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SALMON AND STEELHEAD POPULATIONS OF THE KLAMATH-TRINITY BASIN, CALIFORNIA

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Abstract.-The Klamath River Basin Stock Identification Committee designated breeding populations and metapopulations for fall run chinook salmon *Oncorhynchus tshawytscha*, spring run chinook salmon *O. tshawytscha*, coho salmon *O. kisutch* and spring run steelhead *O. mykiss* of the Klamath and Trinity rivers in northern California. Designations were based on geographic location of various fish populations and their spatial relationships to other populations, timing of river entry and upriver migration by adults, time and location of spawning, timing of juvenile outmigration, hatchery stocking locations, straying of marked fish to various locations in the basin, and reported genetic similarities or differences. For fall chinook 12 Klamath and Trinity river breeding populations and 4 metapopulations were identified. Seven spring chinook breeding populations and two metapopulations were dilineated for the entire basin. Coho salmon were placed in one metapopulation. Only spring run steelhead were categorized, 12 breeding populations and 2 metapopulations. Information needs were identified for various salmonid groups. The breeding population/metapopulation concept and its application to management of Klamath Basin stocks were discussed.

Introduction

In 1986, Congress authorized a 20 year Klamath River Basin Conservation Area Restoration Program for rebuilding the basin's anadromous fish resources. The Act created a Fisheries Task Force to implement the Program. The Act also provided for the preparation of a comprehensive long term plan to guide implementation of the Restoration Program (Klamath River Basin Fisheries Task Force 1991). Chapter 4 of the Long Range Plan, which was completed in January 1991, identified anadromous fish stock groups and general trends in their run strength. Later in 1991, the Klamath Task Force formed a 12 person Klamath Basin Stock Identification Committee with the assignment to examine the list of salmon and steelhead stock groups listed in the Plan, to evaluate the rationale for identifying these as discrete groups, to review and update information on these stocks, and to identify information needs regarding fish stocks of the basin. This paper summarizes the Stock I.D. Committee's findings.[1]

[1]The Klamath River Task Force has not formally adopted the stock identification report as a guiding document to-date.

A fundamental problem for fisheries managers is the definition of stocks for management (MacLean and Evans 1981). The term "stock" has been used in several ways to define groups of fish -- broadly to define a species, less broadly to define units within a species (often called races), and then often smaller units or populations and even subpopulations (Larkin 1972). For example, in the management of ocean salmon fisheries "Klamath River chinook" *O. tshawytscha* has been designated a stock; for in-river management there is a "Klamath River fall chinook stock" and a "Klamath River spring chinook stock". These are sometimes further divided, such as "Blue Creek and Horse Linto Creek fall chinook stocks". Or are these sub-stocks? The Klamath Long Range Plan identifies "stock" as a species or population that maintains itself over time in a defined area. Nehlsen et al. (1991) used Ricker's (1972) stock concept in their paper identifying Pacific salmon stocks at risk. Ricker defined a stock as the fish that spawn in a particular river system (or portion of it) at a particular season, and that do not interbreed to a substantial degree with any group spawning in a different place, or in the same place at a different time. The term a substantial degree is open to subjectivity. The Stock I.D. Committee could not arrive at a consensus for a working definition of "stock" for its assignment.

Because the metapopulation/breeding population concept is more precise in its application, we used this mechanism for our task. This concept originated in terrestrial conservation biology and helps to explain the apparent persistence over time of many relatively small populations or groups of animals of the same species inhabiting highly variable environments. The concept is that these small populations persist as part of a larger population -- populations within a population. The concept is practical because it considers the spatial distribution of animals and their reproductive behavior which allows for varying degrees of genetic interchange among groups. This concept can be applied with success to populations of anadromous salmonids because of their natal homing behavior as adults and the tendency of juveniles to remain as discrete groups during freshwater residency.

In the jargon of conservation biology, a metapopulation consists of a group of sub-populations which are geographically located such that there is likely to be, over time, genetic exchange between sub-populations. The metapopulation is the unit which can be identified as having persisted through time. The sub-populations within the metapopulation individually may persist for shorter lengths of time (Figure 1). However, long term potential and persistence of the metapopulation depends on the continued existence of sufficient subpopulations. As such, there is an advantage to having many subpopulations (breeding populations) to aid in long term survival of the metapopulation - say over 500 years. For salmon and steelhead, strong homing to discrete spawning grounds identifies breeding populations. Natural straying insures a flow of genes between breeding populations which is valuable for maintaining genetic diversity, insuring long term survival of very small breeding populations, and for recolonizing certain areas. For various reasons, a breeding population of fish located on one tributary may go extinct, but neighboring breeding populations can recolonize the tributary over time, through straying. The metapopulation, then, is composed of an interacting system of local breeding populations that over time may suffer extinctions but can be recolonized from within the geographic region covered by the metapopulation (Figure 1). If only few breeding populations remain, probably the dynamic balance between extinction rate and recolonization rate has been lost, and the entire metapopulation is then in danger of extinction.

Another related concept from terrestrial ecology is the existence of sink and source populations (Pulliam 1988). A metapopulatioan might

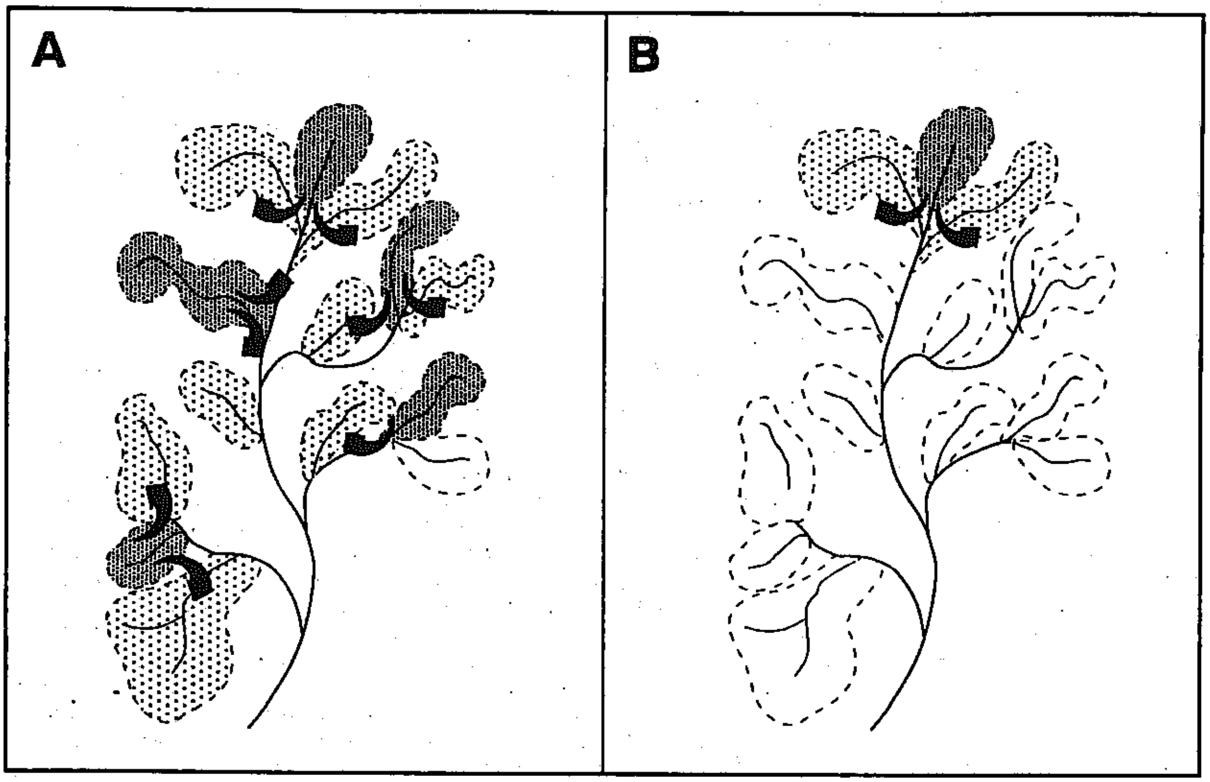

Figure 1. Hypothetical representation of the distribution of salmonid populations in an undisturbed basin (A) and a disturbed basin (B). All the populations of the basin comprise one metapopulation. The darker shading represents strong breeding populations or "source" populations in optimal habitat with the potential for dispersal to and support of other surrounding populations. The lighter shading represents weaker breeding populations or "sink" populations in marginal habitat which may persist over time due to support from nearby populations. Unshaded areas represent unsuitable or disturbed habitat that support no fish. In (B) the dynamic balance between extinction rate and recolonization rate of breeding populations has probably been lost due to the loss of several breeding populations. The metapopulation is threatened with extinction. (Adapted from Rieman et al. 1993).

consist of a combination of sink and source populations. Sink populations are weaker populations from marginal habitats or smaller tributaries that can disappear with extreme environmental changes or they may persist nevertheless, being locally maintained by the stronger source populations in optimal or buffered habitats that persist and act as colonizers through active dispersal (straying or invading suboptimal habitat when it becomes optimal in good years). Some of our designated breeding populations may be source populations, others sink populations. The long term persistence of the metapopulation then is dependent on the identification and protection of source breeding populations. A proper management strategy might be the establishment of refugia for important source populations to ensure their protection and persistence.

Methods

Based on information available to the Stock I.D. Committee, metapopulations and breeding populations for spring and fall chinook salmon *O. tshawytscha*, coho salmon *O. kisutch*, and steelhead *O. mykiss* were identified for the Klamath-Trinity basin (Figure 2). The results presented here are based on the experience of committee members, each with varying degrees of knowledge on Klamath-Trinity Basin anadromous stocks, special reports to the Committee by California Department of Fish and Game biologists on fish weir data (run timing and marked fish recovery data), stream survey data by the Department of Fish and Game, the U.S. Forest Service, or U.S. Fish and Wildlife Service (adult fish holding information, recovery of marked fish in spawning surveys, spawning times, electrofishing surveys of juveniles), Iron Gate and Trinity River Hatchery reports giving information on stocking history, out planting and recovery of marked fish, special fish rearing projects, California Department of Fish and Game creel census reports, and special reports such as Leidy and Leidy (1984) on life stage periodicities of Klamath basin anadromous salmonids, Kucas (1983) on stocking history of the South Fork Trinity River, and Gall et al. (1990) on genetic analysis of chinook salmon. Most of the information examined by the Committee was unpublished. As reports and other information were gathered, they were made available to all Committee members to review. The Committee met several times to discuss the information, to delineate breeding populations and metapopulations and to identify data gaps.

To delineate various populations, the following criteria or attributes were considered: geographic location of various populations and their spatial relationships to other populations, timing of river entry and upriver migration by adults, time and location of spawning, timing of juvenile outmigration, hatchery stocking locations, straying of marked fish to various locations in the basin, and reported genetic similarities or differences.

Results

Chinook Salmon

Fall Chinook.-Adult fall run chinook begin entering the Klamath River in July, usually peak in numbers in late August to early September, and some fish continue to enter the river as late as November. Fall chinook arrive at Iron Gate Hatchery on the upper Klamath River in about the third week of September, peak in abundance in mid-October and continue to appear until mid-November. Fall chinook enter Trinity River Hatchery from mid-October through early December. In general, fall chinook salmon in the upper basin spawn earlier and lower basin populations spawn later. However, a recent report by Shaw (1994) showed mainstem fall chinook

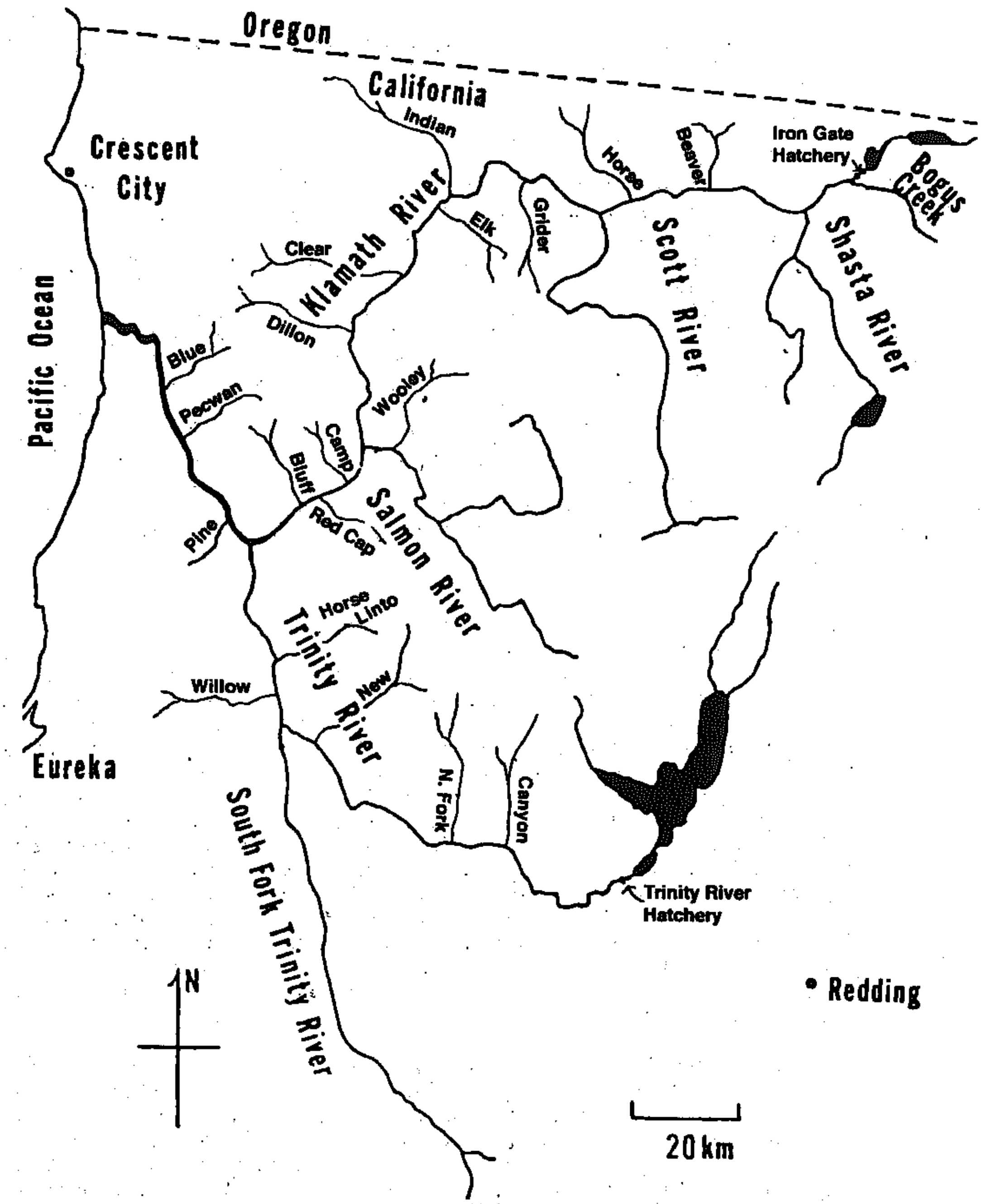

Figure 2. Klamath River Basin showing Klamath River, Trinity River, major tributaries and Iron Gate and Trinity River hatcheries.

spawners peaking in abundance a week earlier near Happy Camp than those just below Iron Gate Dam. There are some late running populations that spawn into January such as Horse Linto salmon on the lower Trinity River and Blue Creek salmon on the lower Klamath River.

Adult spawners are primarily age three and four; fish five years old or older make up an insignificant portion of the runs. About 5-30% of each annual run is comprised of age two fish, called "jacks" or "grilse". These fish are mostly mature males and they will try to spawn with older females on the spawning grounds. The average run size of Klamath River fall chinook for 1990-1993 was 38,000 adults and 7,000 jacks (PFMC 1994).

Most Klamath River juvenile chinook salmon are "ocean type" or Type I fish (Sullivan 1989) which rear in freshwater for a few months before migrating to the ocean during the spring or early summer. Type II juvenile chinook, or "stream type" fish, rear in freshwater during the spring and summer and typically enter the ocean in the fall. Sullivan (1989) found that the Scott and Salmon River drainages produced higher frequencies of Type II juveniles. There are also small numbers of Type III "stream" salmon which remain in freshwater through the winter and enter the ocean as yearlings the following spring. Healey (1991) indicated that 86% of Klamath River chinook are ocean type fish and 14% are stream type.

Spring Chinook.-Adult spring run chinook enter the Klamath River April through July. Many of the later entering adults are Trinity River Hatchery origin (Tuss et al. 1989). The adults move at varying rates through the system. Adult spring chinook will congregate and hold in deep, cool pools in tributaries of the Klamath and Trinity Rivers from June through September and then move up to their spawning areas shortly before time to spawn. Spring chinook generally spawn a few weeks earlier than fall chinook although there is some overlap in timing. They also tend to spawn farther up in the drainage although there is some overlap with fall chinook spawning grounds. Spawning usually begins in September, peaks in October and ends in November. Spring chinook salmon were historically the dominant run of salmon on the Klamath, but Snyder (1931) reported that by the turn of the century the spring run had nearly disappeared. The estimated escapement of adult spring chinook for 1988 was nearly 55,000 but runs have averaged only 4,300 for the years 1990 through 1993. Trinity River Hatchery fish usually comprise 30-50% of the total Klamath Basin escapement.

Because of the amount of information on chinook salmon in the Klamath Basin, the Committee was able to designate breeding populations and metapopulations for both fall run chinook and spring run chinook. Figures 2-5 and Table 1 are examples of information used for considering salmon populations of the upper Klamath River. Run timing to Iron Gate Hatchery, Bogus Creek, Shasta, Scott, and Salmon rivers was compared (Figures 3,4,5). The straying of Iron Gate Hatchery coded wire tagged salmon to nearby areas was also examined (Table 1). The genetic chinook stock analysis by Gall et al. (1990) revealed similarity patterns of upper river chinook (Figure 6).

Listed below are the breeding populations and metapopulations of fall chinook salmon for the Klamath and Trinity River and their tributaries. These are pictured in Figures 7 and 8.

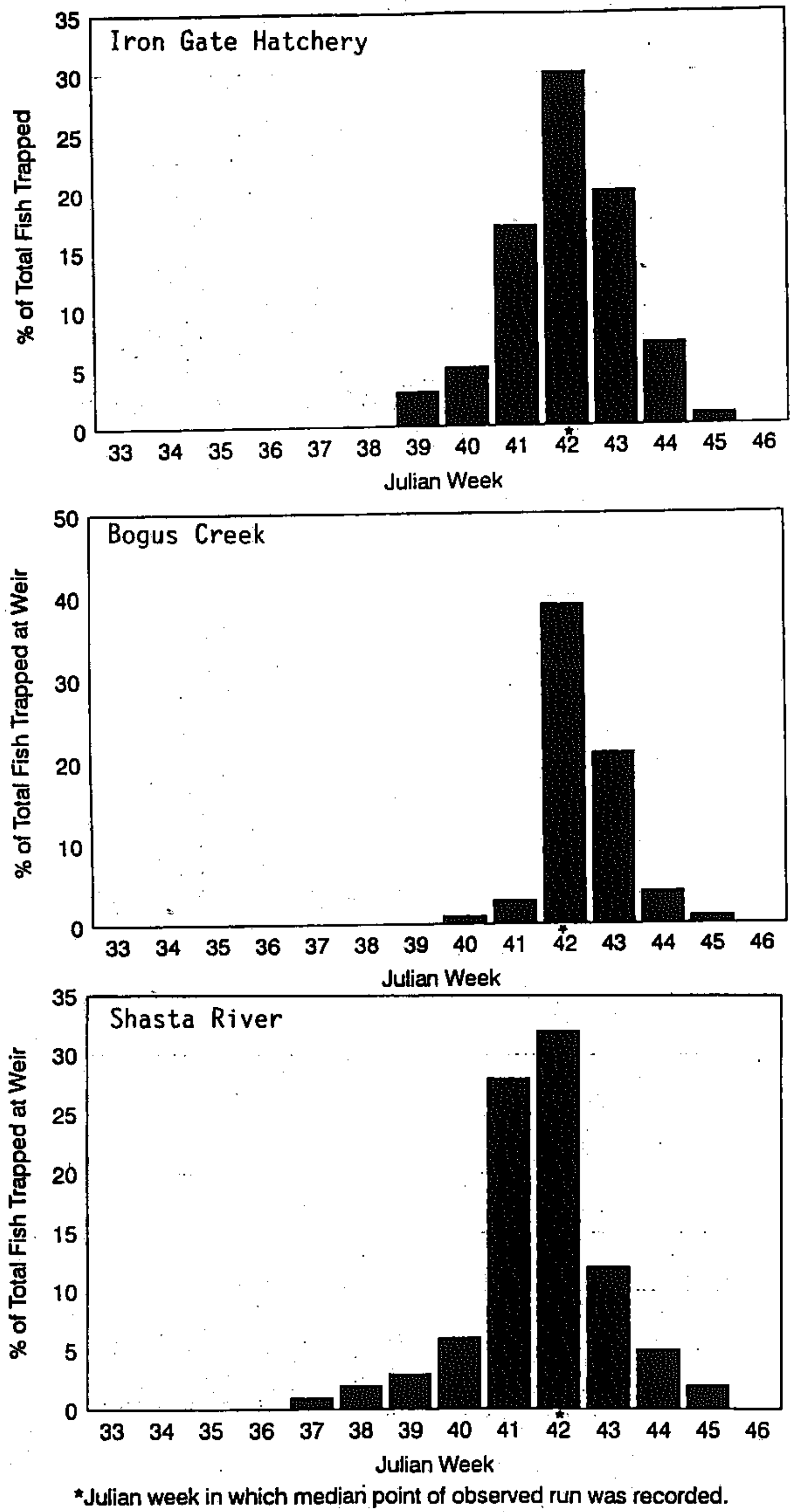

Figure 3. 1991 Klamath River fall chinook run timing at Iron Gate Hatchery, Bogus Creek and Shasta River.

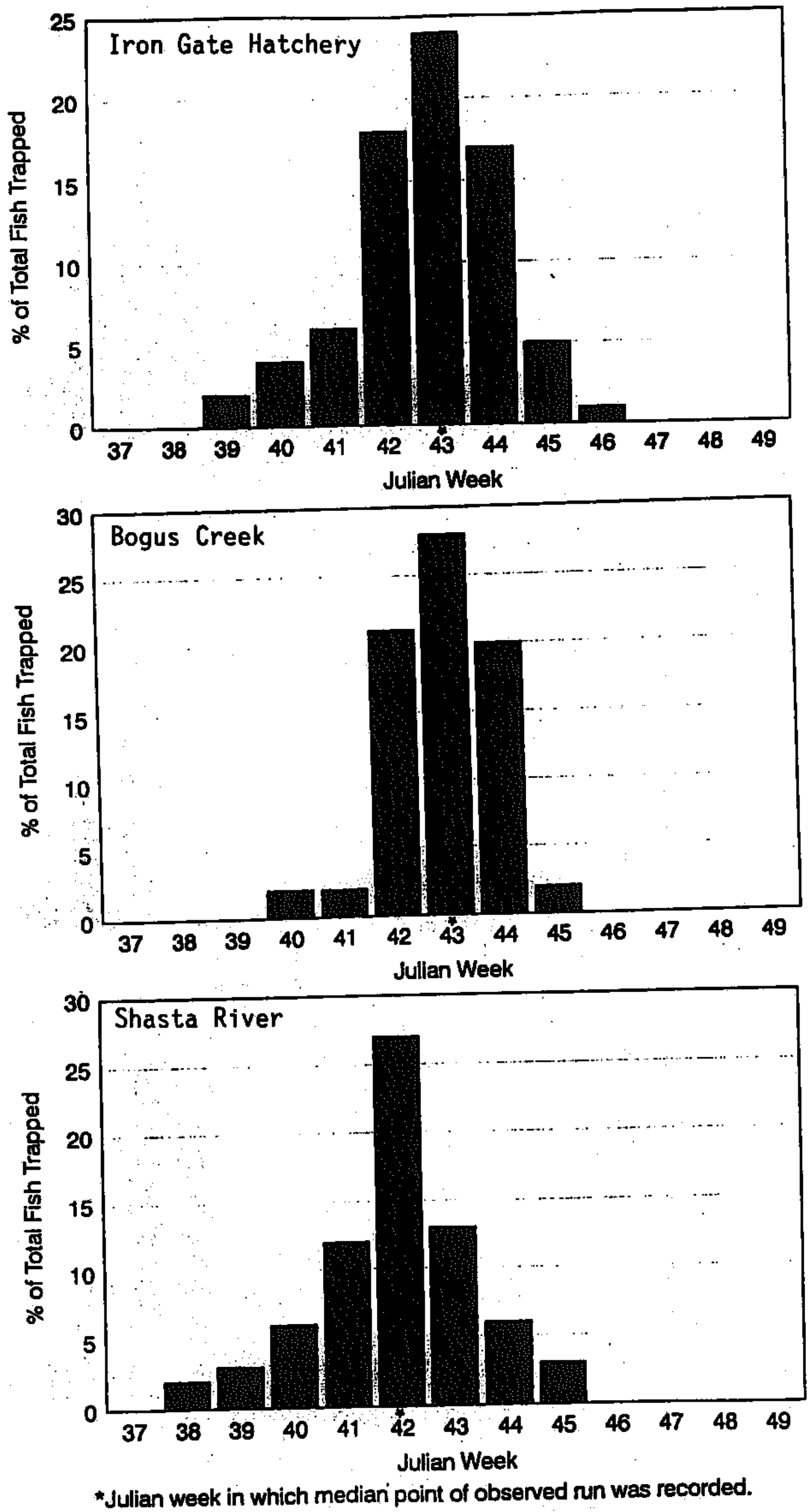

Figure 4. 1992 Klamath River fall chinook run timing at Iron Gate Hatchery, Bogus Creek and Shasta River.

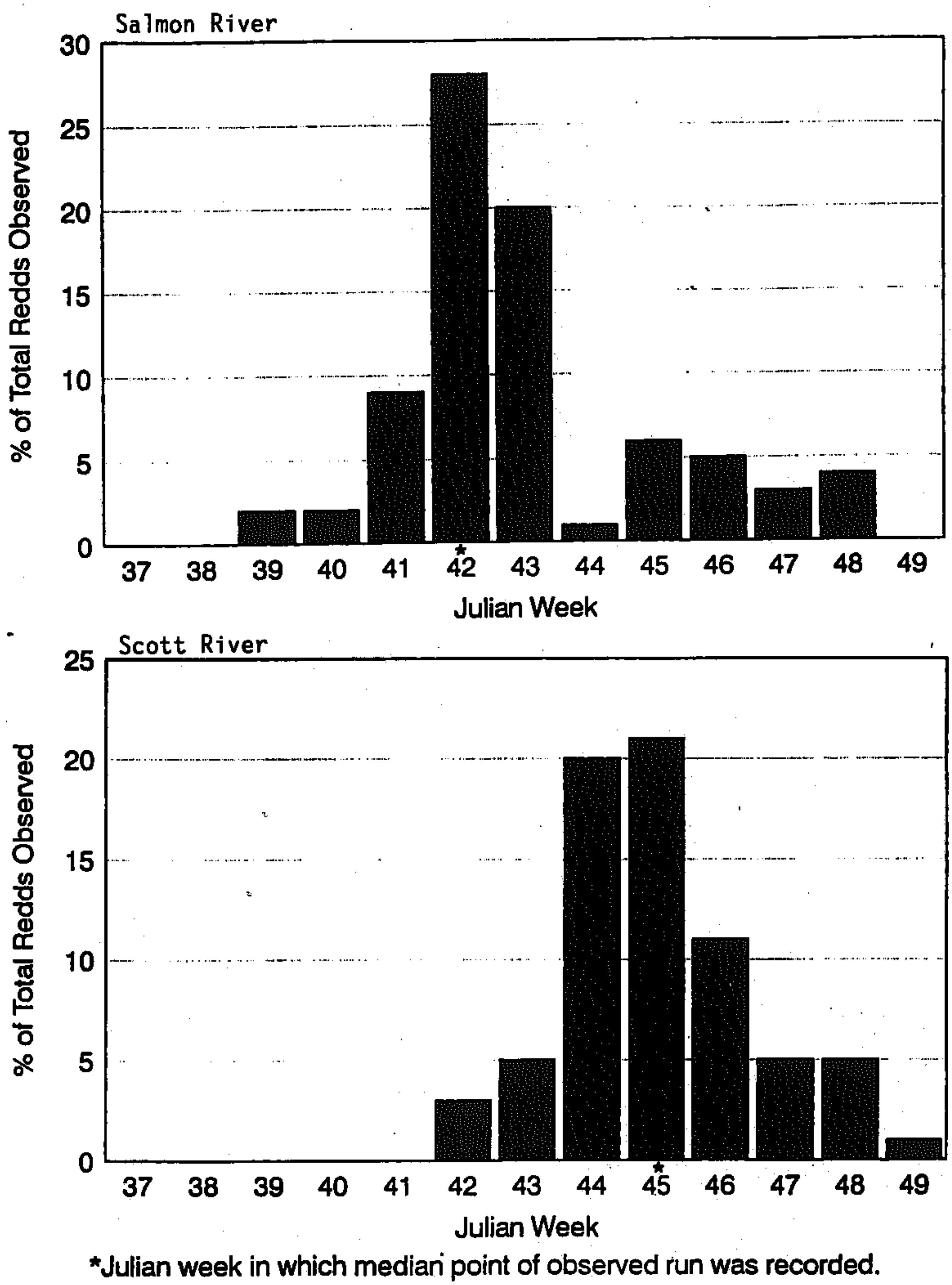

Figure 5. 1992 Klamath River fall chinook run timing at Salmon and Scott rivers.

Table 1. Marked Chinook Salmon Recovered in Bogus Creek and Shasta River, 1980-1990.

Year	Bogus Creek			Shasta River		
	No. Fish Sampled	No. Marked Fish	Source	No. Fish Sampled	No. Marked Fish	Source
1980	2649	-	--	8096	6	Unknown
1981	3642	3	Unknown	12220	0	--
1982	7143	147	145 UNK, 1 IGH, 1 TRH	8455	2	Unknown
1983	3048	14	Unknown	3872	3	Unknown
1984	1807	174	123 UNK, 51 IGH	2842	10	1 UNK, 4 IGH, 5 TRH
1985	4647	10	10 IGH	5124	0	--
1986	7308	110	107 UNK, 2 IGH, 1 BOG	3957	0	--
1987	10706	344	250 IGH, 49 BOG, 32 UNK, 3 TRH	4697	14	5 IGH, 7 Sha, 2 UNK
1988	16043	48	44 IGH, 2 BOG, 2 UNK	848	25	19 IGH, 4 TRH, 2 Sha
1989	2103	33	24 IGH, 3 BOG, 6 UNK	453	8	2 IGH, 1 TRH, 1 Sha, 4 UNK
1990	467	1	1 BOG	116	0	--

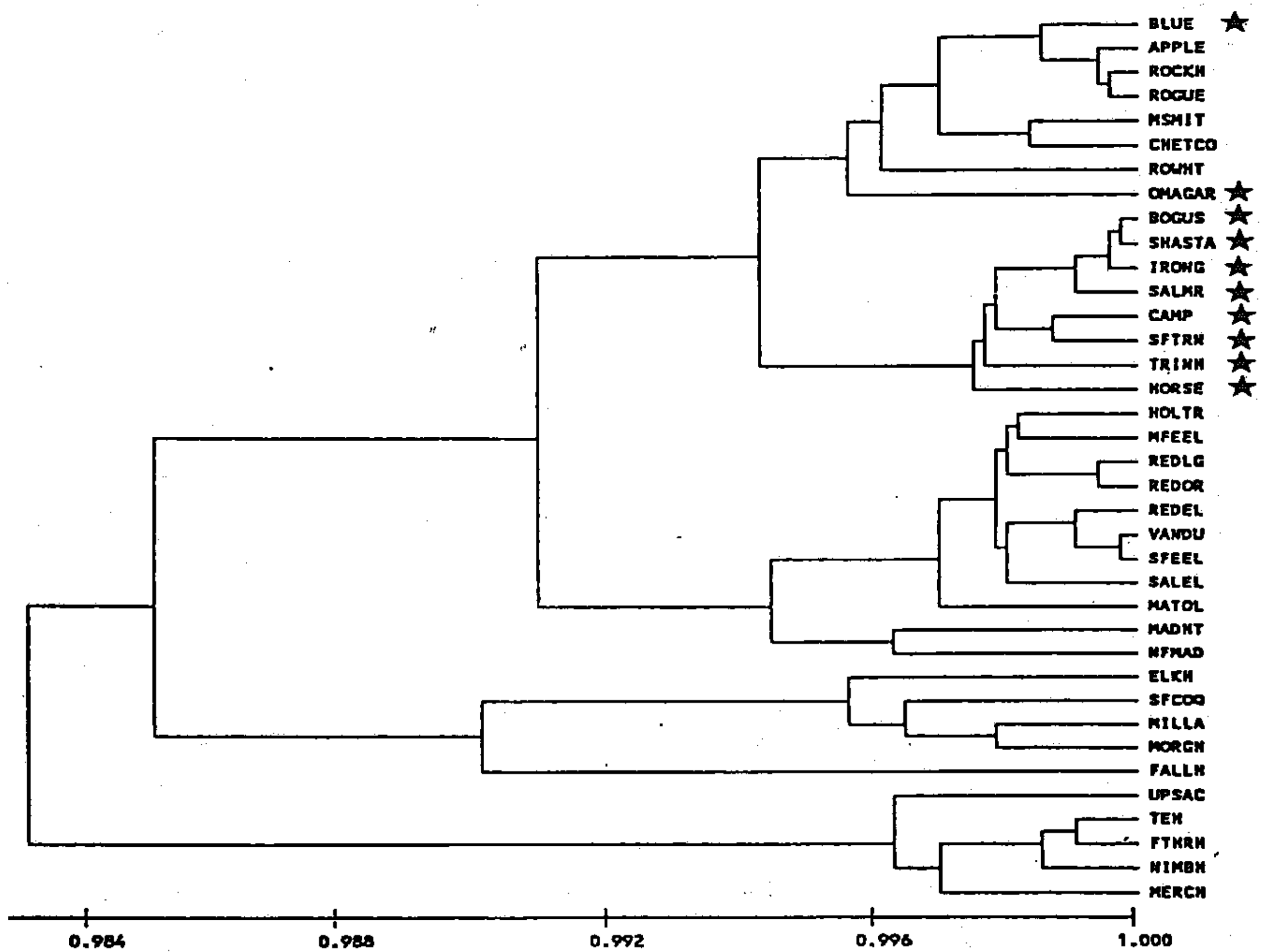

Figure 6. Genetic relationships of selected fall chinook salmon stocks (from Gall et al. 1990). Stars indicate Klamath populations, Blue Creek, Omagar Creek, Bogus Creek, Shasta River, Iron Gate Hatchery, Salmon River, Camp Creek, South Fork Trinity River, Trinity River Hatchery, Horse Linto Creek.

FALL CHINOOK

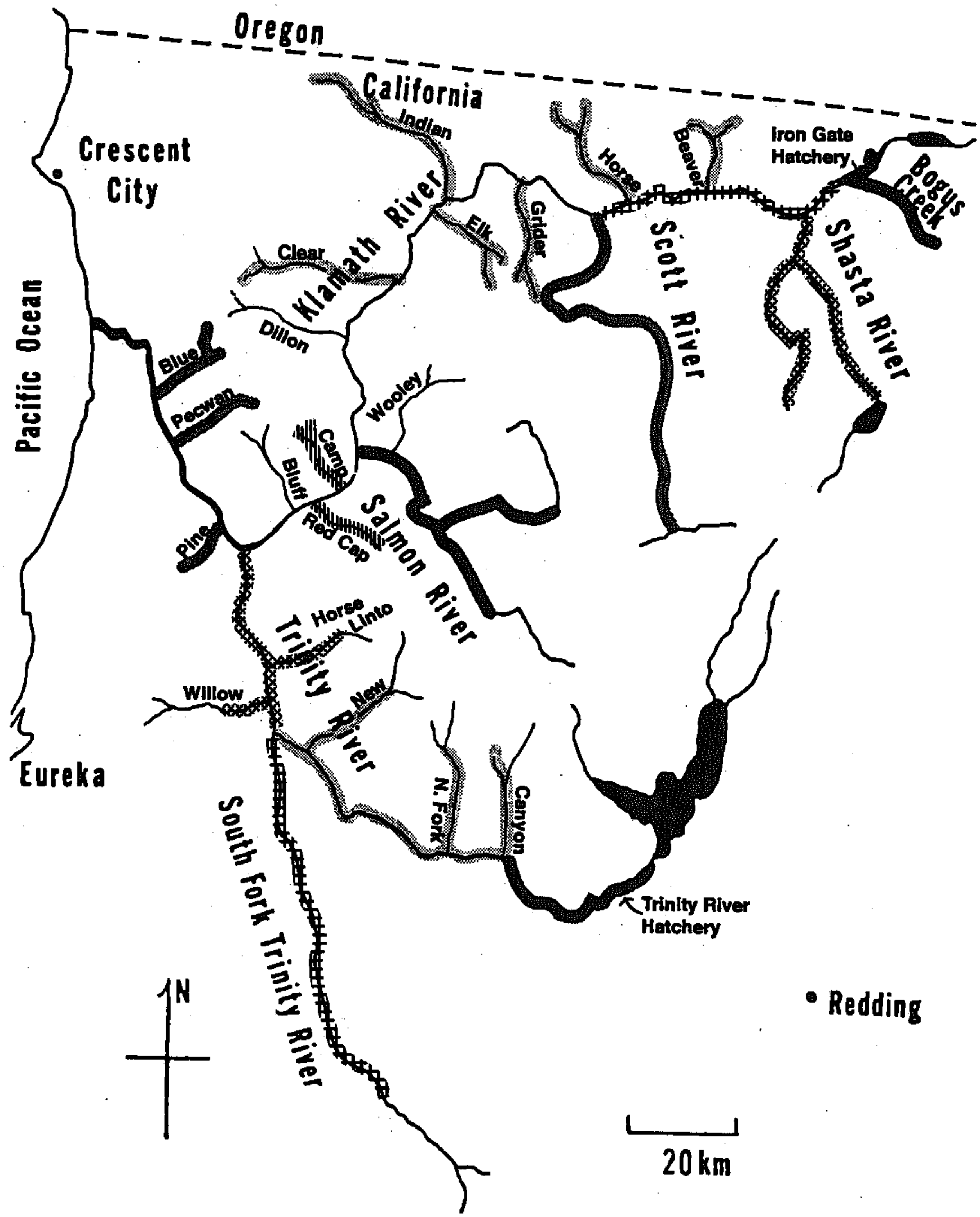

Figure 7. Distribution of Klamath Basin fall chinook salmon breeding populations.

FALL CHINOOK

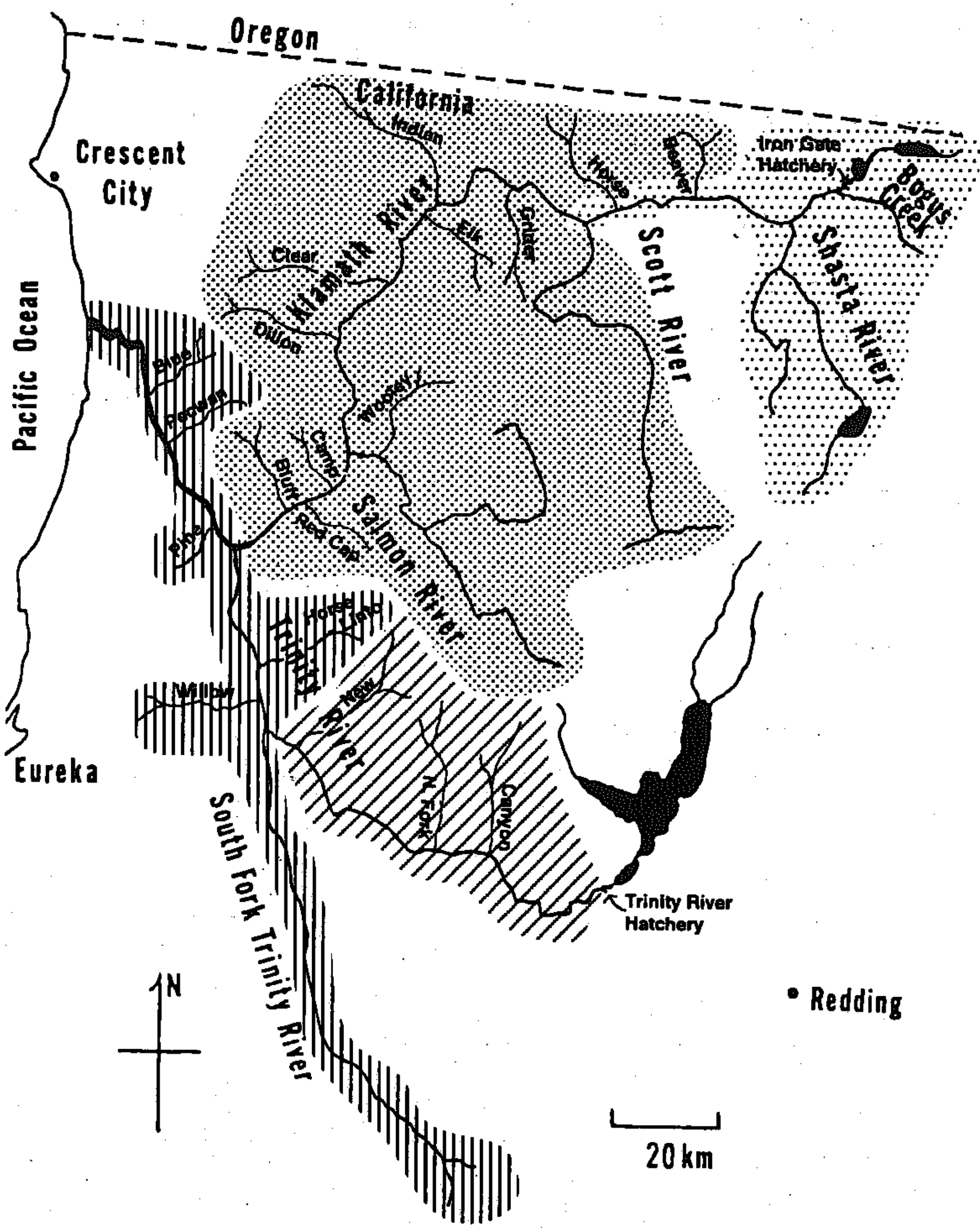

Figure 8. Klamath Basin fall chinook salmon metapopulations.

Fall Chinook.-

Breeding Populations - Klamath River (Figure 7)

1. Iron Gate Hatchery and Bogus Creek
2. Upper Main Stem Klamath River (Iron Gate Hatchery to Scott River)
3. Shasta River
4. Scott River
5. Salmon River
6. Upper Middle Klamath Tributaries (Clear, Beaver, Elk, Indian, Horse, Grider creeks and lesser tributaries)
7. Lower Middle Klamath River tributaries (Red Cap, Camp creeks and lesser tributaries)
8. Lower Klamath River tributaries (Pine Creek, Pecwan Creek, Blue Creek and lesser tributaries)

Breeding Populations - Trinity River (Figure 7)

9. Upper mainstem Trinity River to Canyon Creek including Trinity River Hatchery and tributaries in that reach.

10. Mainstem Trinity River from confluence with Canyon Creek to South Fork Trinity River - reach includes Canyon Creek, North Fork Trinity River, and New River.

11. South Fork Trinity River.

12. Mainstem Trinity River from South Fork to confluence with Klamath River - including tributaries in that reach (Willow Creek, Horse Linto Creek, Hoopa Valley Reservation tributaries).

Metapopulations - Klamath/Trinity Rivers (Figure 8)

A. Iron Gate Hatchery, Bogus Creek, Shasta River and the upper mainstem Klamath River from Iron Gate to mouth of Scott River. (Breeding populations 1,2,3)

B. Scott River, Salmon River, the mainstem Klamath River from Scott River to mouth of Trinity River including all tributaries listed above in that reach. (Breeding populations 4,5,6,7)

C. Mainstem Klamath River from mouth of Trinity River to mouth of Klamath River including tributaries Pine, Pecwan, and Blue creeks; the lower Trinity River from mouth up to confluence with South Fork Trinity including tributaries; South Fork Trinity River. (Breeding populations 8,12)

D. Mainstem Trinity River, from Trinity River Hatchery down to confluence of South Fork and tributaries in that reach named above. (Breeding populations 9,10,11)

The survey of upper Klamath River mainstem chinook spawning conducted by the California Coastal Fisheries Resource Office (Shaw 1994) revealed that mainstem spawning of fall chinook extended down to Indian Creek near Happy Camp, California. The upper mainstem breeding population should probably be extended to that point although the downriver fish spawned earlier than those near Iron Gate.

Two designated metapopulations were assigned without consensus of the entire committee:

1. Metapopulation A - Should Shasta River fall chinook salmon be designated a breeding population or a separate metapopulation? Based on similar run timing, evidence of straying, outmigration patterns and genetic characteristics, Shasta River fall chinook are shown here as one breeding population in the larger upper Klamath River metapopulation. However, the run consists of largely natural fish and warrants special protection.

2. Metapopulation C - Based on late run-timing of adult chinook into tributaries of the lower Trinity River, the lower Trinity River was combined with the lower mainstem Klamath below the confluence of the Trinity River. Tributaries of the lower Klamath River are also late run streams. Blue Creek is an anomaly because of its genetic dissimilarity to other Klamath populations. The South Fork Trinity River was included in this metapopulation until further information is available on this major Trinity River tributary. Some reviewers of this document suggested that South Fork Trinity River fall chinook should be a separate metapopulation.

   Additional genetic studies of naturally spawning populations of fall chinook such as Shasta River and South Fork Trinity River fish are needed to help to determine their relationships to other populations in the system.

Spring Chinook.-

Listed below are the breeding populations and metapopulations of spring chinook salmon for the Klamath and Trinity rivers and their tributaries (Figures 9,10).

<u>Breeding Populations - Klamath River</u> (Figure 9)

1. Salmon River
2. Wooley Creek

<u>Breeding Populations - Trinity River</u> (Figure 9)

3. Upper mainstem Trinity River and Trinity River hatchery
4. North Fork Trinity River
5. Canyon Creek
6. New River
7. South Fork Trinity River

<u>Metapopulations</u> (Figure 10)

A. Klamath River (Breeding populations 1,2)
B. Trinity River (Breeding populations 3,4,5,6,7)

The Committee discussed at length the designation of Wooley Creek spring chinook as a separate breeding population. Because annual increases or decreases in run size were not synchronous with Salmon River runs, Wooley Creek spring chinook were separated.

One reviewer suggested that Trinity River breeding populations should be separated into two metapopulations, an upper river population and a lower river population. Genetic studies on Trinity River hatchery, New River, South Fork Trinity River, and Salmon River spring chinook stocks are underway and should provide information helpful to delineation of these populations.

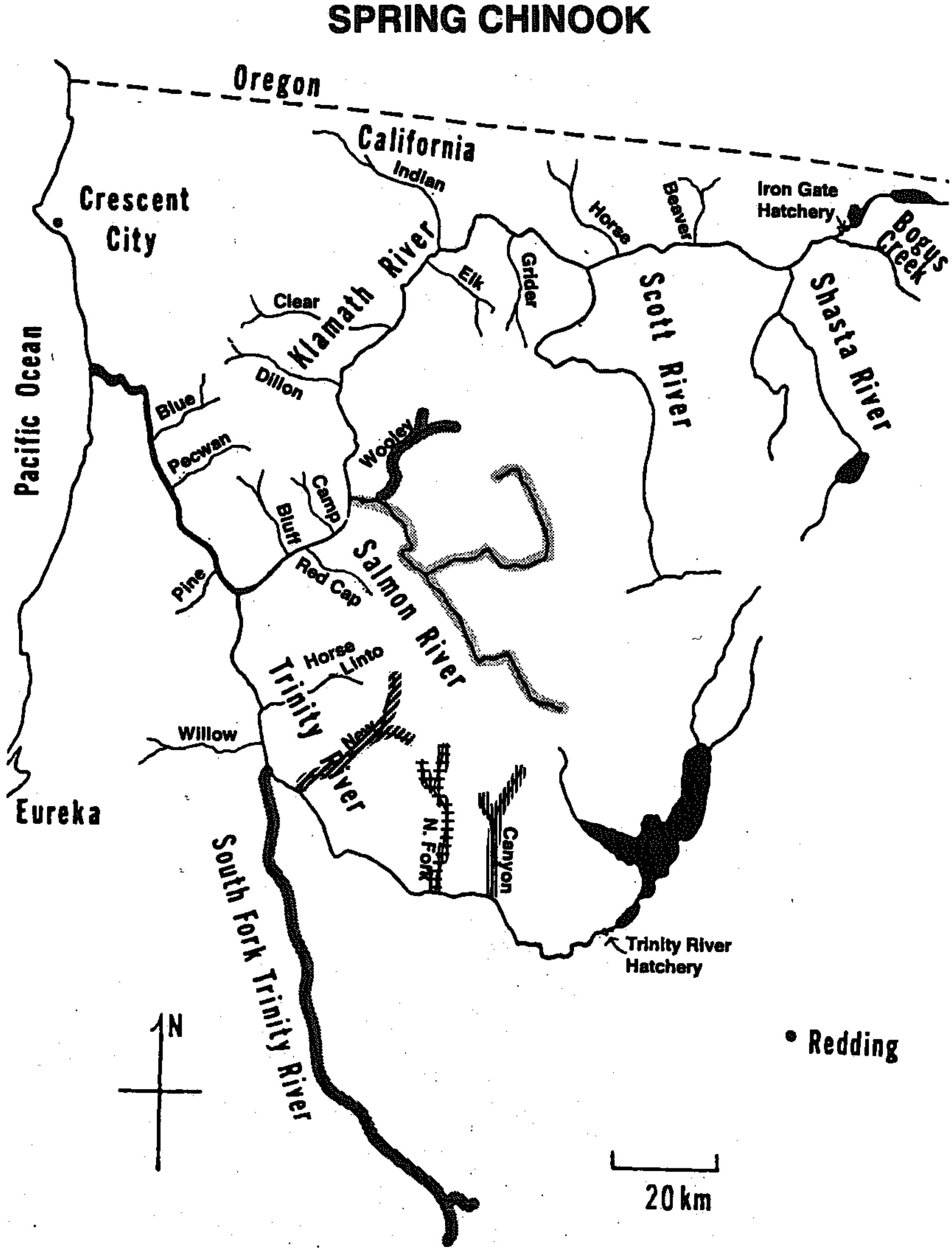

Figure 9. Distribution of Klamath Basin spring chinook salmon breeding populations.

SPRING CHINOOK

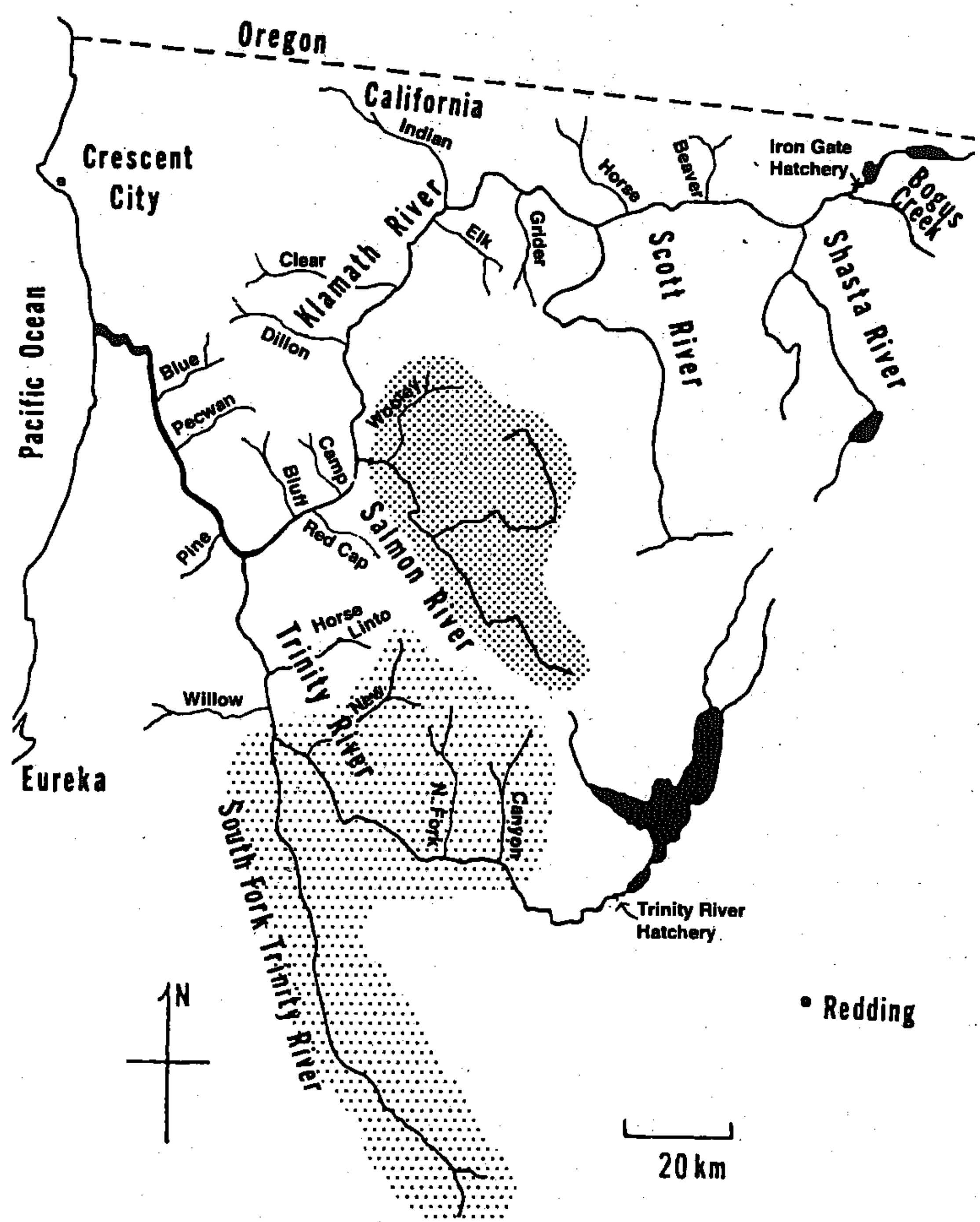

Figure 10. Klamath Basin spring chinook metapopulations.

Coho Salmon

Adult coho salmon generally enter the Klamath River from mid-September through December. Snyder (1931) reported significant coho salmon runs, particularly in lower Klamath River Basin. The California Fish and Wildlife Plan (CDFG 1965) estimated that about 15,000 coho salmon entered the Klamath River annually. Recent coho run size is unknown. Small numbers of juvenile coho salmon have been reported in many tributaries throughout the basin. In recent years adult coho annual returns to Iron Gate Hatchery and Trinity River Hatchery have averaged about 1300 and 4000 fish, respectively (Fish and Game hatchery reports).

Adult coho, mostly three year old fish, spawn from November through January in the Klamath system. Coho salmon tend to migrate further up spawning tributaries than chinook salmon. The status of native coho populations in the Klamath River Basin is unknown; there may still be pure strains in tributaries of the lower Klamath River such as Hunter and Terwer creeks. The hatchery runs of coho for both Iron Gate and Trinity River hatcheries were created from broodstock from Cascade Hatchery in the Columbia River Basin (Hubbell 1979). Coho juveniles from both hatcheries have been outplanted to many other portions of the basin, notably the Salmon River and the South Fork Trinity River. Brown et al. (1994) reported that of the larger tributaries, the Scott River probably holds the largest number of native coho.

Most juvenile coho rear in freshwater for one year, usually in tributary streams. Smolt outmigration occurs from February through mid-June.

Based on the history of hatchery introductions and intrabasin transfers of coho the Committee categorized Klamath Basin coho as <u>one metapopulation</u>. The Committee did not attempt to define breeding populations due to lack of information. Hassler et al. (1991) lists 111 Klamath and Trinity river tributaries reported to contain coho salmon at times. One reviewer suggested that Klamath Basin coho populations be divided into two metapopulations, an Upper Basin group and a Lower Basin group based on differences in time of adult entry to freshwater and time of spawning.

As with chinook salmon, the Committee suggested genetic studies be carried out to ascertain difference in coho populations. One objective would be to determine the existence of remnant native Klamath River coho. More information on the straying rate of hatchery coho throughout basin tributaries would be valuable also. General information on the status of coho populations, their size, and distribution are needed.

Steelhead

Steelhead provide an important recreational fishery in the Klamath River Basin. The California Fish and Wildlife Plan (CDFG 1965) estimated an annual run of about 200,000 steelhead. The Klamath River has a unique annual upstream migration of immature steelhead termed "half pounders" that provides a popular sport fishery during the fall. Numbers of steelhead have declined markedly during the past two decades primarily due to floods and drought effects on habitat. Most juvenile steelhead in the system rear for two years in freshwater before emigrating to the ocean. Both Iron Gate and Trinity River hatcheries have outplanted steelhead extensively to other areas in the basin.

Based on their time of entry into the Klamath system and to some extent where they hold after entry, there are at present three major groups or races of maturing adult steelhead; the division is not based on spawning time or location because there may be considerable overlap for the groups.

1. <u>Spring run steelhead</u>: these fish enter the Klamath system from May-July (often termed summer steelhead). They tend to migrate to the upper reaches of cool water tributaries where they hold until spawning season which probably occurs from December-February.

2. <u>Fall run steelhead</u>: these fish enter the Klamath system from August-October and probably disburse widely throughout the system, spawning from February-April in many different tributaries. Spawning time can overlap with spring run steelhead early and winter-run steelhead late.

3. <u>Winter run steelhead</u>: these fish probably enter the Klamath system from November-February and spawn relatively soon after entry. Lower river tributaries are probably used for spawning only by winter run steelhead because these tributaries are not accessible earlier due to low flows and sediment accumulation at their stream mouths (exception is Blue Creek). However, winter run steelhead could easily migrate to upriver areas and spawn in widely distributed areas. Spawning period probably extends from January-April.

The stock identification committee feels that peak runs of steelhead now occurring in the Klamath system may well be remnants of a much larger more protracted run of fish which dominated the system before man's activities interfered sufficiently to reduce the population size and extirpate portions of the run. Research on Rogue River steelhead (Everest 1973) has revealed that spring run and fall run steelhead are related in that both groups show a half-pounder life history (96-97% of all adults). Winter run steelhead may be genetically different but more information is needed.

Because considerable information on spring run steelhead was available coupled with their unique characteristic of summering over in upper tributary reaches, the committee did designate breeding populations and metapopulations for this race. These populations are also pictured in Figure 11 and 12.

I. Spring run steelhead ("summer steelhead") - Breeding Populations (Figure 11)

A. Klamath River System

1. Indian Creek
2. Elk Creek
3. Clear Creek
4. Dillon Creek
5. Salmon River
6. Wooley Creek
7. Red Cap Creek
8. Bluff Creek

B. Trinity River System

9. Canyon Creek
10. North Fork Trinity River
11. New River
12. South Fork Trinity River

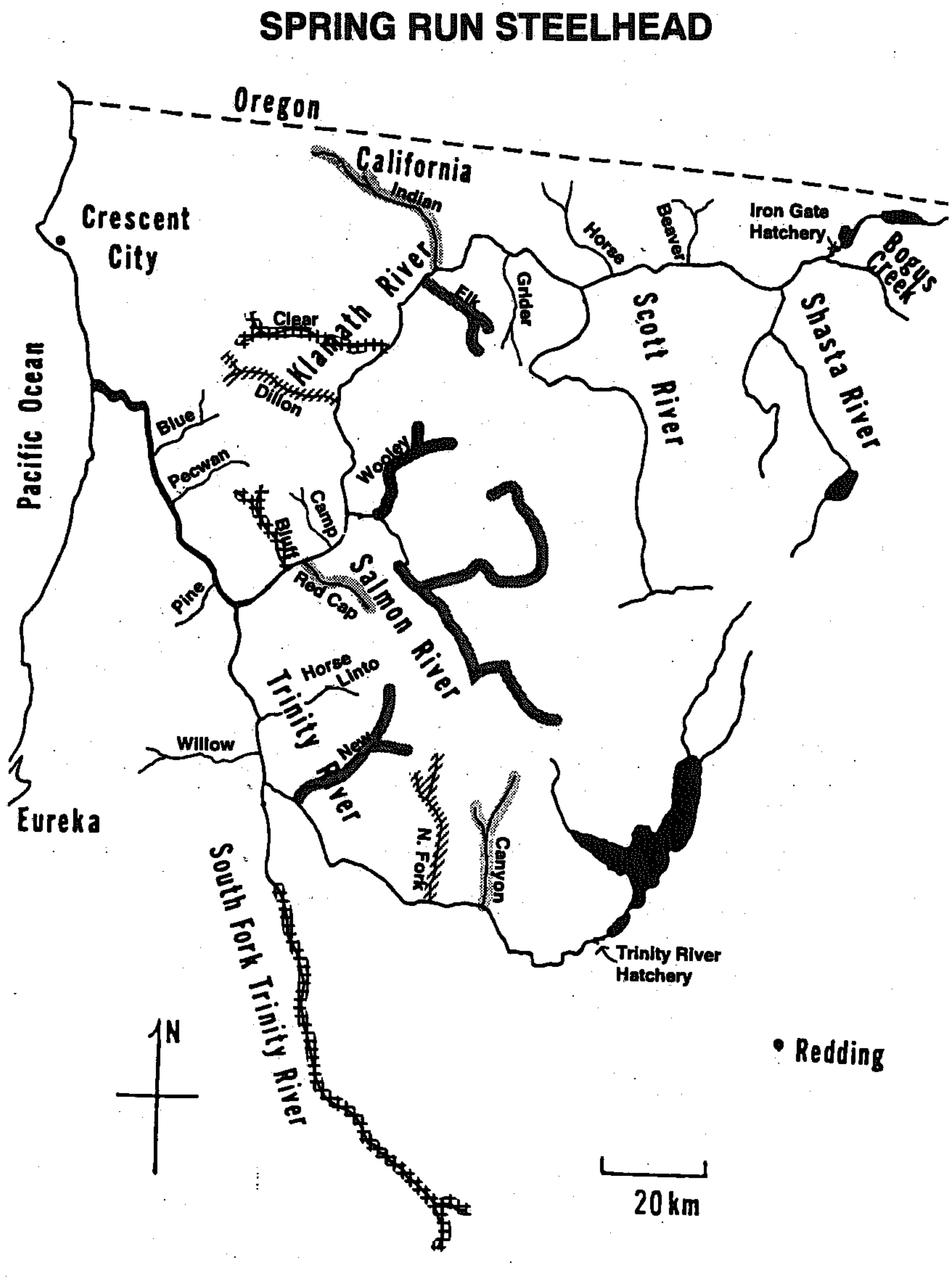

Figure 11. Distribution of Klamath Basin spring run steelhead breeding populations.

SPRING RUN STEELHEAD

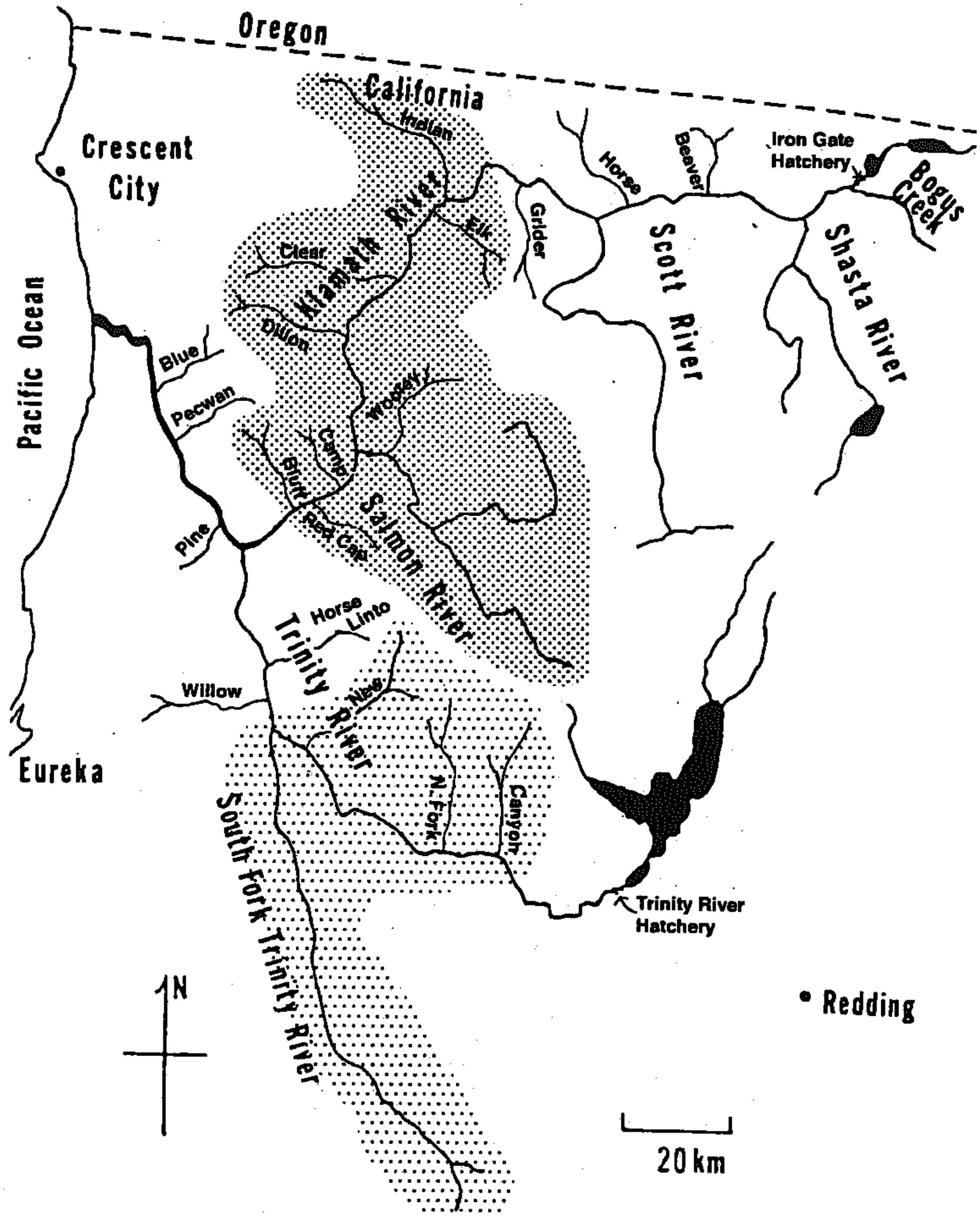

Figure 12. Klamath Basin spring run steelhead metapopulations.

II. Spring run steelhead - Metapopulations (Figure 12)

A. Klamath River Metapopulation (Breeding populations 1,2,3,4,5, 7,8)

B. Trinity River Metapopulation (Breeding populations 9,10,11,12)

Because of a lack of information on fall run and winter run steelhead the committee could not identify discrete breeding populations and as a result was hesitant to distinguish metapopulations. The Klamath-Trinity River winter steelhead may be a separate metapopulation.

The Committee identified the following information gaps for steelhead:

1. Spawning location and spawn timing for different river entry groups.

   a. Do spring run steelhead tend to spawn only with spring run steelhead in the tributaries where they have resided over summer?

   b. Do winter run steelhead spawn with fall run fish to a considerable degree?

2. What is the status of winter run steelhead?
   Population size, spawn location and timing, meristic characters.

3. Assessment of genetic differences between three steelhead groups - may require DNA analysis.

Discussion

A real problem for anadromous salmonid resource managers is how to conserve the biodiversity of locally adapted stocks or breeding populations and at the same time designate stock or population boundaries that conveniently fit into useful harvest and hatchery management strategies. As such, there seems to be no ideal stock designation. Discussions of this topic generally reveals two strongly held positions characterized by the terms "lumpers and splitters". Lumpers tend to recognize few stocks and a simple population structure. Splitters view Pacific anadromous salmonids as rich in "stocks" with a rather complex population structure. Our Committee was comprised of both lumpers and splitters. The designated breeding populations and metapopulations represent a compromise; the population boundaries may be changed as more data become available.

The designations, for the most part, tend to be conservative so that local populations will be protected. The natural genetic material in a metapopulation is valuable to an unknown degree. We do not know what adaptive characteristics will be needed in the next 500 years. Each breeding population is a significant element of the metapopulation and impacts which would hasten the loss of a breeding population should be avoided. A primary objective of restoration should be to reestablish or maintain the metapopulation demography: the maintenance of natural genetic diversity, the allowance of gene flow among sub-populations, and the continuance of natural evolutionary processes. Restoration practices involving interim artificial propagation of anadromous salmonids should be carefully scrutinized in this regard. One danger to be aware of is the possible genetic swamping of unique breeding populations of fish by continuous large releases of hatchery fish. Conversely, viable populations of fish returning to the hatchery each year do have value because they probably have genetic material valuable to the long term survival of certain metapopulations.

Pacific anadromous salmonids can be organized in a hierarchical structure. The biological units in the hierarchy are species, stock or metapopulation, breeding population or subpopulation, and individual fish; their associated geographic units are region (ocean area, river basin); river, tributary and individual redds (Currens et al. 1991). Resource managers should match the appropriate level in the hierarchy to the management activity. Currens et al. (1991) state that the objective should be to select the most inclusive biological geographic unit for which a management strategy will not cause a loss of genetic diversity contained in the less inclusive groups. Managers of Klamath River salmonid resources need to match appropriate levels of the breeding population/metapopulation hierarchy to their specific management activities with this objective in mind.

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