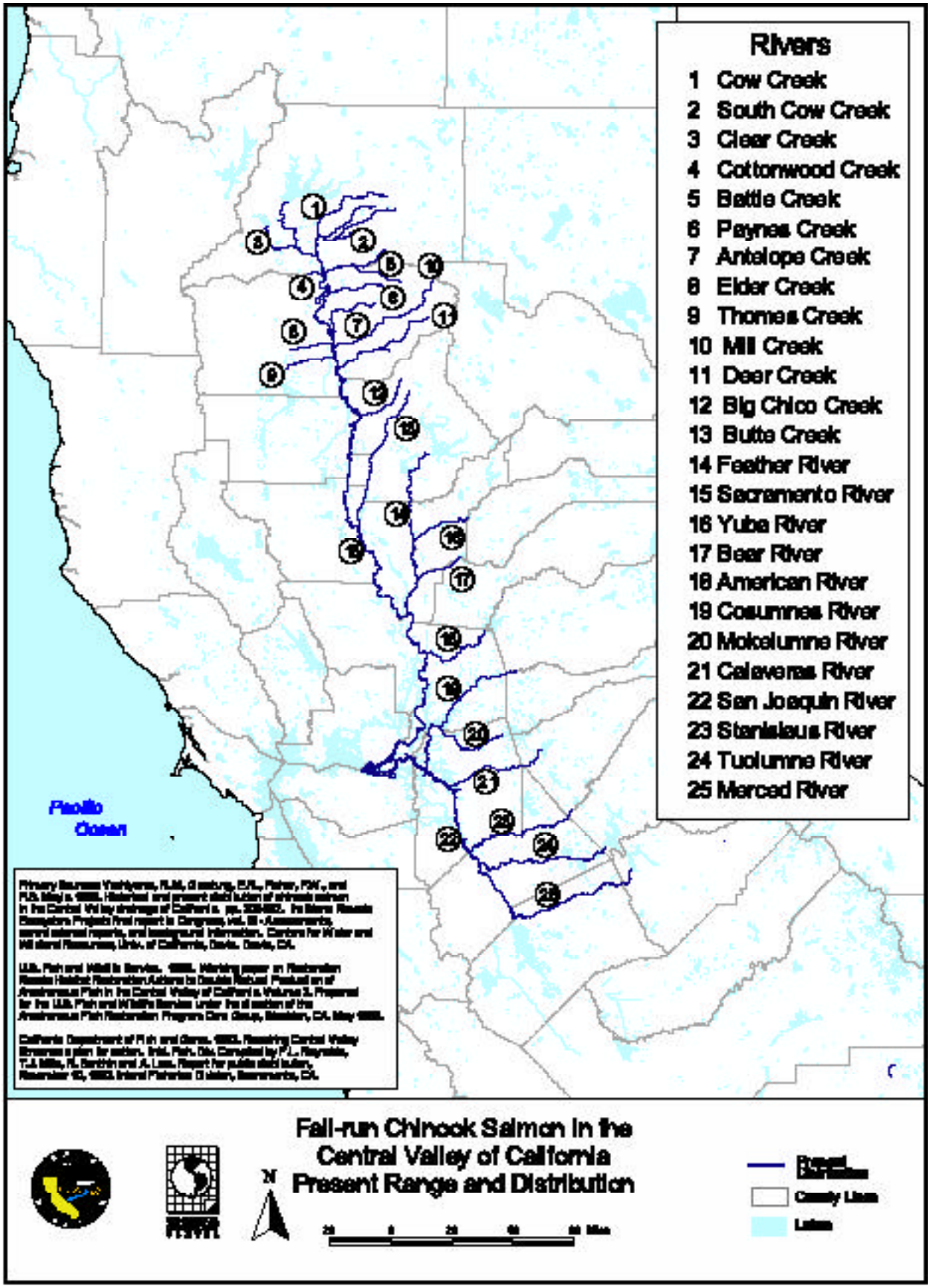

Rivers
1 Cow Creek
2 South Cow Creek
3 Clear Creek
4 Cottonwood Creek
5 Battle Creek
6 Paynes Creek
7 Antelope Creek
8 Elder Creek
9 Thomes Creek
10 Mill Creek
11 Deer Creek
12 Big Chico Creek
13 Butte Creek
14 Feather River
15 Sacramento River
16 Yuba River
17 Bear River
18 American River
19 Cosumnes River
20 Mokelumne River
21 Calaveras River
22 San Joaquin River
23 Stanislaus River
24 Tuolumne River
25 Merced River
Pacific Ocean
Fall-run Chinook Salmon in the Central Valley of California Present Range and Distribution
N
County Lines
Lakes

Figure 17

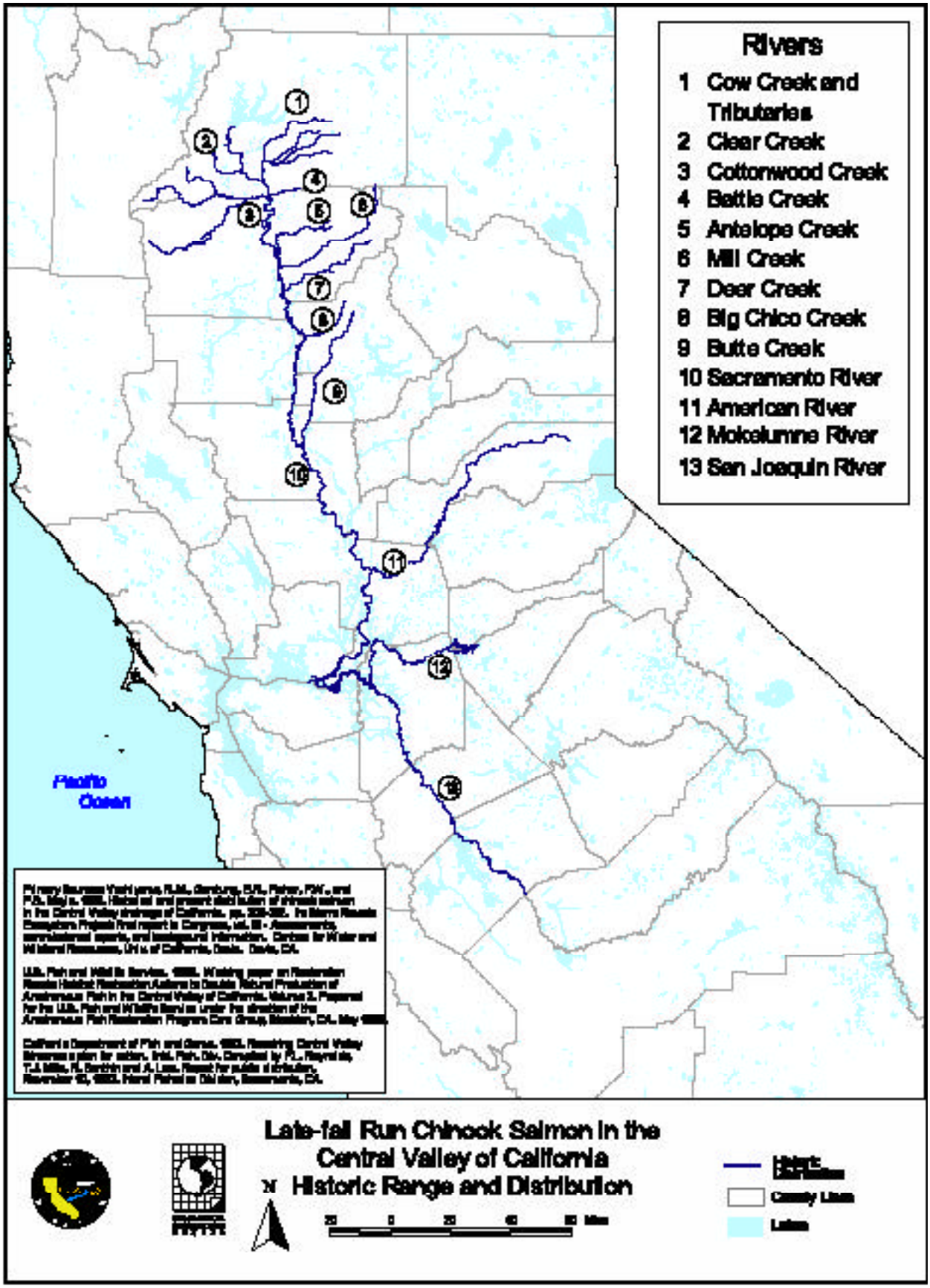

Rivers
1 Cow Creek and Tributaries
2 Clear Creek
3 Cottonwood Creek
4 Battle Creek
5 Antelope Creek
6 Mill Creek
7 Deer Creek
8 Big Chico Creek
9 Butte Creek
10 Sacramento River
11 American River
12 Mokelumne River
13 San Joaquin River
Pacific Ocean
Late-fall Run Chinook Salmon in the Central Valley of California
Historic Range and Distribution
N
County Lines
Lakes

Figure 18

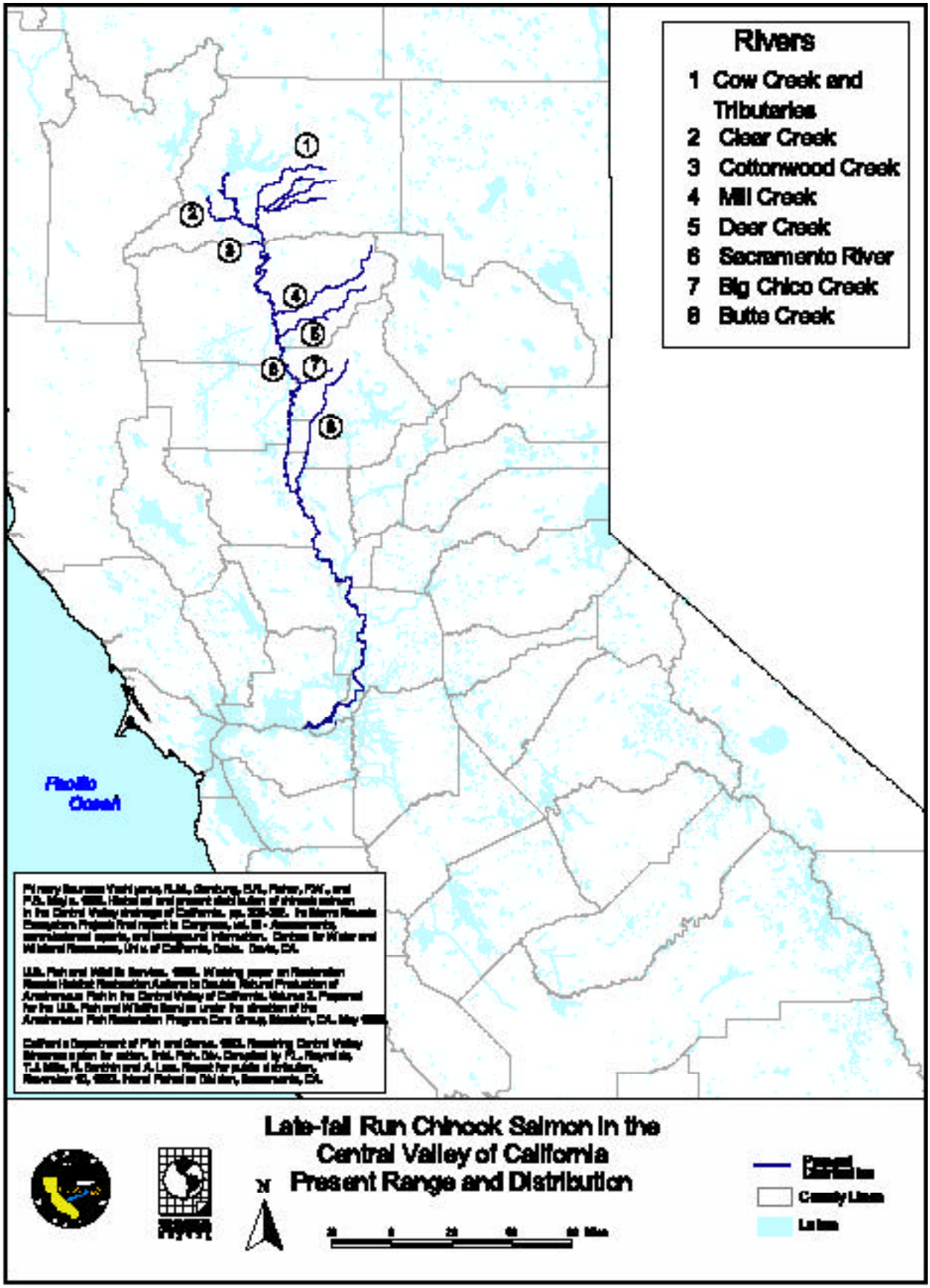

Rivers
1 Cow Creek and Tributaries
2 Clear Creek
3 Cottonwood Creek
4 Mill Creek
5 Deer Creek
6 Sacramento River
7 Big Chico Creek
8 Butte Creek
Pacific Ocean
Late-fall Run Chinook Salmon in the Central Valley of California
Present Range and Distribution
N
County Lines

Figure 19

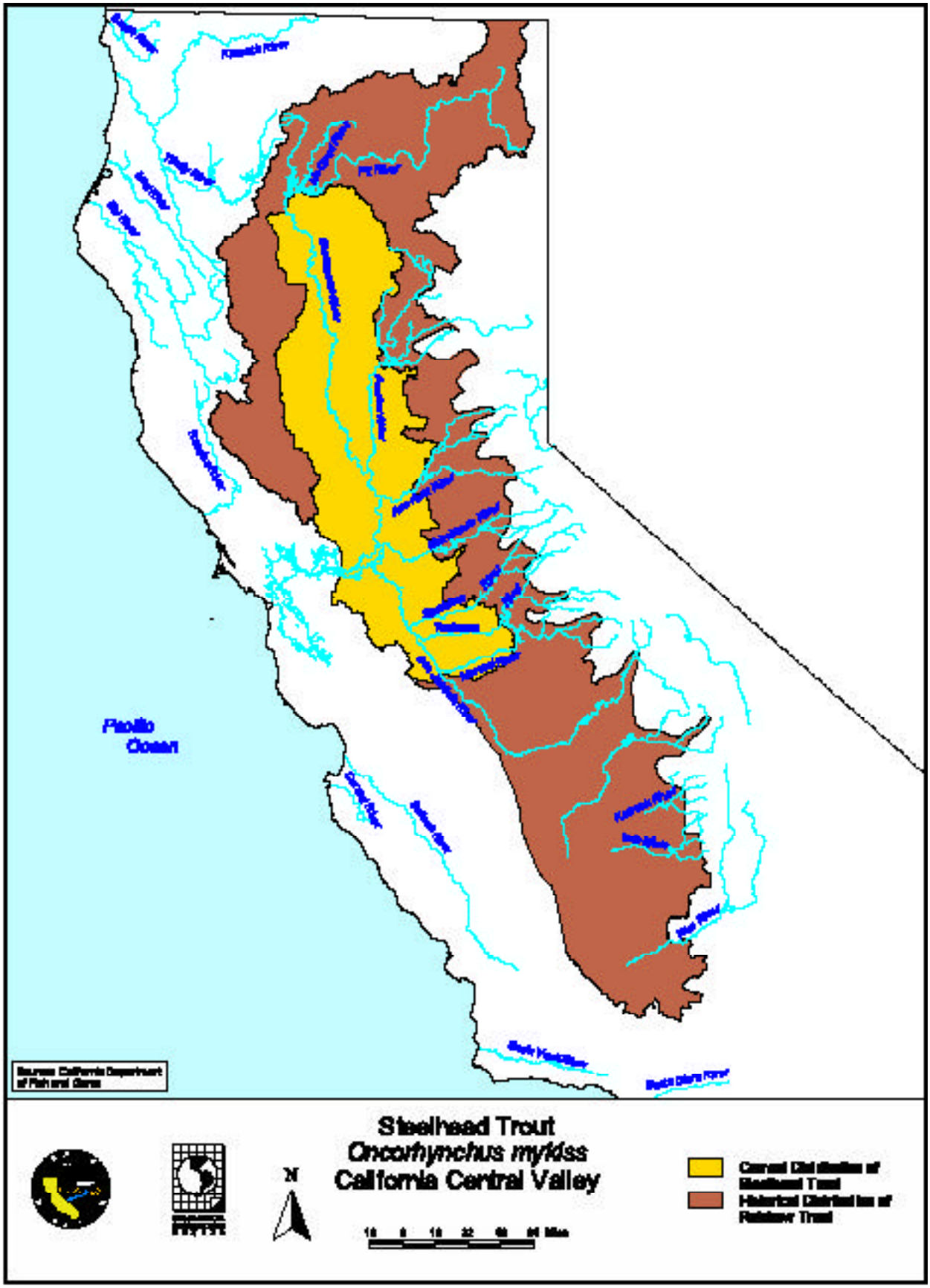
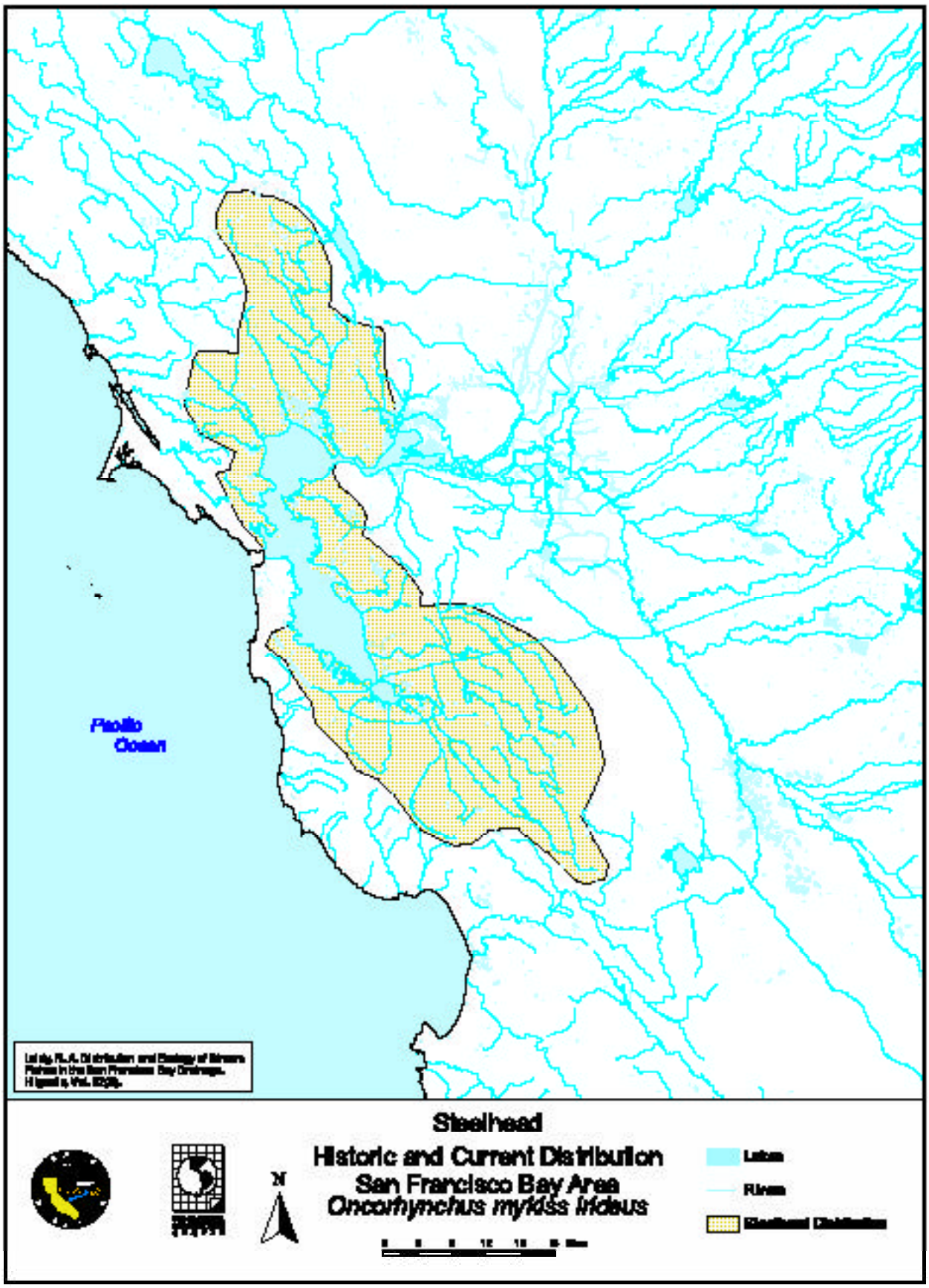

Pacific
Ocean
Steelhead Trout
Oncorhynchus mykiss
California Central Valley
N

Figure 20


Pacific
Ocean
Steelhead
Historic and Current Distribution
San Francisco Bay Area
Oncorhynchus mykiss irideus
N
Lakes
Rivers

Other Chapters

Chapter 1. The Problem: Fewer Salmon and Steelhead in the Central Valley and San Francisco Bay Area

Chapter 2. Solving the Problem

Chapter 3. Existing Habitat Conditions and Status of Fish Populations

Chapter 4. Current Program Activities

Appendix A Known Structures Within CALFED ERP Geographic Scope

Appendix B: Applicable Laws and Examples of Fish Passage Programs at Other Agencies

Appendix C: Structure Removal Examples and Challenges

Appendix D: Evolutionarily Significant Units, Critical Habitat, and Essential Fish Habitat

Appendix E: Literature Cited