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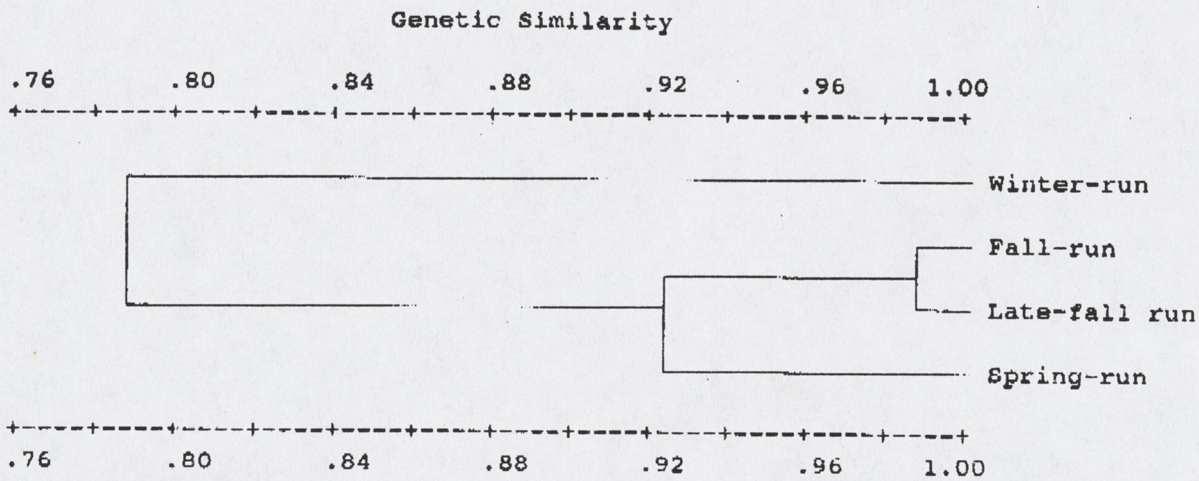
April 1, 1996

Robert Treanor, Executive Director
Fish and Game Commission
1416 Ninth Street, 13th Floor
Sacramento, California 95814

Dear Mr. Treanor,

We wish to communicate some research findings relevant to the petition pending before the Fish and Game Commission to list the Sacramento Valley spring-run chinook under the California Endangered Species Act. These findings have emerged from our studies of the genetic differentiation of Central Valley chinook salmon, including the spring-run.

We are developing, for research and conservation of California's salmon stocks, a new class of genetic markers, called "microsatellites", which are the same type of highly informative DNA markers that were recently thrust into the limelight by the trial of O. J. Simpson. Our primary focus is on the Sacramento River winter-run chinook, which has already received protection under federal and state laws. The need to discriminate winter-run from other runs of chinook salmon in the Central Valley has caused us, so far, to examine, in addition to samples of all the winter-run brood stock used for the artificial propagation and captive breeding of this stock, samples of the fall-run and late-fall run from Battle Creek (Coleman National Fish Hatchery stocks) and of spring-run from Deer Creek. The genetic similarity of these population samples, averaged over five microsatellite markers, is depicted in the following tree-diagram. On this scale, a similarity of 1.00 would represent genetically identical populations.



Winter-run is clearly the most distinctive of the four runs, but the next most distinctive population is the spring-run. The relatively large genetic differences between each of these two runs and the rest are certainly consistent with the distinctiveness of their life histories and the geographical and seasonal differences in their spawning habitats. Even the seemingly slight divergence of the fall- and late-fall runs on this diagram comprises statistically significant differences in the frequencies of microsatellite markers, indicating the absence of gene flow between these closely related populations. Likewise, we see no evidence for natural hybridization between spring-run and other runs in the Sacramento River, despite deterioration of the geographic isolation that the spring-run enjoyed prior to construction of various foothill dams. Thus, we conclude on the basis of such evidence that spring-run, like winter-run, could be considered a subspecies qualifying for listing under the CESA.

We are presently engaged in a much broader survey of microsatellite variation in Central Valley chinook salmon stocks, which we hope to complete and publish within the next year. This study, which will report data for up to eight informative markers in multiple local populations of all but the winter-run, many of which have been sampled in more than one year, should provide definitive evidence concerning genetic divergence among the chinook salmon stocks of California's Central Valley.

Finally, we have reviewed and wish to comment upon a document prepared by Dr. Robert J. Taylor for the Commission, expressing doubt that the subspecies concept applies to spring-run chinook salmon. We disagree completely with Dr. Taylor's narrow application of the definition of subspecies and believe that his conclusion violates the spirit and intent of the CESA to preserve significant biological diversity.

In his document, Dr. Taylor cites Prof. Ernst Mayr, who applied the biological species concept to the science of systematics in his famous 1942 book. In rebuttal, we cite an earlier authority, Prof. Theodosius Dobzhansky, with whom one of us (D.H.) had the priviledge of studying at UC Davis in the mid 1970s. In 1937, Th. Dobzhansky published an extremely important and influential book, *Genetics and the Origin of Species* (Columbia University Press), which provided what evolutionary biologists now call the modern synthesis of the ideas of Mendel, concerning inheritance, and Darwin, concerning natural selection. In his 1970 update of this famous work, *Genetics of the Evolutionary Process*, Dobzhansky provided the following definitions.

"A race is a cluster of local populations that differs from other clusters in the frequencies of some gene alleles or chromosomal structures. A subspecies (following Mayr 1969 [and quoted by Taylor]) is a 'geographically defined aggregate of local populations which differ taxonomically from other such subdivisions of the species.' A subspecies is, then, a race that a taxonomist regards as sufficiently different from other races to bestow upon it a Latin name." (Dobzhansky 1970, p. 310)

The genetic differentiation of spring-run chinook salmon in the Sacramento Valley, together with the considerable information about the distinct life history and geographical and seasonal spawning habitat of this run, is entirely consistent with Dobzhansky's definition of a race. As Dobzhansky points out, races embody all of the evolutionary potential of taxonomic subspecies, and in the case of spring-run, two emerging facts support this evolutionary potential. First, there was and is, in places like Deer and Mill Creeks, geographic segregation of spring-run spawning habitat at higher elevations than the fall-run habitat. Dr. Taylor is disingenuous in stating that there is no geographic separation of spring-run from the other races. Second, the absence of evidence for hybridization of spring-run and other races in the Sacramento River mainstem, where dams have recently disrupted this geographic separation, suggests an incipient, pre-zygotic, reproductive isolation that could, over the millenia lead to the formation of a new species of chinook salmon. Spring-run is clearly a cluster of populations adapted to a geographcially and seasonally distinct spawning habitat in the Central Valley. Furthermore, the term "spring-run" itself communicates that difference to scientist, manager, fisher, and lay person alike. What separates the spring-run from qualifying as a subspecies, then, is merely the absence of a Latin name.

Please feel free to call upon either of us for clarification of our research results, these views, or the progress of our broader survey of Central Valley stocks.

Sincerely,

Dennis Hedgecock

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Dr. Jennifer L. Nielsen

4/1/96

Robert Treanor, Executive Director
California Fish and Game Commission
1416 Ninth Street
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Sacramento, CA 95814

Dear Mr. Treanor,

I am writing to respond to Dr. Robert Taylor's arguments against sub-specific status for the spring-run chinook in the Sacramento River as stated in his unpublished manuscript: "The Subspecies Concept and Its Application to the Spring-run Chinook Salmon." Dr. Taylor, in quoting me from a recent phone conservation states that I suggested that the current set of discrete runs of chinook salmon in the Sacramento River represent "remnants of a larger population of salmon exhibiting continuous variation across the range of potential habitats and timing of runs." He goes on to interpret my statement to imply that anthropomorphic disturbance over the last century has influenced population levels, "destroying intermediate forms."

Dr. Taylor's statement about my concepts on population structure in the Sacramento River chinook is in part correct, but is also in part incorrect. I do follow the philosophy that the wild Sacramento River chinook populations represent a single, complete meta-population that includes highly variable habitat adaptations, migration timings, and reproductive schedules, including the freshwater maturation schedule that we now identify as unique to the spring-run. To what degree anthropomorphic manipulation of that habitat and supplemental fish production by hatcheries subsequent to the European settlement of the Central Valley has "destroyed many intermediate forms," as stated by Dr. Taylor was not, and is not part of my scientific knowledge of the Sacramento

River chinook populations. Without significant speculation, we cannot judge population structure outside of the context in which we find it. We currently have no scientific evidence to suggest that the spring-run was ever identical genetically or ecologically to the other chinook runs in the Sacramento River. Indeed many studies supply evidence to the contrary, including some of my own.

Dr. Taylor incorrectly identified the spring-run as a "more-or-less" discrete population. Molecular genetic analyses using mitochondrial DNA (mtDNA) done in my laboratory in 1993 and 1994 showed significant genetic separation among the Sacramento chinook races (Nielsen et al. 1994). Follow-up studies in 1995 confirm these results and show no significant year-to-year variation in the mtDNA taken from run-specific chinook samples from the Sacramento River (Nielsen 1995). Using these data, an unbiased estimate of gene flow among the four spawning runs of Central Valley chinook was calculated according to methods given in Barton and Slatkin (1989). Based on simulation modeling and mathematical theory, this estimate (0.45 fish per generation), demonstrates significant genetic separation among the four chinook spawning-runs found in the Sacramento River that could not be a product of genetic drift alone, therefore supporting substantial reproductive isolation for the spring-run. A recent study of the chinook salmon stocks transferred from the Sacramento River to streams and rivers in New Zealand at the turn of the century also confirms the long-term continuity of molecular markers found in the Sacramento River chinook runs (Quinn et al. 1996).

The evolution of the spring-run life history type has been documented in other species of *Oncorhynchus*, and *Salvelinus* including Arctic charr and steelhead trout. The distribution of this type of reproductive strategy in other anadromous fishes suggests an ancient evolution of this unique behavior that derived many times in several independent lineages at some time in the past. My recent microsatellite analyses of the Middle Fork Eel River summer-run steelhead that enter the river in late spring as reproductively immature adults and over-summer in deep pools before maturation in freshwater (much like the Sacramento River spring-run chinook) estimated population separation between the winter- and summer-runs of over 160,000 generations using molecular distance analyses drawn from Goldstein et al. 1995 (J. L. N. unpublished data).

A similar analysis using microsatellites in currently underway in my lab for the Sacramento River chinook. However, mtDNA separation between the Eel River steelhead populations was not as convincing of population substructure as it was in the Sacramento chinook (Nielsen et al 1996), suggesting an even longer estimated genetic distance will be found within the Sacramento River chinook groups. It is my belief that Dr. Taylor, with all good intentions, misinterpreted my comments to suggest a recent separation of chinook populations, not the actual time scales supported by the relevant genetic data on these groups.

Dr. Taylor argues that geographic distance alone defines a species or subspecies. Based on the Darwinian theory of change by descent, all living organisms share, to some degree, a recent common ancestor and even some species could, therefore, be considered as members of a single biological unit. Speciation, however, is a matter of time as well as geography. There are no hard and fast rules on how or when speciation becomes permanently fixed within a population. Reproductive isolation is not necessarily easy to conclude, consider the viable hybrids found to represent crosses between chinook and coho salmon in wild salmonid population in California (Bartley et al. 1990; J. L. Nielsen, unpublished data). Does this mean that coho and chinook should be reconsidered as a single species under CESA?

Evolution and population structure can be recognized on many scales. Determining the most appropriate scale for protection of organisms will require considerable information and complex biological decisions. We currently have the tools and scientific principles to judge relevant time scales that separate unique populations using DNA sequence data. In all such studies to date, the spring-run chinook of the Sacramento River shows statistically significant separation from the rest of the runs and should be considered a unique population segment that represent an important component of the evolutionary legacy of the species. The Sacramento River spring-run chinook, therefore, should be classified as a distinct subspecies under the California Endangered Species Act.

Sincerely,

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Literature:

Barton, N. H. and M. Slatkin. 1986. A quasi-equilibrium theory of the distribution of rare alleles in a subdivided population. Heredity 56:409-415.

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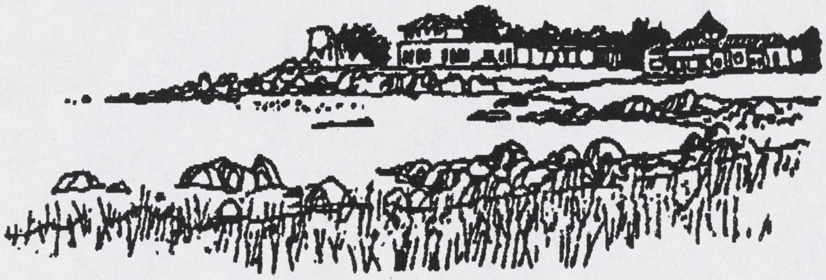

Date: 4/1/96

TO: Kip Wiley

FAX Number: 916 324-3944

FROM: J. C Nielson Phone: 625 6233 (408)

Total Pages: 5

COMMENTS: Per Request.

Judy: fax.doc

FGC - 670.1 (3/94)

A PETITION TO THE STATE OF CALIFORNIA FISH AND GAME COMMISSION

For action pursuant to Section 670.1, Title 14, California Code of Regulations (CCR) and Sections 2072 and 2073 of the Fish and Game Code relating to listing and delisting endangered and threatened species of plants and animals.

I. SPECIES BEING PETITIONED:

Common Name: Spring-Run Chinook Salmon

Scientific Name: (Oncorhynchus t shawytscha (Spring))

II. RECOMMENDED ACTION:

(Check appropriate categories)

a. List [X]

As Endangered [X]

As Threatened [ ]

b. Change Status [ ]

from ____________

to ____________

Or Delist [ ]

III. AUTHOR OF PETITION:

Name: Senator Tom Hayden

Address: Room 2080, State Capitol

Sacramento, CA 95814

Phone Number: (916) 445-1353

I hereby certify that, to the best of my knowledge, all statements made in this petition are true and complete.

Signature: Tom Hayden

Date: 10/16/95

California Legislature

Senate Committee
on
Natural Resources and Wildlife

TOM HAYDEN
CHAIRMAN

CONSULTANTS
CHRISTOPHER WILEY
LISA HOYOS
DARRYL YOUNG
DUANE PETERSON

COMMITTEE SECRETARY
MERCEDES FLORES

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PETITION BY TO LIST THE SPRING-RUN CHINOOK SALMON AS AN ENDANGERED SPECIES UNDER THE CALIFORNIA ENDANGERED SPECIES ACT

Executive Summary

Senator Tom Hayden is formally petitioning the California Fish and Game Commission to list the spring-run chinook salmon (Oncorhynchus tshawytscha) as an endangered species under the California Endangered Species Act (CESA). The spring-run chinook was once the most abundant race of salmon in California producing about one million fish annually, and has been a major cultural, biological and economic asset in this state. Now however, less than 1,000 native spring-run return annually, primarily to Mill and Deer Creeks in Tehama County.

Overall population trends for spring-run chinook have been documented as declining for many decades. More than 20 "historically large populations" of spring-run chinook have been extirpated or reduced nearly to zero since 1940. Much of the population decline in the past has been due to the construction of dams on the Sacramento/ San Joaquin River systems, which have blocked acces to large portions of native spawning grounds. By restricting physical access to natural spawning grounds from construction of dams, spring-run salmon were forced, in many cases, to spawn in areas overlapping with other genetically distinct runs. This has resulted in a hybridization to the detriment of both runs. It is widely accepted that pure spring-run chinook have been rendered extinct in the mainstem Sacramento River and certain east valley rivers. Fishery biologists are in general agreement that true spring-run stocks are now limited to spawning in Mill and Deer Creeks, and possibly to Big Chico, Butte and several other east valley creeks.

In addition to major losses as a result of habitat loss due to dam construction in the past, spring-run populations today are continuing to decline to critical levels. It is generally agreed by experts from state and federal fishery agencies, as well as by independent fishery biologists, that by far, the major impediments to spring-run recovery and survival today are the adverse hydrodynamic conditions in the Sacramento-San Joaquin Delta. Other impacts such as ocean harvest and predation, and tributary conditions are important but of far less magnitude when compared to the situation in the delta.

Currently, spring-run chinook receive no protection from adverse hydrodynamic conditions in the delta. The recent Bay/Delta Agreement calls for mitigation measures for reducing the impacts of water exports only during the months of April through June, with additional measures applying from February through April. However, Deer and Mill Creek spring-run out-migrate through the delta primarilly between November and January, when no protections from the Bay/Delta agreement are in place.

Because of continued losses, due in large part to conditions in the Delta, Mill and Deer Creek spring-run chinook populations, which represent the last vestage of viable populations in the Sacramento-San Joaquin River system have declined by 80% since the 1960's and now total less than 1,000 fish.

This petition recommends actions be taken to improve access and habitat conditions in the Sacramento River tributaries, as well as the following actions to increase smolt survival in the delta.

1) Closure of the cross delta channel during November to January.
2) Limit the maximum total state and federal water projects exports between November and January.
3) Maintain positive net flows in the southern delta.

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Introduction - Threat to Spring-Run Chinook

The spring-run chinook was once the most abundant race of salmon in California producing about one million fish annually, and has been a major cultural, biological and economic asset in this state. Now however, less than 1,000 native spring run return annually, primarily to Mill and Deer Creeks in Tehama County.[1] It is precisely for this type of situation that the safety net of the endangered species laws is designed; when less extensive measures have either not been implemented or have failed to prevent critical population declines, to the point where the possibility of extinction is imminent.

During the middle of this century, spring-run chinook were decimated by dams which closed access to most of their historic spawning habitat. The decline of the spring-run populations stabilized briefly during the 1950's and 60's, but then experienced a further steep decline, particularly over the last decade (Figure 1). There is little question that the major factor in these recent declines has been the increasing level of water exports out of the San Francisco-San Joaquin Delta.

Three of California's preeminent fishery biologists have concluded that spring run chinook should be listed as "endangered".[2] The California Department of Fish and Game (CDFG) has notified the State Water Resources Control Board that spring-run populations have reached record lows, and that this fish should be considered for listing.[3] Most recently, the Delta Native Fishes Recovery Team[4] has given spring run a "recovery potential rating" of 3C, similar to the

[1] Moyle, P. June 26, 1992. Causes of Decline in Estuarine Fish Species, WRINT-NHI-9, p. 6 (hereinafter "WRINT-NHI-9").

[2] See, e.g., Moyle, P.B., J.E. Williams, E.D. Wikramanayake, Fish Species of Special Concern of California. Final Report prepared for California Department of Fish and Game, Inland Fisheries Division. p. 6. (1989)

[3] WRINT-DFG Exhibit No. 14. Water Quality and Water Quantity Needs for Chinook Salmon Production in the Upper Sacramento River, pp 2-3 (hereinafter "WRINT-DFG-14").

[4] The Delta Native Fishes Recovery Team was appointed by the U.S. Fish and Wildlife Service on March 31, 1993 as part of the recovery effort for the delta smelt. The Team was given a much broader mandate than the recovery of that species, however, and is charged to "address the Delta ecosystem as a whole, considering the population declines of other

delta smelt at 2C. This rating indicates that the degree of threat is quite high, "1" being the highest level of threat. By comparison, the Sacramento splittail, already listed as a candidate species, was given a rating of 7C by the Natural Heritage Institute.[5]

In their present state, the remaining isolated populations of spring-run are at high risk, but still have a good potential for recovery. The last genetically pure runs of spring chinook are viable and self propagating only in Mill, Deer and possibily Butte Creeks, tributaries of the Upper Sacramento River. Without further adverse impacts, and increased protection, these populations may remain viable, however, these fish migrate through the delta as yearlings in the October through January period, when very limited smolt protections are in place. Indeed, it is likely that there will be increased adverse impacts on these smolts if the water projects shift more of their pumping to this period as a result of protections for the spring months.

This petition gives recommendations for protection under the California Endangered Species Act, and lists specific management actions for the San Francisco-San Joaquin Bay/Delta and the Sacramento River tributaries. These recommendations are outlined in the text and summarized in the appendix.

Population Trends - Historic Background

Spring chinook were once the most abundant race of salmon in California's Central Valley, and one of the largest runs on the Pacific Coast.[6] Large spring

native fishes, in addition to delta smelt, that require active management to restore sustainable populations." The Team includes representatives from U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, U.S. Geological Service, U.S. Bureau of Reclamation, California Department of Fish and Game, California Department of Water Resources, U.C. Davis, San Jose State University and private consultants. The final report is scheduled for release this summer.

[5] Natural Heritage Institute, Comments and Recommendations to the SWRCB Regarding Review of Standards for the SF Bay/Sacramento-San Joaquin Delta Estuary, July 13, 1994, pg. 3, hereafter NHI Review.

[6] California Department of Fish and Game, Water Projects Branch. June 1966. Sacramento Valley East Side Investigation, Department of Water Resources Bulletin No. 137. p. 3 (hereinafter "CDFG Bul. 137"); California Department of Fish and Game. Nov. 1993.

run populations occupied 26 streams in the Sacramento-San Joaquin drainage, principally in the middle reaches and tributaries of the San Joaquin, Feather, Upper Sacramento, McCloud and Pit Rivers (Recovery Team Draft at 1-2). However, by 1992, "wild spring run populations [were] less than 0.5% of the historic runs" which numbered up to a million fish (WRINT-NHI-9 at 6; NHI Review).

Almost 30 years ago, the California Department of Fish and Game warned of the threat that Central Valley water development posed to spring run chinook:

> "In a little over 100 years, civilization has almost succeeded in destroying this splendid race of salmon [spring run] in California's Central Valley. Only remnants of the once abundant populations remain. With the accelerated expansion of water developments in the Sacramento System and the Sacramento-San Joaquin Delta, spring run salmon in the Central Valley are threatened with extirpation." (CDFG Bull. 137 at 3).

Overall population trends for spring-run chinook have been documented as declining for many decades.[7] More than 20 "historically large populations" of spring run chinook have been extirpated or reduced nearly to zero since 1940. The remnant wild spring-runs on Mill, Deer, Butte and Big Chico Creeks have "exhibited statistically significant declines" over the same period (Campbell and Moyle, 1990).

The primary spring-run populations were eliminated with the construction of dams that blocked access to holding areas in the 1940s and 1950s, and even earlier (Recovery Team Draft at 2). The last large run in the San Joaquin River occurred in 1945, when 56,000 adults returned (Recovery Team Draft at 4). Spring-run were completely eradicated in the San Joaquin River following the

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Restoring Central Valley Streams: A Plan for Action. p. IV-3 (hereinafter "CDFG Plan"); Delta Native Fishes Recovery Team Report; Sacramento Spring Run Chinook Salmon, March 28, 1994 Draft, p. 4 (hereinafter "Recovery Team Draft").

[7] Campbell, E.A. and P.B. Moyle. 1990. Historical and recent population sizes of Spring-Run Chinook Salmon in California. In the proceedings of the 1990 Northeast Pacific Chinook and Coho Salmon Workshop, American Fisheries Society, Humboldt State University, Arcata, California. pp. 155-216 (hereinafter "Campbell and Moyle 1990").

construction of Friant Dam in 1948. This event has been graphically described by CDFG biologist George Warner:

> "In 1948, disaster struck. Friant Dam ... had been completed and the Bureau of Reclamation assumed control of the river ... Bureau officials diverted water desperately needed by salmon down the Friant-Kern Canal to produce surplus potatoes and cotton in the lower San Joaquin Valley." [8]

CDFG crews attempted to trap spring chinook and truck them to the base of Friant to spawn. However, when the juvenile salmon attempted to migrate out to the ocean, they were stranded on a dry stretch of river bed. "The tragic conclusion to the history of the 1948 spring run was that the only beneficiaries of our efforts to salvage a valuable resource were the raccoons, herons and egrets" (Warner 1991). Efforts to rescue spring-run failed as well in 1949 and 1950, and the San Joaquin spring run chinook became extinct (Recovery Team Draft at 4). See also, CDFG Bull. 137 at 3 ("Spring run salmon have been totally eliminated from the San Joaquin river system by large dams on the Mokelumne, Tuolumne, Merced, Stanislaus, and San Joaquin Rivers.")[9]

With the demise of the San Joaquin spring-runs, the Sacramento River stocks constituted the only remaining natural runs in the Central Valley. The Sacramento River drainage as a whole is estimated to have supported spring chinook runs exceeding 100,000 fish in many years between the late 1880's and 1940's, and this estimate may be low by a factor of three or four (Recovery Team Draft at 4; Campbell and Moyle, 1991).

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[8] George Warner, "Remember the San Joaquin" in California Salmon and Steelhead: The Struggle to Restore and Imperiled Resource, A. Lufkin ed., Univ. Of Cal. Press, Berkeley, CA (l991)(hereinafter "Warner 1991").

[9] See also Brown, Randall L. and Sheila Greene. (1994) An Evaluation of the Feather River Hatchery As Mitigation for the Construction of the California State Water Project's Oroville Dam, Environment Services Office, California Department of Water Resources. p. 6 (hereinafter "Brown and Greene 1994") ("The spring Chinook run to the San Joaquin River was eliminated when Friant Dam was built and, and there are presently no spring Chinook in San Joaquin tributaries.")

However, as in the San Joaquin drainage, the Sacramento River populations were dramatically reduced following the construction of barrier dams in the 1940s. Most critically, the closure of Shasta Dam in 1945 cut off access to major spring-run spawning grounds in the McCloud, Pit and Upper Sacramento Rivers (Recovery Team Draft at 5). This limited spring chinook to the mainstem Sacramento, as well as the Feather, Yuba and American Rivers and several tributary creeks downstream of the Red Bluff Diversion Dam, including Butte, Big Chico, Antelope, Mill and Deer (CDFG Bull. 137 at 4). As discussed below, wild spring run remain today only in a few creeks in the Sacramento River drainage.

Current Geographic Range and Distribution

By restricting physical access to natural spawning grounds from construction of dams, spring-run salmon were forced, in many cases, to spawn in areas overlapping with other genetically distinct runs. This has resulted in a hybridization to the detriment of both runs. It is widely accepted that pure spring-run chinook have been rendered extinct in the mainstem Sacramento River and certain east valley rivers. Fishery biologists are in general agreement that true spring-run stocks are now limited to spawning in Mill and Deer Creeks, and possibly to Big Chico, Butte and several other east valley creeks.[10]

In its 1991 Guide to Upper Sacramento River Chinook Salmon Life History, the Bureau of Reclamation determined that spring-run chinook no longer exist in the mainstem Sacramento River.

> "There is a general consensus among fishery scientists that a 'genetically pure' mainstem spawning population of Sacramento River spring run salmon no longer exists .... The fall run and spring run have likely crossbred to become one protected late-summer through fall spawning run in the mainstem. The only remaining genetically-pure spring run stocks in the upper Sacramento River basin are believed to be those utilizing the tributary spawning habitats (e.g., Mill Creek and Deer Creek)." (Vogel and Marine, 1991).

[10] Vogel, Daniel and Keith Marine. July 1991. U.S. Bureau of Reclamation Central Valley Project; Guide to Upper Sacramento River Chinook Salmon Life History, CH2M Hill. p. 4.

Significantly, the Department of Fish and Game supports the Bureau's view. CDFG has concluded that "the only remaining spring run populations in the Central Valley probably exist in Mill and Deer Creeks, and possibly Butte and Big Chico Creeks."[11] Moreover, CDFG has previously informed the State Water Resources Control Board that Mill and Deer Creeks are the key remaining areas where significant numbers of "genetically pure" strains of spring-run chinook continue to exist. (WRINT-DFG-14 at 3).

The multi-agency Delta Native Fishes Recovery Team has reached this conclusion as well, determining that spring-run no longer exist in the mainstem Sacramento River, and that wild spring chinook remaining in the Sacramento drainage are limited to Deer and Mill Creeks, with a few fish present in Antelope, Battle, Butte and Big Chico Creeks in some years (Recovery Team Draft at 2.). University of California Professor Peter Moyle has testified before the State Water Resources Control Board that less than 1,000 true spring chinook remain, "primarily in Deer and Mill Creeks." (WRINT-NHI-9 at 6).

The confinement of spring run to these east valley creeks was accurately predicted by CDFG almost thirty years ago as the inevitable result of this species' unusual "critical habitat requirements" which call for, <u>inter alia</u>, cold deep pools to enable holding over the summer months followed by spawning in the early fall (CDFG Bull. 137 at 4). The closure of Shasta Dam forced spring chinook to spawn in lowland rivers and tributaries historically colonized by fall chinook, which led to the complete hybridization and eradication of spring-run in these areas. By contrast, in Mill and Deer Creeks spring chinook are able to isolate themselves from fall-run during the spawning season by migrating up to higher elevations, thus avoiding the danger of hybridization. Thus, CDFG recognized in 1966, "the role of the Sacramento Valley East Side tributaries in preserving spring-run salmon is a very important one" (CDFG Bull. 137 at 4).

The susceptibility of spring-run to extinction through hybridization with fall-run long has been a major concern of resources agencies and fishery biologists. <u>During the pre-dam period</u>, spring and fall chinook runs were spatially

[11] Fisher, Frank. June 1992. Chinook Salmon, Growth and Occurrence in the Sacramento-San Joaquin River System, Inland Fisheries Division, Cal. Dept. of Fish and Game, Redding, CA. p.38 (hereinafter "Fisher 1992").

separated at different spawning sites, which enabled them to maintain their genetic integrity (Recovery Team Draft at 5). When the major dams blocked spring-run access to their historic spawning grounds, and dam operations altered downstream river temperatures, spring chinook were forced to occupy what had been exclusive fall chinook spawning habitat in the mainstem Sacramento River. As a consequence, spring-run chinook interbred with fall-run fish in the mainstem Sacramento, and other rivers and tributaries which were occupied by fall-run. (Recovery Team Draft at 5).

As early as 1957, the U.S. Fish and Wildlife Service noted that the closure of Shasta Dam had resulted in the hybridization of spring-run stocks in the mainstem Sacramento River. The Service reported that: "A true spring run has not been observed in any numbers either in Battle Creek or below Keswick Dam [on the mainstem Sacramento River] since the season of 1945."[12] The mixing of stocks was facilitated by the fact that spring and fall-run spawning periods substantially overlap. Thus, in 1963 the Service observed that when fall and spring chinook were forced to compete for spawning areas in what had been previously limited to fall-run habitat, spring chinook were eliminated.

> "This competition, plus the indicated hybridizing of the spring and fall races, appears to have held down the spring run, perhaps even to have eliminated it as a distinct race in the mainstem Sacramento River....The status of the spring run in the mainstem is thus speculative." [13]

By 1966, CDFG determined that spring chinook runs on the Yuba and American Rivers were "extinct" as a result of hybridization (CDFG Bull 137). Nearly 30 years later, the Department of Water Resources (DWR) confirmed that true spring-run no longer exist in the Feather River as a result of hybridization occurring at the hatchery.[14] Efforts to replace wild spring-run populations

[12] Cope, Oliver B. and Daniel Slater. 1957. Role of Coleman Hatchery in Maintaining A Ring Salmon Run, Research Report 47, Fish and Wildlife Service, U.S. Department of the Interior. p. 18 (hereinafter "Cope 1957").

[13] Slater, Daniel. Nov. 1963. Winter-Run Chinook Salmon in the Sacramento River, California, Special Scientific Report -- Fisheries No. 461, Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service, U.S. Department of the Interior. Washington, D.C. (hereafter "Slater 1963").

[14] In its 1994 evaluation of the Feather River Hatchery ("FRH"), DWR stated that "it is

through hatchery production elsewhere have failed, as well, and indeed provide further evidence of the vulnerability of this fish to hybridization when forced to cohabitate with fall-run.

> "For Shasta, Friant and Trinity dams, it was assumed that hatchery production would replace lost natural production of salmon. This assumption has proven to be false; hatcheries have succeeded mainly in slowing the decline of California's salmon populations and in substituting fall-run (or hybrid) hatchery fish for wild spring chinook." (Recovery Team Draft at 7).

In sum, water resources and fisheries agencies agree that pure spring chinook currently exist only in a few tributary streams, which were never colonized by fall-run, primarily Mill and Deer Creeks. Spring-run which spawned in the mainstem Sacramento River, and certain tributaries with hatcheries, were completely hybridized by fall-run, rendering spring-run extinct in those areas.

Wild Spring-Run Chinook Salmon Abundance

Based on the foregoing discussion, the relevant data regarding the abundance of spring-run stocks in the Sacramento system are the historic population counts on Mill and Deer Creeks, and other tributaries with genetically pure spring-run populations. According to prior CDFG testimony, spring-run populations in Mill and Deer Creeks declined by over 80% between the late 1960s and the late 1980's (WRINT-DFG-14 at 3).

The Recovery Team has documented this assertion in its recent study:

> "In Mill and Deer Creeks, the estimates of spawning fish averaged 2,300 and 1,200 fish, respectively. Since 1985, the combined yearly

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important to determine if Feather River Chinook called 'springs' by hatchery staff truly belong to this race." (Brown and Greene 1994 at 7.) The resulting data demonstrated that they do not. About 20% of the tagged juvenile salmon from "fall" females were subsequently identified as "spring" run when they returned as adults. Similarly, about 30% of tagged juveniles from "spring" females returned as fall run adults. DWR concluded that the fish labeled "spring run" by the hatchery is not true spring run at all, but rather "a combination of fall and spring races." (Brown and Greene 1994 at 7.)

totals for both creeks have been less than 900 fish ... Spawning populations in other tributary streams are considerably less, with an estimated 40-100 fish in Antelope Creek [incomplete survey]. The spring chinook numbers in Antelope Creek have dropped during the last few years to less than 10 individuals per year (Campbell and Moyle, 1990; NHI Review) Up to 100 fish have held in Big Chico Creek (Marcotte, 1984), but that stream currently supports a much smaller run of probably less than 20 adults (NHI Review). In Butte Creek, the numbers have fluctuated considerably from year to year and in the past have been augmented by fish from the Feather River Hatchery." (Recovery Team Draft at 5).

Adult spring-run population data on Mill and Deer Creeks have been collected with some regularity since 1940. Spring-run data are available on Butte Creek for 1956-1987. These counts are set forth on Table 1. Although the data has gaps, Table 1 clearly establishes a major decline in spring-run abundance in these creeks since the 1950's and 1960's. During the past decade, annual spring-run populations have averaged about 550 fish in Deer Creek, and 390 fish in Mill Creek (CDFG Plan at VII-56, VII-65). This trend is vividly illustrated by Figure 1, which depicts the population data from Table 1 in bar graphs. In all three graphs, the drop off in spring-run abundance during the 1980's is striking.

In the other relevant tributaries, the spring-run declines have been dramatic as well, with remaining populations even smaller than in Mill and Deer Creeks. Antelope Creek historically supported an average annual population of about 500 spring chinook, but in the last decade, this number dwindled to a few individuals (CDFG Plan at VII-25). In the 1950's and 1960's, Big Chico Creek supported an average annual spring-run population of about 500 fish. There is now only "a remnant spring chinook population." (CDFG Plan at VII-38)[15]

Population counts of adult "spring-run" have been taken at Red Bluff Diversion Dam annually since 1967, but these counts reflect the hybrid fall-spring race

[15] The Recovery Team's stated objective for spring chinook is to "restore the rates of outmigrating smolts to levels that existed before the construction of the pumps of the CVP and SWP in the South Delta " That objective translates into a range of 5,000 to 10,000 returning spawners in the tributaries, with a fifteen year average of no less than 8,000 fish. (Recovery Team Draft at 9.)

that now spawns in the mainstem Sacramento River. CDFG has previously informed this Board that the fish labeled as "spring-run" in the Red Bluff Diversion Dam counts are not wild spring-run, but only the hybrid race (WRINT-DFG-14 at 3).

The Recovery Team also has accepted the conclusion that the Red Bluff "spring-run" counts reflect a hybrid species, and therefore do not represent spring-run chinook populations. (See Recovery Team Draft at 5) [16]

Nevertheless, CDFG believes the Red Bluff data do reflect gross trends for spring-run, and tends to support the population data gathered in the tributaries (Fisher, 1992 at 38). The Red Bluff "spring-run" counts are set forth on Table 2. These counts demonstrate that between 1969 and 1980, returning "spring-run" spawners averaged 17,000 fish per year, reflecting a range of 3,600 to 25,000 (Recovery Team Draft at 5). From 1981 to 1993, the average number of returning "spring-run" dropped to 8,902, reflecting a range of 23,400 fish in the early 1980's to a low of 388 fish in 1993.

In sum, Mill and Deer Creek spring-run populations have declined by 80% since the late 1960s, and now number about 1,000 fish total. The population counts at Red Bluff, while not meaningful in terms of total abundance, support the existence of a steep decline in spring chinook populations.

Factors Affecting Ability to Survive and Reproduce

Historically, the major decreases in spring chinook abundance are attributable to the loss of upstream habitat due to upstream water development, the final blow occurring in the 1940s with the closure of Shasta, Friant and other Central Valley dams (Recovery Team Draft at 5-6..). However, as established above,

[16] The Red Bluff counts are taken upstream of the tributaries on which spring run return to spawn, and therefore are unrelated to spring run population counts on Mill and Deer Creeks. Some confusion over spring chinook abundance has resulted from the labeling of mainstem Sacramento and Feather River hybrids as "spring run" in the Red Bluff counts. As demonstrated above, there is wide-spread scientific consensus that spring run have been extirpated in the mainstem Sacramento River. Moreover, aerial spawning surveys conducted by CDFG confirm that spring run no longer exist in the mainstem Sacramento, and that the fish commonly referred to as "spring run" is actually the hybrid race. (Fisher 1992)

spring-run populations have continued to decline in recent decades, long after those permanent losses. It is this recent decline which threatens Sacramento system spring-run with extinction, and which this proposal is intended to address.

During the spring of 1994, the Natural Heritage Institute convened several meetings of state and federal fishery agencies and independent fishery biologists to discuss the status of wild spring-run chinook, and the factors affecting its survival.[17] When asked to rank order the major impediments to spring chinook recovery today, these experts unanimously agreed that adverse hydrodynamic conditions in the delta are the single greatest threat facing spring chinook, with the ocean harvest and tributary habitat conditions rating as lesser, but still important, issues.

Out of Delta Factors

Ocean Harvest

Commercial salmon harvesting has operated under severe restrictions for the last three seasons. In 1992, fishermen lost 60% of their traditional twenty week season north of Point San Pedro, near Half Moon Bay, which did not open until August 1. In 1993, salmon fishing was prohibited for seven weeks between Point San Pedro and Point Arena. This cutback represented 35% out of the heart of the harvest season (June and July), a period during which the greatest number of fish are usually caught.

Last year fishing was prohibited above Point San Pedro until June 11, and from June 15 until the end of June salmon fishing was forbidden along the entire coast with the exception of the relatively small area between Point San Pedro and Point San Reyes.[18] Even prior to the imposition of the current prohibitions, the Pacific Fishery Management Council has imposed various restrictions on the commercial salmon harvest for over a decade. While these restrictions

[17] Meeting participants included representatives from CDFG, FWS, NMFS, UC Davis, EPA and the State Board

[18] Pacific Fishery Management Council, Review of Fisheries (1992-1993); Pacific Coast Federation of Fishermen's Assns.

were not imposed primarily to benefit Sacramento spring-run chinook, their timing is highly likely to have benefited this race given that spring-run migrate upstream from April through June.

Because of the severe restrictions on commercial harvest, commercial fishing pressure does not appear to be a major factor in the spring-run decline.

Tributary Conditions

Unlike many Central Valley tributaries, Mill and Deer Creeks are favored with "relatively pristine" habitat, and CDFG has determined that these two streams have significant potential for increasing natural populations of spring chinook (CDFG Plan at VII-56, VII-66). Nevertheless, a variety of problems in the tributaries have adversely affected spring-run abundance in recent years, primarily agricultural diversions, affecting up and down stream migration, and degradation of riparian habitat, affecting spawning areas. In addition, the U.S. Forest Service has proposed timber harvesting in the upper watershed which threatens loss of additional holding and spawning areas (CDFG Plan at VII-57, VII-65-66).

Within the last two years, a coalition has been formed to tackle wild spring-run chinook habitat and transport issues in the tributary streams. The Spring Run Work Group is an unusual confederation of local landowners, state and federal agencies, commercial and sport fishermen, and conservation organizations. Given the complexity of the issues relating to water use and the traditional antagonism of the parties, the Work Group has made substantial progress.

Specifically, the Work Group members have been successful in obtaining screens for various diversion facilities, fish counting equipment for use on the tributaries and the removal of several barriers to fish migration in Mill and Deer Creeks. Landowners on these creeks are entering into Memoranda of Agreement with the Department of Water Resources for water exchanges designed to benefit fish passage in these streams. Landowners are now working with CDFG in allowing the agency access across private property to assess habitat and conduct fish counts. Some cattle ranchers have voluntarily agreed to fence off the upper part of Deer Creek to protect riparian habitat and water quality. Watershed committees have been formed to address issues specific to Deer, Mill, Butte, Antelope, Clear and Big Chico Creeks.

In addition, the Work Group has had some preliminary success in obtaining public funding for various programs including financing from the Four Pumps Agreement for a warden program to address poaching problems. Public funds are being sought as well for spring chinook recovery activities, development of encroachment maps, and a water gauge for the tributaries.

The Work Group specifically limited its mission to the tributaries in order to target its limited resources to the areas in which its members have the greatest expertise. Nevertheless, there has been clear recognition that resolution of problems in the Sacramento-San Joaquin Delta will be critical to the survival of the spring-run chinook.

Role of the Delta

As indicated above, it is the consensus of fishery experts that delta operations and resultant changes in delta hydrodynamics are the central problems facing spring run chinook today. This consensus reflects the work of the Delta Native Fishes Recovery Team, which has recently concluded that:

> "Smolt mortality is probably a major factor affecting spring run chinook abundance as it is for all runs of salmon in the Sacramento-San Joaquin drainage...When pumping rates are high at the SWP and CVP pumping plants, and outflows are relatively low, spring chinook smolts are probably entrained in large numbers, are consumed by predators in Clifton Court Forebay and other off-channel areas, or are otherwise diverted from their downstream migration." (Recovery Team Draft at 7).

The State Water Resources Control Board has previously been apprised of the critical role played by through-delta smolt survival on the abundance chinook salmon. The State Federal Delta Agreement based certain of its water quality standards and implementation recommendations on evidence previously presented by FWS which strongly indicates that smolt survival is the key to the maintenance of salmon populations. FWS extensively studied the factors relating to chinook survival in the Sacramento River system for the Board's WRINT proceedings, and determined that smolt mortality in the delta appears to be linked directly to the diversion of fishes off of their migratory route and into the interior delta (WRINT-FWS-7).

In particular, FWS identified four problems specific to smolts migrating down the Sacramento River: (1) diversion off of the mainstem into the central delta via the delta cross channel and Georgiana Slough; (2) reverse flows (and related problems) caused by federal and state water project pumping which further propels fish off-course toward the south delta and the pumps, rather than out to sea; (3) high water temperatures in the delta; and (4) low flows through the delta which may impede smolt migration rates, and thus expose these fishes to a variety of delta hazards for longer periods (WRINT-FWS-7). With the exception of water temperature,[19] each of these factors applies to all out-migrating chinook on the Sacramento system (NHI Review).

In addition to data provided by FWS, Professor Peter Moyle presented the State Water Resources Control Board with substantial evidence during the WRINT proceedings demonstrating that the operation of the federal and state water projects "is the single biggest factor causing the declines" in upper estuary biota including salmon (WRINT-NHI-9). Dr. Peter Moyle has developed a matrix rating the factors causing the declines of key species in the Upper Sacramento-San Joaquin estuary, including specifically spring-run chinook (WRINT-NHI-10).

WRINT-NHI-10 establishes that state and federal water project operations are a "major cause of decline" for spring-run chinook. Note that the only other "major" cause of spring chinook declines is "out of delta factors," meaning primarily declines which took place prior to 1970 as the result of dams and diversions. (WRINT-NHI-9). Dr. Moyle concluded that an indispensable component of spring-run recovery must be measures to curtail diversions of fishes into the interior delta during smolt out-migration to reduce their vulnerability to entrainment and to delta predators (WRINT-NHI-9).

[19] Temperature is a major factor for fall run because this species outmigrates during hot spring months. Mill and Deer Creek spring chinook smolts, in contrast, journey through the delta in colder fall and winter months.

In sum. efforts to protect and enhance spring-run by restricting the ocean harvest and curtailing water use in the tributaries are clearly important and worthwhile. Nevertheless, these efforts will be of limited utility unless simultaneous protections are afforded to spring chinook during the out-migration of these fish through the delta.

SPRING RUN LIFE HISTORY

Adult spring-run begin entering the tributaries in early March, continuing through April and peaking in early May. Unlike winter-run and other chinook species, adult spring-run hold over in the tributaries during the hot summer months (Recovery Team Draft at 3). Spring chinook spawning occurs in Mill and Deer Creeks in late August and continues through October (Recovery Team at 3). This is consistent with historic records of spring-run spawning times in the Upper Sacramento drainage, as well as with recent spawning stock surveys (NHI Review). It has been observed that spring-run populations spawning in higher elevation creeks, such as Mill and Deer, do so several weeks earlier than spring-run in creeks at lower elevations, such as Butte and Big Chico (NHI Review). Both spring and winter-runs migrate coincidentally, with each race segregating into separate holding and spawning areas apparently influenced by suitable water temperatures for spawning and reproductive success. No winter-run migrate into Mill, Deer, Chico or Butte Creeks where summertime temperatures are normally adequate for holding adults, but are lethal to incubating salmon eggs.

Spring-run chinook should be considered a weak stock because of their reduced fecundity. Fall-run salmon average about 5,500 eggs per female, whereas spring-run females produce between 3,400 to 5,100 eggs per female. with an average of 4,100 eggs. Eggs are deposited within the gravel where incubation, hatching and subsequent emergence takes place.

Length of time to develop and hatch is primarily controlled by water temperature. Salmon eggs hatch in 50 days when incubated at 50F, but require over 110 days at 40F and 300 days at 35F. Outside these ranges mortality begins to occur at temperatures above 58F and below 35F. After hatching, the larval salmon remain in the gravel living on the yolk sac for an additional period of time, again depending on water temperatures. The strong influence of water temperatures greatly increases the variations observed in juvenile spring-run life history patterns from different drainages. Within Butte and Chico Creeks, juvenile salmon first appear in early December, about 90 days after spawning. However, in Mill and Deer Creeks, juveniles begin to emerge in early March, over six months after first spawning.

Because of their higher elevation, Mill and Deer Creeks more closely resemble historic spring-run spawning habitat. Spring chinook in these creeks thus follow the true incubation and migration pattern for spring-run. Following the long incubation, they rear in the tributaries, and out-migrate beginning in mid-October (Recovery Team Draft at 3). By contrast, in Butte and Big Chico Creeks which are located at lower elevations than Mill and Deer, many of these Butte and Big Chico juveniles do not rear in the tributaries until they are yearlings, but out-migrate soon after hatching, from early December until June.

These two migration patterns for spring-run have led agency personnel to conclude that spring chinook almost certainly out-migrate through the delta from November through March, but most critically in the November through January period when Mill and Deer spring-run are moving through the delta (NHI Review).

The critical nature of the early winter period for spring-run is confirmed by data gathered by FWS regarding out-migration patterns of smolt size fish (See Figure 3).[20] Not surprisingly, the FWS data indicate that most smolts are in the delta in April and May, with still substantial numbers of smolts occurring in March and late February. However, the chart also reveals that smaller populations of smolts are in the delta late November through early January. These numbers probably reflect late fall and some winter-run as well as spring-run out-migrants.

One should bear in mind, however, that the spring run population is down to less than a thousand fish. It is therefore not surprising that spring run out-migrants in the November through January period are not reflected in large numbers in the data.

[20] FWS developed Figure 3 with a series of graphs depicting the log of abundance of salmon smolts in the delta by size from October through June. "Smolt size" was considered to be between 70 - 300mm. FWS obtained this data from several sources as indicated in Figure 3.

IMPACT OF EXISTING MANAGEMENT EFFORTS: APPLICABILITY OF STATE/FEDERAL DELTA AGREEMENT TO SPRING-RUN

The State/Federal Delta Agreement would be in effect only during the months of April through June. Moreover, existing measures required by the winter-run Biological Opinion, which might benefit spring chinook, apply primarily in February through April. However, Deer and Mill Creek spring chinook out-migrate through the delta between November through January, a time when there are only very limited protections in place to protect smolts, and when none are in the State/Federal Delta Agreement.

There is agreement among the state and federal agency personnel and fishery biologists that with the exception of water temperature, the factors affecting fall-run migration through the delta are likely to be the same for spring-run smolts as well. Thus, if spring smolts overlap with fall-run in the delta, State/Federal Delta Agreement implementation measures would afford a similar level of protection to both races. However, the critical Deer and Mill spring-run out-migration through the delta occurs in November through January, and possibly as early as October. As established above, this timing is well outside of the period during which the State/Federal Delta Agreement water quality protections would be in place.

In sum, the relevant State/Federal Delta Agreement protections offer no protection to the remaining pure spring chinook smolts out-migrating from Mill and Deer Creeks during the critical November through January period.

RECOMMENDATIONS

Protection of Spring-Run Smolts in the Delta

There is a high level of agreement that measures which have been proposed for implementation in order to benefit fall chinook, are very likely to benefit spring-run chinook if in place during their critical out-migration period. The three recommendations below are prioritized in terms of the measures which are most likely to obtain the highest benefits for spring-run, and other smolts out-migrating in the late fall and winter period, with the least water costs.

1) Closure of the cross delta channel during the relevant time period.

The cross delta channel diverts approximately 40% of the Sacramento River when the gates are open (WRINT-FWS-7). FWS has established that salmon smolts moving down the Sacramento River are diverted into the central delta in large numbers when these gates are open, and that smolts diverted in this manner have a far lower chance of survival than smolts migrating to the western delta via the mainstem Sacramento River (WRINT-FWS-7). Specifically, tagged experiments in 1983, 1987 and 1988 have established that smolts released below the closed cross delta channel and Georgiana Slough had a 1.3 to 2.4 times better survival index than fish released into the channel at the same time (WRINT-FWS-7 at 11). [21]

The significance of avoiding diversion of smolts into the interior delta also was acknowledged by NMFS in the development of winter-run protections (NMFS Bio. Opin. at 40-42). NMFS has determined that closure of the channel gates during the smolt out-migration period "will improve the overall survival of the winter-run chinook salmon emigrant population by reducing the number of fish exposed to adverse conditions in the central delta" (NMFS Bio. Opin. at 55).

For these reasons, it is recommended that closure of the delta cross channel gates be extended to include the period from November 1 through January 31 (See WRINT-FWS-7, Table 14, Alternative D).

2) Limits on maximum total state and federal water project exports during the relevant time period.

[21] FWS has also recommended closure of Georgiana Slough which diverts about 30% of the Sacramento River into the interior delta with deleterious consequences for outmigrating smolts. (WRINT-FWS-7 at 10.) However, the potential benefits to juvenile chinook salmon from closure of Georgiana Slough may be outweighed by harm to adult chinook salmon migrating upstream as well as other species which use the channel for rearing and migration. Investigations have just begun to try and address this issue. (NHI Review, pg. 18)

As discussed above, FWS data demonstrate that SWP and CVP pumping adversely affect fish diverted into the central delta, and to a lesser degree, fish migrating down the mainstem Sacramento River. CWT smolts released into the Sacramento River have been salvaged at the CVP and SWP facilities, "indicating that they are being directly impacted by the export pumping plants" (WRINT-FWS-7 at 13-22). This is consistent with data developed by CDFG establishing an extremely high correlation between total export volumes during the December through March period, and resultant year class population for salmon smolts. Figure 2 demonstrates that as export volumes during the smolt out-migration months have increased, the populations of returning adults from that smolt class decreased precipitously. The correlation of 0.882, is a highly significant relationship between export volume and smolt population decline. Figure 2 covers the 1967-1992 period (NHI Review, pg. 19). We have relied on late fall-run data because this is the race of chinook salmon which most closely shares the out-migration period of spring chinook from Mill and Deer Creeks.

Of course, this type of statistical correlation does not take into account other causal factors, and therefore is not, by itself, conclusive proof of a causal relationship between high exports and declines in adult chinook populations. Nevertheless, the very high correlation between these events is compelling evidence of a high probability of causality.

The FWS fall chinook Alternative D included a recommendation for a cap on maximum total CVP and SWP exports as follows:

Rainfall Condition	Maximum CVP & SWP Flow
Wet Year	6000 cfs
Above Normal Year	5000 cfs
Below Normal Year	4000 cfs
Dry Year	3000 cfs
Critical Year	2000 cfs

(See WRINT-FWS-7. Table 14, Alternative D.) For the reasons discussed above. it is recommend that export caps in this range be imposed from November 1 through January 31.

3) Maintain Positive Net Flows At Jersey Point.

FWS has indicated that calculated reverse net flows in the southern delta are a likely cause of mortality for out-migrating Sacramento River chinook smolts which have been diverted into the interior delta (WRINT-FWS-7 at 13-22, Figures 4 and 5; NHI Review, pg. 20). The FWS has evaluated the impact of Jersey Point flow on Sacramento River smolt survival indices, and has found that survival increased when Jersey Point flows were greater (WRINT-FWS-7, Table 5). FWS has concluded that "these relationships would support the fact that positive flows at Jersey Point may increase the survival of fish migrating down the Sacramento [River from] Ryde ...as well as for fish diverted into the central delta and moving to the San Joaquin via the Mokelumne River" (WRINT-FWS-7 at 22).

The National Marine Fisheries Service has also recognized the impact of calculated reverse net flows in the south delta on Sacramento River out-migrating smolts, which have been diverted into the interior delta via the delta cross channel or Georgiana Slough. "...upon reaching the mouth of the Mokelumne River on the lower San Joaquin River [after being diverted through the cross channel], juvenile winter-run chinook salmon will often be exposed to upstream (reverse) flows under proposed operation of the Delta water export facilities" (NMFS Bio. Opin. at 41). On this basis NMFS has determined that the export facilities should be operated so as to avoid any reverse flows during winter run out-migration, stating that "elimination of reverse flow conditions in the western delta [during smolt out-migration] is likely to reduce loss of winter-run chinook salmon juveniles in the delta" (NMFS Bio. Opin. at 57.).

The FWS fall chinook Alternative D included a recommendation for a minimum QWEST of 1000 cfs in all water year types. (See WRINT-FWS-7, Table 14, Alternative D.) For this reason, I recommend this measure for the period from November 1 through January 31.[22]

[22] The analyses reported by FWS, and the minimum flow standard recommended here, are based on QWEST, the calculated net freshwater flow at Jersey Point. This flow has never been measured, but is calculated from flows, exports and assumed consumption in the delta. Thus, the uncertainty in QWEST is high. Since QWEST is much smaller than tidal flows in the region, hydrodynamicists do not believe that it is a useful variable in terms of the net movement of salt or particles. However, it has been used extensively as an index of net flow balance in the delta for analyses of salmon and other fish. We believe that until better indices are available, that QWEST should be used to indicate the conditions for fish in the southern delta.

Smolt Survival Index Data

The proposals above are based on the premise that the factors demonstrated by FWS to affect Sacramento fall-run smolt survival are similar to the factors affecting Sacramento spring-run smolts, with the exception of temperature. This thesis has been corroborated by recent Code Wire Tagged (CWT) experiments conducted by the FWS with out-migrating smolts during the late fall and early winter period at issue.

In December 1993, FWS released pairs of CWT late fall hatchery smolts into Georgiana Slough and the Sacramento River at Ryde. This experiment was conducted: (1) to verify that even larger fish than had previously been released would be adversely affected by diversion into the interior delta; and (2) to ascertain whether smolts released in cooler water would have higher survival rates than previously measured (NHI Review, pg. 21). Water temperature at release was 51F, and the size of the two groups at release was 119 and 129 mm respectively.

The experiment outcome paralleled FWS' previous fall-run smolt survival results; the survival index for smolts released into Georgiana Slough was significantly lower than for those released into the Sacramento River at Ryde, just downstream of Georgiana. The smolt survival index was 0.21 for the Georgiana release, and 1.62 for the Ryde release. This data translates into a ratio of mainstem Sacramento River survival to central delta survival of 7.71 (NHI Review, pg. 21). This means that smolts out-migrating in December are almost eight times more likely to survive if measures are taken to keep them on the mainstem migratory route instead of being diverted into the central delta, during a period when temperature was not a contributing factor to mortality. CWT experiments for fall-run demonstrated that mainstem Sacramento survival was higher by at least a factor of three up to a factor of eight (NHI Review, pg. 21). [23]

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[23] In making these observations we do not suggest that the delta is inherently inhospitable to salmon. To the contrary, the data establish that the altered hydrodynamics in the delta are harmful, underscoring the need to institute measures to restore the delta for all species and to halt further habitat decline.

These results are significant in several respects. First, they indicate that even larger smolts, which out-migrate when they are yearlings, are highly susceptible to the adverse impacts of diversion into the delta and high exports. This is directly applicable to spring-run smolts which out-migrate as yearlings. Second, at 51 degrees, temperature was almost certainly eliminated as a cause of smolt mortality, thus strongly suggesting that water project pumping was primarily responsible for the high relative mortality level of the Georgiana releases. Exports during the experiment were extremely high, in excess of 10,000 cfs between release date and peak recovery at Chipps Island for both groups (NHI Review, pg. 22).

Although the December 1993 experiment was conducted with late fall-run smolts instead of Mill and Deer spring chinook, the data clearly support the position that, aside from temperature, factors affecting fall-run affect spring-run as well, and that similar protective measures should be established during their critical out-migration period in November-January.

Protection of Spring-Run in the Sacramento River Tributaries

In addition to delta protections for out migrating smolts and returning adults, it is important to protect and restore spring-run habitat and access to historical spawning areas in the tributaries of the Sacramento River. The following are examples and recommendations where restoration efforts can increase spring-run chinook salmon populations.

<u>Antelope Creek</u>

Antelope Creek flows southwest from the Cascade Range foothills entering the Sacramento River nine miles southeast of Red Bluff. The drainage is approximately 123 square miles and the annual discharge is 107,200 acre-ft per year. Fish habitat is relatively unaltered above the valley floor but lack of adequate flows to the Sacramento River prevents optimum use by salmon.

Historically 500 spring-run chinook salmon annually used Antelope Creek. The recent drought and excessive in-basin water diversions have resulted in inadequate migrations flows. The creek has the potential to produce a sustainable population of 2,000 spring-run salmon.[24] Antelope Creek needs to provide and maintain adequate passage flows from October 1 through June 30 below the Edwards and Los Molinos Mutual Water Company diversion dam. In addition adequate migration flows and temperature to attract spring-run chinook salmon must be provided at Antelope Creeks confluence with the Sacramento River. To provide for these flows there should be an exchange of surface water for ground water with existing landowners, additional instream flows from the Los Molinos Mutual Water Company and a reevaluation of water rights.

Battle Creek

Battle Creek enters the Sacramento River approximately five miles southeast of Cottonwood. It flows into the Sacramento Valley from the east, draining a watershed of 360 square miles. Prior to development Battle Creek was one of the most important chinook salmon spawning streams in the Sacramento Valley including spring-run.[25] Development has consisted of the Coleman National Fish Hatchery (CNFH) and Pacific Gas and Electric Company's hydropower operations. The blockage of the fall-run migration at CNFH and the affect of low flows caused by PG&E's hydropower operations have combined to eliminate salmon spawning above the hatchery. PG&E owns and operated the Battle Creek Project consisting of two storage reservoirs, four unscreened hydropower diversions on the North Fork, three unscreened hydropower diversions on the South Fork, a complex system of canals and forebays, and five powerhouses. In addition there are two significant agricultural diversions on the main stem of Battle Creek, only one of which is screened.

Surveys conducted prior to the construction of Shasta Dam indicate that with sufficient water the stream reaches above the Coleman National Fish Hatchery could provide spawning for over 1,800 pair of salmon.[26] The North Fork of Battle Creek, Eagle Canyon in particular, contain deep, cold, and isolated pools ideal for holding spring-run chinook salmon throughout the summer. A recent evaluation identified 186,000 square feet of spawning gravel distributed

[24] Restoring Central Valley Streams: A Plan for Action. Department of Fish and Game - November 1993. pg. VII-25.

[25] Ibid., pg. VII-28.

[26] Ibid., pg. VII-30.

between Coleman Powerhouse and Macumber Dam on the North Fork and between the powerhouse and South Diversion Dam on the South Fork. The Department of Fish and Game has stated that "because of the critically low numbers of spring-run within the Sacramento River drainage, any expansion of available habitat for that race has a high priority."[27]

Restoration of naturally spawning anadromous fish populations in Battle Creek above the Coleman National Fish Hatchery will require physical and operation changes in PG&E's projects including the screening of the diversions on the North Fork and South Fork, increased releases from project diversions, and cessation of the practice of removing gravel which accumulates at project diversions.

Big Chico Creek

Big Chico Creek enters the Sacramento River five miles west of Chico. It flows into the Sacramento Valley from the east draining a watershed of 72 square miles. There are no significant impoundments on the stream and the only major water diversion is within one mile of the mouth. The unscreened M&T pumping station, comprised of five large pumps with a combined capacity to divert more than 135 cfs, is located on Big Chico Creek near its confluence with the Sacramento River.

In 1958 the spring-run chinook salmon population was estimated to be at 1,000 adults.[28] Substantial streamflow reversal during juvenile salmon emigration occurs in approximately one in four years. During these periods, all downstream migrants are lost.[29] Adult spring-run chinook salmon migrating up the Sacramento River on their return have difficulty locating the mouth of Big Chico Creek when flows are reversed. In addition, adult spring-run chinook salmon are deterred by intermittent flows in Lindo Channel, inadequate fish passage at the One and Five Mile Recreation areas, and at Iron Canyon in Upper Bidwell Park.

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[27] Ibid.

[28] Ibid., pg. VII-38

[29] Ibid

To correct these problems it is recommended that the M&T diversion be relocated to the Sacramento River and that fish screens be installed. The control structures at Five Mile Dam and Lindo Channel should be repaired or rebuilt. The existing fish ladders should be inspected and repaired.

Butte Creek

Butte Creek originates in the Lassen National Forest and enters the Sacramento at Butte Slough. Spring-run chinook salmon exist in Butte Creek. As late as the 1960's, Butte Creek supported over 1,000 adult spring-run chinook salmon. More recently the spring-run populations have ranged from fewer than 200 adults to over 1,000.[30] CDFG annual estimates indicate that typically few adult spring-run chinook salmon reach upper Butte Creek when conditions are most favorable for holding and spawning.[31]

The decline of spring-run is attributed to inadequate flows, unscreened diversions, inadequate passage over diversion dams, unblocked agricultural return drains that attract and strand adult fish, poor water quality, declining availability of adequate spawning gravel and poaching. There are 9 diversion dams on Butte Creek that supply water for power generation, irrigation, gun clubs, and domestic use. All are known to impair and delay migrating fish. Passage at seven of the dams could be improved by upgrading the fish ladders. All but one of the diversions are unscreened.

Restoration of Butte Creek would allow the spring-run chinook salmon population to return to an annual spawning population of about 4,000.[32]

Deer Creek

Deer Creek is a major tributary to the Sacramento River originating on the slopes of Butte Mountain. The watershed drains 200 square miles and enters the Sacramento River about 1.5 miles north of Woodson Bridge State Park. During the last decade approximately 500 spring-run chinook salmon have

[30] Ibid., pg. VII-42

[31] Ibid

[32] Ibid., pg. VII-45

annually spawned in Deer Creek, however the creek could support a sustainable population of 4,000.[33]

Inadequate flow for upstream passage is the most significant problem on Deer Creek. During low flow periods, the fish ladder on the lower diversion dam does not pass fish. The water right permit for this diversion does not require adequate bypass flows to provide for fish passage. Recent state legislation would provide for statutory protection for this stream (AB 1413, Chapter 183, Statutes of1995), however unlike the nearby Mill Creek no agreement has been reached on an agreement to exchange groundwater for surface water to maintain adequate flows to the mouth of the stream. Such an agreement is necessary to protect migration and spawning.

Mill Creek

Mill Creek is also a major tributary of the Sacramento River, flowing from the southern slopes of Mt. Lassen and entering the Sacramento River one mile north of Tehama. The watershed drains an area of 134 square miles.

Spring-run chinook salmon have ranged from 3,500 to a low of zero. Recent populations have averaged around 390.[34] Mill Creek has a high silt load and turbidity during the spring snow melt period. Much silt originates from naturally occurring volcanic ash and glacial till in Lassen Volcanic Park. Additional silt enters Mill Creek from Lassen National Forest land due to timber harvest, road construction, and cattle grazing. Spawning areas in lower Mill Creek consist primarily of large cobble and boulders with very little spawning gravel. Spawning gravel does naturally recruit to the lower reaches of the stream but is either trapped behind diversion dams or is flushed from the stream.

A key element in restoring Mill Creek's anadromous fisheries is obtaining dependable flow in the lower stream reaches. Improving flows to allow unobstructed passage, removing barriers to migration. and protecting existing adult holding habitat can restore spring-run chinook salmon to historic levels.

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[33] Ibid., pg. VII-56

[34] Ibid., pg. VII-65

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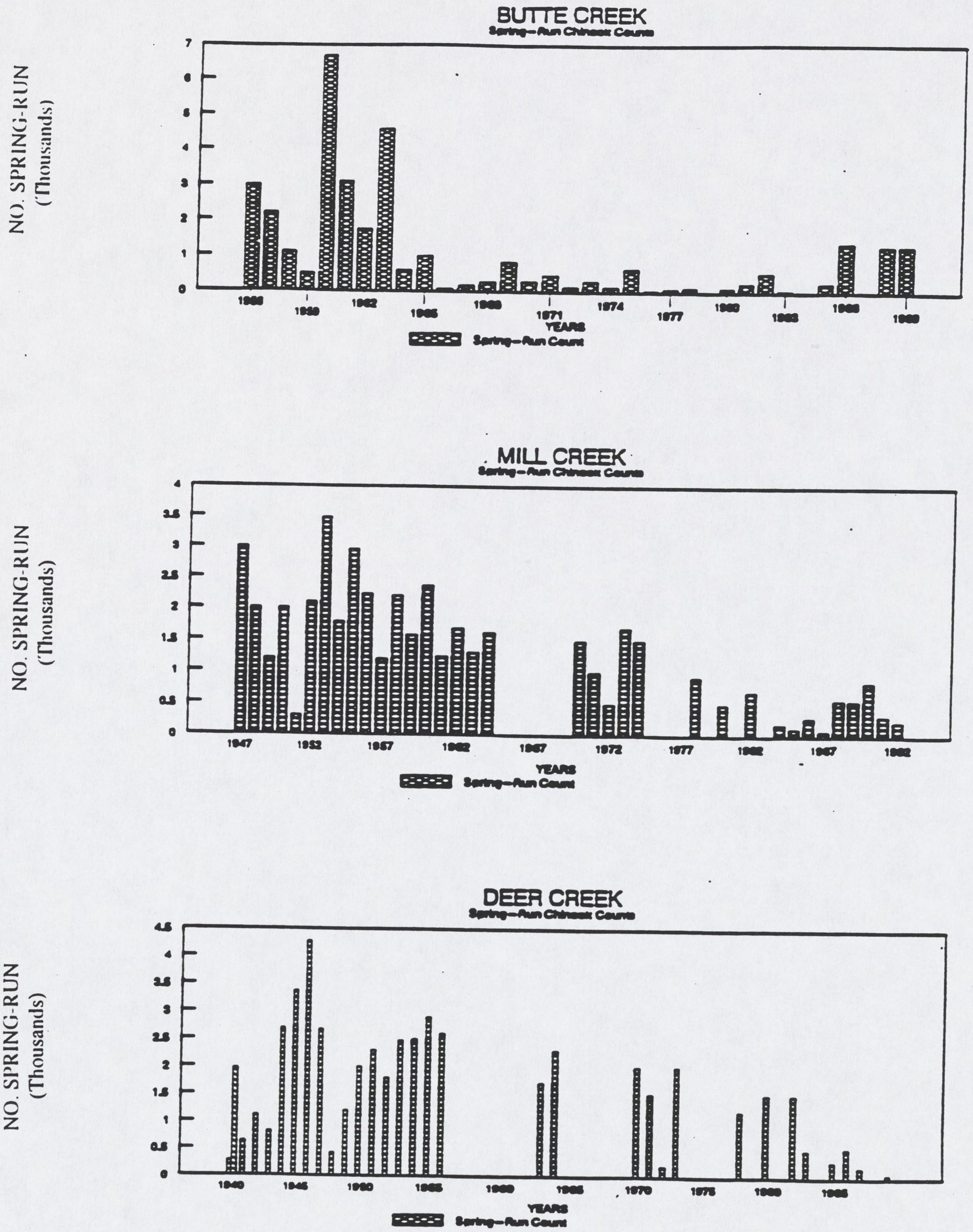
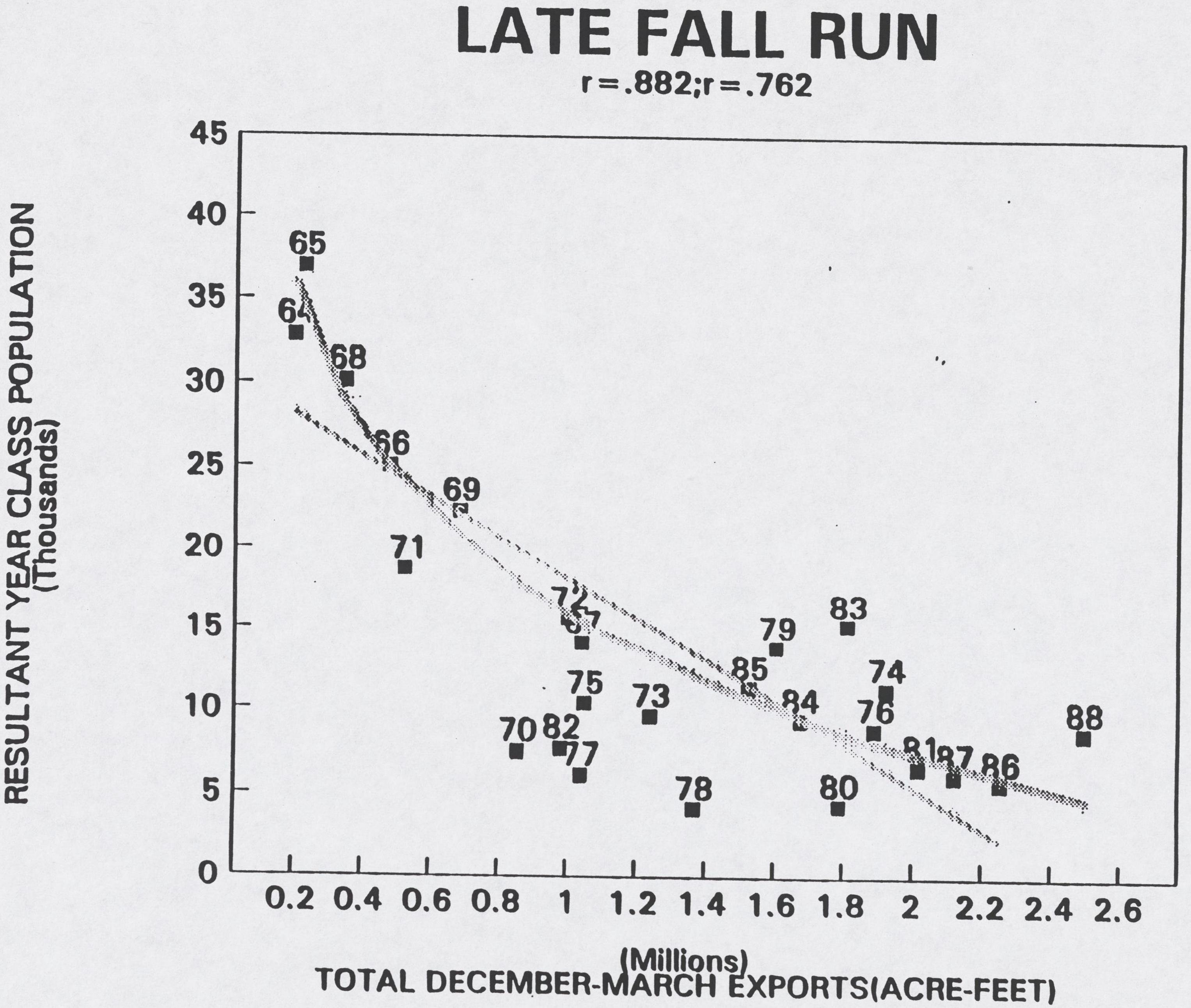
FIGURE 1



(Source: CDFG, Inland Fisheries Division (1994))

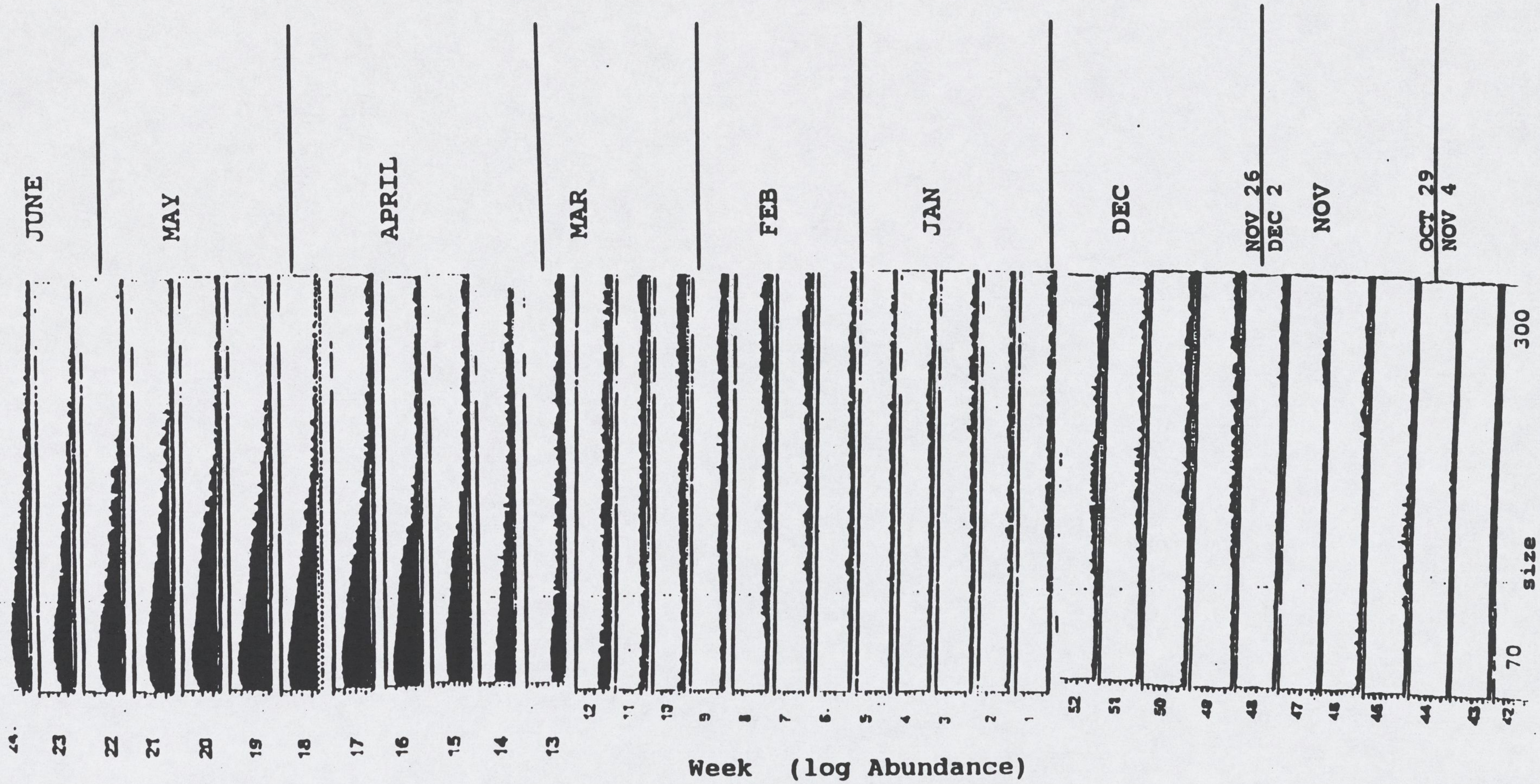
FIGURE 2



(Source: CDFG, Inland Fisheries Division)

FIGURE 3

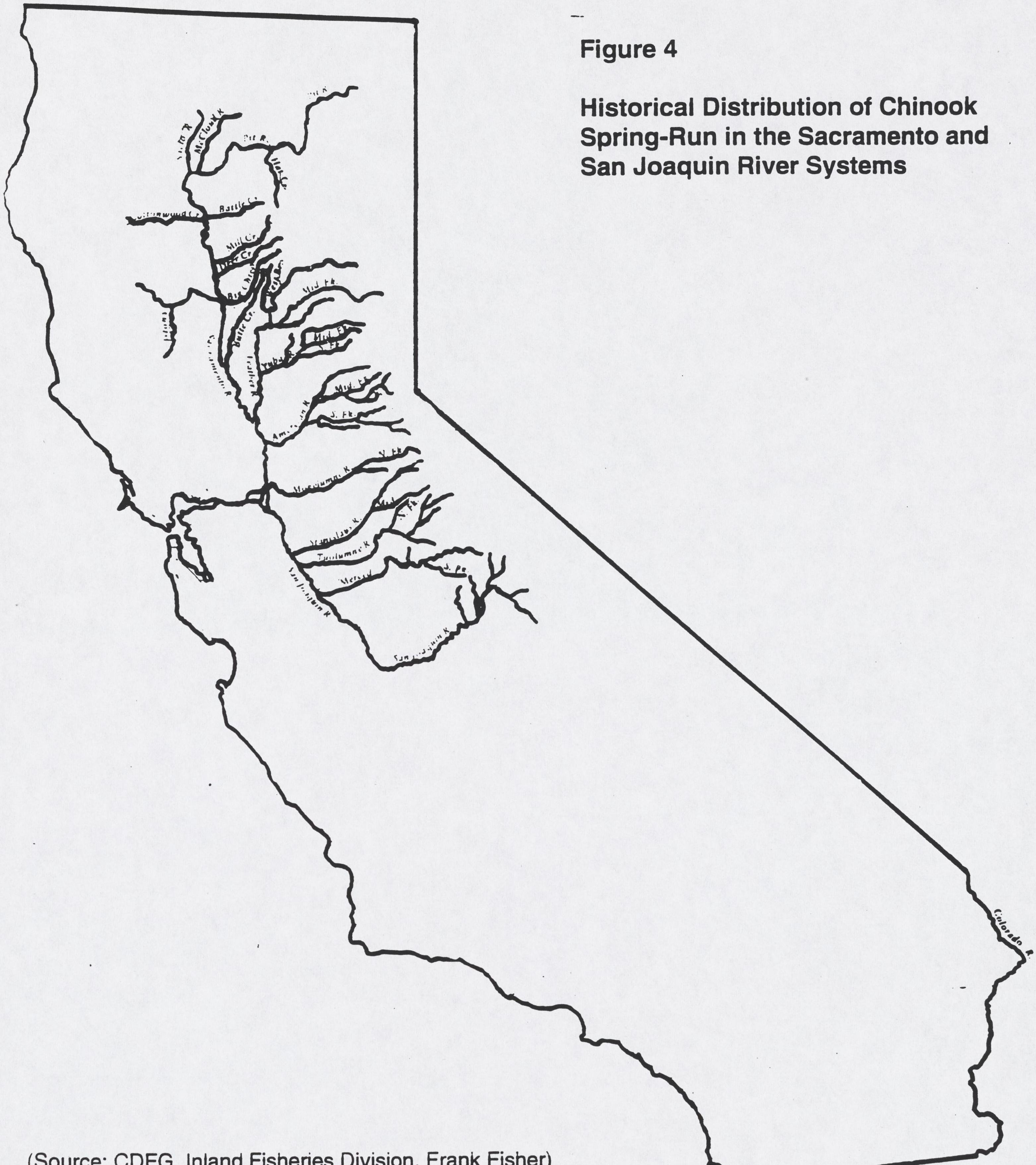
A series of graphs one for each week, between the end of October through June, depicting the log of abundance of juvenile salmon in the Delta (y axis) versus size (between 70mm to 300mm). Data was obtained from several sources, Sacramento trawl, Chipps Island trawl and Beach seine (1991-1993), Montezuma Slough and fyke nets at Sacramento (1992-1993), rotary screw trap in the cross channel and push net (throughout Delta, 1993), fish facility recoveries from the CVP and SWP between 1980 and March of 1994. Tagged fish were excluded with the exception of fish facility recoveries between 1980 and 1991.



(Source: U.S. Fish and Wildlife Service (1994))

Figure 4

Historical Distribution of Chinook Spring-Run in the Sacramento and San Joaquin River Systems

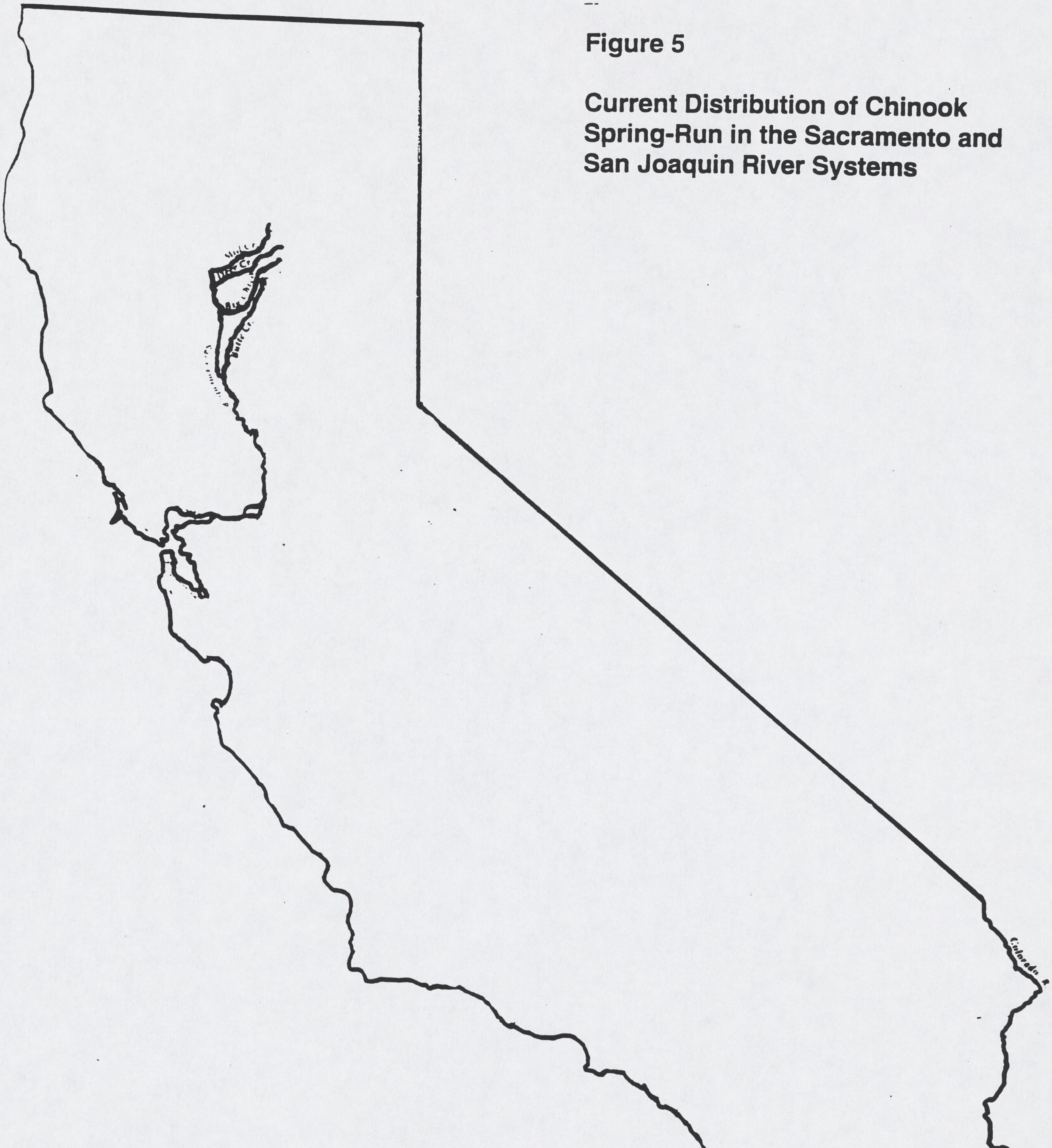


(Source: CDFG, Inland Fisheries Division, Frank Fisher)

Scale: 1:4.000.000

Figure 5

Current Distribution of Chinook Spring-Run in the Sacramento and San Joaquin River Systems



(Source: CDFG, Inland Fisheries Division, Frank Fisher)

Scale: 1:4.000.000

TABLE 1

Spring-Run Population Estimates

(Source: CDFG Inland Fisheries Division (1994))

Year	MillCreek	Deer Creek	Butte Creek
1940	-	268	-
1941	-	635	-
1942	-	1108	-
1943	-	812	-
1944	-	2692	-
1945	-	3363	-
1946	-	4272	-
1947	3000	2669	-
1948	2000	419	-
1949	1200	1200	-
1950	2000	2000	-
1951	300	2300	-
1952	2100	1800	-
1953	3485	2475	-
1954	1789	2500	-
1955	2967	2900	-
1956	2233	2600	3000
1957	1203	-	2192
1958	2212	-	1100
1959	1580	-	500
1960	2368	-	6700
1961	1245	-	3100
1962	1692	-	1750
1963	1315	1702	4600
1964	1628	2290	600
1965	-	-	1000
1966	-	-	80
1967	-	-	180
1968	-	-	280
1969	-	-	830
1970	1500	2000	285
1971	1000	1500	470
1972	500	200	150
1973	1700	2000	300
1974	-	-	150
1975	-	-	650
1976	-	-	46
1977	-	-	100
1978	-	-	128
1979	-	-	10
1980	-	-	119
1981	-	-	250
1982	-	-	534
1983	-	-	50
1984	191	-	23
1985	291	-	254
1986	-	543	1371
1987	90	200	14
1988	572	-	-
1989	563	77	-
1990	844	-	-
1991	319	449	-
1992	237	209	-
1993	73	259	-
1994	723	591	-
Yrs of Record	32	30	32

TABLE 2

Spring-Run Population Estimates
Red Bluff Diversion Dam
(Source: CDFG Inland Fisheries Division (1994))

Year	Spring-Run Counts
1967	23514
1968	14864
1969	26505
1970	3652
1971	5830
1972	7346
1973	7762
1974	3933
1975	10703
1976	25893
1977	13730
1978	5903
1979	2900
1980	9696
1981	21025
1982	23438
1983	3931
1984	8147
1985	10747
1986	16691
1987	11204
1988	9781
1989	5255
1990	3922
1991	773
1992	431
1993	388
Yrs of Record	27

Table 3

SUMMARY OF RECOMMENDATIONS

Delta Recommendations

1 Closure of the cross delta channel during the relevant time period from November 1 through January 31.

2 Limits on the maximum total state and federal water project exports from November 1 to January 31.

3 Eliminate net reverse flows in the southern delta from November 1 to January 31. Maintain positive flows at Jersey Point.

Tributary Recommentations

<u>Antelope Creek</u>

1 Provide and maintain adequate passage flows from October 1 through June 30. below the Edwards and Los Molinos Mutual Water Co. diversion dam.

2 Provide and maintain adequate migration flows and temperature to attract spring-run chinook at the confluence with the Sacramento river during migration periods.

<u>Battle Creek</u>

1 Modify operation of PG&E's projects to include screening of the diversions on the North and South Fork;

2 Increase releases from project diversions; and

3 discontinue practice of removing gravel accumulating at project diversions.

<u>Big Chico Creek</u>

1 Relocate the M&T diversion to the Sacramento River, and install fish screens.

2 Repair or rebuilt control structures at Five Mile Dam and Lindo Creek.

3 Inspect and repair existing fish ladders.

Table 3 (continued)

Butte Creek

1 Upgrade fish ladders and install fish screens at the 9 diversion dams on Butte Creek.

2 Restoration of creek habitat - provide adequate spawning gravel, and improve water quality.

Deer Creek

Provide and maintain adequate flows to the mouth of stream for upstream passage, by negotiating agreement to exchange ground water for surface water.

Mill Creek

1 Provide and maintain dependable flow in lower stream reaches.

2 Remove barriers to migration.

3 Restoration of creek habitat - provide adequate spawning gravel. and reduce silt load from upstream timber. road building and cattle grazing operations.

how would you give to workshop & COOW,

Genetic Techniques

I General Definitions
- A) Gene
- B) Locus
- C) Allele
- D) Allozyme
- E) Phenotype
- F) Genotype

II DNA Structure

III Transcription

IV Translation

V Molecular Genetic Methods

VI Sample Size 1

Sample Size 2

VII Protein Structure
- A) Primary
- B) Secondary
- C) Tertiary
  - 1) Monomer
  - 2) Dimer
  - 3) Tetramer

VIII Electrophoresis
- A) General Description
- B) Point Mutations
- C) One Polymorphic Locus
- D) One Polymorphic Locus and One Monomorphic Locus
- E) One Polymorphic Locus and One Monomorphic Locus
- F) Species Identification - Diagnostic Key
- G) Example of Findings using Protein Electrophoresis and Hybrid Index

IX Isoelectric Focusing

X SDS - PAGE

XI PCR

XII SSCP

XIII RAPD - See Additional Outline

XIV Mitochondrial DNA (mtDNA)
- A) Structure of mtDNA
- B) Restriction cut of mtDNA
- C) Run Gel
- D) Variant Pattern
- E) Quantitative Results

F) Example using Five Salmonid Species
   1) Fragment Patterns
   2) Phylogenetic Tree
   3) Phylogenetic Tree
G) Example using a Mixed Stock of Brown Trout

XV Minisatellite VNTR (Variable Number of Tandem Repeats)
   A) Minisatellite Variant Repeat (MVR) Mapping
   B) Minisatellite Variant Repeat (MVR) Mapping

XVI DNA Fingerprinting from VNTR Loci

XVII Sequencing

RAPD-PCR
Random Amplification of Polymorphic DNA PCR

I Amplification
- A) maximum distance is 2.5 to 3.0 kb
- B) 3' end of single 10 oligonucleotide primer face each other
- C) Random Primer sequence must be at least 60% GC rich
- D) Large number genomic regions can be amplified in a single PCR reaction

II Mutations that disrupt amplification
- A) Point mutation in annealing site (dominant marker)
- B) Inversion containing one annealing site (dominant marker)
- C) Insertion that increased distance between annealing sites beyond what can be extended by routine PCR (dominant marker)
- D) Deletion results in one strand being smaller than the other (codominant marker)

III Applications
- A) Identification of cryptic members of species complexes
- B) Identification of members of closely related species that can only be identified at a particular life stage
- C) Identification of very small specimens

IV Disadvantages
- A) Contamination
  - 1) Arbitrary primers are "universal". Any DNA that fulfills the amplification conditions will act as a template. Thus parasites, pathogens, phoretic organisms may produce fragments that will be visualized and mistaken for genetic variability in the target species.
  - 2) However contaminating DNA is of minor concern when target species are large because the target DNA will greatly exceed contaminating template in a routine DNA isolation.
  - 3) Similarly specific tissues can be used that are less likely to contain contaminating templates
- B) Replication of Results
  - 1) Extreme sensitivity to factors in PCR reaction (e.g., concentration of primers, magnesium, and nucleotides)
  - 2) Products can vary due to the quality and amount of template DNA. However this problem can be eliminated with primer concentrations $\geq 1\,\mu l$
  - 3) This reaction is very sensitive to temperature and ramp time during amplification. Reactions on different thermal cyclers will almost certainly vary. Avoid this problem by standardizing these conditions (e.g., compare patterns among reactions with identical templates but run on different days or in different laboratories).
- C) The majority of polymorphisms segregate as dominant markers. This means individuals with one dominant copy (heterozygous) or two

dominant copies (homozygous) cannot be discerned.
NOTE: Codominant markers RFLP , isozymes

D) Patterns are complex and require careful interpretation and statistical analysis
   1) Fragments may vary within species. So method used for comparison and identification of specimens must account for intraspecific variability.

V Overcoming Problems

A) A single primer is usually sufficient to distinguish even closely related species. It is not likely two species will have similar patterns for the same primer.
B) Choose a primer with little intraspecific variability - examine patterns from individuals collected from a number of different geographic regions in which you are going to carry out your study.
C) Select primers that produce simple patterns with few a consistently well amplified DNA fragments

VI Data Analysis

A) Interspecific - if follow rules above no need for statistical analysis
B) Intraspecific Analysis
   1) Create a data base of all known patterns for a species complex, standardized with ladders. Use discriminant analysis to identify the bands that provide maximum discrimination among species or populations.
   2) Cluster Analysis, such as RAPDPLOT, compares RAPD patterns of unknown individuals with known patterns and forms a dendogram.
      a) Cluster analysis is a useful tool because it simultaneously compares all interspecific and intraspecific patterns.

First Distance Measurement

      b) Distance is calculated in each pair-wise comparison using Nei and Li (1985) Similarity Index (S) where

$$S = 2N_{AB} / (N_A + N_B)$$

N_{AB} = number of fragments individual A and B have in common
N_A = number of fragments in individual A
N_B = number of fragments in individual B

Distance between A and B is simply 1 - S

NOTE: This measure is widely used in VNTR (Variable Number of Tandem Repeats) and Restriction Maps.

Second Distance Measurement

      c) Shared Absence or Presence of a Fragment
NOTE: Missing band (homozygote recessive) is more informative than the presence of a band (homozygote

dominant or heterozygote)

RAPDPLOT estimates the fraction of matches (M) where

$M = N_{AB} / N_T$

N_{AB} = Total number of matches between A and B (e.g., both missing band or both with band)

N_T = Total number of loci scored in the overall study.

If M = 1; Two individuals have identical patterns
If M = 0; Two individuals have different patterns

VII Dendograms

A) Use of dendograms is purely for discrimination of species NOT evolutionary relationships.

B) For use in systematic analysis you'd have to assume that fragments of equal mobility are evolutionarily homologous - ie derived from a common ancestral gene. But they are not necessarily homologous. For example different mutations at the primer site could interrupt annealing and match two evolutionarily non-homologous individuals. Similarly fragments of equal mobility are not necessarily homologous.

GENERAL DEFINITIONS

<u>GENE</u> - A segment of DNA involved in producing a polypeptide chain.

<u>LOCUS</u> - The position on a chromosome at which the gene for a particular trait resides; locus may be occupied by any one of the alleles for the gene. (plural <u>loci</u>)

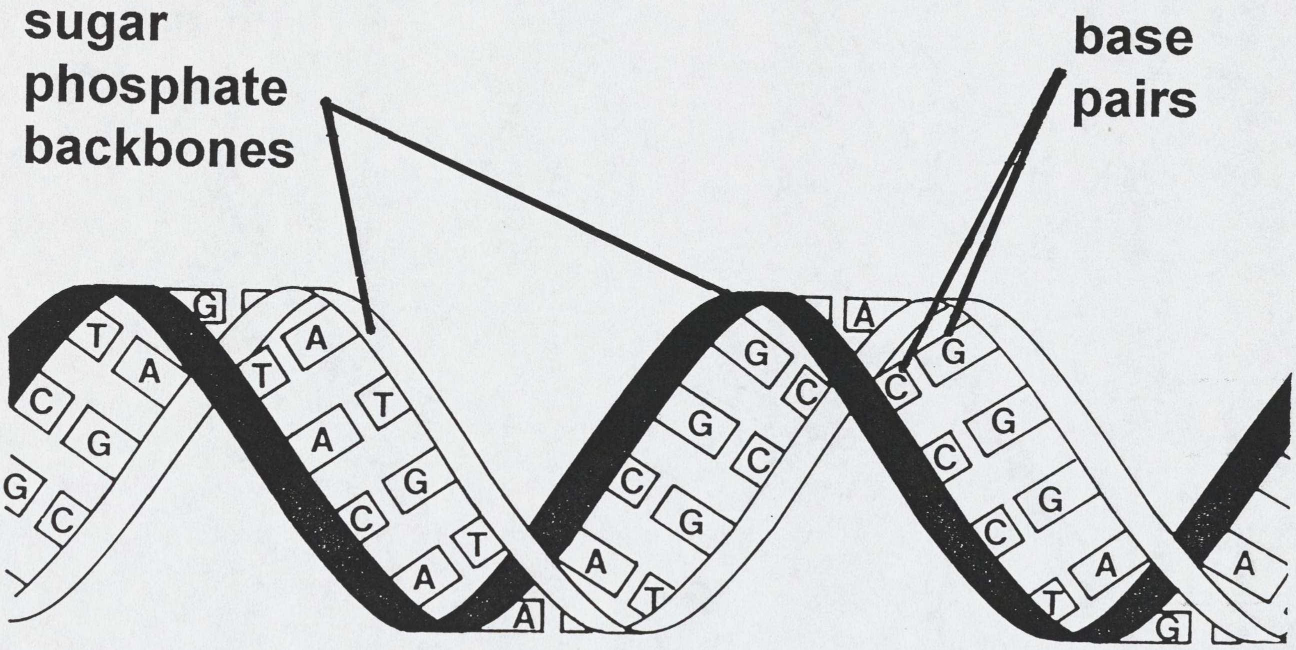
<u>ALLELE</u> - One of a series of possible alternative forms of a given gene, differing in DNA sequence and affecting the functioning of a single product (RNA and/or protein).

<u>ALLOZYMES</u> - Allelic forms of an enzyme that can be distinguished by electrophoresis,

<u>PHENOTYPE</u> - The observable properties of an organism, produced by the genotype in conjunction with the environment.

<u>GENOTYPE</u> - The genetic constitution of an organism.

DNA
Deoxyribonucleic Acid



Double Helix

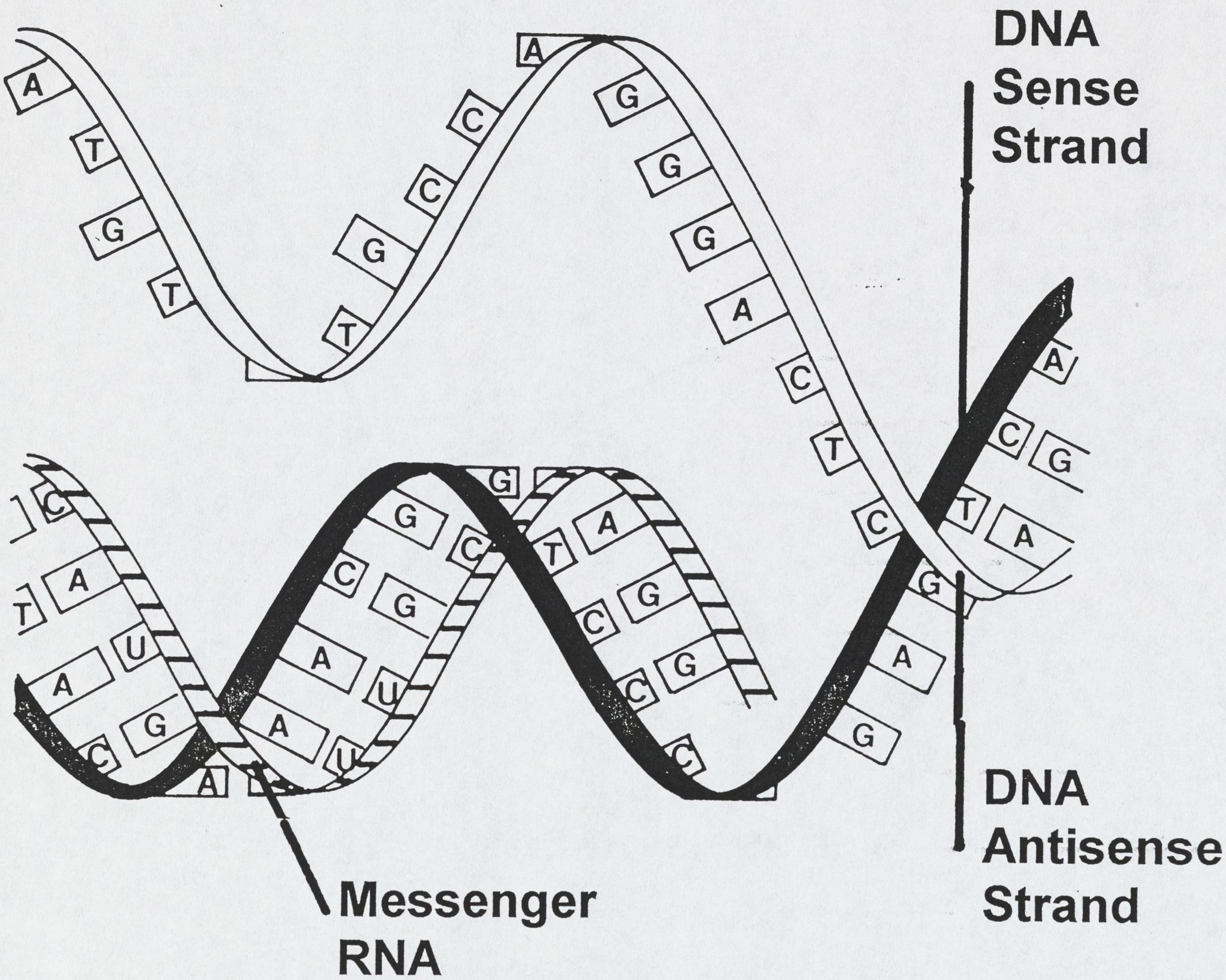
Purine Bases

A = Adenine
G = Guanine

Pyrimidine Bases

T = Thymine
C = Cytosine

TRANSCRIPTION



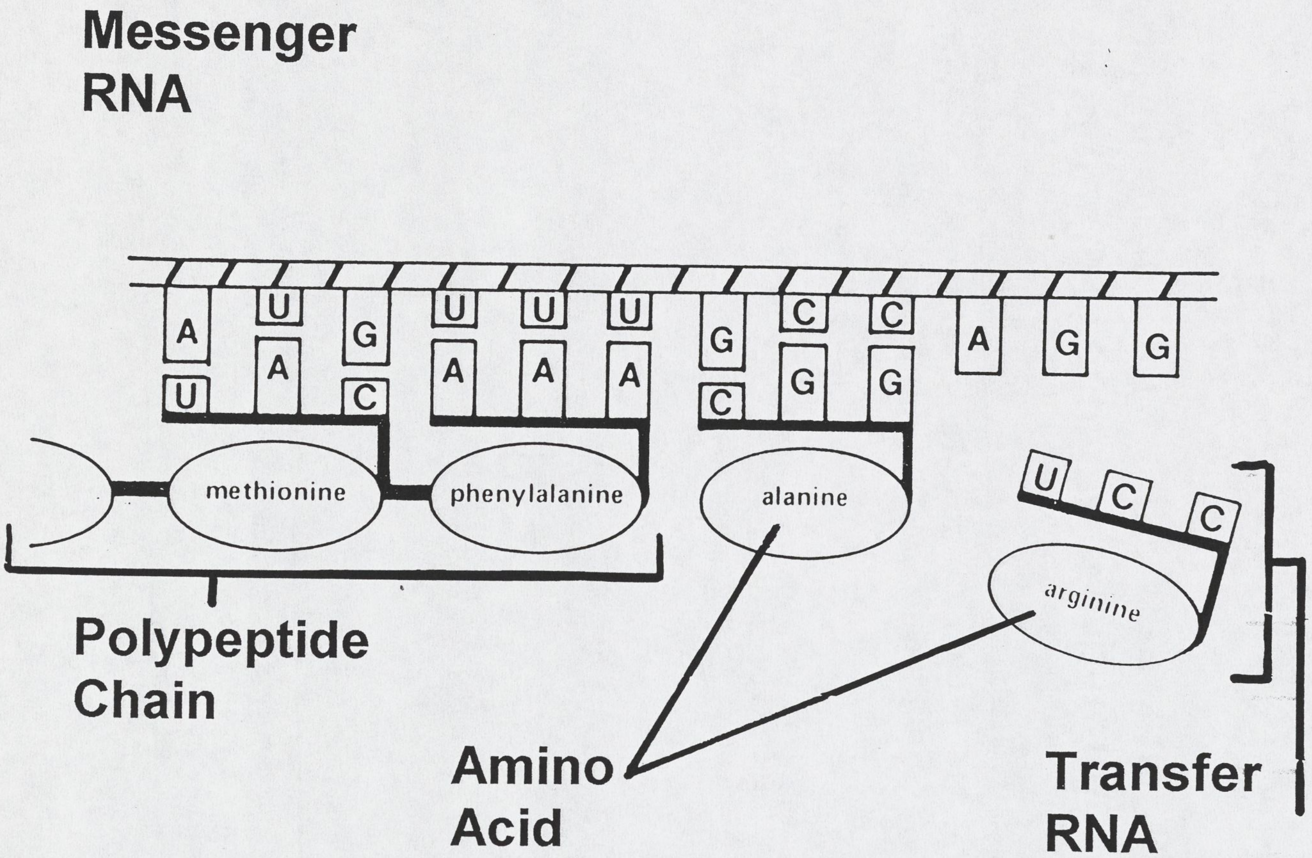
Purine Bases

A = Adenine
G = Guanine

Pyrimidine Bases

T = Thymine
C = Cytosine
U = Uracil

TRANSLATION



Purine Bases

A = Adenine
G = Guanine

Pyrimidine Bases

T = Thymine
C = Cytosine
U = Uracil

MOLECULAR GENETIC METHODS

Levels of evolutionary divergence at which various molecular genetic methods normally provide informative phylogenetic markers (modified from Hillis and Moritz 1990).

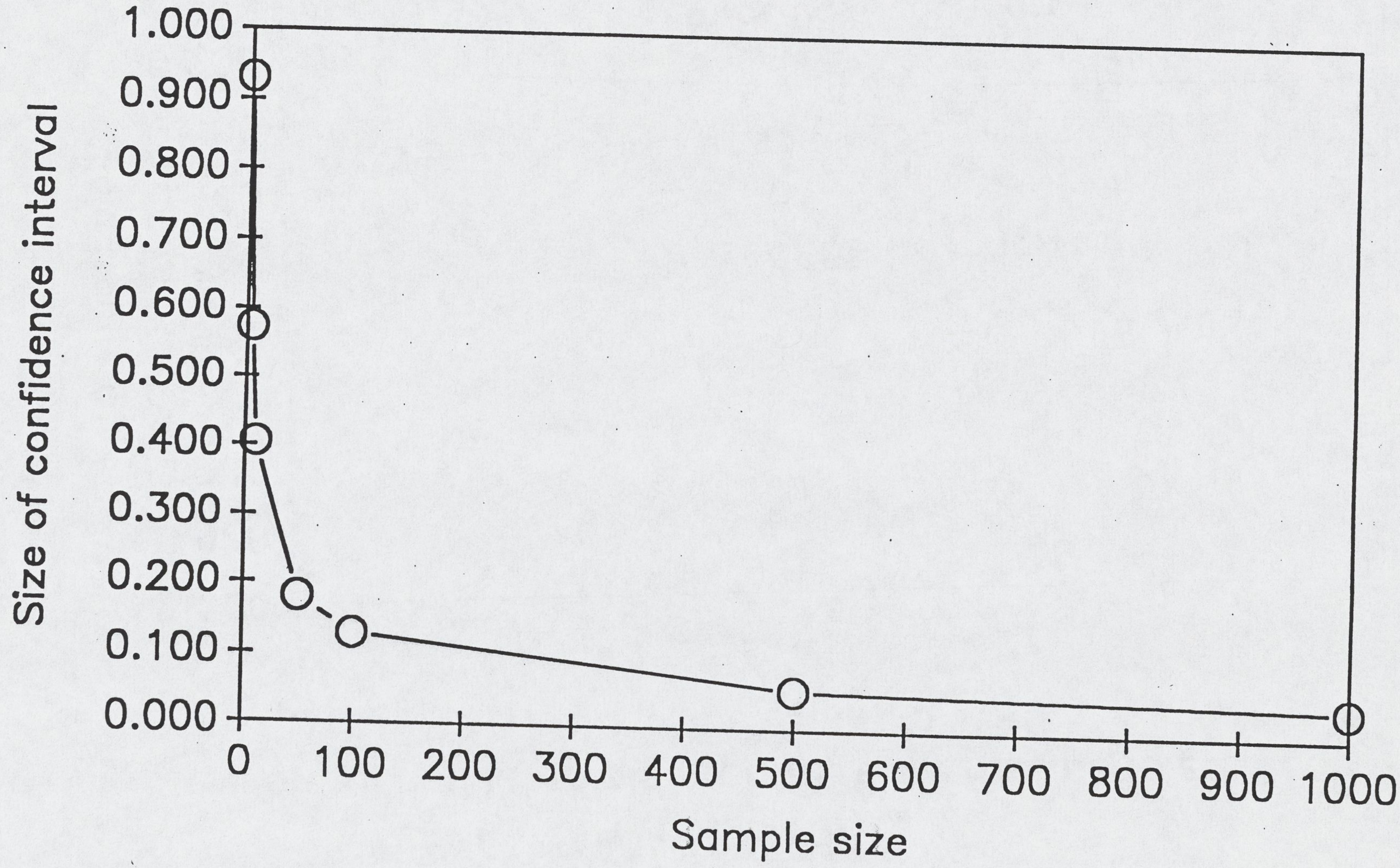
Box 4.2. Levels of Evolutionary Divergence at Which Various Molecular Genetic Methods Normally Provide Informative Phyogenetic Markers (Modified from Hillis and Moritz, 1990).

Hierarchical Level	Protein Immunology	Protein Electrophoresis	DNA–DNA Hybridization	RFLP Analyses of mtDNA	RFLP Analyses of scnDNA	RFLP Analyses of VNTR Loci	DNA Sequencing
Genetic identity/ nonidentity	—	*	—	*	*	**	*
Parentage	—	*	—	*	**	**	*
Conspecific populations	—	**	—	**	**	*	*
Closely related species	*	**	*	*	*	—	*
Intermediate taxonomic levels	**	*	**	—	—	—	**
Deep separations (>50 mya)	*	—	*	—	—	—	**

(**)—highly informative; (*)—marginally informative, but not an ideal approach for reasons of cost-ineffectiveness or other difficulties; (—)—inappropriate use of method. Not all categorizations are absolute. For example, some isozyme characters such as presence/absence of duplicate gene products can be useful at higher taxonomic levels.

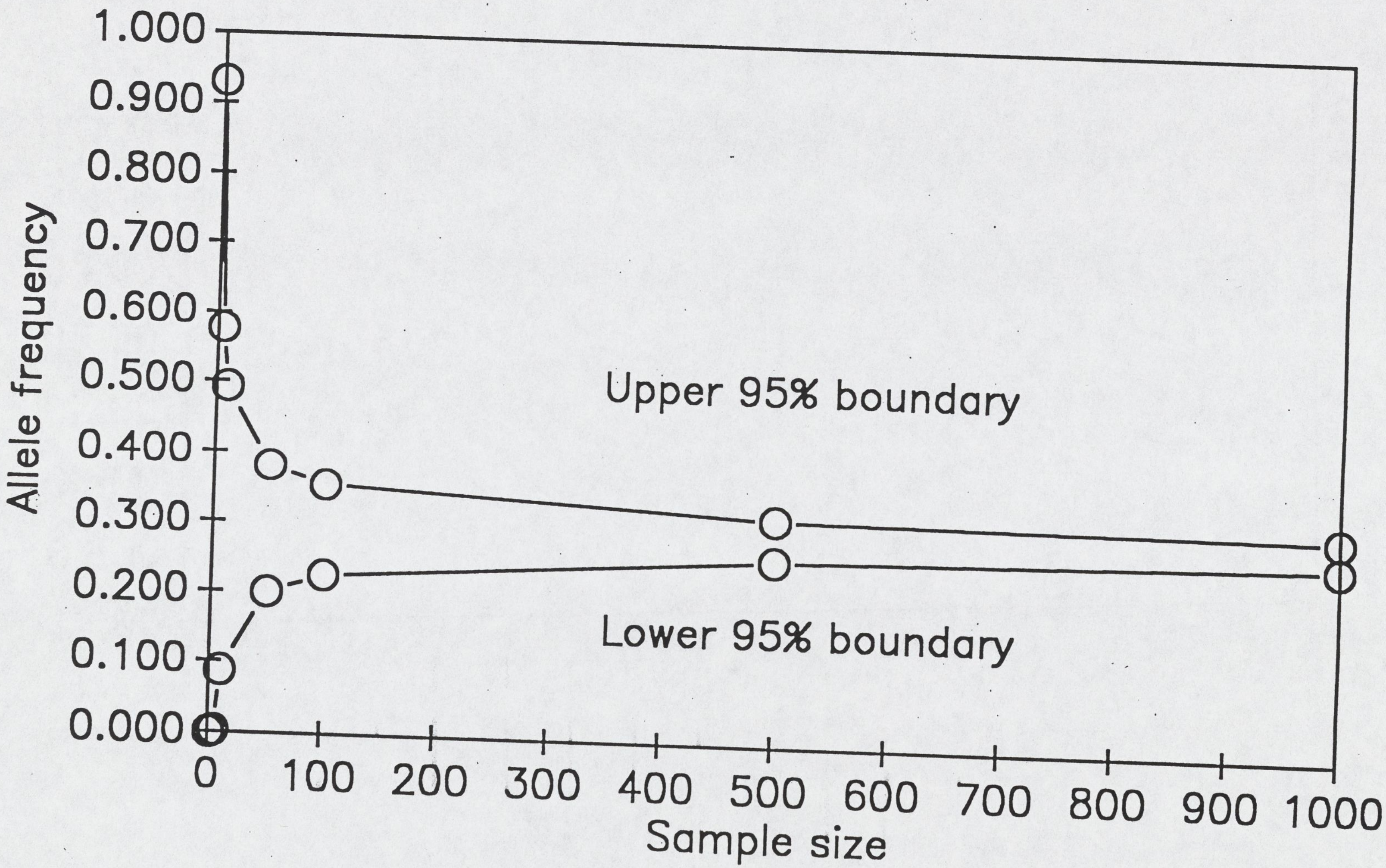
(Avise 1994)

SAMPLE SIZE


1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Size of confidence interval
0
100
200
300
400
500
600
700
800
900
1000
Sample size

SAMPLE SIZE

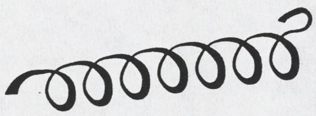
Confidence Intervals around Allele Frequencies as a Function of Sample Size



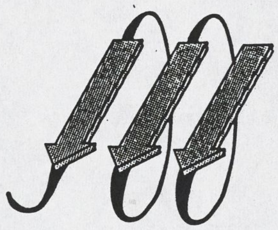
PROTEIN STRUCTURE

Primary Structure -Ala - Glu - Val - Thr - Asp - Pro -

Secondary Structure

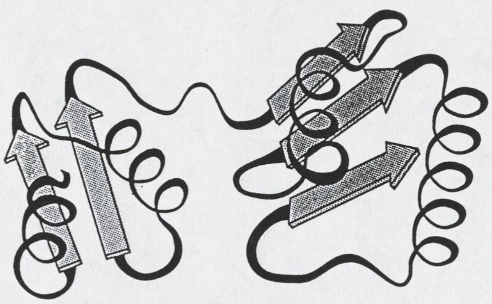


α Helix



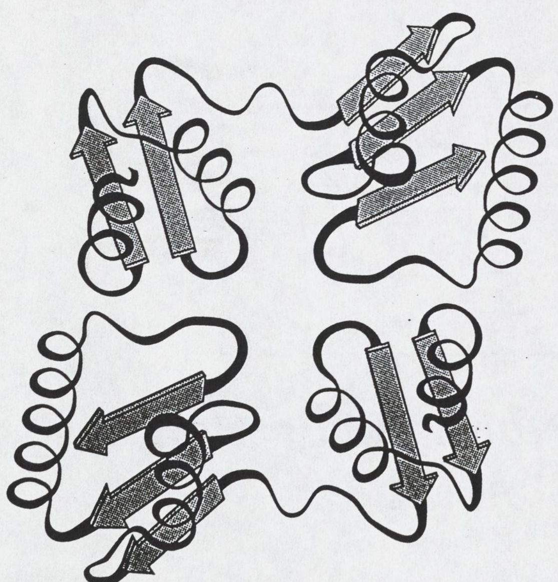
β Sheet

Tertiary Structure

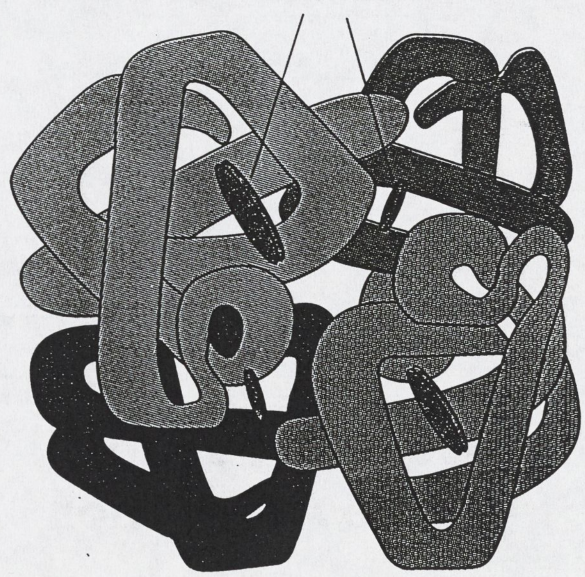


monomer

Quaternary Structure

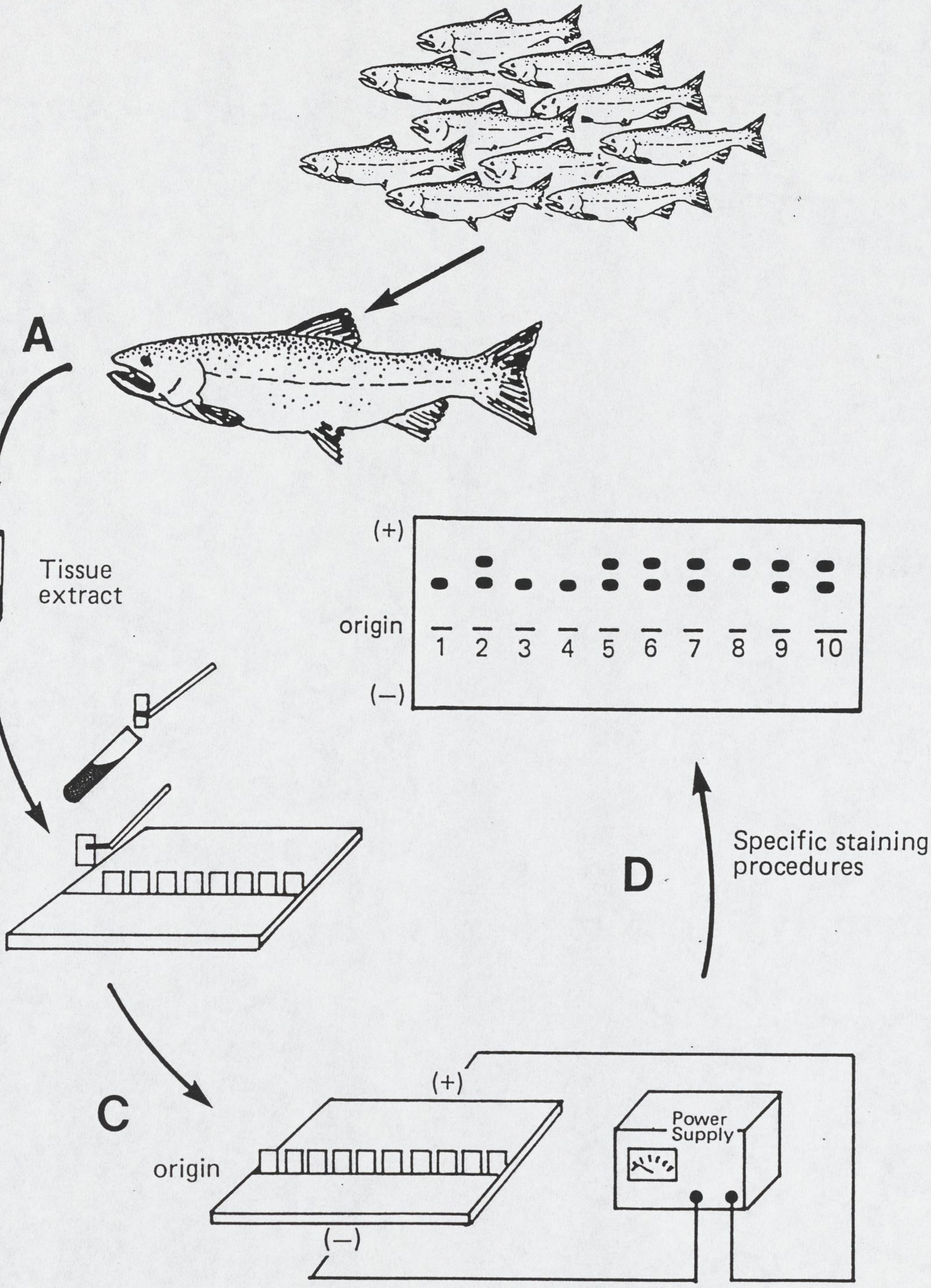


dimer



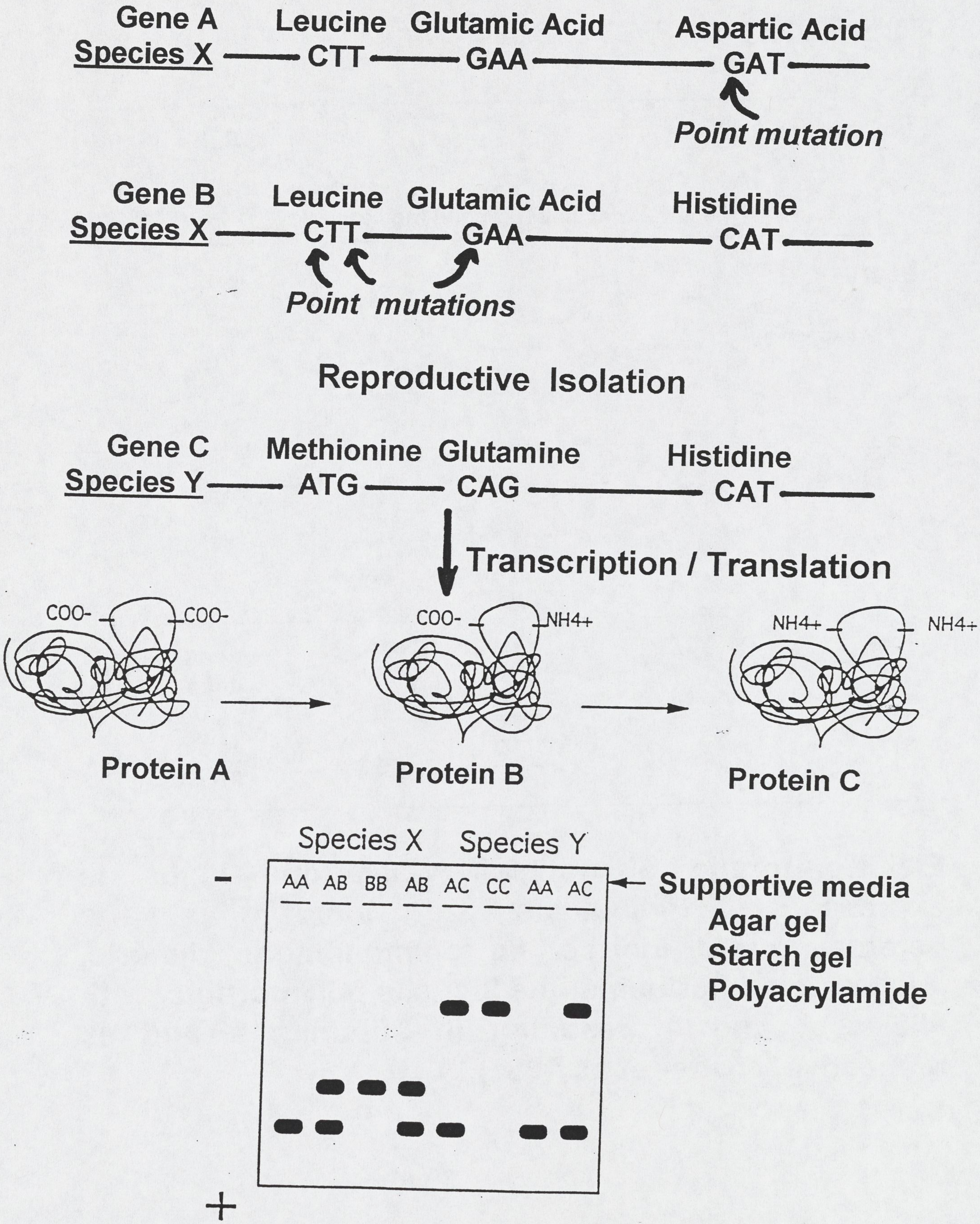
tetramer

ELECTROPHORESIS



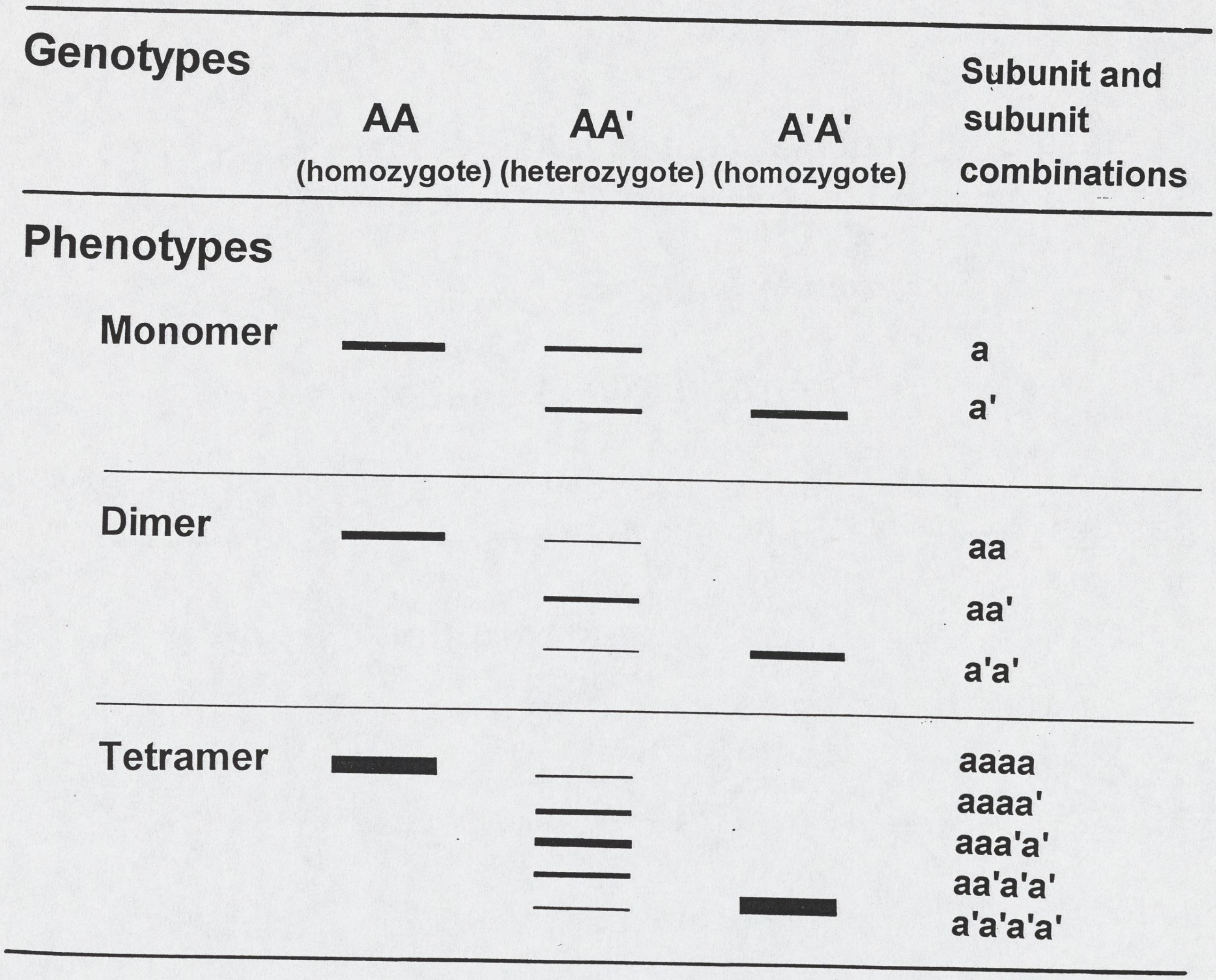
A) Tissue Extraction
B) Tissue Application
C) Protein Migration
D) Staining

PROTEIN ELECTROPHORESIS



ELECTROPHORESIS

ONE POLYMORPHIC LOCUS



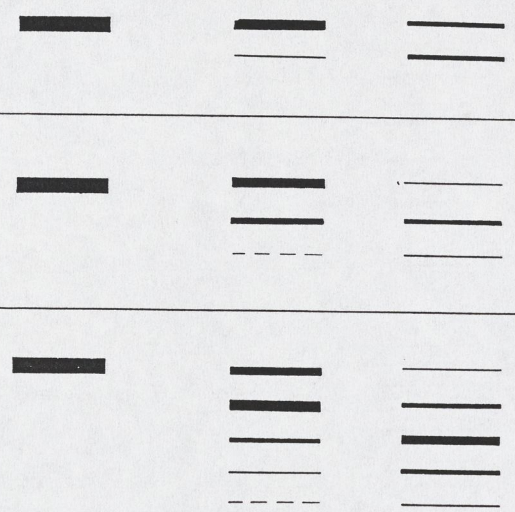
Elelctrophoretic phenotypes when one locus is expressed. Individuals are homozygous and heterozygous at loci coding for monomeric, dimeric, and tetrameric proteins: the locus is polymorphic, with alleles A and A' resulting in subunits a and a', respectively (Utter et al. 1987).

ELECTROPHORESIS

Consideration of Isoloci

One Polymorphic Locus and One Monomorphic Locus

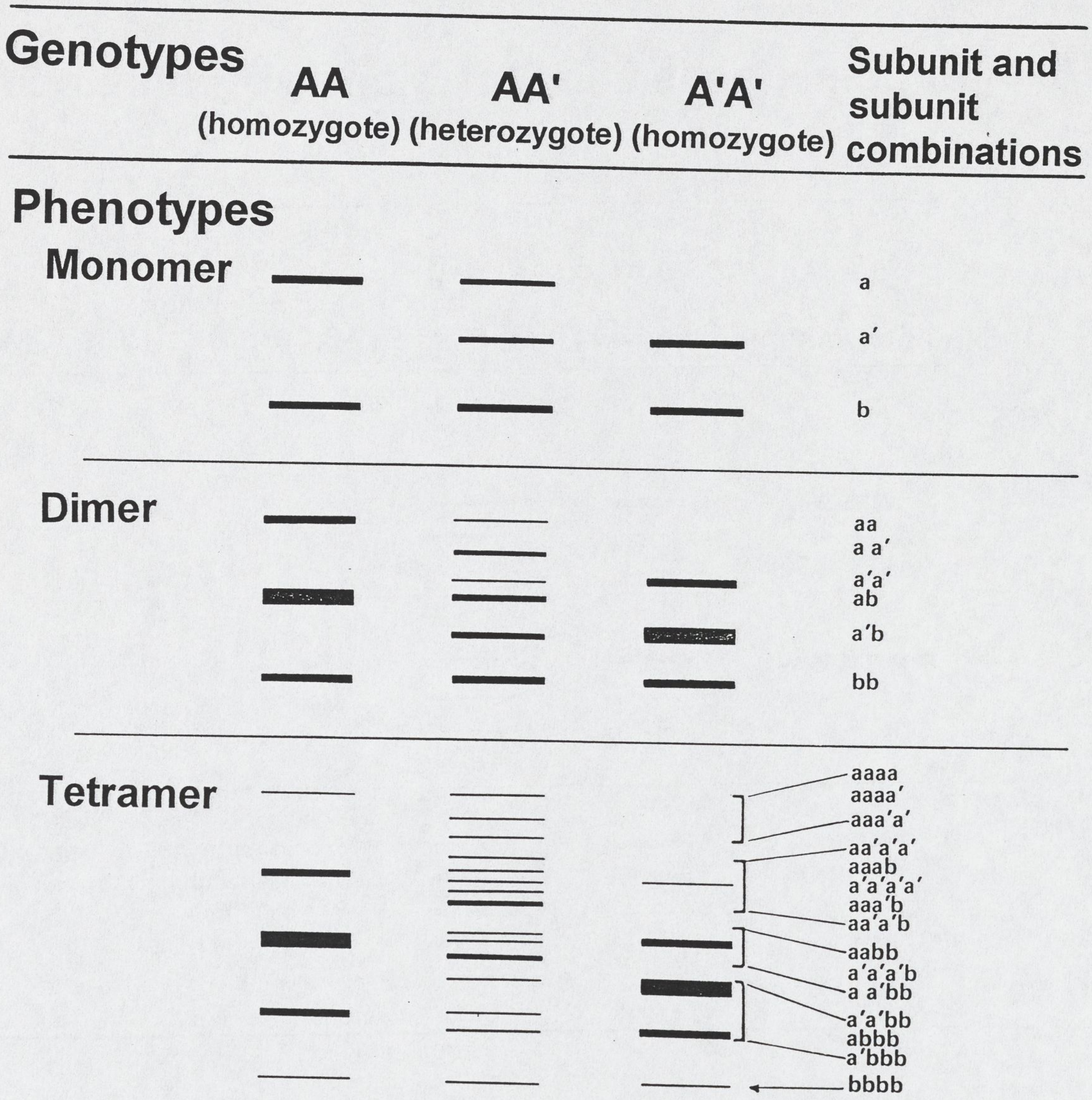
Genotypes	AA (homozygote)	AA' (heterozygote)	A'A' (homozygote)	Subunit and subunit combinations
Phenotypes				
Monomer				a, b a′
Dimer				aa, ab, bb aa′, a′b a′a′
Tetramer				aaaa, bbbb, aaab, aabb, abbb aaaa′, a′bbb, aaa′b, aa′bb aaa′a′, aa′a′b, a′a′bb aa′a′a′, a′a′a′b a′a′a′a′



Elelctrophoretic phenotypes when isoloci are expressed. Individuals are homozygous and heterozygous at loci coding for monomeric, dimeric, and tetrameric proteins: one locus is polymorphic, (with alleles A and A' resulting in subunits a and a', respectively); and a second is monomorphic, coding for a subunit (b) with an electrophoretic mobility identical to that of subunit (a) (Utter et al. 1987).

ELECTROPHORESIS

One Polymorphic Locus and One Monomorphic Locus



Elelctrophoretic phenotypes when two loci are expressed. Individuals are homozygous and heterozygous at loci coding for monomeric, dimeric, and tetrameric proteins: one locus is polymorphic, (with alleles A and A' resulting in subunits a and a', respectively); and a second is monomorphic, coding for a subunit (b) with an electrophoretic mobility that differs from subunits a and a' (Utter et al. 1987).

SPECIES IDENTIFICATION

Diagnostic allozyme loci (A) and dichotomous biochemical key (B) to four sibling species in the *Anopheles quadrimaculatus* complex of mosquito species.

A. Diagnostic Loci for Species Pairs

A:B	A:C	A:D	B:C	B:D	C:D
Idh-1	*Acon-1*	*Acon-1*	*Acon-1*	*Acon-1*	*Got-1*
Idh-2	*Idh-2*	*Idh-2*	*Idh-1*	*Idh-1*	*Had-1*
Est-2	*Had-1*	*Got-1*	*Had-1*	*Got-1*	*Had-3*
Est-5	*Had-3*	*Got-2*	*Had-3*	*Got-2*	*Pep-4*
Est-7	*Pep-2*	*Pep-2*	*Got-2*	*Pep-2*	*Pgi-1*
Had-1	*Got-2*	*Pep-4*	*Pep-2*	*Pep-4*	*Me-1*
6Pgd-1	*Pgi-1*	*Me-1*	*Pgi-1*	*Me-1*	*Est-2*
	Est-2	*Mpi-1*	*Est-4*	*Est-2*	*Mpi-1*
	Est-6		*Est-5*	*Est-7*	
	Mpi-1		*Est-6*	*Mpi-1*	
	6Pgd-1		*Est-7*		
	Xdh-3		*Mpi-1*		
	Ao-1		*Xdh-3*		

B. Biochemical Key

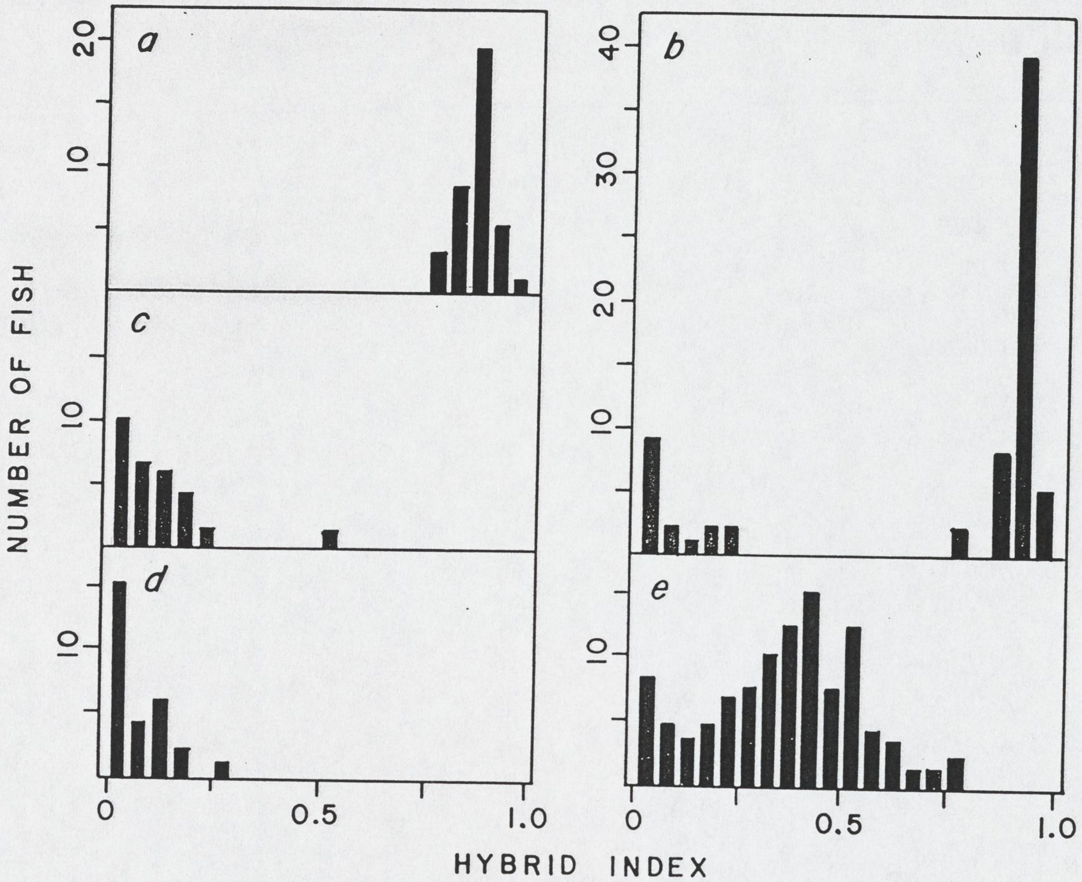
1. *Mpi-1* slow (62 allele, rarely with 52 as heterozygote) . . . . species D
   Mpi-1 faster (78 or greater) . . . . go to 2
2. *Idh-1* slow (86) and *Idh-2* fast (162) . . . . species B
   Idh-1 faster (≥ 100, sometimes with 86 as heterozygote);
   Idh-2 fast or slower (100, 132, 162) . . . . go to 3
3. *Had-3* slow (45); *Pgi-1* slow (95) . . . . species C
   Had-3 faster (100, sometimes with 45 as heterozygote);
   Pgi-1 faster (100, rarely with 95 as heterozygote) . . . . species A

[a]The diagnostic loci provide correct identification with probability greater than 99%. In the key shown (one of many that could be generated), the numbers indicate electromorph mobilities relative to a standard strain.

Source: After Narang et al. (1989b).

Hybrid Index Scores

for Two Sympatric Species of Trout



Hybrid index scores for two sympatric species of trout, steelhead trout and coastal cutthroat trout, and their suspected hybrid descendants from three sample sites within a small stream. Individuals with values of the index close to 1.0 or 0.0 expressed composite electrophoretic phenotypes that have a high relative probability of occurring in *O. mykiss* or *O. clarki clarki*, respectively. (a) Site 1, age 0+ fish (*mykiss* only); (b) site 2, age 0+ fish (*clarki* and *mykiss*, no hybrids); (c) site 2, age 1+ fish (*clarki* and 1 unknown or hybrid fish); (d) site 3, age 1+ fish (*clarki* only); (e) site 3, age 0+ fish (*clarki* + a large number of suspected hybrids). Campton and Utter (1985)

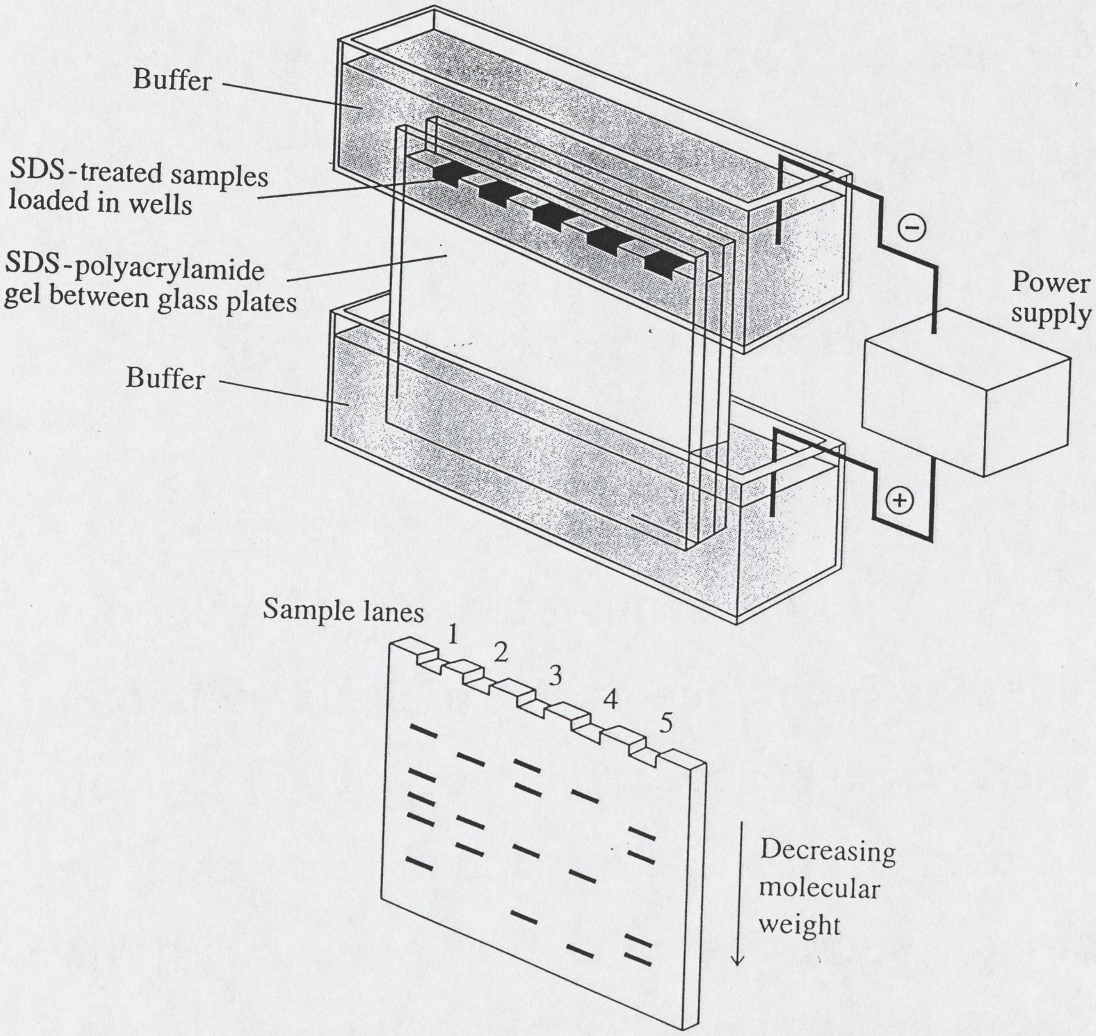
ISOELECTRIC FOCUSING

When protein samples are electrophoresed in a polyacrylamide gel containing a pH gradient each protein will migrate to a point in the pH gradient at which it is no longer charged. in other words each protein will band at its isoelectric point (pI).

<u>ISOZYMES</u> - An isomer of an enzyme. <u>Isomers</u> are compounds with the same molecular formula but with different three-dimensional molecular shapes or orientations in space. While isozymes of a given enzyme catalyze the same reaction, they differ in properties such as the pH or substrate concentration at which they function best. Isozymes often have different isoelectric points and therefore can be separated by electrophoresis.

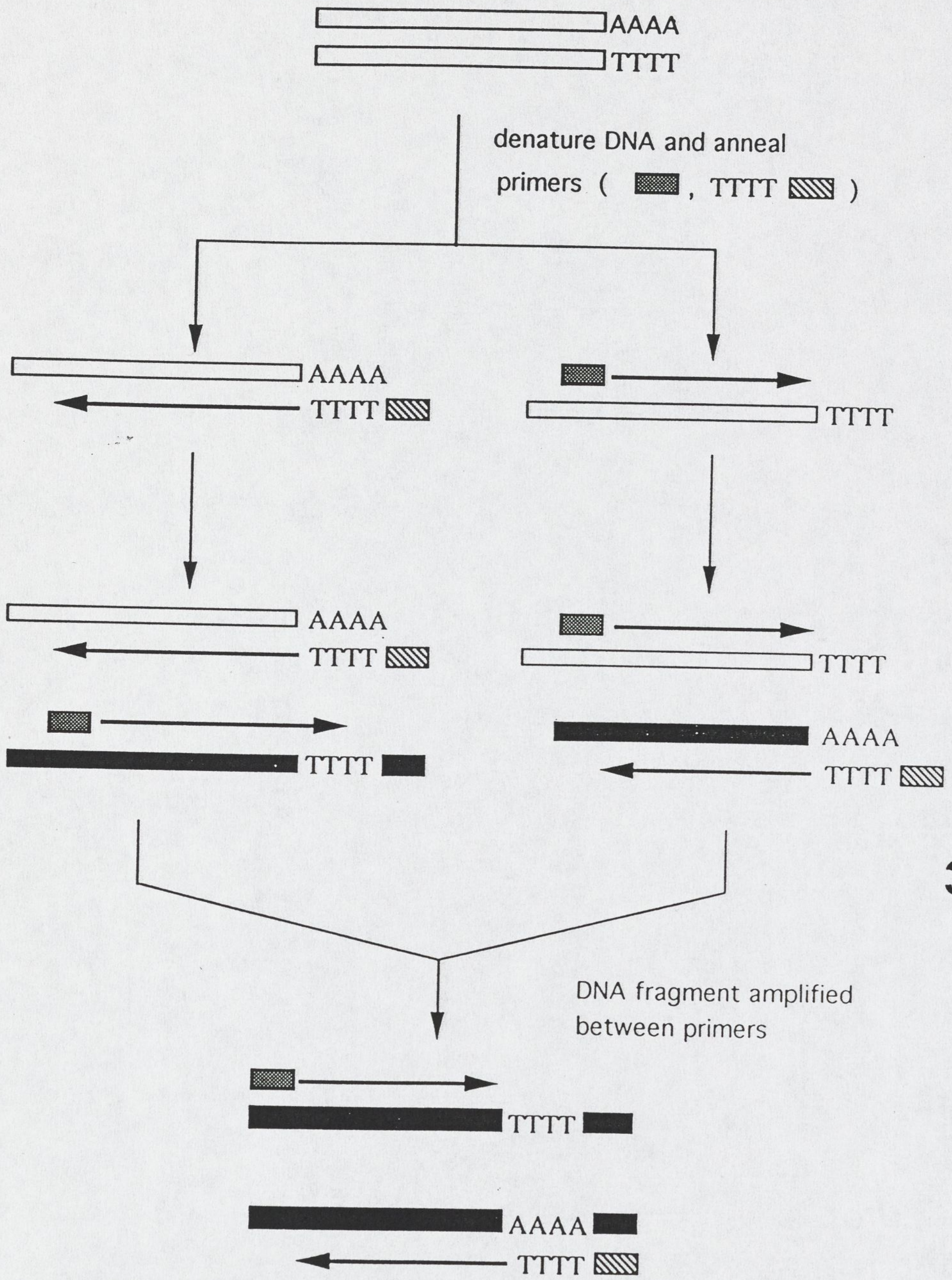
SDS - PAGE

Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis



Samples are treated with SDS and loaded into the wells. Since proteins complexed with SDS are negatively charged they migrate toward the anode. Proteins of the lowest molecular weight (smallest size) migrate the fastest and are at the bottom of the gel (Horton et al. 1993).

POLYMERASE CHAIN REACTION (PCR)



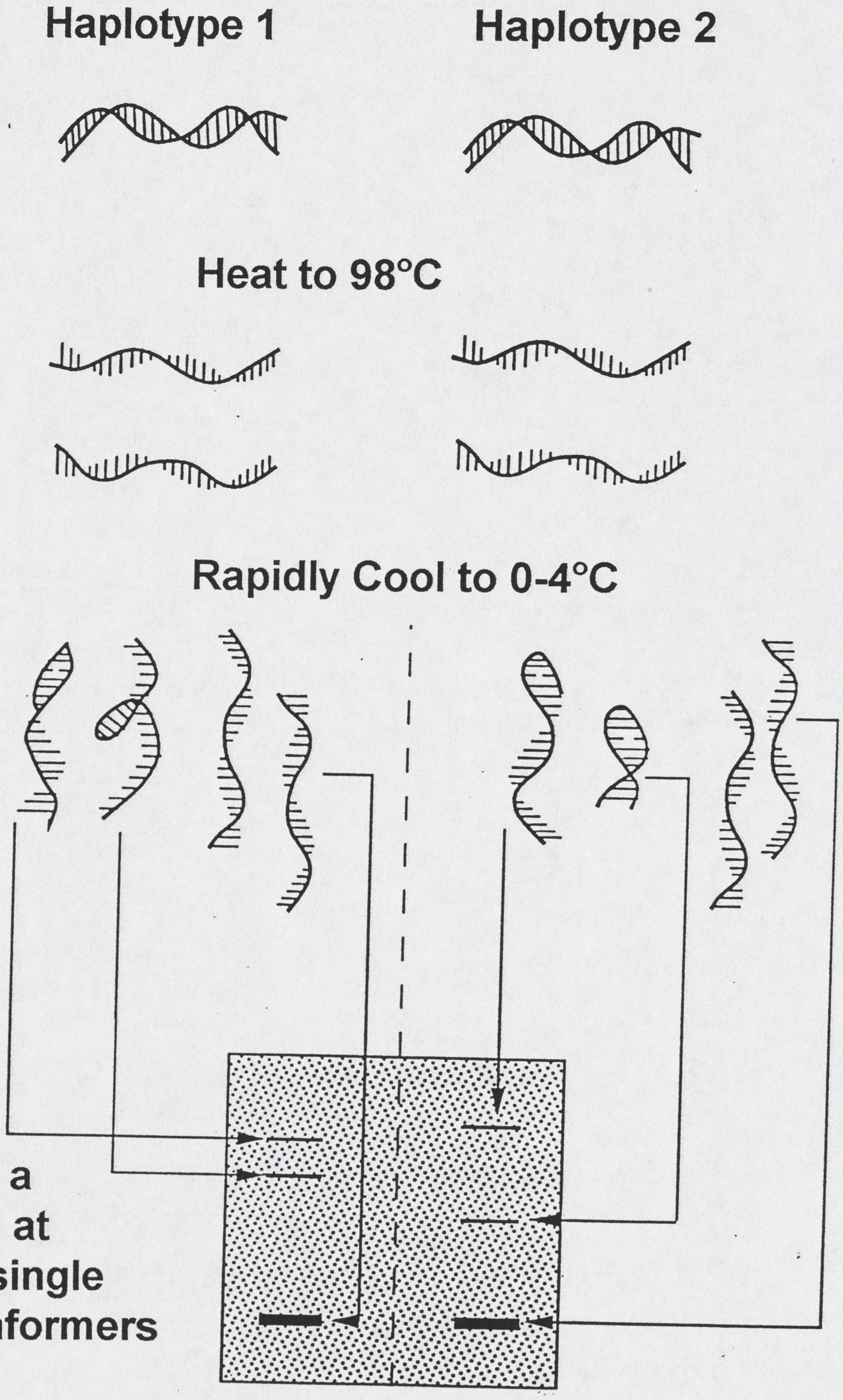
Three Major Steps

1) Denature DNA
2) Anneal Primers

3) Amplify DNA Fragment

A schematic diagram of the polymerase chain reaction (PCR) showing the sense and antisense (oligo dT) primers used to amplify a fragment of DNA. The black boxes represent newly amplified DNA (Sherwood and Parker 1993).

SSCP
Single Strand Conformation Polymorphism



Double Stranded PCR Product

Double Strands Melted to Single Strands

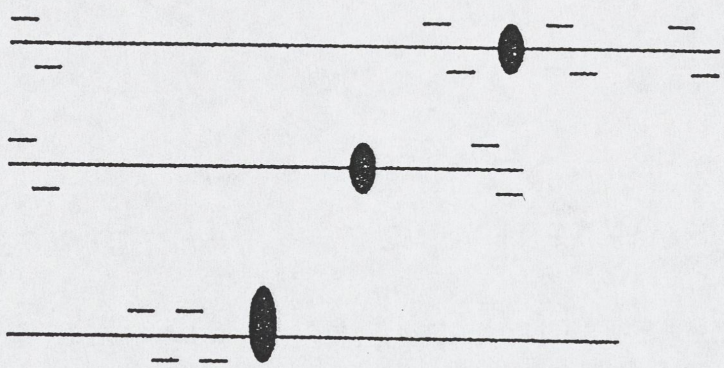
Single Strands Reanneal to Form:
1) Stable single strand conformations with intra-strand base pairing
2) One or more conformations between complementary strands

Chilled products loaded on a non-denaturing gel and run at low amperage to maintain single strand conformations. Conformers migrate at a rate inversely proportional to their impedance in the gel.

RAPD - PCR
Random Amplified Polymorphic DNA by the Polymerase Chain Reaction

STEP 1. PRIMER ANNEALING

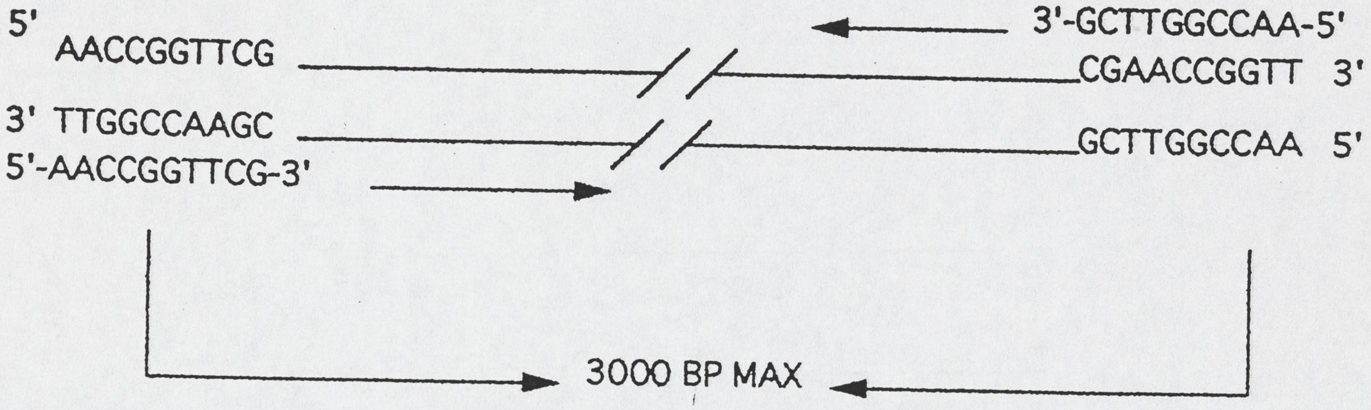
CHROMOSOMES (2N = 6)



A 10bp primer anneals to complementary regions of the genome.

RAPD - PCR
Random Amplified Polymorphic DNA by the Polymerase Chain Reaction

STEP 2. PRIMER EXTENSION



THESE ENDS OF THE AMPLIFIED FRAGMENT ARE *INVERTED REPEATS*

INVERTED REPEAT DNA SEQUENCES ARE FOUND IN:

A) HETEROCHROMATIC REGIONS
   TELOMERES
   CENTROMERES

B) THE ENDS OF TRANSPOSABLE ELEMENTS

AMPLIFIED REGIONS ARE NOT RANDOMLY LOCATED

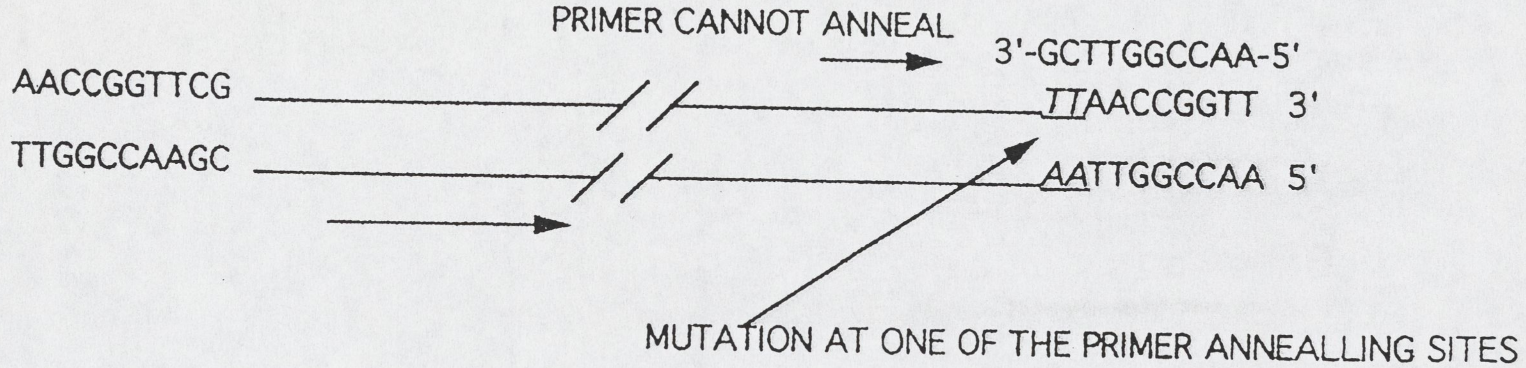
STEP 3. AMPLIFICATION BY PCR

POLYMORPHISMS REVEALED BY RAPD - PCR

Mutations at or Surrounding Primer Annealing Sites

Point Mutations

- No amplification on one strand = segregates as a dominant marker



Inversion of Either Primer Annealing Site

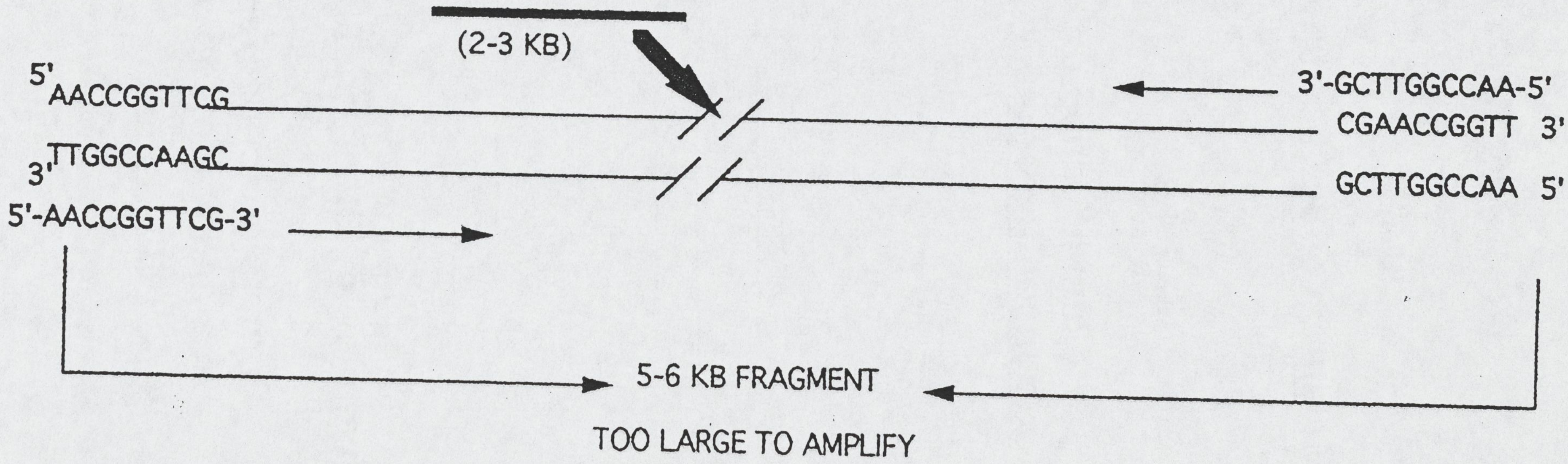
- Primers no longer face one another
- No amplification on one strand = segregates as a dominant marker

POLYMORPHISMS REVEALED BY RAPD - PCR

Mutations within Amplified Regions

Insertion of Large (2 - 3KB) Fragment

- No amplification on one strand = segregates as a dominant marker

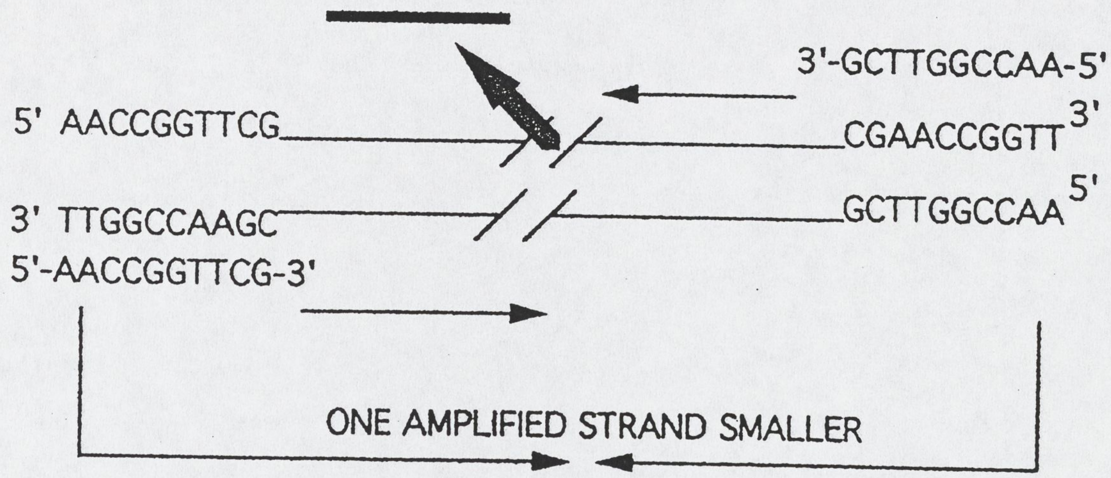


POLYMORPHISMS REVEALED BY RAPD - PCR

Mutations within Amplified Regions

Deletion of Internal Region

- One strand is smaller than the other = segregates as a codominant marker



ANALYSIS OF RAPD - PCR DATA

Nearest neighbor classification of known individual mosquitoes into populations based on presence/absence of 16 RAPD fragments amplified with primers A2, B3, and B13. */ Ten individuals from each population were tested. Individuals with unclassifiable band patterns were classified as other (Black, CSU).

	PERCENT CLASSIFIED INTO POPULATION*/											
FROM	OG	S2	S3	S4	AG	IG	EN	RX	SA	V6	TN	OTHER
OG	90	0	0	0	0	0	0	0	0	0	0	10
S2	0	90	0	0	0	0	0	0	0	0	0	10
S3	0	0	80	0	0	0	0	0	0	0	0	20
S4	0	0	0	100	0	0	0	0	0	0	0	0
AG	0	0	0	0	90	0	0	0	0	0	0	10
IG	0	0	0	0	0	90	0	0	0	0	0	10
EN	0	0	0	0	0	0	100	0	0	0	0	0
RX	0	0	0	0	0	0	0	100	0	0	0	0
SA	0	0	0	0	0	0	0	0	70	0	0	30
V6	0	0	0	0	0	0	0	0	0	100	0	0
TN	0	0	0	0	0	0	0	0	0	0	70	30

Discriminant analysis is performed on all offspring using the k-nearest neighbor measure, PROC NEIGHBOR (SAS, 1991). This method is nonparametric. Canonical discriminant analysis assumes a multivariate normal distribution for the data. This assumption is clearly violated by the discontinuous measure of bands (0 or 1) employed in RAPD-PCR studies. This analysis is only used to identify the bands that provide maximum discrimination among species or populations. It would not be of use in field situations.

ANALYSIS OF RAPD-PCR DATA

Through cluster analysis an existing presence/absence dataset can place or identify "unknown" specimens within an existing group. This analysis identifies the fraction of matches (M) between pairs of individuals a and b through a program RAPDPLOT written by Dr. Bill Black, CSU.

M is calculated among all pairs of individuals in the analysis using the formula:

$$M = N_{ab}/N_T$$

N_{ab} is the total number of matches (both bands absent or present) in individuals a and b
N_T is the total number of fragments scored

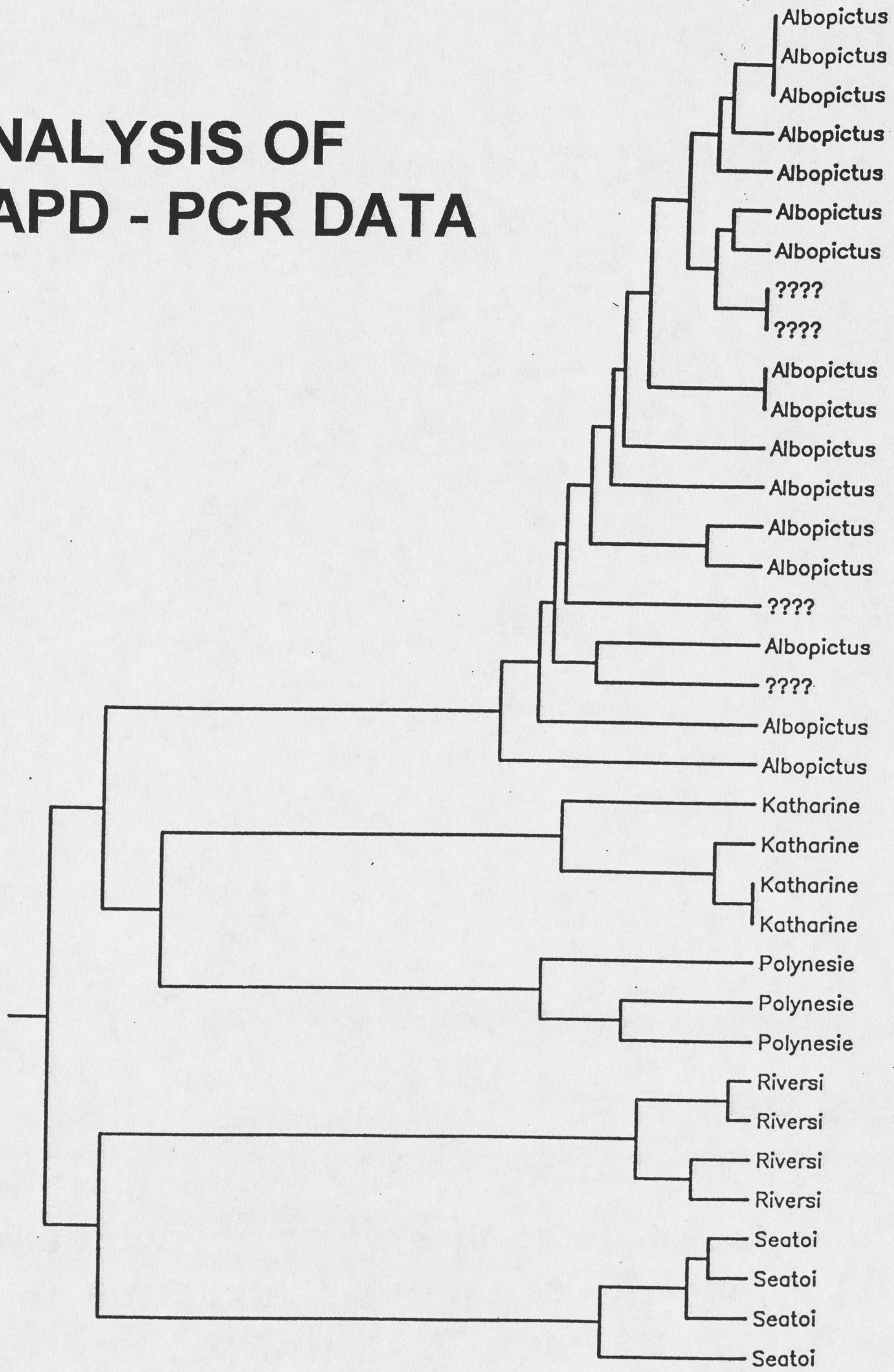
A value of 1 for both measures indicates that two individuals have identical patterns; a value of 0 indicates that two individuals have completely different patterns.

ANALYSIS OF RAPD - PCR DATA

```
NUMBER OF INDIVIDUALS:  35
REVEAL CYCLE:   0
TITLE: AEDES ALBOPICTUS POPULATIONS/SPECIES
NUMBER OF FRAGMENTS: 108
 (A14,108I1)
GALVESTON       000000000000000000100001000010000110001010100100010000000000000010000
GALVESTON       000000000000000000100001000010000010001010100000010000000110001000O
GALVESTON       000000000100000000101001000010000110001010100100010000000000000010000
GALVESTON       000000000100000000100000000010000110001000000100010000000000000010000
?????????       000000000100100000100001000010000110001010100100010000000000000000000
?????????       000000000100100000100001000010000110001010100100010000000000000010000
?????????       000000000000000000100000000010000010001010000100010000000000000010000
?????????       000000000000000010100001001010010010001010100100010000000000000000000
BEIJING         000000000000000100100001000010000110001010100100010000001000000000
BEIJING         000000000000000100101001000010000110001010100100000000000000001010000
BEIJING         000000000100000000100001000010000110001010100100010000000000000000000
SINGAPORE       000000000100000000100001010010100110001010000100010000000000000000000
SINGAPORE       000000000000000000100001000010000110001010100100010000000000000000000
SINGAPORE       000000000000000000100001000010000110001010100100010000000100010010
SINGAPORE       000000000000000000000000100001000011000000000100010000000100001001O
SINGAPORE       000000000000000000100001000010000010000010100000010000000000000010010
ZAMA            000000000000000000000000000010100110001010110100010000100000000000
ZAMA            000000000000000000100001000010000110001010000100010000100000000000
ZAMA            000000000000000000100001000010100110000010100100010000001000010000
ZAMA            000000000000000000100001000010100110000010100100010000000000000010000
Katharinensis 101000000010010011000110000100001010000010100000000000000000010000101
Katharinensis 101000000000000011000110100000001010000010000000000000000000010000101
Katharinensis 101000000000000011000110100000001010000011000000000000000000010000100
Katharinensis 101000000000000011000110100000001010000011000000000000000000011000100
 olynesiensis 000010000000100011000101001010010011000010100000000000000000000000000
Polynesiensis 000010000000100001000000001010010011000010100101010101001100000100O
Polynesiensis 000010010101000010000010010100100110000101001010100000001000000000
Riversi         010110101010001000010001001101010000101000011000001001100000000000O
Riversi         010110101010000000010001001101010000101000011000001001000000100100
Riversi         010110101010000000010001001000000000100000011000001000100000100101
Riversi         010110101010000000010001001000000000101000011000001001000000100101
Seatoi          000000000000000000000100100000100010101000001000100010100110000011O
Seatoi          000000000000000000000100100000010010101000100000100010100110000011O
Seatoi          000000000000000000000100100000110010101000001000100010100110000011O
Seatoi          000000000000000000000100000000110010101000001000100010100110000001O
```

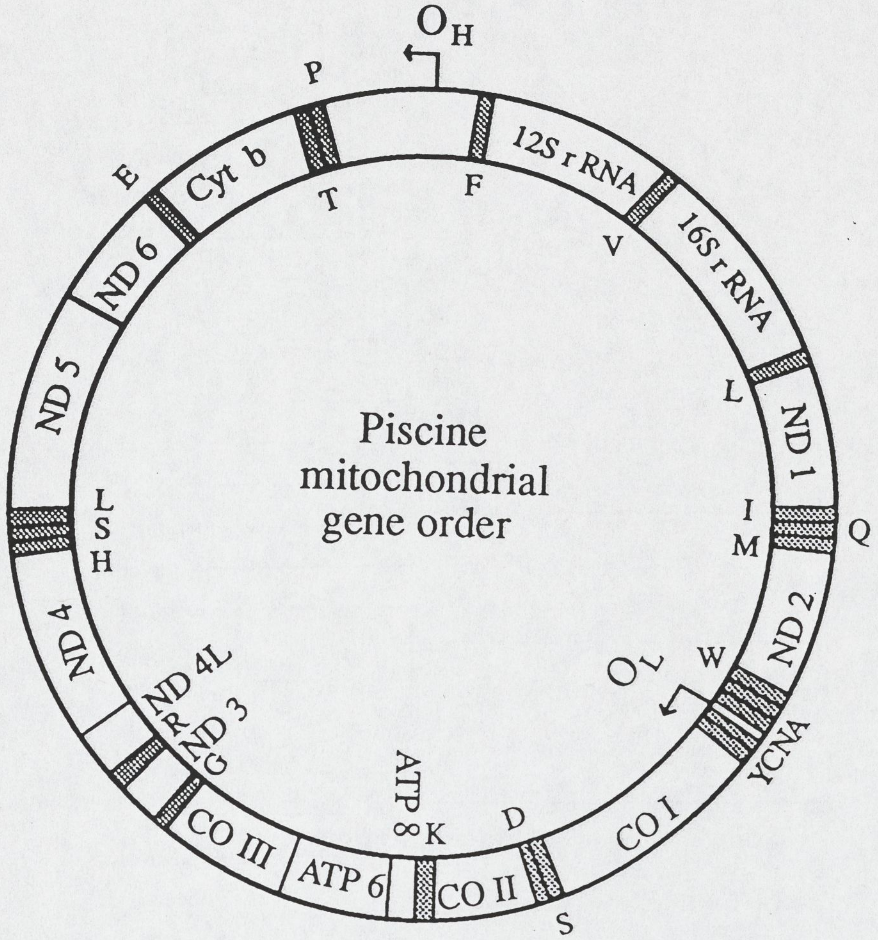
Data is arranged into a presence / absence matrix. In this form the data can be analyzed using discriminant analysis or cluster analysis.

ANALYSIS OF RAPD - PCR DATA



Dissimilarities among individuals (1-M) are placed in a distance matrix. Cluster analysis is performed using the unweighted pair-group method with arithmetic averaging algorithm (UPGMA) on the values of 1-M using RAPD-PCR marker in the program RAPDPLOT (Kambhapati et al. 1992).

MITOCHONDRIAL DNA



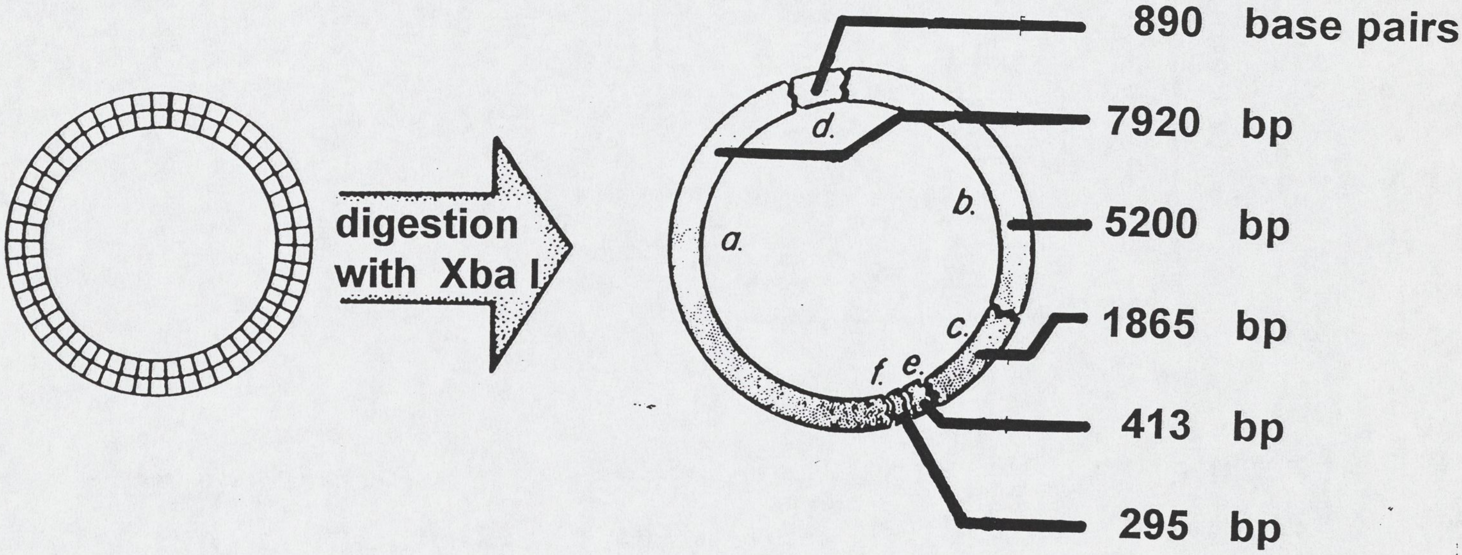
Mitochondrial DNA (mtDNA) is a Double stranded molecule with 13 genes coding for proteins, two genes coding for ribosomal RNA's (small 12S and large 16S), 22 genes coding for transfer RNAs (tRNAs) and one major non-coding region (control region in vertebrates). Of all mitochondrial genes the control region, which contains the Displacement loop (D-loop), has the highest substitution rate. Transfer RNA genes are shown in shaded boxes. The Origin of the heavy strand O_H is in the control region and the origin of the light strand O_L is in a tRNA gene cluster. (Meyer, 1993)

MITOCHONDRIAL DNA

RECOGNITION SEQUENCE
OF RESTRICTION ENZYME Xba I : T↓ CTAGA

```
____TCTAGA____
____AGATCT____
       ↓
____T        CTAGA____
____AGATC        T____
```

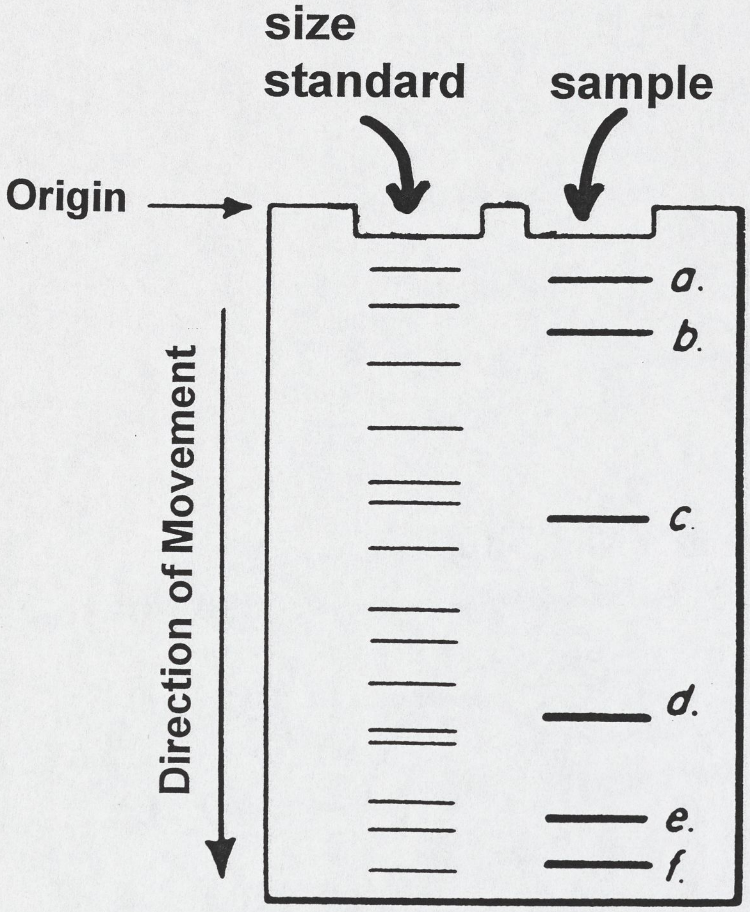
RESTRICTION ENZYME DIGEST



Six TCTAGA recognitions sites are cleaved (Ferris and Berg (1987).

MITOCHONDRIAL DNA

SEPARATION BY GEL ELECTROPHORESIS



size of fragments

a = 7920 base pairs

b = 5200 bp

c = 1865 bp

d = 890 bp

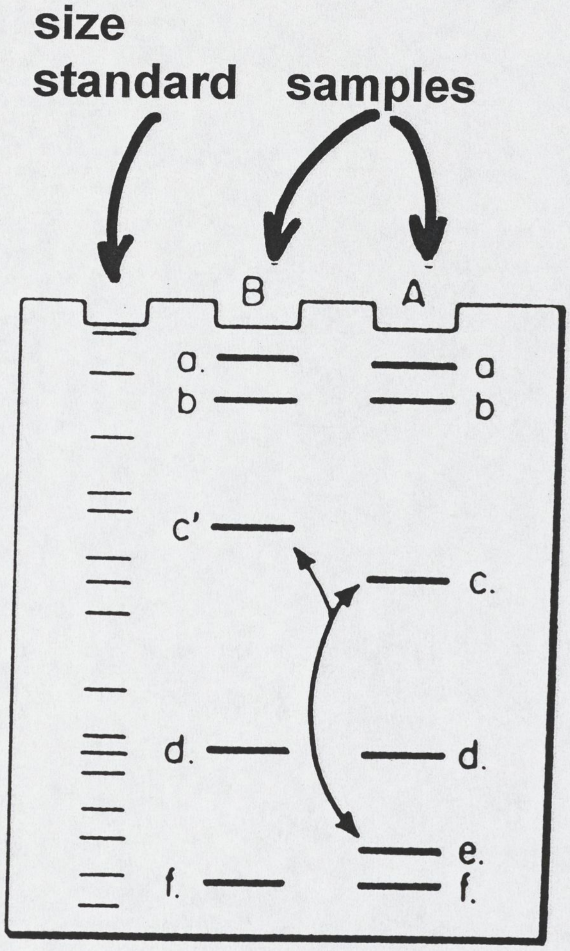
e = 413 bp

f = 295 bp

Fragments are electrophoresed on a agarose gel. Fragments are then visualized by ethidium bromide staining (under UV light) or ^{32}P end-labeling. Fragment sizes are determined by reference to size standards (Ferris and Berg, 1987).

MITOCHONDRIAL DNA

INTERPRETATION OF RESULTS



size of fragments

c' = 2278 base pairs

c = 1865 bp

e = 413 bp

Variant pattern B differs from common pattern A by three fragments (bands). Fragment length sum (A,c + A,e) equales length of fragment B,c. (Ferris and Berg, 1987).

MITOCHONDRIAL DNA

INTERPRETATION OF RESULTS

QUANTITATIVE RESULTS

A

Number of mutations $\approx \dfrac{\text{band differences}}{3} = \dfrac{3}{3} = 1$

B

Percent sequence difference $\approx \dfrac{\text{number site changes}}{\text{total bp}}$

total bp = (f x l)

$$= \frac{1}{6 \times 6} = 3\%$$

where f = total number of fragments (for the most common pattern, in this case A)

l = recognition length of enzyme (in this example it is 6 because the restriction enzyme was TCTAGA)

Mitochondrial DNA Fragment Patterns in Five Salmonid Species

Species	Sample size	*Ava* I	*Ava* II	*Bam*H I	*Bgl* I	*Bgl* II	*Fnu*D II	*Hinc* II	*Hind* III	*Hpa* I	*Pst* I	*Pvu* II	*Sma* I	*Xba* I
Brown trout														
Gullspång	5	A	A	A	A	A	A	A	A	A	A	A	A	A
Åvaån	4	A	B	A	A	A	A	A	A	A	A	A	A	A
Atlantic salmon														
Åtran	4	B	C	B	B	A	B	B	B	B	B	B	A	B
Lule	5	B	D	B	B	A	B	B	B	B	B	B	A	B
Westslope cutthroat trout														
Creston	3	C	E	C	C	B	C	C	C	C	C	C	A	C
Yellowstone cutthroat trout														
Big Timber	3	C	F	C	D	C	D	D	D	C	C	C	A	C
Rainbow trout														
Swedish hatchery	4	D	G	D	E	D	E	E	E	C	D	C	B	C
Arlee Lake	5	E	H	D	E	E	E	E	F	C	D	C	B	C
Eagle Lake	4	F	I	D	E	F	F	F	E	C	D	C	B	C
Brook Trout														
Wings Pond	3	G	J	E	F	G	G	G	G	D	E	D	C	D

Note: A capital letter (A, B, C, etc.) denotes a particular fragment pattern obtained with a given restriction enzyme. Fragment patterns with same letter for different enzymes are not related.

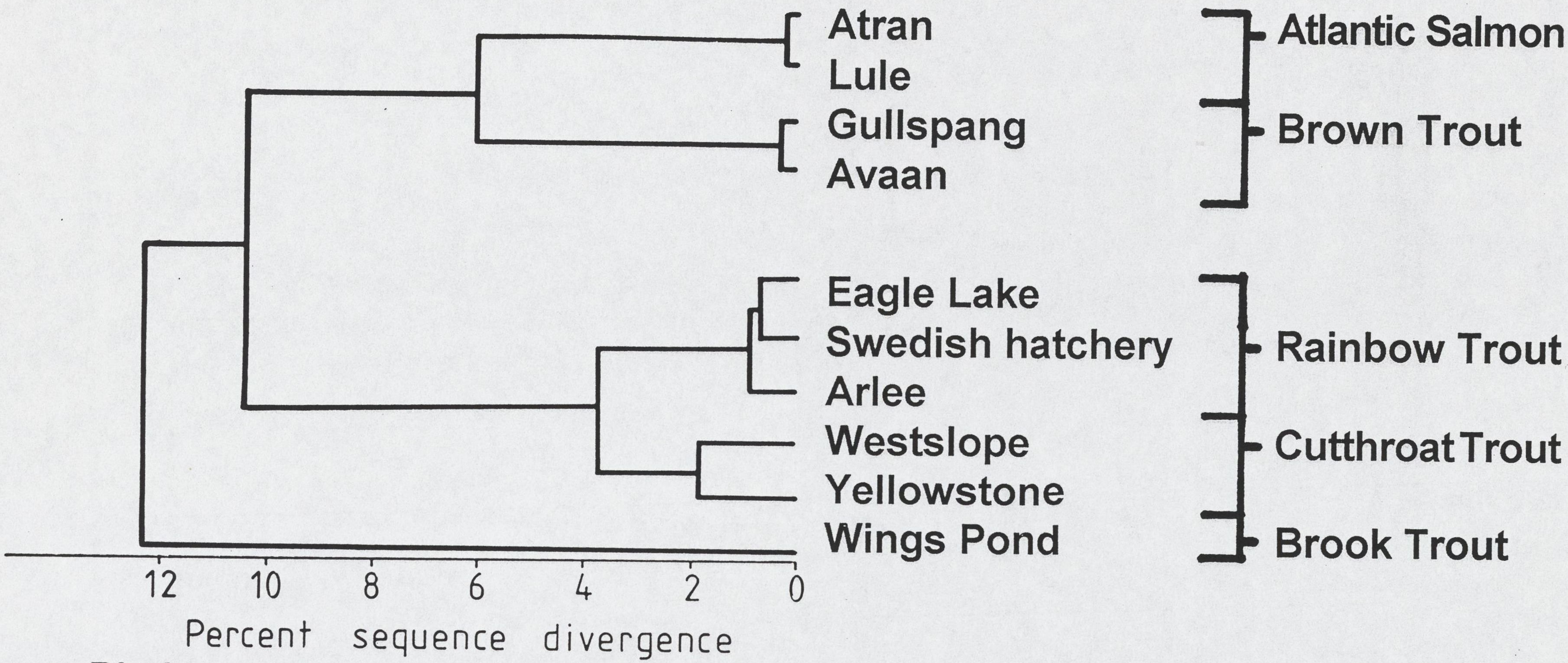
Gyllensten and Wilson (1987)

PHYLOGENETIC TREE

	Brown trout		Atlantic salmon		Cutthroat trout		Rainbow trout			Brook trout
No.	Gullspång 1	Åvaån 2	Ätran 3	Lule 4	Westslope 5	Yellowstone 6	Swedish hatchery 7	Arlee 8	Eagle Lake 9	Wings Pond 10
1	—	6	69	70	82	83	85	90	84	92
2	0.36	—	70	70	83	86	86	92	86	93
3	6.18	6.52	—	1	94	94	101	104	99	99
4	6.45	6.45	0.12	—	94	93	100	102	98	98
5	9.20	9.20	13.20	13.11	—	29	54	59	52	88
6	9.44	9.88	11.45	11.38	1.98	—	49	58	51	91
7	9.70	9.05	13.21	13.14	4.09	3.39	—	15	14	90
8	9.27	10.16	14.19	14.13	4.82	4.27	0.82	—	19	93
9	8.28	8.96	13.14	13.06	4.21	3.72	0.75	1.08	—	92
10	13.38	13.32	18.05	18.00	12.00	12.43	11.43	11.48	11.36	—

Number of fragment differences (above diagonal) and percent sequence divergence (below diagonal), estimated according to Nei and Li (1979), among 10 salmonid taxa. Fragment patterns observed were the result of cleavage of mtDNA from the 10 taxa with each of 13 restriction enzymes (Gyllensten and Wilson 1987).

PHYLOGENETIC TREE



Phylogenetic tree relating mtDNA from nine hatchery populations representing two species of *Salmo*, two species of *Oncorhynchus* and on e natural population of a species of *Salvelinus* (brook trout). Thirteen restriction enzymes were used to cleave the mtDNA. Of a total of 219 DNA fragments, 141 (64%) were phylogenetically informative; that is, they occurred in more than one but not in all of the taxa (Gyllensten and Wilson 1987).

Composition of a Mixed Stock of Brown Trout through Digestion of mtDNA with Seven Restriction Enzymes

Variation of mtDNA within and between five Swedish hatchery stocks and one mixed stock of brown trout (*Salmo trutta*). Gyllensten and Wilson (1987)

Hatchery stock	Sample size	Fragment patterns produced by enzymes							Diversity of lineages (*h*)
		*Ava*II	*Fnu*DII	*Hae*III	*Hinc*II	*Hinf*I	*Hpa*II	*Taq*I	
Åvaån	4	B	A	C	A	A	C	A	0
Fituna	3	A	A	A	A	B	A	C	0
Weichsel	3	A	A	B	A	C	D	A	0
Gullspång	3	A	A	A	A	B	A	C	0
Dalälven	4								0.5
1		B	A	A	A	C	A	A	
2-4		A	A	C	A	A	C	A	
Lule[1]	9								0.72
1-5		A	A	A	A	B	A	C	
6		B	A	A	A	A	C	A	
7		E	A	B	A	C	A	B	
8		A	A	B	A	B	A	B	
9		B	A	C	A	C	A	A	

[1] Putative mixed stock

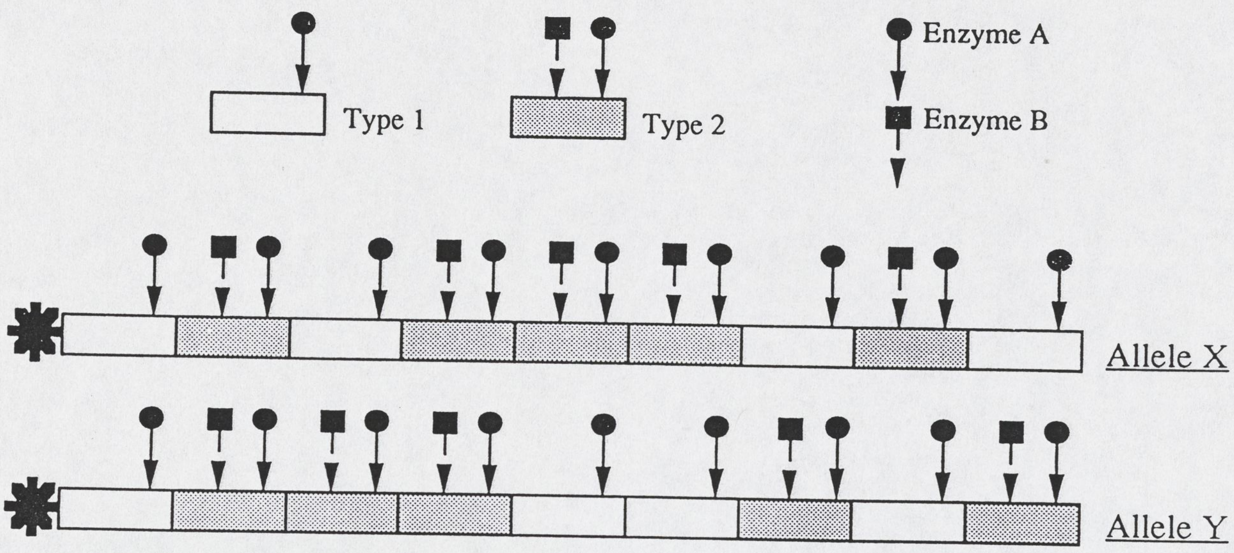
MINISATELLITE VNTR

```
GATCGCATCTCTTGTGGGTGAACAATATCAACATGTGCTCTACGACCAG
      1.      A-AGGTCGGGTT
      2. CTATACAGGGCTGGTT
      3. CTATACAGGGCTGGTT
      4. CTATACAGGGCTGGTT
      5. CTATACAGGGCTGGTT
      6. CTATACAGGGCTGGTT
      7. GTATACAGGGCTGGTT
      8. CTATACAGGGCTGGTT
      9. CTATACAGGGCTGGTT
     10. CTATACAGGGCTGGTT
     11. CTATACAGGGCTGGTT
     12. CTATACAGGGCTGAGGAGAGATGGT
     13. CTATACAGGGCTGGT-
     14. CTATACAGGGCTGGT-
     15. CTATACAGGGCTGGT-
     16. GTATACAGGGCTGGT-
     17. CTATACAGGGCTGGT-
     18. CTATACAGGGCTGGT-
     19. CTATACAGGGCTGG--
    (approximately 2.3 kb 143-153 repeats)
     20. CTATACAGGGCTGGTT
     21. CTATACAGGGCTGGTT
     22. CTATACAGGGCTGGTT
     23. CTATACAGGGTCGGTT
     24. CTATACAGGGCTGGTT
     25. CTATACAGGGCTGGTT
     26. CTATACAGGGCTGGTT
     27. CTATACAGGGCTGGTT
     28. CTATACAGGGCTGGTT
     29. CTATACAGGGCTGGCTGGTT
     30. CTATACAGGGCTGGTT
     31. CTATACAGGGCTGGTT
     32. CTATACAGGGCTGGTT
ACATGACAGAAAACTACACCTAGCAGTTTGTCTTATCACCCTTCCACACACACACATGCACGTAC
GTACGCACGCACGCACACACAGAGCCTCCTTTTGCAGATTATAAAATCGGAGCAAAAGACAATTA
TCATAAATCATTTTGATTGAGGATC
```

Consensus Sequence CTATACAGGGCTGGTT

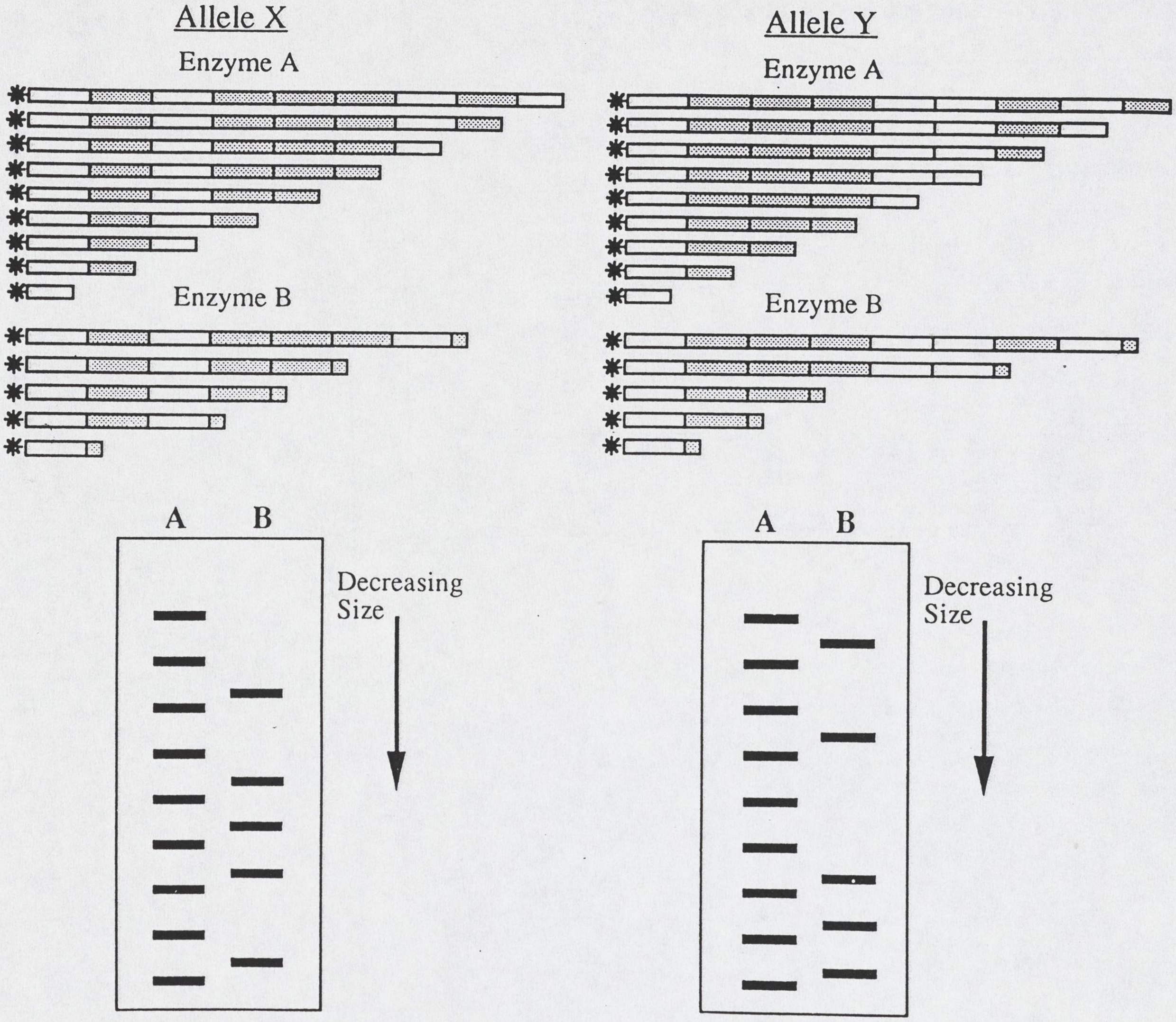
Nucleotide sequence of a minisatellite VNTR (variable number of tandem repeat) from Atlantic salmon (Ssa1). The monomer repeats are ordered and numbered to emphasize their homogeneity. Differences in the nucleotide sequence of monomer repeats from the derived consensus sequence are underlined. No restriction endonuclease recognition sites are present in the sequenced tandem array. A 46 bp alternating purine-pyrimidine tract (i.e. a cryptic microsatellite) juxtaposed to the minisatellite VNTR sequence is underlined (Wright 1993).

MINISATELLITE VARIANT REPEAT (MVR) MAPPING



Minisatellite variable number of tandem repeat sequences (VNTRs) are amplified by PCR using two primers complementary to unique sequences flanking the minisatellite tandem array. Partial restriction endonuclease digestion occurs in every monomeric unit (enzyme A) or sporadically in some of the monomeric array (enzyme B) (Wright 1993).

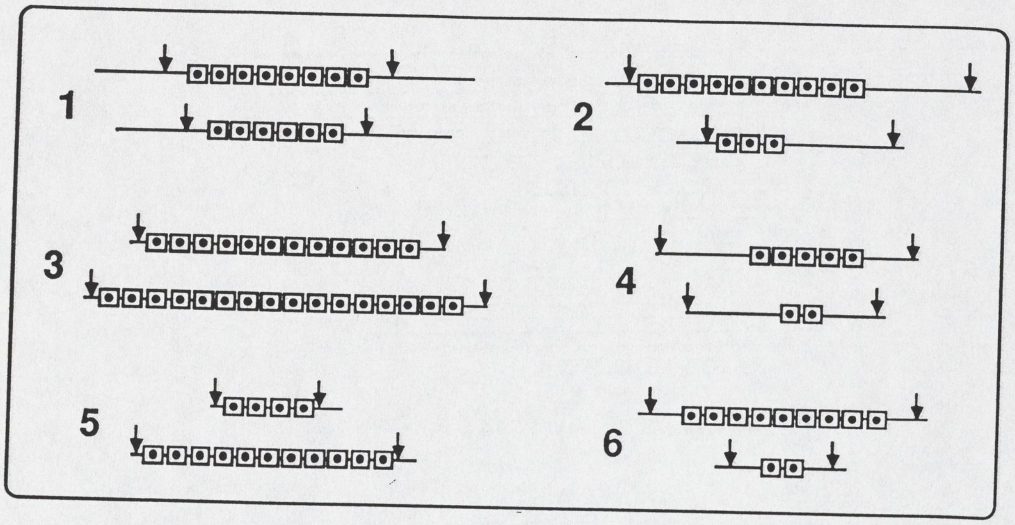
MINISATELLITE VARIANT REPEAT (MVR) MAPPING

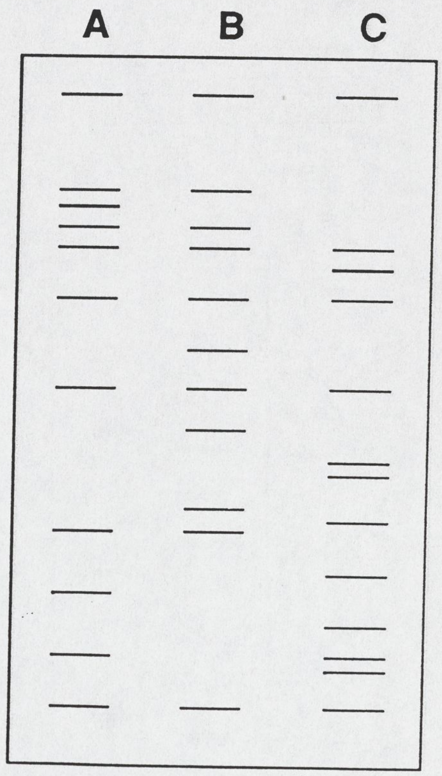


One end of the amplified minisatellite VNTR (variable number of tandem repeat) is radiolabeled prior to application of restriction enzymes. The end-labeled restriction fragments are fractionated by gel-electrophoresis and detected by autoradiography revealing the different internal variation across the tandem array of allelic-variants (Wright 1993).

DNA FINGERPRINTING FROM VNTR LOCI

chromosomal segments in individual A





gel autoradiograph

Shown are six dispersed chromosomal segments (on the same or different chromosomes), each of which may harbor variable numbers of the tandem repeat elements. Solid circles within the repeats indicate the conserved core sequence. A restriction enzyme that cuts (arrows) outside the repeat regions thus reveals a complex digestion profile on a gel autoradiograph (Avise 1994).

SEQUENCING

Sanger (Enzymatic) Sequencing

5'-GTTTTCCCAGTCACGACAATCAGGCTTAAA-3'
3'-CAAAAGGGTCAGTGCTGTTAGTCCGAATTT-5'

Denature DNA to produce single-stranded template (only one strand shown)

3'-CAAAAGGGTCAGTGCTGTTAGTCCGAATTT-5'

Add primer and anneal
5'-GTTTTCCCAGTCACGAC-3'

5'-GTTTTCCCAGTCACGAC
3'-CAAAAGGGTCAGTGCTGTTAGTCCGAATTT-5'

Divide into four samples, each with dATP, dCTP, dGTP, dTTP (at least one dNTP radioactively labeled) and DNA polymerase

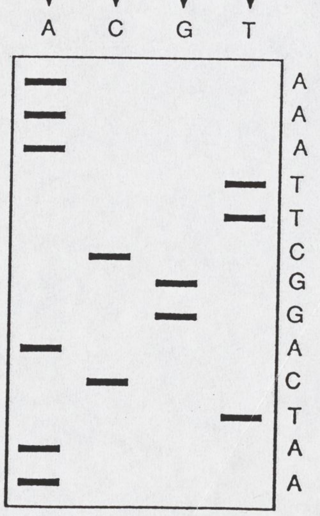
ddATP
primer+A
primer+AA
primer+AATCA
primer+AATCAGGCTTA
primer+AATCAGGCTTAA
primer+AATCAGGCTTAAA

ddCTP
primer+AATC
primer+AATCAGGC

ddGTP
primer+AATCAG
primer+AATCAGG

ddTTP
primer+AAT
primer+AATCAGGCT
primer+AATCAGGCTT

Separate fragments by electrophoresis and visualize by autoradiography



State of California
FISH AND GAME COMMISSION
(916) 653-4899

Meeting of
April 4, 1996 (Thursday)
10:00 a.m.

Resources Auditorium*
1416 Ninth Street
Sacramento

AGENDA

ALL MEETINGS OPEN TO THE PUBLIC

DISCUSSION ITEMS

1. EMERGENCY ACTION TO AMEND SECTION 27.80, TITLE 14, CCR, RE: INCREASING MINIMUM SIZE LIMIT FOR OCEAN SPORT SALMON.

2. CONSIDERATION OF PETITION TO LIST THE SACRAMENTO RIVER SPRING-RUN CHINOOK SALMON (Oncorhynchus tshawytscha) AS AN ENDANGERED SPECIES.

3. REQUEST OF BIG BEAR VALLEY RECREATION AND PARK DISTRICT, BIG BEAR LAKE, FOR A WAIVER OF SECTION 671.3(a)(10) AND 671.3(b)(2)(K)7.(v), TITLE 14, CCR, RE: THE REQUIREMENT FOR A CEILING ON THEIR GRIZZLY BEAR COMPOUND AT MOONRIDGE ANIMAL PARK.

4. PRESENTATION BY U.C. SANTA CRUZ SCIENCE AND TECHNOLOGY CENTER ON THE FORT ORD PROJECT RE: DEVELOPMENT AND NATURAL RESERVE PROGRAM.

5. APPROVAL OF 1996-97 CALIFORNIA DUCK STAMP AND DUCKS UNLIMITED M.A.R.S.H. PROJECTS.

6. PUBLIC FORUM - ANY MEMBER OF THE PUBLIC MAY ADDRESS AND/OR ASK QUESTIONS OF THE COMMISSION RELATING TO THE IMPLEMENTATION OF ITS POLICIES OR ANY OTHER MATTER WITHIN THE JURISDICTION OF THE COMMISSION. THIS NEED NOT BE RELATED TO ANY ITEM ON THE AGENDA.

LICENSE AND PERMIT CONSIDERATIONS

7. REQUESTS OF JEFF GRIFFIN, LEUCADIA, AND PETER A. ZUCKERMAN, LOS ANGELES, FOR REINSTATEMENT OF EXPIRED COMMERCIAL SEA URCHIN DIVING PERMITS.

8. REQUEST OF DAN J. WILHELMI, FORT BRAGG, FOR A WAIVER OF THE COMMERCIAL SEA URCHIN LANDING REQUIREMENTS FOR PERMIT YEAR 1995-96.

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*These facilities are accessible to persons with disabilities.

9. REQUEST OF RALPH DAY, SAN JUAN CAPISTRANO, FOR A WAIVER OF THE COMMERCIAL ABALONE LANDING REQUIREMENTS FOR PERMIT YEAR 1995.

10. REQUEST OF DWIGHT H. RAMEY, FORT BRAGG, FOR REINSTATEMENT OF AN EXPIRED COMMERCIAL SALMON VESSEL PERMIT FOR F/V MANANA.

OTHER

11. RECEIPT OF DEPARTMENT REPORT RE: LEGISLATION.

12. RECEIPT OF DEPARTMENT INFORMATIONAL ITEMS.

    A. BUDGET UPDATE.

    B. STATUS REPORT ON THE NATURAL COMMUNITY CONSERVATION PLANNING PROGRAM (NCCP).

13. RECEIPT OF COMMISSION INFORMATIONAL ITEMS.

14. RECEIPT OF LEGAL COUNSEL INFORMATIONAL ITEMS.

    A. CONFLICT OF INTEREST.

EXECUTIVE SESSION
(NOT OPEN TO PUBLIC)

PURSUANT TO THE AUTHORITY OF GOVERNMENT CODE SECTION 11126(q), THE COMMISSION WILL MEET IN CLOSED EXECUTIVE SESSION. THE PURPOSE OF THIS EXECUTIVE SESSION IS TO CONSIDER:

PENDING LITIGATION TO WHICH THE COMMISSION IS A PARTY:

(A) CALIFORNIA DOMESTIC FERRET ASSOCIATION vs. FISH AND GAME COMMISSION, ET AL., RE: FERRETS.

(B) MOUNTAIN LION FOUNDATION, ET AL., vs. FISH AND GAME COMMISSION, ET AL., RE: MOHAVE GROUND SQUIRREL.

(C) NATURAL RESOURCES DEFENSE COUNCIL, ET AL., vs. FISH AND GAME COMMISSION RE: CALIFORNIA GNATCATCHER.

(D) JAMES VEVERKA vs. FISH AND GAME DEPARTMENT AND COMMISSION, ET AL., RE: REINSTATEMENT OF NATIVE REPTILE CAPTIVE PROPAGATION PERMIT.

(E) POSSIBLE LITIGATION INVOLVING THE COMMISSION.

State of California
FISH AND GAME COMMISSION
(916) 653-4899

Meeting of
April 5, 1996 (Friday)
8:30 a.m.

Resources Auditorium
1416 Ninth Street
Sacramento

AGENDA

ALL MEETINGS OPEN TO THE PUBLIC

DISCUSSION ITEMS (continued)

15. REQUEST TO PUBLISH NOTICE OF INTENT TO AMEND SECTION 7.50(b), TITLE 14, CCR, RE: SPORT SALMON REGULATIONS FOR THE KLAMATH RIVER BASIN WITH A DISCUSSION OF THE PROPOSED OPTION TO INCREASE THE IN-RIVER QUOTA ALLOCATION FROM SIX (6) PERCENT TO NINE (9) PERCENT.

16. RECEIPT OF PUBLIC TESTIMONY ON PROPOSED CHANGES TO SECTION 27.80, TITLE 14, CCR, RE: OCEAN SALMON SPORT FISHING REGULATIONS. (ADOPTION HEARING IS SCHEDULED FOR APRIL 25, 1996 TELECONFERENCE HEARING IN SACRAMENTO.)

17. CONSIDERATION OF FINAL CERTIFICATION OF ENVIRONMENTAL DOCUMENT, ADOPTION OF FINDINGS AND PROPOSED PROJECT (OR ALTERNATIVE), AND ADOPTION OF AMENDMENTS OF SECTION 122, TITLE 14, CCR, RE: COMMERCIAL LOBSTER FISHING.

18. RECEIPT OF PUBLIC TESTIMONY ON PROPOSED CHANGES TO SECTION 600, TITLE 14, CCR. RE: LICENSED GAME BIRD CLUBS. (ADOPTION HEARING IS SCHEDULED FOR MAY 6, 1996 IN SACRAMENTO.)

19. CONSIDERATION OF PROPOSED POLICY RE: STRIPED BASS.

20. DISCUSSION OF PROPOSALS FOR CHANGES IN THE 1996-97 MAMMAL HUNTING AND TRAPPING REGULATIONS.

CONSENT CALENDAR

21. AMENDMENT OF SECTIONS 650 AND 653, TITLE 14, CCR, RE: SCIENTIFIC COLLECTING PERMITS.

22. REQUEST TO PUBLISH NOTICE OF INTENT TO AMEND SECTION 7.50(b) RE: SPORT FISHING REGULATIONS FOR THE CALAVERAS, KLAMATH, SMITH, AND VAN DUZEN RIVERS.

23. REQUEST OF KEN BATES AND PHIL GLENN, EUREKA, TO RENEW EXPERIMENTAL GEAR PERMIT NO. X-1820 TO USE A LAMPARA NET TO HARVEST ANCHOVIES IN DISTRICTS 8 AND 9, HUMBOLDT BAY, FOR BAIT PURPOSES.

<u>OTHER</u>

24. ANNOUNCEMENT OF FUTURE MEETINGS.

Note: The public is encouraged to comment on any item on the agenda. Written comments received in the Commission office by noon on the Friday preceding the meeting will be forwarded to the Commissioners that same day for their leisurely review. Written comments received after that date will be submitted to the Commission at the meeting.

If you decide to speak at the Commission meeting, please begin by giving your name and affiliation (if any) and the number of people represented by your organization. Then tell the Commission your concerns in five minutes or less. The Commission is interested in your views; don't worry about how to say them. If several people have spoken, try not to be repetitious. If there are several with the same concerns, please try to appoint a spokesperson. The Commission is particularly interested in the <u>specific reasons</u> you are for or against a proposal because the Commission's decision needs to be based on <u>specific reasons</u>.

State of California

Memorandum

To : Mr. Robert R. Treanor
Executive Director
Fish and Game Commission

Date : January 16, 1996

JAN 17 1996

From : **Department of Fish and Game**

Subject : Agenda Item for March 7-8, 1996 Commission Meeting Re: Petition to List Sacramento Spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) as Endangered

The Department has reviewed the petition transmitted by your memo of October 18, 1995 to list the Sacramento Spring-run Chinook Salmon as endangered. Pursuant to Sections 2072.3 and 2073.5 of the Fish and Game Code, the Department has determined that, based upon the scientific information contained in the petition, there is sufficient information to indicate that the petitioned action may be warranted. The Department recommends that the petition be accepted and considered, and that the Sacramento Spring-run Chinook Salmon be noticed as a Candidate Species.

Also for your consideration and information, the Department will provide you with an update by February 1, 1996 on the status of completed and proposed restoration actions specific to Sacramento Spring-run Chinook Salmon. These actions are taking place within the Sacramento River, its tributaries, and the Sacramento-San Joaquin Delta.

Should the Fish and Game Commission accept the petition, the Department will commence a 12-month status review of the Candidate Species pursuant to Section 2074.6 of the Fish and Game Code. In light of the efficacy of existing management efforts, the Department is also drafting recommendations for the Commission's consideration to provide for incidental take of Sacramento Spring-run Chinook Salmon during the 12-month candidacy period should the petition be accepted. Recommendations will be drafted in the form of a Special Order which the Commission may enact pursuant to Section 2084 of the Fish and Game Code.

C F Raysbrook

C. F. Raysbrook
Interim Director

Attachment

California Department of Fish and Game
Evaluation Report for Sufficient Scientific Information
Petition to List Sacramento Spring-Run Chinook Salmon
as an Endangered Species
January 17, 1996

The Fish and Game Commission (Commission) received a petition on October 16, 1995 to list Sacramento spring-run chinook salmon as an endangered species under provisions of the California Endangered Species Act (CESA). The Commission reviewed the petition for completeness and, pursuant to Section 2073 of the Fish and Game Code, referred the petition to the Department of Fish and Game (Department) on October 18, 1995 for evaluation. As required by Section 2073.5 of the Fish and Game Code, the Department has until January 17, 1996 (90 days from the date of referral from the Commission) to evaluate the petition and report one of the following recommendations to the Commission:

(1) Based upon the information contained in the petition, there is not sufficient information to indicate that the petitioned action may be warranted; or

(2) Based upon the information contained in the petition, there is sufficient information to indicate that the petitioned action may be warranted, and the petition should be accepted and considered.

The Department's recommendation is based on evaluation of information contained in the petition. When the Department had no information to contradict that contained in the petition, the petition's information was assumed to be accurate. The Department also relied upon information and data contained in its files to interpret the petition's information. Petition information was evaluated according to the criteria specified in Fish and Game Code Section 2072.3.

The Department finds that information in the petition is generally sufficient to indicate the petitioned action may be warranted. The following table is a matrix that compares the legal requirements of a petition to the contents of the Sacramento spring-run chinook salmon petition.

Considerations	Findings Based on Petition
Population Trend	Population has undergone a significant long-term decline since historic times because of loss of spawning habitat; More than 20 historically large populations have been extirpated or reduced to nearly zero since 1940.

Abundance	Spring-run chinook salmon runs in California's Central Valley may have exceeded 1 million fish in the late 1800s; Now less than 1,000 native spring-run return annually to spawn, primarily to Mill and Deer creeks in Tehama County.
Range and Distribution	Once occupied 26 streams in the Sacramento-San Joaquin drainage; Range is now highly restricted from elimination of access to spawning areas by dam construction; Populations in the Sacramento-San Joaquin drainage now found primarily in Mill, Deer, Butte, and Big Chico creeks.
Life History and Reproduction	Lower fecundity than fall-run chinook salmon; Differentiated from other chinook salmon races by maturity of fish entering freshwater, time of spawning migrations, spawning areas, and emigration timing of juveniles; Reproductive isolation maintained by geographic separation of spawning habitat.
Habitat Necessary for Survival	Adults need access to cold deep pool habitat to enable them to survive and protect gamete viability over the summer months followed by spawning in early fall months; Adults need access to tributary headwaters where they can be geographically isolated from fall-run; Spring-run are susceptible to extinction through hybridization with fall-run chinook salmon in absence of geographic isolation; Spring-run require adequate water quality and quantity for adult holding, spawning, egg incubation, juvenile rearing, and migration.
Factors Affecting the Ability to Survive and Reproduce	Loss of historical spawning habitat; Sacramento-San Joaquin Delta hydrodynamics may affect spring-run juveniles emigrating through the Delta from October through January; Habitat problems in spawning tributaries affecting adults and juveniles such as inadequate migration flows, fish passage, and unscreened diversions; Susceptibility to hybridization with fall-run chinook salmon.
Degree and Immediacy of Threat	Remaining populations found in Mill, Deer, Butte, and Big Chico creeks; Observations of a few fish in Antelope Creek; Severely restricted range; Population decline, low population abundance, and high population fluctuation; Populations highly susceptible to natural and human-caused impacts.

Impact of Existing Management Efforts	Sacramento-San Joaquin Delta water project operations could provide benefit to juveniles in spring months; Watershed conservancies on Mill and Deer creeks and a coalition of stakeholders called the Spring-run Workgroup have formed to address habitat restoration needs in spawning tributaries; Other watershed groups are forming on Butte, Big Chico, Battle, and Clear creeks.
Suggestions for Future Management Efforts	Recommendations for habitat restoration, re-introductions, population restoration goals for spawning tributaries, and operations of the State and Federal water projects in the Sacramento-San Joaquin Delta.
Availability and Sources of Information	Provides references to sources of information available in libraries and agency files.
A Detailed Distribution Map	Provides maps which adequately depict past and present population range and distribution.

If the Sacramento spring-run chinook salmon becomes a Candidate Species for listing, a 12-month status review will be conducted. This status review will be comprehensive and include all available scientific information pertaining to the above factors. The following are examples of issues which will require in-depth analysis during the status review:

- Status of Sacramento spring-run chinook salmon biological and taxonomic relationship to other Central Valley chinook salmon stocks.[1]
- Effect of the State Water Resources Control Board's 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1995 Bay/Delta Plan) on Sacramento spring-run chinook salmon.
- Influence of hatchery practices and potential for introgression with wild spring-run chinook salmon populations.

[1] The Department is aware of several issues related to the taxonomy of the petitioned species, including the extent to which the taxonomy of separate salmon runs is unresolved as a matter of science. Because the petition is silent on this issue, the Department expresses no opinion at this time with respect to taxonomy.

- Degree or absence of introgression with fall-run chinook salmon.

- Influence of infectious disease.

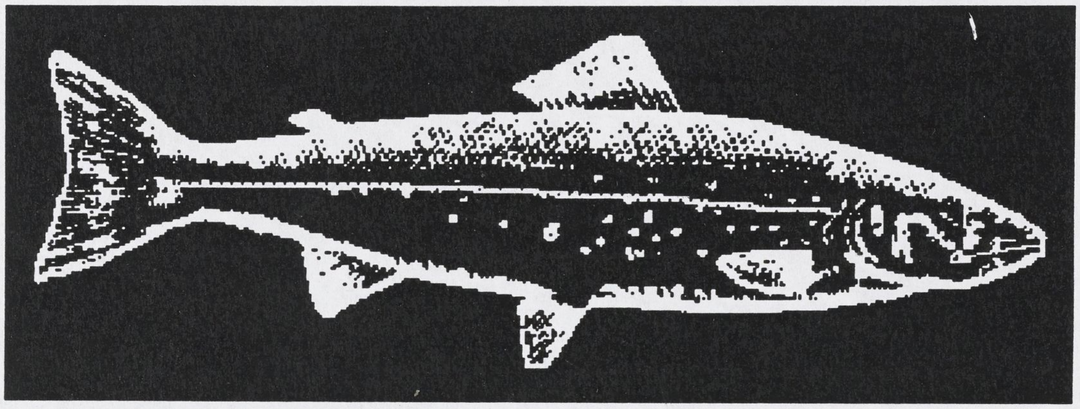
- Mortality caused by ocean commercial, ocean recreational, and inland sport fisheries.

- **Population estimates and methodologies used to indicate population trends.**

- **Potential for increasing the abundance, range, and distribution of Sacramento spring-run chinook salmon to reduce vulnerability to extinction from catastrophic events.**

- **Population recovery objectives based on population goals and indices of population growth rate (cohort replacement rate).**

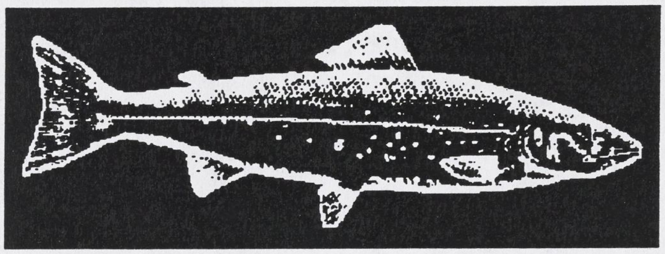
CALIFORNIA SALMON



ON THE VERGE OF EXTINCTION

Senate Committee on
Natural Resources and Wildlife
Tom Hayden, Chairman

CALIFORNIA SALMON



ON THE VERGE OF EXTINCTION

By Senator Tom Hayden

The purpose of this hearing is to receive testimony on the critical decline of the California salmon.

Fifty years ago Governor Earl Warren exclaimed that California "should not relax" until we "put into operation a statewide program that will put every drop of water to work". At the same water conference, a Unitarian minister named Everett Pesonen replied that California should listen to "the voice of the salmon", whose survival would be threatened by those who only see water as a "sterile inanimate liquid". On the contrary, he said, the existence of salmon showed that water "is a medium in which life occurs", and planning of water use "must be expanded to include all the life-supporting values of water".

We are here today to examine whether our greed to use water to the last drop has been restrained enough to protect the California salmon, or whether we have threatened the extinction of salmon with our thirst for irrigation and overdevelopment.

Far from being doubled in numbers by the year 2000, the California salmon may well be doomed.

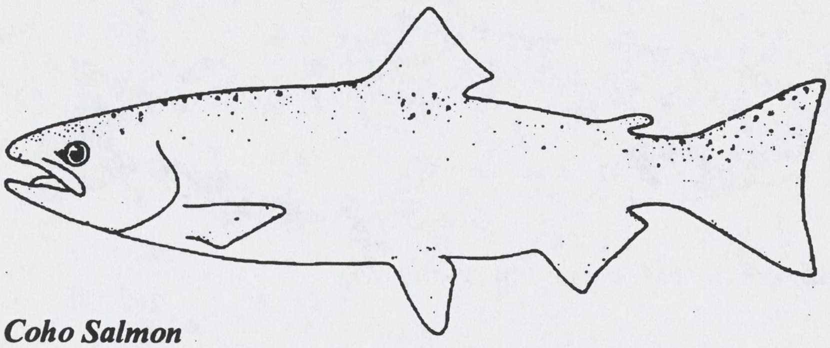
The decline of salmon is not only a California phenomenon, but is occurring at alarming rates on the Pacific and Atlantic coasts. A scary headline in the New York Times last year read "U.S. Fishing Fleet Trawling Coastal Water Without Fish", and reported that the salmon decline is "catastrophic--threatening to wipe out not only whole industries but culture and communities" (3/7/94). Just this month, new research indicated that remaining salmon are becoming smaller in 45 of 47 runs from California to Japan. The number of eggs per female is also continuing to shrink. "Biologists tend to blame human action, mainly the overgrazing of the ocean by billions of hatchery fish and fishing techniques that skim off big fish". (AP, 72-7/95)

Officially, both state (SB 2261, 1988) and the federal Central Valley Project Improvement Act state a goal of doubling the numbers of naturally-spawning California salmon by 2000 and 2002, respectively.

But nowhere in public policy is there a greater gap between words and deeds than in the flaunting of these mandates of the law.

Far from being doubled in numbers by the year 2000, the California salmon may well be doomed.

The statistics of decline are chilling. In 1969 there were 100,000 winter-run chinook counted in the Sacramento River. Between 1982 and 1988, counts averaged 2,334 adult fish annually, a 97 percent decline. The fish were "nearing extinction" according to studies published by the University of California in 1991, because of "conscious management decisions that demonstrated a lack of concern for the needs of the species".



Coho Salmon

Other runs of chinook and coho are declining as well. Coho salmon have been petitioned for listing under the ESA. 1991 studies indicated that the spring chinook were "seriously depleted from historic levels and fast approaching the need for protection under the Endangered Species Act". UC expert Professor Peter Moyle now states that, from a biological standpoint, listing the spring- and late-fall runs on the Sacramento River as endangered is clearly justified, and that the fall-run is in decline.

For a more vivid example, one should visit the Steinhart Aquarium in San Francisco where 261 chinook salmon circle in a large holding tank. A placard tells the public that the Aquarium is attempting "to preserve the genetic material of this imperiled

Winter run chinook salmon (Chris van Dyck)

salmon. We are only buying time until the (Sacramento) river improves. Like the condor, the last of this race will disappear in captivity unless we save their habitat".

We are only buying time until the Sacramento River improves. Like the condor, the last of this race will disappear in captivity unless we save their habitat.

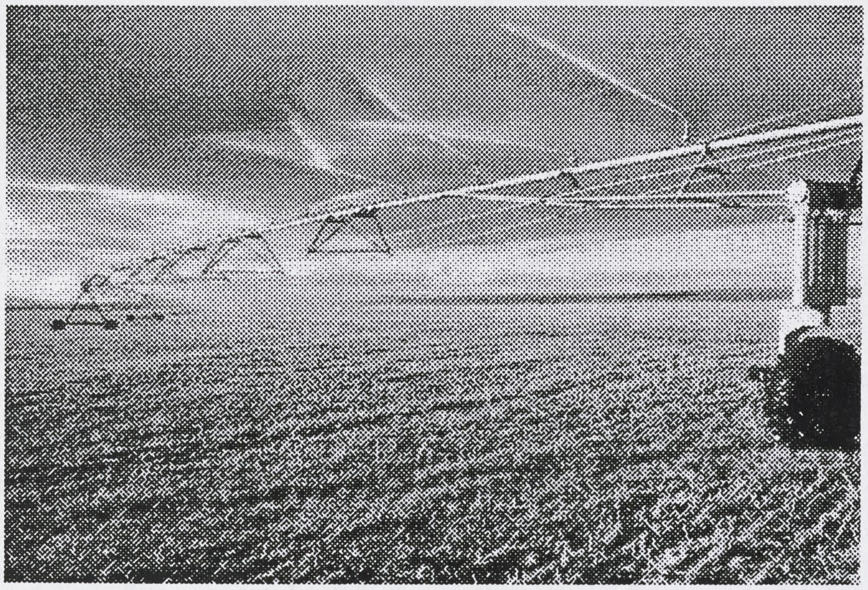
A world without salmon would be a diminished world for humans. Not only would thousands of jobs and billions of dollars be lost in California's oldest industry, as a 1998 report by Meyer Resources, Inc. has pointed out. But the loss of salmon also would mean the loss of wild rivers and rich forests that salmon depend on.

Gone too would be the genetic intelligence that has allowed salmon to undertake an odyssey from their freshwater spawning grounds to the vast ocean and back again to the same spot, to spawn again and die. A world without salmon would diminish the human imagination.

Salmon have been a source of inspiration for poetry and nature-writing for centuries, and they are considered sacred in many cultures. In Irish tradition, they originally were a god of wisdom.

The Yurok people considered the joining of the Klamath and Trinity Rivers as Qu'-nek, the center of the world. Among all coastal tribes from California to Alaska the seasonal cycle of the salmon was regarded with reverence.

Recently state and federal officials held a press conference in Sacramento to celebrate the Bay-Delta Agreement which, among other promises, claimed to provide more fresh water for several runs of salmon. With the press conference, the signatories claimed an “end to California’s water wars”.



This hearing will raise serious questions about whether salmon are indeed safe and the water wars are over. Announcement of the Bay-Delta Agreement was not accompanied by any scientific information on which its claims were based. There is nothing in the plan to achieve the goal of doubling the numbers of naturally-spawning fish by 2000-2002. The water promised in dry years is 400,000 acre feet short of what the State Water Board itself recommended in its 1988 draft salinity standards, which were dropped because of political pressure.

The Bay-Delta Agreement was not accompanied by any scientific information on which its claims were based.

Many environmentalists and commercial salmon fishermen were unrepresented in the negotiations. The handful of environmentalists who did sign this unenforceable "statement of principles" have no guarantees that it will keep the Delta from going the way of Mono Lake.

This hearing also will examine whether the Endangered Species Act should be invoked to save California salmon. Currently only the winter-run in the Sacramento River are listed as endangered, and that decision came only after years of public pressure and outcry.

When salmon are facing a threat of extinction it is no time to be thinking of weakening the Endangered Species Act. As Zeke Grader and Glen Spain of the Pacific Coast Federation of Fishermen's Associations have argued, "the ESA is the key to the watershed restoration and salmon protection throughout the region. It is also the only hope for putting a stop to onshore practices which destroy fishermen's livelihoods".

But weakening the ESA is clearly the agenda of our new leaders in Congress and a major priority of Governor Wilson as well. According to internal documents, the Governor plans to use execu-

tive orders as well as legislation to weaken the protections that the Endangered Species Act provides to salmon and other Species. For example, the Governor would exclude consideration of "habitat modification" from definitions of illegal "taking" of species that are threatened or endangered. But clearly salmon are doomed if their water is exported to southern California, if streams are silted by erosion, and if the Delta is filled with pesticide runoff.

Does Governor Wilson want to be known in history as the Governor who presided over the extinction of the California salmon? That is just the legacy his policies are risking unless there is serious reconsideration of the state's priorities.

As a first step, the Governor needs to give a clear signal to his fish and wildlife officials to disregard special interest pressures and do their jobs as independent professionals. It is widely believed, as the fish and game wardens own association has charged, that "political pressure from adversaries of the salmon upon the governor and the legislature cause the Department to discourage field personnel from enforcing the law".

I have asked Charles Warren, the distinguished former head of the President's Council on Environmental Quality, and former member of this legislature, to serve as Special Consultant to our committee on the Endangered Species Act. We will hold three to five public hearings on the Act to examine all grievances from all

Pete Wilson
Governor

Does Governor Wilson want to be known in history as the Governor who presided over the extinction of the California salmon?

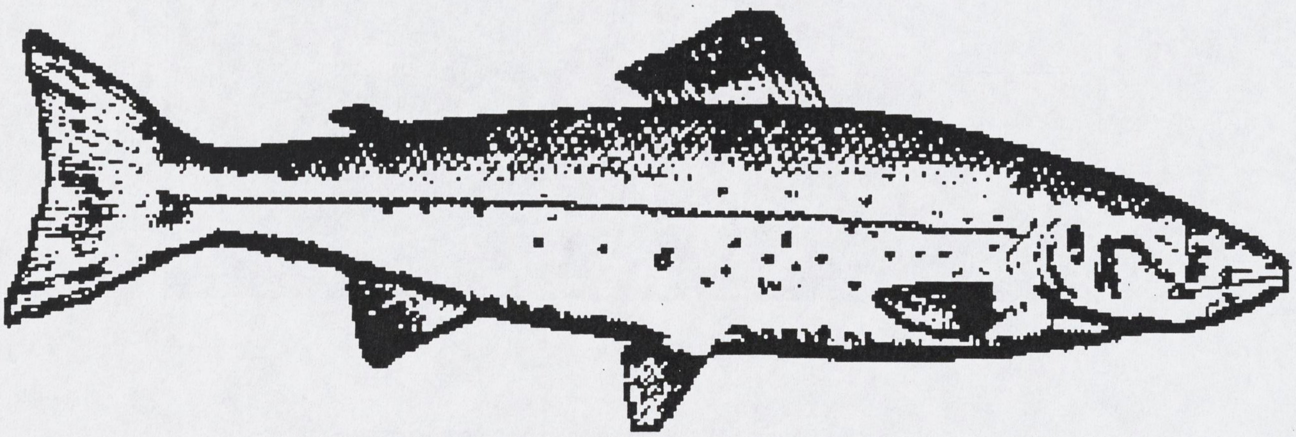
The Governor needs to give a clear signal to his fish and wildlife officials to disregard special interest pressures

After 25 years of study, it is time to question whether we are studying the salmon to death

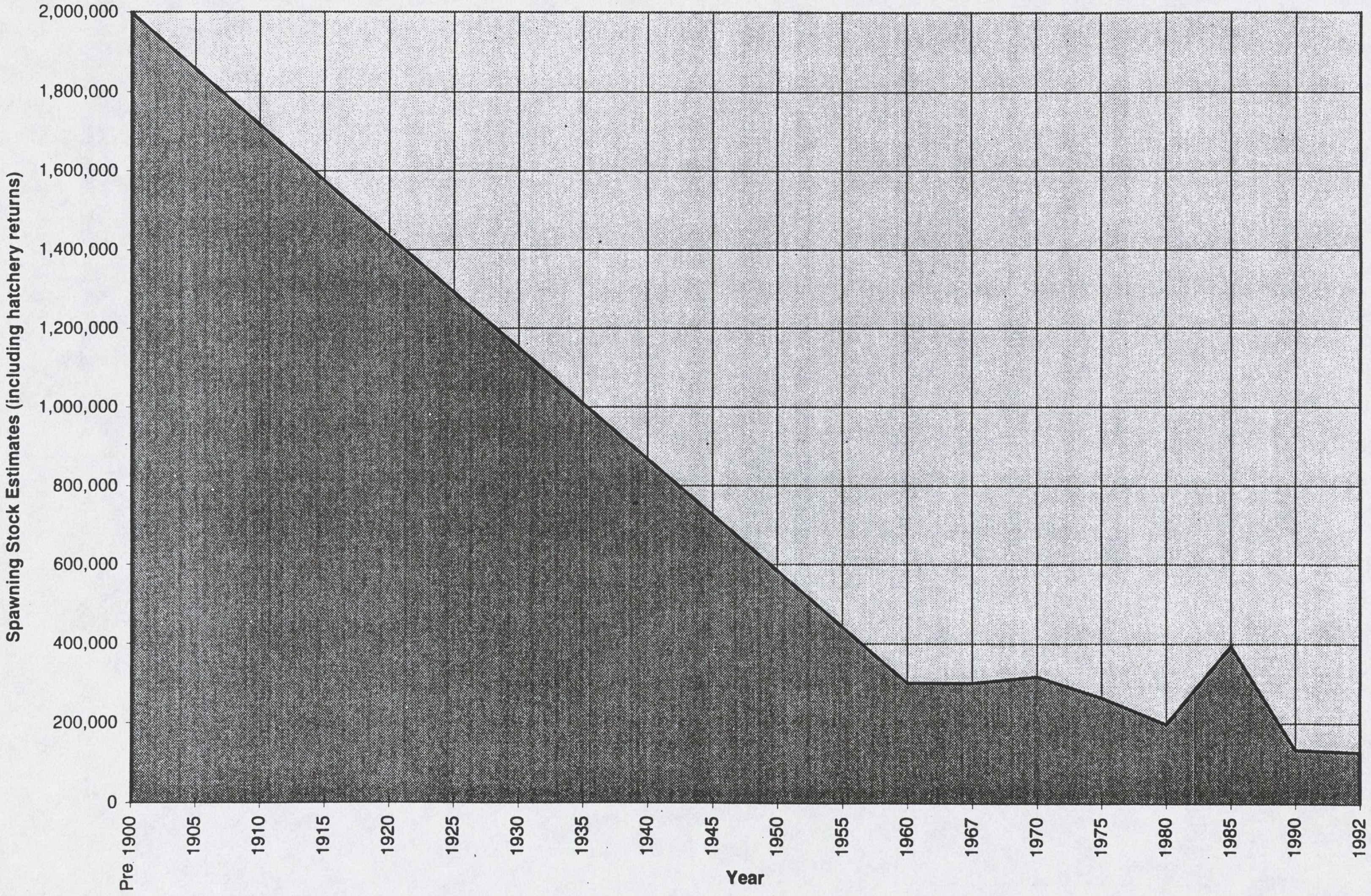
parties and find ways that the Act may achieve its intended goals more effectively.

After 25 years of study, it is time to question whether we are studying the salmon to death. In 1970 a citizen's advisory committee was formed to study salmon and steelhead declines. In 1971, the committee issued a report called An Environmental Tragedy, calling for habitat restoration. In 1972, there was a second report, A Conservation Opportunity. In 1975, the report was titled The Time Is Now. In 1982, a new Committee was formed. They published five more reports, including The Tragedy Continues. After the 1988 report, the state adopted the doubling of the population of salmon and steelhead by the year 2000 as an official goal. Twice the State Water Resources Board issued draft standards, in 1988 and 1993, but both times the draft plans were dropped because of pressure by water exploiters.

It is perhaps the last chance to face this issue now, before the streams and rivers of California are turned from spawning grounds to burial grounds of the last of the salmon.



CENTRAL VALLEY CHINOOK SALMON

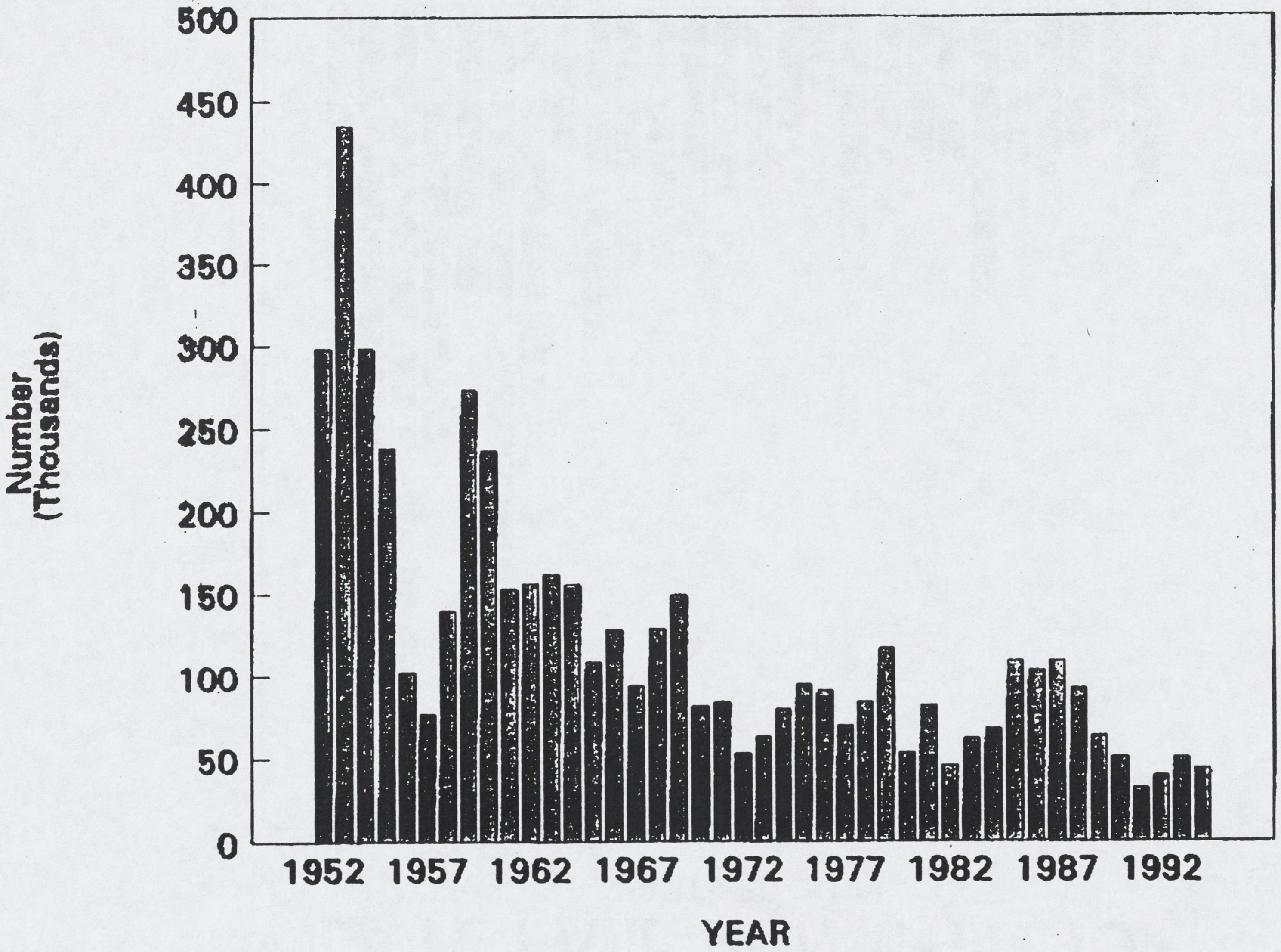


Spawning stock estimates for
Pre 1900 to 1967 are an average
of decline.

Prepared by
Senate Natural Resources & Wildlife Committee

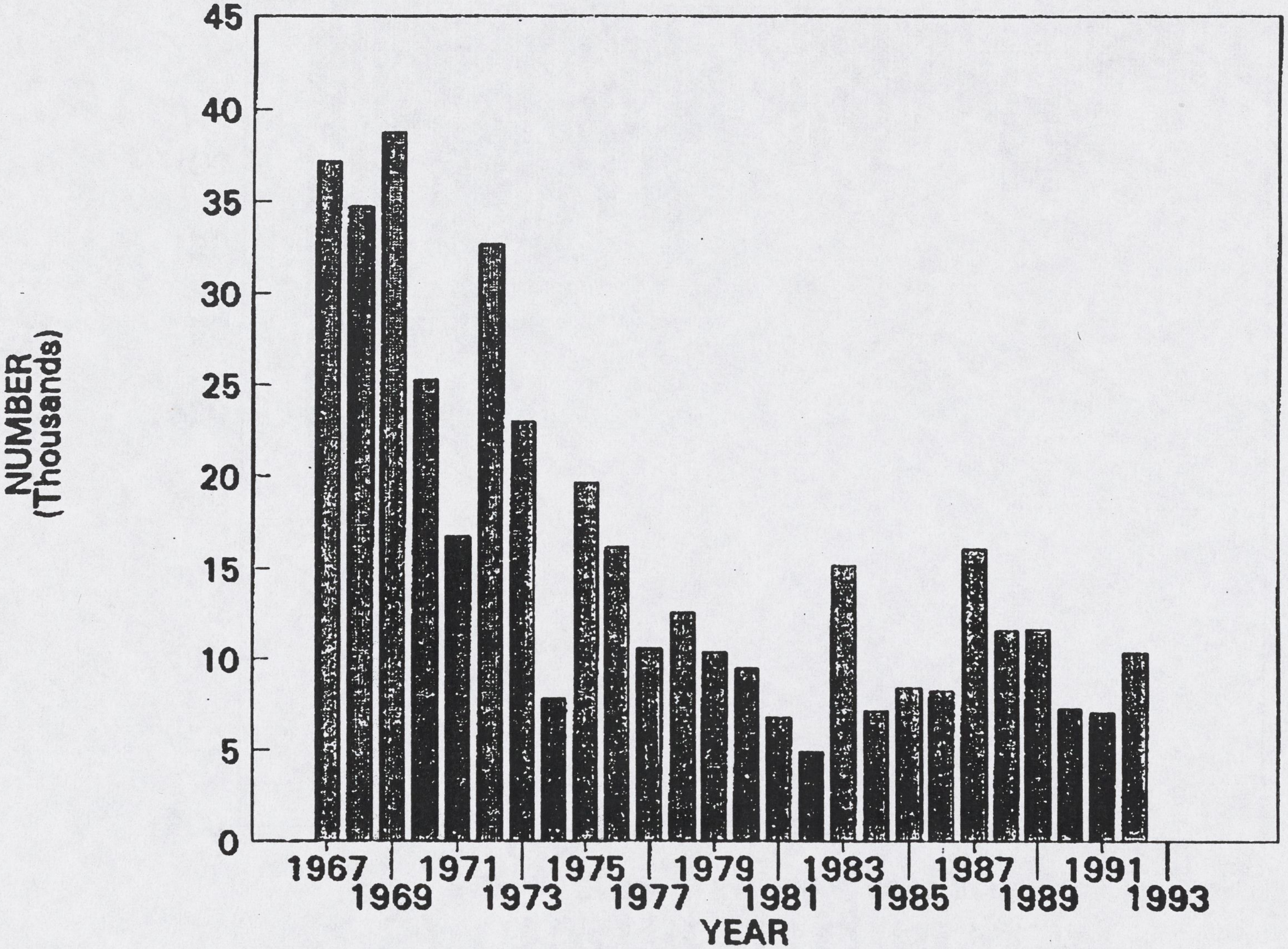
SACRAMENTO RIVER

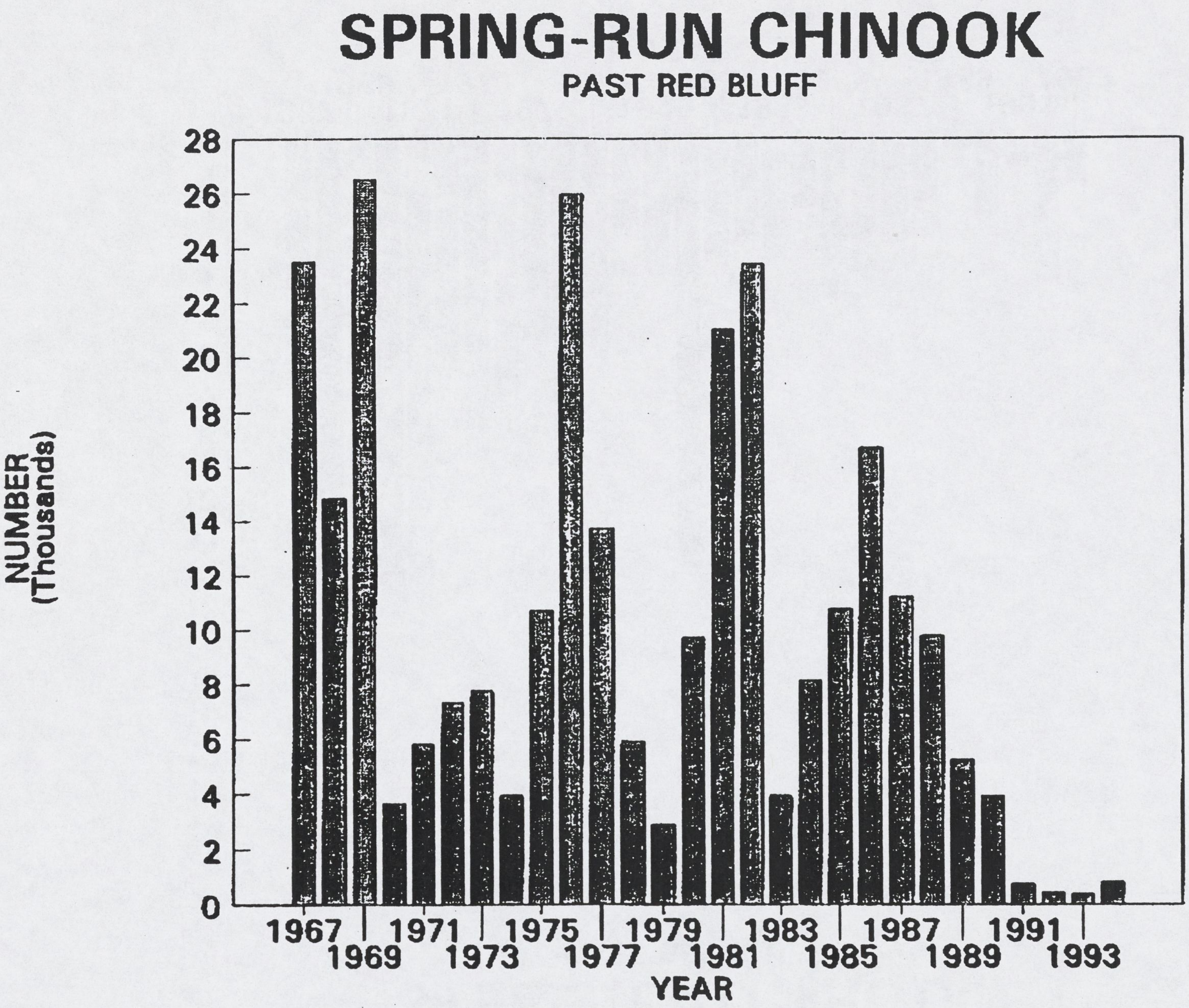
Fall-run Chinook salmon escapement

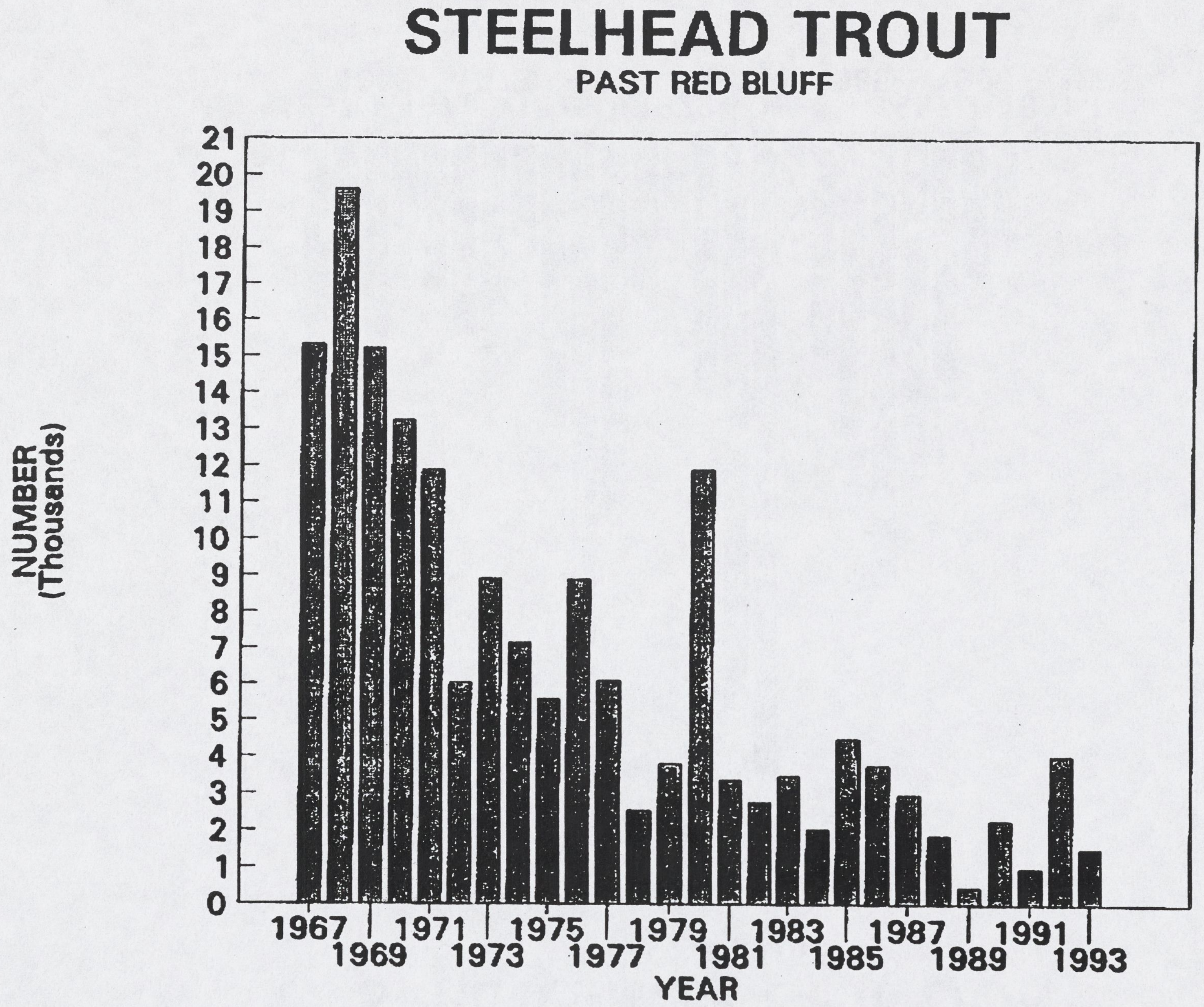


LATE FALL-RUN CHINOOK

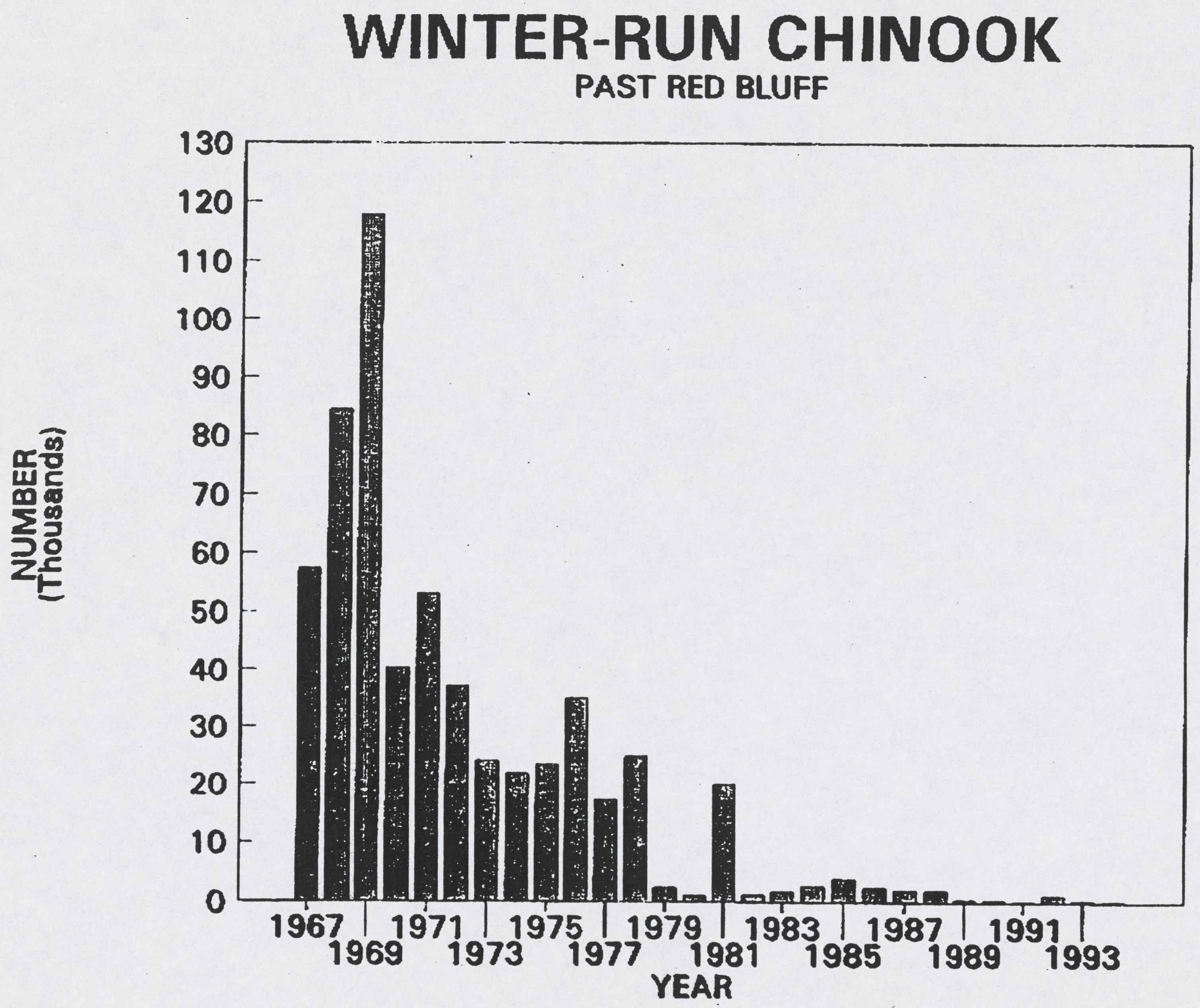
PAST RED BLUFF




SPRING-RUN CHINOOK
PAST RED BLUFF
NUMBER (Thousands)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
YEAR



STEELHEAD TROUT
PAST RED BLUFF
NUMBER (Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
YEAR


WINTER-RUN CHINOOK
PAST RED BLUFF
NUMBER (Thousands)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
YEAR

Saving California's Salmon: The Legacy of Ishi

by Peter B. Moyle, Ph.D.

A leading expert in the conservation biology of fishes, the ecology of California stream fishes, and the effects of introduced aquatic organisms, Peter B. Moyle has authored or co-authored more than 100 publications, including seven books on fish ecology, and conservation. Dr. Moyle has taught at the University of California, Davis, since 1972, and was chairman of the department of wildlife and fisheries biology from 1982 to 1987. He received his Ph.D. in zoology from the University of Minnesota in 1969.

In 1911, Ishi, the last member of the aboriginal Yahi tribe, stepped into civilization from the rugged canyon of Deer Creek, in Northern California. He had grown up there, living with his family without contact with other people. Then the family camp was destroyed by a mining survey party and his family was dispersed to die. It is not a coincidence that the last spring-run chinook salmon in the vast Sacramento River drainage survive in that same rugged canyon and in two other nearby canyons. The steep volcanic walls that hid Ishi and the clear, cold creeks that sustained him have done the same for the salmon. And a similar tragic end is rapidly approaching them. Ishi died of tuberculosis contracted in the anthropology museum at the University of California, Berkeley; the last Sacramento spring chinook could eventually die of some common disease in a fish hatchery.

It is too late to save Ishi and his tribe, but the salmon that remind us of them will go extinct only if we allow them to go extinct. So far, we have done our best to make that happen. At one time spring Chinook were the salmon of the Sacramento and San Joaquin rivers, the two streams that drain California's great Central Valley. No one was counting salmon in the nineteenth century, but best estimates are that somewhere between 500,000 and one million spring Chinook entered the rivers every year. Not surprisingly, major fisheries developed in the rivers to supply the canneries that appeared, rapidly depleting the populations. However, the most lethal blows to the fish were given by dams and diversions which denied them access to their upstream holding and spawning areas. For example, the remaining run of 50,000 spring Chinook in the San Joaquin River was deliberately extirpated. In the words of George Warner, a biologist for the California Department of Fish and Game (CDFG) who witnessed the event:

> *In 1948, disaster struck. Friant Dam ... had been completed and the Bureau of Reclamation assumed control of the river ... Bureau officials diverted water desperately needed by salmon down the Friant-Kern canal to produce surplus potatoes and cotton in the lower San Joaquin Valley. Only enough water was released in the river to supply downstream canals and some of the pumps.*

CDFG crews managed to rescue nearly 2,000 of the salmon and truck them to the base of Friant Dam. Here the salmon held through the summer in the coldwater releases and spawned in the fall. When the juvenile salmon attempted to move out to sea, however, they got only as far as the dry stream bed on the valley floor. In the words of Warner: "The tragic conclusion to the history of the 1948 spring run was that the only beneficiaries of our efforts to salvage a valuable resource were the raccoons, herons, and egrets."

Today, the creeks in Ishi's country support only about 500 spring run spawners each year. A similar number is all that remain of the large runs that once existed in the Klamath River. Yet the plight of spring run chinook salmon is only the most spectacular of the declines of all anadromous fish in California. Even coho salmon, a widely dispersed, forest dependent species, is down to less than 5,000 wild spawners statewide, from an estimated 200,000 50 years ago. Its decline is directly related to the destruction of coastal watersheds by logging and road building.

The decline of coho and of spring Chinook in California is also tied to the simultaneous declines of other sea-run species and races, whose names make a litany of diversity and beauty: winter-run Chinook salmon, fall-run Chinook salmon, pink salmon, chum salmon, winter steelhead, summer steelhead, southern steelhead, green sturgeon, eulachon, longfin smelt, delta smelt, Pacific lamprey, and river lamprey. These fish have faded away despite promises of recovery of salmon and steelhead through hatcheries and weekend stream improvement programs.

Now even the memory of these fish is fading. There are few people in California who remember salmon so thick "you could practically walk across the stream on their backs" yet stream-packing runs were once common. Now we are rapidly losing the memories of days when a reasonably skilled angler could expect to hook 10 or 20 steelhead or coho in a day, fishing until the arms were too tired to cast a line. At least I have had the experience of snorkeling in cool pools of Ishi's canyon to see 30-40 spring Chinook slowly cruising about below me. My son and daughter have seen these same fish, but will the next generation? I doubt it, unless drastic action is taken.

By "drastic action" I mean large scale, expensive action. The near-destruction of our anadromous fishes is the result of abuse of our land and waterways on a massive scale by a society with too much faith in technological solutions to environmental problems, too little view towards the future, and too little memory of what has been lost. Reversing this process cannot be done with hesitant, half-way measures. Our society will have to put back into the system some of the wealth it has carelessly extracted from it. Some of the needed action includes:

1. Operate state and federal water projects as if native fish mattered. In the past, the huge water projects built in the West treated fish as an afterthought. Salmon, after all, could be raised in hatcheries and exotic fishes in reservoirs could replace native fishes in streams. Surprisingly, in recent years major progress has been made to change this policy. The Miller-Bradley Bill, passed in 1992, tells the Bureau of Reclamation that one of its mandates in California is now to provide water for fish and wildlife; it allocates 800,000 acre feet per year for that purpose. The operation of Red Bluff Diversion Dam on the Sacramento River, a major salmon killer, has been modified to allow the fish safe passage. The dam may eventually be abandoned. Much still needs to be done, however. For example, water from Friant Dam (now treated as holy water by the agricultural interests) should be restored to the San Joaquin River to help keep the San Joaquin fall run chinook from going extinct and to provide more outflows through the estuary, necessary for passage of salmon smolts.

2. End double subsidies to California agriculture. Farmers in California receive federal water at cheap subsidized rates and often get crop subsidies as well. This system encourages waste of water and results in additional costs to society in terms of lost fisheries and water returned to the rivers laden with pesticides, fertilizers, and substances such as selenium. The double subsidy system has helped to create in California the most productive agricultural system in the world but it is a system with a short history and low long-term sustainability. If present trends continue, it is easy to envision vast dusty tracts of the San Joaquin Valley with soil too saline to be farmed and rivers without salmon or most other fish. Surely we can do better!

3. Manage National Forest lands as if fish mattered. The catastrophic decline of coho salmon and other fishes in streams of California's north coast is largely the result of watersheds being devastated by logging practices unsuitable for steep slopes and erodible landscapes. To reverse these trends, the remaining tracts of old growth forest should be protected, clear-cutting banned, and low-impact logging promoted. Recently, The Sierra Club Legal Defense Fund won a major court battle with the U.S. Forest Service, halting a timber sale on the South Fork of the Trinity River on the grounds that the increased sedimentation from logging activities would do further harm to the salmon and steelhead in the river. The fact that this case was so stubbornly fought by USFS indicates that, in the minds of many foresters, the short-term gains from logging still take precedence over long-term gains from fisheries. Even in the short run, economic analyses sponsored by the Sierra Club and the Wilderness Society indicate that lost fisheries are often more valuable than the value of the logging that caused the loss. Such studies should not even be necessary, because it should be possible to conduct logging in ways that do not harm, or that even promote, fish populations.

4. Begin a program of large-scale stream restoration. A study Dr. Larry Brown and I recently completed showed that nearly half of all streams that once contained coho salmon runs in California no longer do. The main reason the runs are gone is that the habitat for juvenile salmon is gone; shallow, braided, gravelly stream beds have replaced the deep shady pools and undercut, forested banks that the young coho require. Such streams cannot be restored by well-meaning volunteers installing a few logs and boulders on weekends. They require massive intervention in the degradation process, starting with erosion control measures in the headwaters and continuing with major channel modifying measures lower down. Hydrologist David

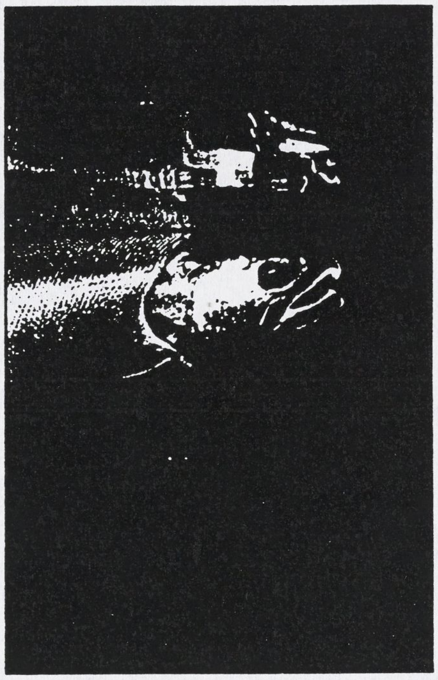


PHOTO: SCOTT RIPLEY

Coho salmon

Rosgen, one of the main practitioners of radical restoration efforts, advocates whole stream approaches in which the restoration process harnesses the energy of the stream, rather than working against it through rip-rapping and other band-aid techniques. Rosgen-style restoration, however, requires lots of person-power and heavy equipment, so is very expensive in the short run. It is arguably much cheaper in the long run, of course, because it offers more permanent solutions to the problems. This is obviously an opportunity for a large public works program that could employ some of the fishermen and loggers put out of work as the result of failed public policy in the past. Such a program could help sustain the local economies until fisheries are restored and sustainable timber harvest is practiced.

5. Place a temporary ban on the harvest of wild salmon and steelhead. This recommendation is painful to make because it hurts people most who are not the ultimate cause of the problem. Yet wild populations are in such bad shape that continued fisheries are probably preventing or delaying their recovery. A compromise of sorts is to mark all fish produced in hatcheries and allow only marked fish to be taken by both commerical and sport fishermen. Marking millions of hatchery fish will be expensive and allowing continued fishing will result in some mortality of wild fish. But at least this policy would allow people to continue to fish, helping to keep fishing traditions and skill alive. One of my biggest concerns about shutting down fisheries is that by doing so we may lose some of the strongest advocates of environmental restoration, the fishermen.

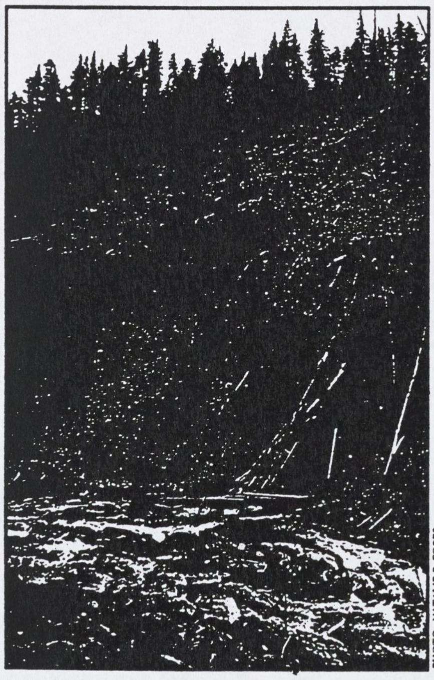


PHOTO: NATALIE B. FOBES

This hillside is beginning to slide due to improper logging. Cascade Mountains, WA.

6. Develop a coherent, integrated policy on fish hatcheries for the Pacific Northwest. We need a hatchery policy that recognizes that ocean-going fish do not recognize state boundaries, that hatchery production can have a negative effect on wild salmon and steelhead populations, and that there are hundreds of localized strains of fish that need special management. In practice, what this policy could mean is an integrated system of three kinds of hatcheries: large scale production hatcheries, experimental hatcheries, and temporary streamside hatcheries.

Production hatcheries are needed to maintain commercial fisheries; we have simply irreversibly lost too much upstream habitat to think we can rely on wild production to support fisheries, at least in the foreseeable future. We need to be thinking creatively, however, about the kind of fish raised in the hatcheries. What we need are fish that are easy to recognize as hatchery fish, segregate from wild fish for easier harvest, and have low probability of reproductive success in the wild. These are already the basic characteristics of hatchery trout, which often allow wild trout fisheries and put-and-take domestic trout fisheries to coexist. Why not genetically engineer (or simply breed) salmon that have peak runs at different times than wild fish, or that are sterile, or that have hereditary markers? Rather than disdaining domesticated fish, we should recognize that they can have a place in salmon management schemes.

Experimental hatcheries are needed not only for research to support production hatcheries, but as places where endangered species and races of fish can be reared for their entire life cycle. This can help to keep endangered forms from dying out while habitat is being restored or while the status of wild populations is uncertain. Such a program is now underway for winter-run Chinook salmon from the Sacramento River, although the facilities are ad hoc (Bodega Marine Laboratory, Steinhart Aquarium) rather than specially developed for the purposes of conservation. Unfortunately for the winter-run Chinook, there is no real "natural" habitat to which to return, only the regulated flows of the Sacramento River and patches of gravel dumped into the river for their spawning.

Temporary streamside hatcheries will probably be vital for the recovery of many depleted runs of salmon and steelhead, especially coho salmon. The idea is to have a small facility located on or near a stream that concentrates on enhancing a declining natural run until the run is once again self-sustaining or until habitat restoration efforts are completed. The key is the temporary nature of the facility; if it has to be maintained for more than 10 or 15 years, then it has failed in its mission. In California, one of the few bright spots in the coho salmon story is Lagunitas Creek, Marin County, where a temporary hatchery sponsored by Trout Unlimited, coupled with watershed management efforts, has resulted in an expanding coho population.

7. Keep the federal Endangered Species Act strong and healthy. The ESA is the most powerful piece of environmental legislation we have. Of the anadromous fishes in trouble in California, only two (winter-run Chinook and delta smelt) have been formally listed. A number of others clearly qualify for listing, including spring Chinook. This does not mean that we should automatically list every qualified species. In fact, listing should be avoided if possible because the ESA automatically engenders controversy and confrontation. I do think that using the ESA to prod agencies and private interests to work together to solve problems with our anadromous fishes is a good strategy, however. Coho salmon, for example, would benefit from multiagency recovery efforts but these are likely to come about much more quickly if it is made very clear (as has happened) that a petition is ready to be filed. Such a petition is already available for California coho populations and a state petition has been filed for the two southernmost populations in Santa Cruz County (including the famed Waddell Creek where the classic studies on coho spawning behavior were done).

8. Make environmental education

an integral part of our school systems. Except for volunteer efforts, environmental education has been cut from (or never developed in) most of our elementary and secondary schools. As a consequence, our kids usually know more about dinosaurs than they do about salmon or local natural history (Is *Oncorhynchus* any more difficult to learn than *Tyrannosaurus*?). If we do not teach our children what natural wonders they have now and what they are missing, there is little hope for our salmon and steelhead. The Clinton Administration has proposed national service in exchange for government payment of college bills. What could be a better use of enthusiastic, fresh college graduates than to teach children about salmon (and other aspects of the environment)?

In short, if the spring Chinook of Deer Creek are not to go the way of Ishi, the last of the Yahi, and if coho salmon are going to continue to spawn in Waddell Creek, then we need large-scale intervention in the processes that degrade streams and watersheds. Implementing such a program will be a major test of the sincerity of the Clinton Administration and the Congress in working towards a sustainable future.

Documentation for the information and ideas in this paper can be found in Alan Lufkin's California's Salmon and Steelhead: The Struggle to Restore an Imperiled Resource *(1991; Univ. Calif. Press, Berkeley. This is the source of the quotes by George Warner), in P.B. Moyle and R.M. Yoshiyama* Fishes, Aquatic Diversity Management Areas, and Endangered Species: A Plan to Protect California's Native Aquatic Biota *(1992; $20 from California Policy Seminar, 2020 Milvia St. Berkeley CA 94704), and in P.B. Moyle, J.E. Williams, and E. Wikramanyake* Fish Species of Special Concern of California *(1989; $30 from California Department of Fish and Game, 1416 Ninth St., Sacramento, CA 95616; revised edition should be out in late 1993). A more general account of fish ecology and conservation can be found in P. B. Moyle* Fish: An Enthusiast's Guide *(1993, University of California Press).*

Past and Present Status of Central Valley Chinook Salmon

California's Central Valley chinook salmon populations are a fragment of their former abundance. Water development for hydroelectric production, irrigation, domestic water supplies, and flood control has restricted or eliminated much of the natural habitat formerly occupied by Central Valley salmon. Much of the species historical habitat has been replaced by hatcheries. Where certain runs are difficult to domesticate for hatchery culture, only isolated population remnants remain.

Adult chinook salmon in the ocean and juveniles in freshwater are very similar anatomically and morphologically. Only adult salmon, returning to spawn and completing their life cycle, exhibit radical differences among individuals. Therefore, Central Valley salmon runs have been vaguely defined based upon migration timing and inconsistent reports of spawning times. Stone (1874) described three runs of salmon in the Sacramento River: spring, summer (fall), and winter runs based upon their appearance in tide-water. A fourth run, late-fall, was described by Fry (1961) after large numbers of mid-winter spawning chinook salmon were trapped during Keswick operations of Coleman National Fish Hatchery. In 1967, with completion of the Red Bluff Diversion Dam and the associated fish trap, salmon migration and spawning timing at Red Bluff was determined from aerial and spawning ground surveys. Although there is considerable overlap within migration times between each run, spawning occurs at distinctly different times. Therefore each run is temporally isolated from each other, with the exceptions of overlap between fall and spring runs. Formerly fall and spring runs were spatially isolated from each other with spring run occupying the headwaters and fall run occupying the lower portions of streams near the valley floor. Cope and Slater (1957) questioned the genetic integrity of spring and fall runs after forced coexistence in the Sacramento River below Shasta Dam indicated hybridization had occurred. They concluded, from marking experiments, that each run tended to return at their appropriate time but some mixing had occurred. Slater (1963) later concluded that serious hybridization was taking place between the fall and spring runs, with fall run out-competing spring run for available spawning habitat in the Sacramento River. Other evidence based upon recent coded-wire tag returns from Feather River Hatchery indicate that current hatchery practices, using arbitrary spawning dates, leads to a significant amount of mixing between these runs.

Other unique biological characteristics further define Central Valley Chinook salmon runs (Table 1). Winter and spring runs are particularly vulnerable to catastrophic events because of the nearly singular age at maturity and because there is little contribution by older-year classes. The dominance of three-year-old females results in reduced population fecundity and places these runs at risk if changes in egg or juvenile mortality increase or excessive exploitation takes place.

All of the Central Valley salmon runs have incurred permanent habitat losses of varying amounts. In 1872 Stone (1874) observed that the absence of salmon in the American, Feather, and Yuba Rivers was due to poor water quality from intense mining activity. Although hydraulic mining was abolished in 1884, these rivers were later recolonized by salmon for only a short time before water development activities permanently cut off access to the spawning grounds. From 1900 to 1930 hydroelectric development and irrigation projects truncated large portions of the headwaters of most Central Valley rivers by dam construction. By 1928 Clark (1929) estimated 510 lineal miles remained of the original 6000 miles, an 80% reduction of principally spring-run spawning area. With completion of the Friant Dam in 1942, spring-run salmon were eliminated from the San

Table 1. Descriptive characteristics of Central Valley salmon runs.

Characteristic	*Late Fall Run*	*Winter Run*	*Spring Run*	*Fall Run*
Migration period	October–April	December–July	March–July	June–December
Peak migration	December	March	May–June	September–October
Spawning period	early January–early April	late April–early August	late August–early October	late September–December
Peak spawning	early February	early June	mid-September	late October
Average percent grilse	11%	22%	24%	20%
Percent female at:				
Age 2	2%	1%	2%	3%
Age 3	57%	91%	87%	77%
Age 4+	41%	8%	11%	20%
Average population fecundity	5806 eggs	3743 eggs	4895 eggs	5498 eggs
Juvenile emergence period	April–June	July–October	November–March	December–March
Juvenile residency	7–13 months	5–10 months	3–15 months	4–7 months
Ocean entry	October–May	November–May	March–June & November–March	March–July
Juvenile size at ocean entry	160 mm (F.L.)	120 mm (F.L.)	80 mm (F.L.)	80 mm (F.L.)
Former spawning habitat	Upper mainstem rivers	spring-fed streams	headwaters	lower rivers and tributaries

Joaquin drainage. Simultaneously, the Shasta Dam on the Sacramento River eliminated an estimated 200 miles of spring-run habitat and nearly all winter-run spawning grounds. Only Mill, Deer, and Butte Creeks remain to support remnant populations of spring run and none of the original spring-fed habitat is useable or available to winter run. Winter-run salmon were displaced into the Sacramento River downstream of the Shasta Dam where water temperatures were initially suitable for successful reproduction. However, Moffett (1949) forewarned of changes in water temperatures after the Central Valley Project became fully operational and during drought periods. Water temperatures became unfavorable for successful spawning during 1976–1977 and recent droughts.

Late-fall salmon were formerly present in the San Joaquin River (Hatton and Clark 1942) and the Sacramento River system (Hanson et al. 1940). The original late fall–run spawning grounds were apparently located at the northern and southern extremes of the valley floor where summertime water temperatures afforded suitable juvenile rearing conditions. The Friant Dam eliminated the San Joaquin habitat for late fall–run salmon and the Shasta Dam altered the Sacramento River. Of the four salmon runs, the fall run has been least affected by dam construction. The fall run is the most cosmopolitan run in the Central Valley, occupying the lower reaches of most tributary streams and valley floor rivers where suitable spawning gravel is present. Overall, most of the historical range for fall run remains except for the San Joaquin River and a portion of the Sacramento upstream of the Shasta Dam. However, conditions throughout the San Joaquin drainage have been severely altered by water projects, and salmon production is strongly related to spring flow conditions (Kjelson & Brandes 1989). Kielson and Brandes (1989) also found that habitat changes due to water development in the Sacramento–San Joaquin Delta significantly affected Sacramento River stock, with fall-run smolt survival being highly correlated to river flow, temperature, and percent of inflow diverted.

Annual landings from the Sacramento–San Joaquin gill-net fishery may provide an insight into the history of Central Valley salmon runs (Clark 1929; Clark 1940; Skinner 1962). By 1870 a gill-net fishery was already well established with markets developed for fresh salmon and an expanding canning industry. Salmon fishing initially was concentrated primarily on winter and spring runs because of their fresh appearance and excellent condition with fall run of limited value because of their advanced spawning condition (Stone 1874).

A run index, based upon limited monthly landing records and known migration characteristics for each run, was developed that indicates the relative catches for each run by decade (California Fish Commission 1882, 1900; Clark 1940). Up until 1900 spring run dominated the catches with fall run being of secondary importance. This decline in spring run closely parallels the reduction of habitat at the turn of the century and increased emphasis on fall run hatchery production (Shebley 1922). Applying the developed run index to annual landings and assuming that one half of the winter and spring runs were harvested each year provides an estimate of run size (Fulton 1968). I used a harvest rate of one third for late fall and fall runs because of their inferior quality and limited harvest by the early fishery. Using this approach, although circumspect, provides an abundance index for each of the four Central Valley runs before the twentieth century. It is possible that maximum spawning runs, including harvest, may have approached 2,000,000 fish, comprising 100,000 late fall–, 200,000 winter-, 700,000 spring-, and 900,000 fall-run salmon.

Recent population estimates for the Central Valley indicate a substantial reduction in spawning salmon taking place within the past two decades, mainly on late-fall and winter runs (Table 2). Wild spring run populations in Mill and Deer Creeks show a continuing decline with fluctuating populations present in Butte Creek. A possible listing of spring-run salmon under the Federal Endangered Species Act is imminent. Only fall-run salmon continue to maintain reasonable, although low, spawning runs that are heavily supported by hatchery production.

Table 2. Total Central Valley chinook salmon spawning stock estimates, including hatchery returns, 1967–1992.

Year	Late-fall Run	Winter Run	Spring Run	Fall Run	Total
1967	37,208	57,306	23,840	182,828	301,182
1968	34,733	84,414	15,360	211,371	345,878
1969	38,752	117,808	27,447	322,475	506,482
1970	25,310	40,409	7672	244,145	317,536
1971	16,741	63,089	9274	241,958	331,062
1972	32,651	37,133	8652	154,665	233,101
1973	23,010	24,079	11,967	273,880	332,936
1974	7855	21,897	8281	236,228	274,261
1975	19,659	23,430	24,044	197,789	264,922
1976	16,198	35,096	26,786	196,189	274,269
1977	10,602	17,214	13,951	185,390	227,157
1978	12,586	24,862	8358	158,198	204,004
1979	10,398	2364	2960	229,143	244,865
1980	9481	1156	11,937	175,370	197,944
1981	6807	20,041	21,784	265,752	314,384
1982	4913	1242	28,082	240,108	274,345
1983	15,190	1831	6193	220,651	243,865
1984	7163	2663	9923	264,488	284,237
1985	8436	3962	13,055	368,942	394,395
1986	8286	2464	20,329	293,399	324,478
1987	16,049	1997	12,720	276,636	307,402
1988	11,597	2094	18,486	275,576	307,753
1989	11,639	533	12,266	172,778	197,216
1990	7305	441	6630	119,832	134,208
1991	7089	191	5944	127,119	140,343
1992	10,370	1180	2997	113,948	128,495

The Decline of Anadromous Fishes in California

California contains the southernmost populations of a majority of the anadromous fishes of the Pacific coast of North America. The fact that all of these southern populations are in decline indicates that large-scale environmental changes are taking place, especially in river systems. The native species in decline include river lamprey, *Lampetra ayersi,* Pacific lamprey, *Lampetra tridentata,* green sturgeon, *Acipenser medirostris,* white sturgeon, *A. transmontanus,* delta smelt, *Hypomesus transpacificus,* longfin smelt, *Spirinchus thaleichthys,* eulachon, *Thaleichthys pacificus,* chinook salmon, *Oncorhynchys tshawystcha,* coho salmon, *O. kisutch,* pink salmon, *O. gorbuscha,* chum salmon, *O. keta,* rainbow trout (steelhead), *O. mykiss,* and coastal cutthroat trout, *Oncorhynchus clarki clarki.* In addition, two introduced species, striped bass, *Morone saxatilis,* and American shad, *Alosa sapidissima,* are in severe decline in the state.

Of the six *Oncorhynchus* species, pink salmon are already extinct in the state, chum salmon are reduced to three small populations, and coho salmon probably qualify for threatened species status. Only fall run chinook salmon and winter run steelhead still support real fisheries (albeit greatly reduced and dependent on hatchery fish); other runs of these two species are already listed as endangered or qualify for threatened status. Cutthroat trout distribution coincides with that of coastal rainforest and its populations are greatly depleted as a consequence.

The universal decline of anadromous fishes in California reflects the general decline in the quality of aquatic environments. However, each species may be declining for a different combination of anthropogenic reasons in conjunction with a period of naturally stressful conditions in both fresh and salt water. In an attempt to evaluate the relative importance of various factors affecting the fish populations, I lumped them into nine categories (Table 1):

1. **Watershed degradation,** encompassing the effects of logging, road construction, overgrazing, and urbanization;
2. **Diversions,** anything reducing or altering the flow of streams, such as large dams and irrigation diversions;
3. **Pollution,** toxic substances of all kinds;
4. **Overfishing,** excessive harvest by sport, commercial, and subsistence fisheries;
5. **Hatcheries,** negative effects of hatchery fish on wild populations;
6. **Oceanic conditions,** negative effects of changed oceanic conditions, e.g., el Niño effects, decreased coastal productivity;
7. **Precipitation,** negative effects of increased variability in precipitation in recent years, especially droughts;
8. **Predation,** negative effects of enhanced predator (e.g., marine mammals, introduced fishes) populations on declining wild stocks;
9. **Other factors,** including altered food supply (smelt, lampreys).

Table 1. Relative importance of factors contributing to the decline of anadromous fishes in California. Subjective scores for each species range from 1 (major cause of decline) to 5 (not a cause).

Species	*Water Degradation*	*Diversions*	*Pollution*	*Overfishing*	*Hatcheries*	*Ocean Conditions*	*Precipitation*	*Predation*	*Other*
River lamprey	1	3	3	4	4	3	2	2	3
Pacific lamprey	1	2	3	4	4	3	2	2	2
White sturgeon	3	2	3	2	4	4	2	4	4
Green sturgeon	2	2	3	1	4	3	2	4	3
Delta smelt	3	1	3	4	4	4	2	3	2
Longfin smelt	2	1	3	4	4	3	2	2	2
Eulachon	2	2	4	3	4	2	3	2	4
Chinook	1	1	3	2	2	3	2	2	3
Coho	1	1	3	2	1	2	2	3	3
Pink	2	3	4	4	4	2	2	2	2
Chum	1	3	4	4	4	2	2	2	2
Steelhead	1	1	2	2	2	3	2	2	3
Cutthroat trout	1	3	4	3	3	2	2	3	3
Total points	21	25	42	44	45	43	27	33	34
Rank	1	2	6	8	9	7	3	4	5

For each species each factor was rated on a subjective 1–4 scale, where 1 indicates the factor was probably a major cause in the decline of the species; 2 a moderate contributing factor to the decline; 3 a minor cause; or 4 had no effect on the species. The scores for each factor were added and ranked from lowest to highest, with the lowest scores indicating the factors with the highest overall impact on anadromous fish populations. Watershed degradation, diversions, and variation in precipitation were ranked 1, 2, and 3, respectively (Table 1).

Decisions being made now will determine which species and stocks will become extinct in California in the near future and what segments of the original gene pools will be in existence for future use and evolution. It is possible that California stocks may be especially vulnerable if warming trends push oceanic and stream conditions to which salmonids are adapted further north. Conservation of California's anadromous fishes requires a systematic program of ecosystem protection (Moyle & Williams 1990; Moyle & Yoshiyama, 1994).

Literature Cited

Moyle, P. B., and J. E. Williams. 1990. Biodiversity loss in the temperate zone: decline of the native fish fauna of California. Conservation Biology 4:275–284.

Moyle, P. B., and R. M. Yoshiyama. 1994. A five-tiered approach to protecting aquatic biodiversity in California. Fisheries (Bethesda) 19(2):6–18.

Peter B. Moyle
Department of Wildlife and Fisheries Biology
University of California—Davis
Davis, CA 95616, U.S.A.

Present Populations

SPRING RUN CHINOOK SALMON DISTRIBUTION

Historical Range

Present Populations

Historical Range

March 5, 1996
Technical Services Branch
Geographic Information System Unit

Inland Fisheries Division

SENATE STAFF TRAVEL REQUEST

Employee Robert Behnke

Senator Tom Hayden

Office/Committee Natural Resources

STAFF TRAVELING TO SAME FUNCTION

Secretary

Consultant

Sergeants

Purpose of Trip Consult with Committee Chair and staff

Destination	Departure Date	Return Date
Sacramento	4/3	4/4

TRAVEL ARRANGEMENTS

1) Private Auto ________ License Number ________

2) State Vehicle/General Services Pool Card Requested? ________

3) Air Tickets requested as follows:

AIRLINES	FLIGHT NUMBER	DATE & TIME DEPARTURE PT.	DATE & TIME ARRIVAL PT.	LOCATOR NUMBER*	PRICE**
United	1297 274	4/3 8:05pm 4/4 5:00pm	4/3 9:27pm 4/4 8:14pm	SODXYO	375.00

INSTRUCTIONS

4 PM Marriott 9 30 return

1) STAFF ARE TO MAKE THEIR OWN RESERVATIONS.

2) *Locator Number is provided by the airlines when reservations are made.

3) **PLEASE INFORM THE AIRLINE THAT YOU ARE TRAVELING ON STATE BUSINESS.

4) Current Statement of Compliance for insurance purposes must be on file before departure.

I hereby certify under penalty of perjury that the travel requested is required in the conduct of official State business authorized by the Committee Chair or Senator and that I will use the State-owned vehicle for official use only.

Traveler's Signature Robert D Behnke Phone (970)491-5320 Date IV:2:96

Senator's Signature

RETURN FORM TO: SENATE RULES ACCOUNTING
Room 400, State Capitol

*Balance

* as of

Approved by Executive Officer ________ *Current Expense ________

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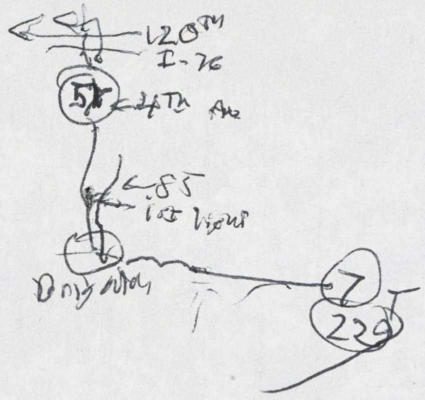

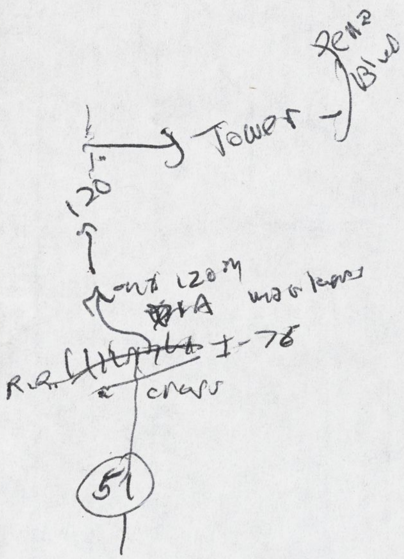

The Bay Institute
of San Francisco

By fax and by mail

April 3, 1996

Robert R. Treanor, Executive Director
Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

RE: PETITION TO LIST SACRAMENTO RIVER SPRING-RUN CHINOOK SALMON AS ENDANGERED

Dear Mr. Treanor,

This letter is submitted as the additional comments of The Bay Institute of San Francisco on the petition pending before the Fish and Game Commission to list the Sacramento River spring-run chinook salmon as an endangered species under the California Endangered Species Act (CESA). The Bay Institute continues to support the recommendation of the California Department of Fish and Game (CDFG) that sufficient information exists to indicate that the petitioned action may be warranted, and urges the Commission to accept and consider the petition.

These comments address two issues raised before the Commission:

(1) the status of the spring run as a evolutionarily significant unit;

(2) the status of efforts to improve conditions for the spring run in the Sacramento-San Joaquin Delta.

<u>Status of the spring run as a evolutionarily significant unit</u>

We believe arguments that the spring run are not an evolutionarily significant unit (ESU) are, as Dr. Peter Moyle argues, "specious," and we concur with and incorporate by reference into our comments Dr. Moyle's letter, which we understand has been submitted to the Commission

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(March 22, 1996 letter from Dr. Peter Moyle to Mr. Kip Wiley). The Fish and Game Commission and the National Marine Fisheries Service have both previously found the Sacramento River winter-run chinook salmon to be an ESU for the purposes of CESA and the federal Endangered Species Act (FESA), and the winter-run has been listed as such under both acts. Arguments for the spring run as an ESU are at least as strong as those for winter run. Failure to find that the petitioned action is warranted on these grounds would therefore be both scientifically incorrect and contradict the Commission's previous findings.

Status of efforts to improve conditions for the spring run in the Sacramento-San Joaquin Delta

Because the direct requirements in the 1995 Water Quality Control Plan (WQCP) for the Bay-Delta estuary allow high export rates, low San Joaquin River flows, and potentially adverse Delta Cross Channel operations during the November - January period, the Delta remains the area of highest risk to spring run survival. The 1995 WQCP's direct requirements for water quality and fish protection must therefore be supplemented by other measures to prevent extinction of the spring run. In its status report to the Commission, CDFG identified sixteen actions in the Delta to protect and recover spring run in addition to the 1995 WQCP's direct requirements.

Unfortunately, the Commission cannot assume that these additional actions (referred to below in the order they are listed in the CDFG report) are being implemented now, or that they are being implemented in a way that will benefit spring run:

- some, such as actions # 1, 2, and 3, are not adequately focused on meeting spring run needs, over and above those of currently listed species;

- some, such as actions # 4 and 15, rely in large part on implementation through the Category III Program, which may be hindered in its ability to support these activities since it has only received one-sixth of the $180 million funding called for in the Bay-Delta Accord;

- some, such as actions # 6, 8, 14, and 16, are part of ongoing study programs without clear implementation deadlines; and,

- some, such as actions # 7, 9, 11, 12, and 13, will be considered and implemented in the long term only after programmatic and project-level environmental review as part of the CALFED Bay-Delta Program.

Given the inadequacy of the 1995 WQCP's direct requirements and the inability of a number of these initiatives to provide specific near-term benefits to spring run, it seems clear that only through the use of operational flexibility by the CALFED Coordinated Operations Group (Ops Group), the implementation of the Central Valley Project

Improvement Act's Anadromous Fish Restoration Plan (AFRP), and other related measures can an adequate level of near term protection for the spring run be achieved during the November - January period. Unfortunately, the impetus to formulate adequate and comprehensive measures to protect spring run is lacking in these programs absent guidance from state and federal regulators charged with protection of endangered species.

By accepting and considering the petition to list the spring run, the Commission can provide such guidance to those entities whose actions in the Delta would significantly improve near term protection of the spring run. These actions should include:

- decisions by the Ops Group to improve conditions specifically for spring run, including use of operational flexibility to modify flows, export rates, Gate closure and/or other parameters during the November - January period;

- designation by the U.S. Fish and Wildlife Service and implementation by the U.S. Bureau of Reclamation of Delta prescriptive measures under the AFRP specifically to achieve doubling of natural production of spring run;

- water purchases by governmental or private parties to reduce export and improve hydrological conditions specifically for spring run during the November - January period; and,

- allocation of responsibility for meeting spring run doubling requirements of the 1995 WQCP among water users by the State Water Resources Control Board in its water right proceedings.

It is worth noting that despite the good intentions that existed in regards to winter run prior to its listing under CESA and FESA, it was only subsequent to listing that habitat improvement measures were implemented which are now beginning to bring the winter run back from the brink of extinction.

Without the Commission's recognition of the threat to spring run and guidance on recovery measures, it is unlikely the actions listed above will be undertaken to the extent necessary to prevent extinction of spring run.

Thank you for the opportunity to comment on the petition. Please enter this letter into the record of the April 4, 1996, meeting of the Commission.

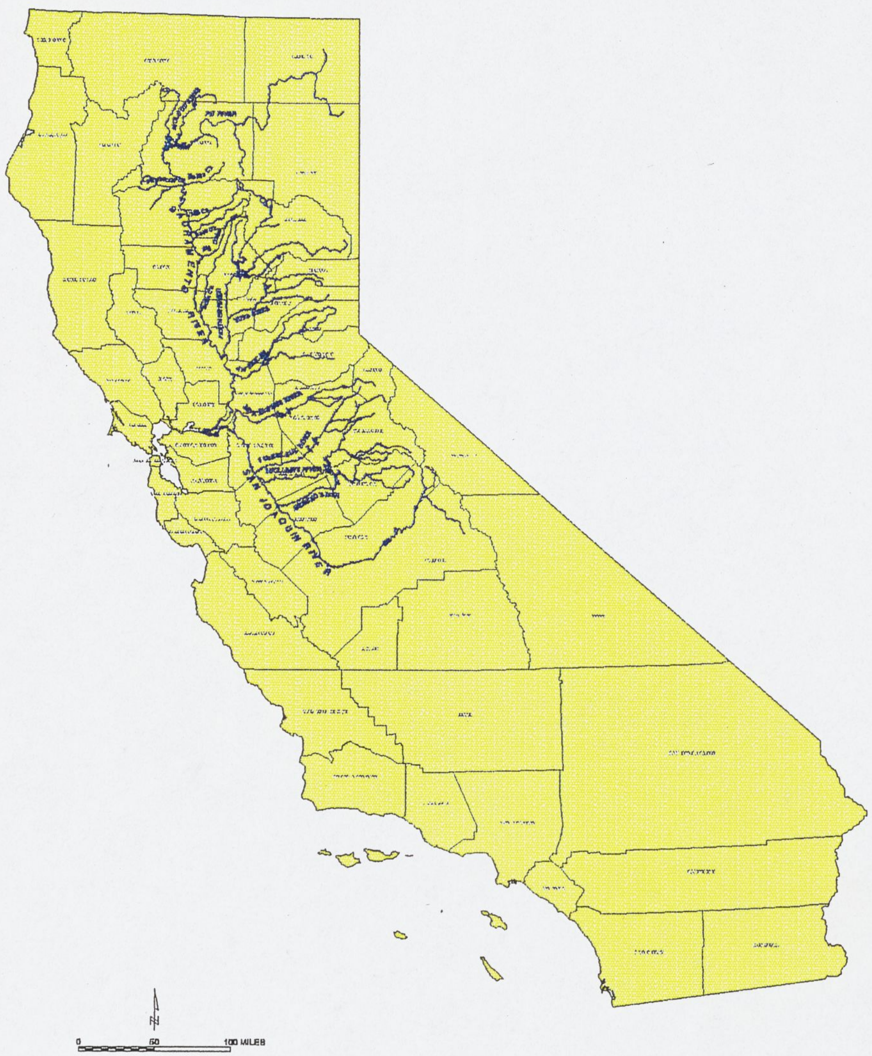
Sincerely,

David Behar
Executive Director

Present Populations

SPRING RUN CHINOOK SALMON DISTRIBUTION

Historical Range



Present Populations

Historical Range

March 5, 1996
Technical Services Branch
Geographic Information System Unit

Inland Fisheries Division

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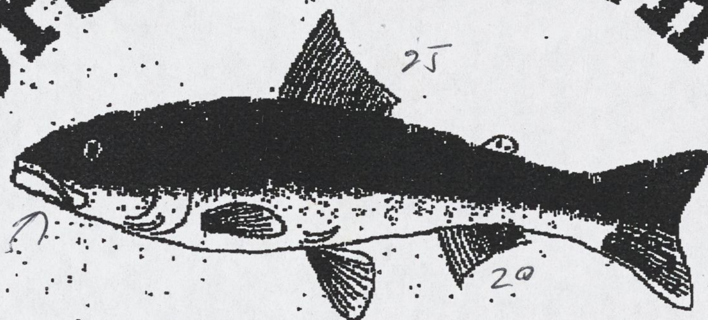
Date 4/2/96	# of pages ▶ 1		
To DA. Bob Behnke		From Pete Rafle	
Co./Dept. CSU		Co. TU	
Phone # (303) 491-5320		Phone (703) 284-9412	
Fax # ~~(970)~~ 491-5091		Fax # 9400	

Northwesterners



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P.3 45

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COOPERATIVE EXTENSION

DEPARTMENT OF WILDLIFE, FISH, AND CONSERVATION BIOLOGY
DAVIS, CALIFORNIA 95616-8751
FAX (916) 752-4154

23 March 1996

Mr. Kip Wiley
Senate Office of Research
California Legislature
1020 N St., Suite 565
Sacramento Ca 95814

Re: Spring run chinook salmon

Dear Mr. Wiley:

Thank you for asking for my comments on spring run chinook salmon conservation.

I regard the arguments that spring run chinook salmon in the Sacramento River drainage do not deserve special protection because they are not a distinct evolutionary unit (i.e. subspecies, distinct population segment, evolutionary significant unit) as being specious. There are several reasons for this opinion: (1) the populations in Deer, Mill, Butte, and nearby smaller creeks have all the hall marks of being evolutionarily distinct, (2) the alternative to treating spring run chinook salmon as a threatened species is to list all wild runs of Sacramento River chinook together as threatened, and (3) regardless of whether or not spring run chinook fit neatly into one of the human-constructed definitions of an evolutionary unit, they exist and deserve special protection as part of our California heritage.

1. **The populations in Deer, Mill, Butte, and nearby smaller creeks have all the hallmarks of being evolutionarily distinct.** These fish are segregated from other chinook salmon in both space and time. They 'run' up these creeks in the spring, just before the lower reaches become impassable to other salmon. They then hold in deep pools through the summer and spawn as soon as flows and temperatures permit in the fall. Usually spawning takes place in September and early October, well before any fall run chinook are spawning in the lower creek (typically November). Studies by Frank Fisher of CDFG indicate that these adult fish differ from their conspecifics in a number of other broad characters such as fecundity, size at different ages, and age class structure. The juveniles then spend a year in the stream before leaving the system in the winter or spring to migrate out to sea. Such distinctive life history traits must have a genetic basis. Given enough time and a sufficiently stable environment, the distinctive life history pattern that effectively isolates spring run populations from other salmon populations could lead to speciation. The seven

species of Pacific salmon (pink, chum, chinook, coho, sockeye, cherry, steelhead) all had a common ancestor and is quite likely that segregation based on life history differences lead to the evolution of these species. Because the environment is inherently unstable (through climatic change, etc.) most isolation events do not lead to distinct species , but the potential is always there (as it is today with spring run chinook salmon).

I suspect one of the arguments against the above view is that spring run and fall run hybridize in the Feather River hatchery and in the Sacramento River, essentially eliminating the distinction between the runs in the main river. It is possible that some of the hybrid fish may be part of the runs up the tributary streams but even if this is the case the environment will be strongly selecting *against* fall run and hybrid traits and *for* the traits that made spring run chinook once the most abundant run in the state. The result is the persistence of the distinctive spring run chinook life history pattern we now observe.

The genetic basis of the distinctive runs of Central Valley chinook salmon is now under investigation by Dr. Dennis Hedgecock at UCD's Bodega Marine Laboratory. I understand that preliminary results have identified distinct gene (allele) patterns for winter run chinook in the limited portion of the genome that has been investigated. It is likely that similar patterns will be found for spring run chinook. However, even if they are not found in Dr. Hedgecock's investigation, the run could still be genetically distinct because the distinctive parts of the genome were not recognized using techniques available. One way or another, genetic 'programming' is the best explanation for the life history adaptations of the spring run chinook salmon.

These arguments have been examined in great detail in relation to Columbia River chinook salmon; these runs have similar or more severe problems of interbreeding but have nevertheless been protected under the Endangered Species Act. For a good summary of the reasoning that allowed protection see R. S. Waples (1995) "Evolutionarily Significant Units and the conservation of biological diversity under the Endangered Species Act." Pages 8-27 *in* J. L. Nielsen, Editor. *Evolution and the aquatic ecosystem: defining unique units in population conservation.* American Fisheries Society Symposium 17.

2. The alternative to treating spring run chinook salmon as a threatened species is to list all wild runs of Sacramento River chinook together as threatened. My understanding is that there is little question that all Sacramento River fish together form a distinguishable genetic unit, of which the four runs (fall, late fall, winter, spring) are presumably subsets. All four runs, whether individually or together, are in decline. Hatcheries have slowed the decline of fall run (now the biggest remaining run), creating a number of new problems for wild fish in the process, but they have not stopped the decline of salmon overall. Thus an alternative, and highly justifiable, strategy to listing the runs separately would be to list the three unlisted runs together and have a recovery plan would focus on maintaining the genetic and ecological diversity that the four runs represent. Obviously, the consequences to sport and commercial fisheries of this action would be severe.

3. Regardless of whether or not spring run chinook fit one of the definitions of an evolutionary unit, <u>they exist</u> and deserve special protection as part of our California heritage. Spring run chinook once were abundant in all major tributaries to the Central Valley, numbering a million or more fish per year. These huge runs were rather callously sacrificed in order to build big dams to provide cheap water to fuel California's economy. Spring run chinook were clearly marvelously adapted to the unusual flow regimes of Central Valley streams and their distinctness was recognized by Native Americans and 19th century fish biologists. The last remnants of these runs are in a few small tributaries the Sacramento River. They look and behave like the original spring run chinook salmon. To let them disappear because of arcane genetic arguments would be tragic. Considering how many populations of spring run chinook salmon have been lost and how much water has been gained as a consequence, keeping the remaining populations going seems like a small cost for conserving a priceless part of our natural heritage.

Sincerely,

Peter B. Moyle
Professor

cc. B. May, L. Davies, Fish & Game Commission

The Bay Institute
of San Francisco

By fax and by mail

March 6, 1996

Robert R. Treanor, Executive Director
Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

RE: PETITION TO LIST SACRAMENTO RIVER SPRING-RUN CHINOOK SALMON AS ENDANGERED

Dear Mr. Treanor,

This letter is submitted as the comments of The Bay Institute of San Francisco on the petition pending before the Fish and Game Commission to list the Sacramento River spring-run chinook salmon as an endangered species under the California Endangered Species Act (CESA).

The Bay Institute supports the recommendation of the California Department of Fish and Game (CDFG) that sufficient information exists to indicate that the petitioned action may be warranted, and urges the Commission to accept and consider the petition. The long-term trend of population decline, loss of spawning habitat and consequent restrictions in range, and continuing threats to survival, particularly from direct and indirect effects of entrainment by the federal and state water projects, which characterize the spring run clearly lead to the conclusion that consideration of listing under CESA is warranted. In fact, the substantial scientific evidence available indicates that the spring run are in as much or more danger of extinction than other Bay/Delta fish species currently listed under the federal and state Endangered Species Acts.

Our recommendation is not intended to minimize or discourage in any way the efforts of local fishing and farming leaders working in

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cooperation with agency officials in the Deer, Mill, and Butte Creek watersheds to address upstream causes of the decline of the spring run. These efforts should be an important element of any upstream program to restore spring run populations, and we urge the Commission and CDFG to support these local efforts. Far from damaging these efforts, we believe consideration of a spring run listing will assist local leaders by lending urgency and attracting critical resources to their restoration efforts.

Upstream measures alone, however, will not bring the spring run back from the brink of extinction. If significant measures in the Delta are not adopted to allow safe Delta outmigration for spring run smolts, promising partnerships addressing upstream habitat conditions will be of no avail.

It is our hope that acceptance and consideration of the petition by the Commission, and a subsequent status review by CDFG, will provide the necessary focus over the next twelve months to efforts by the CALFED Coordinated Operations Group, the SWRCB in its water rights proceedings, the Category III program, the Central Valley Project Improvement Act's Anadromous Fish Restoration Plan and other initiatives to implement activities in the Delta to improve short-term conditions for the spring run. We urge the Commission to offer guidance to these efforts subsequent to accepting the petition. The available evidence suggests that increased closure of the Delta Cross-Channel Gates, reduced export pumping, and improved San Joaquin River flows in the November - January period would contribute most strongly to spring run protection.

As a signatory to the December 15, 1994, Principles for Agreement on Bay-Delta Standards, The Institute has always acknowledged that the water quality standards recommended in that Agreement and codified in the direct requirements for salmon protection in the State Water Resources Control Board's (SWRCB) 1995 Water Quality Control Plan (WQCP) for the San Francisco Bay-Delta estuary are inadequate in and of themselves to protect the Sacramento River spring-run chinook salmon. Our endorsement of the Agreement was based in part on the fact that it provides other tools — namely, the use of operational flexibility and the dedication of "Category III" funds — which, in conjunction with implementation of the Central Valley Project Improvement Act and other federal and state initiatives, allow many short-term opportunities to substantially improve protection of spring run and other salmonid stocks at risk. Those tools can most effectively be employed when guidance is forthcoming from the proper quarter.

We belive that these efforts may successfully provide at least short-term relief for the spring run. Failure to do so will necessitate adoption of more stringent direct requirements for salmon protection under the federal and state Endangered Species

Acts, by the SWRCB in revising the 1995 WQCP, and other measures. In any event, programs to ensure long-term recovery of the spring run will largely depend on the future efforts of CDFG and the Commission.

Please enter this letter into the record of the March 7 - 8, 1996, meeting of the Commission.

Sincerely,

David Behar
Executive Director

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BODEGA MARINE LABORATORY
P.O. BOX 247
BODEGA BAY, CALIFORNIA 94923

April 1, 1996

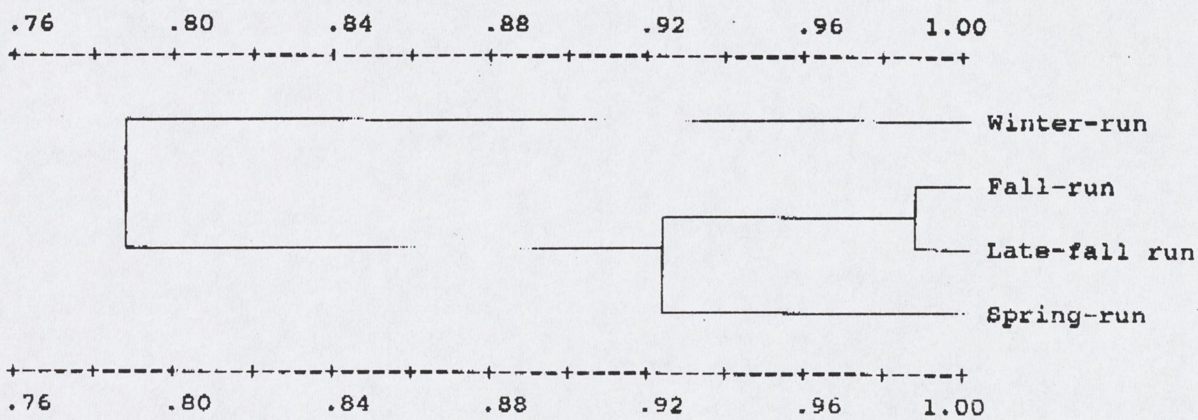
Robert Treanor, Executive Director
Fish and Game Commission
1416 Ninth Street, 13th Floor
Sacramento, California 95814

Dear Mr. Treanor,

We wish to communicate some research findings relevant to the petition pending before the Fish and Game Commission to list the Sacramento Valley spring-run chinook under the California Endangered Species Act. These findings have emerged from our studies of the genetic differentiation of Central Valley chinook salmon, including the spring-run.

We are developing, for research and conservation of California's salmon stocks, a new class of genetic markers, called "microsatellites", which are the same type of highly informative DNA markers that were recently thrust into the limelight by the trial of O. J. Simpson. Our primary focus is on the Sacramento River winter-run chinook, which has already received protection under federal and state laws. The need to discriminate winter-run from other runs of chinook salmon in the Central Valley has caused us, so far, to examine, in addition to samples of all the winter-run brood stock used for the artificial propagation and captive breeding of this stock, samples of the fall-run and late-fall run from Battle Creek (Coleman National Fish Hatchery stocks) and of spring-run from Deer Creek. The genetic similarity of these population samples, averaged over five microsatellite markers, is depicted in the following tree-diagram. On this scale, a similarity of 1.00 would represent genetically identical populations.

Genetic Similarity



Winter-run is clearly the most distinctive of the four runs, but the next most distinctive population is the spring-run. The relatively large genetic differences between each of these two runs and the rest are certainly consistent with the distinctiveness of their life histories and the geographical and seasonal differences in their spawning habitats. Even the seemingly slight divergence of the fall- and late-fall runs on this diagram comprises statistically significant differences in the frequencies of microsatellite markers, indicating the absence of gene flow between these closely related populations. Likewise, we see no evidence for natural hybridization between spring-run and other runs in the Sacramento River, despite deterioration of the geographic isolation that the spring-run enjoyed prior to construction of various foothill dams. Thus, we conclude on the basis of such evidence that spring-run, like winter-run, could be considered a subspecies qualifying for listing under the CESA.

We are presently engaged in a much broader survey of microsatellite variation in Central Valley chinook salmon stocks, which we hope to complete and publish within the next year. This study, which will report data for up to eight informative markers in multiple local populations of all but the winter-run, many of which have been sampled in more than one year, should provide definitive evidence concerning genetic divergence among the chinook salmon stocks of California's Central Valley.

Finally, we have reviewed and wish to comment upon a document prepared by Dr. Robert J. Taylor for the Commission, expressing doubt that the subspecies concept applies to spring-run chinook salmon. We disagree completely with Dr. Taylor's narrow application of the definition of subspecies and believe that his conclusion violates the spirit and intent of the CESA to preserve significant biological diversity.

In his document, Dr. Taylor cites Prof. Ernst Mayr, who applied the biological species concept to the science of systematics in his famous 1942 book. In rebuttal, we cite an earlier authority, Prof. Theodosius Dobzhansky, with whom one of us (D.H.) had the priviledge of studying at UC Davis in the mid 1970s. In 1937, Th. Dobzhansky published an extremely important and influential book, *Genetics and the Origin of Species* (Columbia University Press), which provided what evolutionary biologists now call the modern synthesis of the ideas of Mendel, concerning inheritance, and Darwin, concerning natural selection. In his 1970 update of this famous work, *Genetics of the Evolutionary Process*, Dobzhansky provided the following definitions.

"A race is a cluster of local populations that differs from other clusters in the frequencies of some gene alleles or chromosomal structures. A subspecies (following Mayr 1969 [and quoted by Taylor]) is a 'geographically defined aggregate of local populations which differ taxonomically from other such subdivisions of the species.' A subspecies is, then, a race that a taxonomist regards as sufficiently different from other races to bestow upon it a Latin name." (Dobzhansky 1970, p. 310)

The genetic differentiation of spring-run chinook salmon in the Sacramento Valley, together with the considerable information about the distinct life history and geographical and seasonal spawning habitat of this run, is entirely consistent with Dobzhansky's definition of a race. As Dobzhansky points out, races embody all of the evolutionary potential of taxonomic subspecies, and in the case of spring-run, two emerging facts support this evolutionary potential. First, there was and is, in places like Deer and Mill Creeks, geographic segregation of spring-run spawning habitat at higher elevations than the fall-run habitat. Dr. Taylor is disingenuous in stating that there is no geographic separation of spring-run from the other races. Second, the absence of evidence for hybridization of spring-run and other races in the Sacramento River mainstem, where dams have recently disrupted this geographic separation, suggests an incipient, pre-zygotic, reproductive isolation that could, over the millenia lead to the formation of a new species of chinook salmon. Spring-run is clearly a cluster of populations adapted to a geographcially and seasonally distinct spawning habitat in the Central Valley. Furthermore, the term "spring-run" itself communicates that difference to scientist, manager, fisher, and lay person alike. What separates the spring-run from qualifying as a subspecies, then, is merely the absence of a Latin name.

Please feel free to call upon either of us for clarification of our research results, these views, or the progress of our broader survey of Central Valley stocks.

Sincerely,

Dennis Hedgecock

Dennis Hedgecock, Ph.D
Geneticist

Michael A. Banks

Michael A. Banks, Ph.D.
Assistant Research Geneticist

Animal rights group targets sport fishing

By Gloria Campisi
Knight-Ridder News Service

PHILADELPHIA — The people who brought you blood-splashed furs and liberated lobsters have trained their sights on a new target: The fishing rod and the people behind it.

The animal rights group People for the Ethical Treatment of Animals this summer will hit Cape May, N.J., and other coastal spots, lakes and fishing holes around the country, beating the waters for a ban on sport fishing. PETA fish campaign coordinator Tracy Reiman promised that protesters, accompanied by 6-foot mascot "Gill the Fish," will maneuver their boats among fishing craft.

Other protesters will "skip rocks in the water where people are fishing," she said. Some also have discussed blockading fishing piers.

"But as time goes on we will escalate the campaign by doing things which will actually save individual fish lives," Reiman said.

The animal rights movement has gained increasing respectability since a 1984 raid on a University of Pennsylvania lab where researchers inflicted head injuries on baboons.

Polls show that two-thirds of Americans believe it seldom or never right to use animals to test cosmetics.

Fifty-nine percent say killing animals for fur is wrong. More than half believe sport hunting is wrong.

Fish, however, are farther down the food chain. Even an official with the Humane Society of the United States criticizes PETA's anti-fishing campaign in a published report as "somewhat silly and possibly counterproductive."

KRT / Andrea Mihalik

FIN-ISH: Saving fish is latest crusade of PETA.

PETA's Reiman, a vegetarian, said she sees it this way: "Fish are animals. Lobsters are animals. Crabs are animals. Just because they don't scream doesn't mean they don't suffer."

Reiman said the animal activist organization, which has a worldwide membership of a half-million and a galaxy of celebrity supporters, turned its attention to fishing because "fish comprise probably the largest number of animals as a group to be killed for food or fun."

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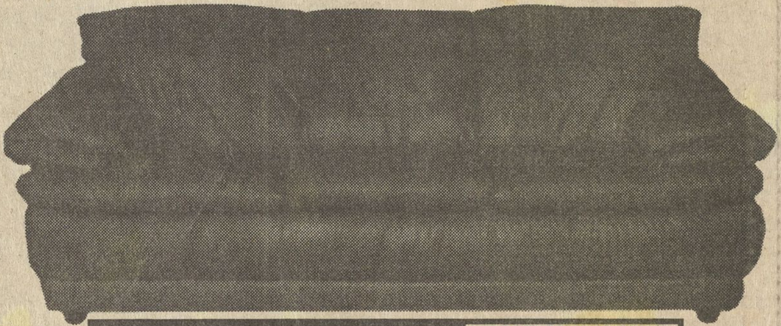

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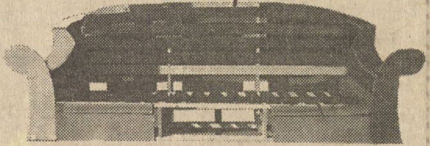

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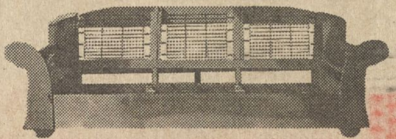

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TOM HAYDEN
CHAIRMAN

CALIFORNIA SALMON TO BE SAVED OR DRIVEN TO EXTINCTION?

FISH & GAME COMMISSION TO RULE THURSDAY AT CONTENTIOUS HEARING

contact: Duane Peterson
916/445-5441

April 3, 1996

STATE CAPITOL -- The dwindling Sacramento River Spring-run Chinook Salmon will be either protected or doomed to extinction by the state's Fish and Game Commission at its Thursday, April 4 meeting in Sacramento.

The Problem

"These salmon are nearing extinction and need protection now under our endangered species laws," said Sen. Tom Hayden in support of the petition he filed with the Commission to protect the Salmon. "The Spring-run Chinook was once the most abundant race of California salmon producing about 1 million fish annually. Now less than 10,000 native Spring-run return annually from their ocean odyssey representing a tragic collapse that we must turn around or witness the extinction of these amazing animals," Hayden added.

The Process

In a formal opinion to the Commission, the Department of Fish & Game concluded that scientific evidence is sufficient to warrant adoption of Hayden's petition and adding the salmon to the list of candidates for threatened or endangered status. Accepting such a petition would trigger a year-long study of the species, its habitat and conditions that imperil it -- at the end of which the Commission decides if it is in danger (or not) of going extinct and adds it to the endangered list, or not. During that year's review, so-called candidate species are afforded the same protections as an endangered species -- a prohibition on killing them either intentionally or unintentionally. **Opposing these protections at the meeting will be representatives from timber, grazing, farming and urban water districts.**

California Legislature

Senate Committee
on
Natural Resources and Wildlife

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CHAIRMAN

LEGAL REQUIREMENTS FOR THE COMMISSION'S CONSIDERATION AND ACCEPTANCE OF THE PETITION TO LIST SPRING RUN SALMON

Under the California Endangered Species Act (CESA), the Commission alone is responsible for determining whether to list a species as "endangered" or "threatened." An "endangered species" is defined as a native species or subspecies of fish which "is in serious danger of becoming extinct throughout all or a significant portion of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition or disease." (Cal. Fish & Game Code § 2062.) A "threatened species" is a native species or subspecies of fish that is likely to become an endangered species in the foreseeable future absent the special protections and management efforts required under CESA. (Cal. Fish & Game Code § 2067.)

The Commission must determine whether to accept a petition to list a species for further consideration (and advance the species to candidate status) based only on **scientific evidence** and other information **contained in the petition**. (Natural Resources Defense Council v. Dep't of Fish & Game, 28 Cal. App. 4th 1104, 1118 n.11 (1994) ("[l]ike CESA, candidacy determination under [the federal ESA] is to be based on science, not economics"); *see also* 14 Cal. Code Regs. § 670.1(e)(1).) Under section 2074.2 of the Fish and Game Code, the Commission **must** advance a species to candidate species if it determines that "the **petition** provides **sufficient information** to indicate that the petitioned [listing] **may be warranted.**" (Cal. Fish & Game Code § 2074.2(a)(2) (emphasis added); *see also* 14 Cal. Code Regs. § 670.1(e)(2).)

In Natural Resources Defense Council v. Dep't of Fish & Game, 28 Cal. App. 4th at 1119, the Third District Court of Appeal interpreted the phrase "sufficient information that the petitioned [listing] may be warranted" to mean "that amount of information . . . which would lead a reasonable person to conclude" that there is a "substantial possibility that the listing could occur." (*Id.* at 1119, 1125.) "Substantial possibility" is more than a "fair argument," but less than a "reasonable probability," that a listing will occur. (*Id.*)

The Commission may **only** apply the above standards when determining whether to accept a petition for consideration and advance the spring run salmon to candidate status. The Commission must consider whether there is sufficient scientific information in the petition to lead a reasonable person to conclude that there is a substantial possibility that the salmon meets CESA's definitions of "endangered" or "threatened," quoted above. Under CESA, the **Commission may not consider other information which does not bear upon the species' potentially endangered or threatened status.**

If the Commission determines that the information in the petition meets the above standard, it **must** make a finding to that effect and publish notice of its finding that the petition has been accepted for consideration. (Cal. Fish & Game Code § 2074.2(a)(2).) This notice **must** include notification that "the petitioned species is a candidate species." (*Id.*) In other words, the Commission cannot determine that listing may be warranted and conduct a status review of the species without advancing the species to candidacy status.

NRDC

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April 2, 1996

Douglas McGeoghegan, President
Richard Thieriot, Commissioner
Frank Boren, Commissioner,
Ted Dutton, Commissioner
Marjie Phares, Commissioner
California Fish and Game Commission
Box 944209
Sacramento, CA 94244-2090

Re: Petition to List Sacramento Spring-Run Chinook Salmon (Oncorhynchus tshawytscha) As Endangered

Dear President McGeoghegan and Members of the Commission:

On behalf of the Natural Resources Defense Council ("NRDC") and its members,[1] we write in support of the pending petition to list the Sacramento Spring-Run Chinook Salmon as an endangered species under the California Endangered Species Act ("CESA"), Cal. Fish & Game Code §§ 2050 et seq. For the reasons set forth below, and based upon the petition and submissions in support thereof (including testimony offered at the hearings on the petition), we believe that, without question, listing of the Spring-Run Chinook Salmon "may be warranted." Cal. Fish & Game Code § 2072.3.

As the Department of Fish and Game has recommended, therefore, we respectfully submit that the petition must be accepted and the Spring-Run Chinook Salmon listed as a candidate species. In addition, as discussed at Point V infra, we believe

[1] NRDC is a non-profit environmental advocacy organization with approximately 200,000 members nationally and a staff of 165 lawyers, scientists, and resource specialists. Established in 1970, NRDC has advocated for decades on behalf of rare, endangered, and threatened species and enforced endangered species laws both nationally and in California.

that, notwithstanding a candidacy listing, the Commission unquestionably has the authority to accommodate ongoing collaborative programs or other conservation efforts that are consistent with the fundamental policies of CESA. Cal. Fish & Game Code § 2084.[2]

I. BACKGROUND

On October 16, 1995, Senator Tom Hayden, Chair of the California State Senate Natural Resources and Wildlife Committee, submitted a Petition to the California Fish and Game Commission ("Commission") to list the Sacramento Spring-Run Chinook Salmon ("the Spring-Run") as an endangered species under CESA. As required by statute, the Commission referred the Petition to the California Department of Fish and Game ("Department"). (Cal. Fish & Game Code § 2073.)

After evaluating the Petition, the Department found that it contained sufficient scientific information and adequately addressed all required criteria specified in California Fish & Game Code § 2072.3. Accordingly, the Department recommended that the Commission accept the Petition for consideration and list the Spring-Run as a candidate for endangered protection. (Cal. Fish & Game Code § 2073.5.)

Upon receiving this recommendation from the state's own wildlife experts and the record of overwhelming scientific

---

[2] In the interest of brevity, we will not attempt to reiterate here the supporting factual information and legal arguments that have been, or will be, introduced into the record from other sources. All such information is incorporated herein by reference.

evidence upon which the recommendation is based, the Commission scheduled and then held a hearing on March 7, 1996 to consider the Petition, the Department's favorable recommendation, and comments received. It then adjourned the hearing to April 4, 1996, and left the hearing record open for further consideration of the subject. Specifically, the Commission sought further consideration of (1) whether the Petition is adequate or complete in light of the criteria prescribed by CESA for acceptance of a petition; and (2) whether the Spring-Run qualifies as a "species" or "subspecies" under CESA.

II. CESA'S CANDIDACY STANDARD

CESA was enacted to afford protection to threatened and endangered species and their habitats. The statute establishes a two-step process by which an interested person may petition the Commission to list a species as endangered. The first step of the process is a determination of "candidacy status": that, based on the scientific information contained in the Petition, protection of the species "may be warranted." (Cal. Fish & Game Code § 2072.3.) The second step, which follows the candidacy finding and completion of a twelve-month status review or study period, is a determination of "listing status": that protection of the species in fact "is warranted." (Cal. Fish & Game Code §§ 2074.6, 2075.5.)

In this proceeding, the Department found that the scientific information contained in the Petition was sufficient for the first-step determination that listing may be warranted. It therefore recommended to the Commission that the Petition be accepted, that the Spring-Run be advanced to candidacy status, and that the status review be initiated.

The Commission must now consider the Petition, the Department's favorable recommendations, and comments received, and make one of two possible findings:

> (1) If the commission finds that the petition does not provide sufficient information to indicate that the petitioned action may be warranted, the commission shall publish a notice of finding that the petition is rejected, including the reasons why the petition is not sufficient.
>
> (2) If the commission finds that the petition provides <u>sufficient information to indicate that the petitioned action may be warranted</u>, the commission shall publish a notice of finding that the petition is accepted for consideration.

(Cal. Fish & Game Code § 2074.2 (emphasis added).) If the Commission determines that the listing "may be warranted," it must designate the species as a candidate species.

Most important, at this stage of the review, the question facing the Commission is <u>not</u> whether listing as an endangered or threatened species <u>is</u> warranted, but whether it <u>may be</u> warranted. Specifically, § 2074.2 of the California Fish & Game Code provides that the Commission must advance a species or subspecies to candidacy status if it determines that "the petition provides <u>sufficient information</u> to indicate that the petitioned [listing] <u>may be warranted</u>." (Cal. Fish & Game Code §

2074.2 (a)(2) (emphasis added); see also 14 Cal. Code Reg. § 670.1(e)(2).)

This "may be warranted" language has recently been interpreted by the California Court of Appeal in an action challenging the Commission's failure to advance the Coastal California Gnatcatcher to candidacy. Natural Resources Defense Counsel v. California Fish & Game Commission, 28 Cal.App.4th 1104, 1119 (1995) ("NRDC"). In NRDC, the Court of Appeal concluded that a "may be warranted" finding (and hence acceptance of the petition) is required where there is such information that "would lead a reasonable person to conclude" that there is a "substantial possibility that the listing could occur." Id. at 1119, 1125. "Substantial possibility" is more than a "fair argument," but less than a "reasonable probability," that a listing will occur. Id. Thus, applied here, the NRDC case makes clear that the only question now before the Commission is whether, based on the Petition, there is a substantial possibility that listing of the Spring-Run could occur.

By establishing this two stage process -- with a low threshold for acceptance at the candidacy stage, followed by a twelve-month status review -- the Legislature clearly envisioned that all scientific uncertainties would not and need not be resolved for a petition to be accepted. Indeed, the intervening status review was intended to provide ample opportunity for the Department to compile and review all available information, conduct such studies as are necessary, and develop a thoroughly informed recommendation on listing for consideration by the Commission. At this stage, CESA requires only that a petition contain each of the prescribed elements and "sufficient scientific information" to conclude that the listing of the Spring-Run "may be warranted" -- a standard plainly met by the pending Petition.

III. <u>THE PETITION CONTAINS EACH OF THE ELEMENTS REQUIRED BY CESA TO SUPPORT A FINDING THAT LISTING OF THE SPRING-RUN AS AN ENDANGERED SPECIES MAY BE WARRANTED</u>.

In its January 17, 1996 Evaluation Report recommending candidacy, the Department correctly found that the Petition contains sufficient scientific information and adequately addresses all the required criteria under CESA. To be sufficient, a petition must contain the following scientific information:

> information regarding the population trend, range, distribution, abundance, and life-history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant.

(Cal. Fish & Game Code § 2072.3.)

The Department's favorable recommendation is thoroughly justified by the Petition, which, as summarized below, satisfies each of the required statutory elements. Briefly summarized, the Petition sets forth, and discusses in detail, at least the following information:

<u>POPULATION TREND</u>: The Spring-Run has undergone a significant long-term decline since historic times because of loss of spawning habitat. More than 20 historically large populations have been extirpated or reduced to nearly zero since 1940.

<u>ABUNDANCE</u>: The Spring-Run was once the most abundant race of salmon in California's Central Valley, producing about one million fish annually, and has been a major cultural, biological and economic asset of the state. The Mill and Deer Creek Spring-Run populations, which represent the most important remaining populations in the Sacramento-San Joaquin River system, have declined by 80% since the 1960s.

<u>RANGE AND DISTRIBUTION</u>: The Spring-Run once occupied 26 streams in the Sacramento-San Joaquin drainage. Their range is now highly restricted from elimination of access to spawning areas by dam construction on the Sacramento-San Joaquin River system. It is widely accepted that pure Spring-Run have been rendered extinct in the mainstream Sacramento River and certain East Valley rivers. Fishery biologists are in general agreement that the true Spring-Run stocks are now limited to spawning in Mill and Deer Creeks, and possibly to Big Chico, Butte and several other East Valley creeks.

<u>LIFE HISTORY AND REPRODUCTION</u>: Spring-run have a lower fecundity than fall-run chinook salmon. They are differentiated from other chinook salmon races by maturity of fish entering freshwater, time of spawning migrations, spawning areas, and emigration time of juveniles. There is reproductive isolation by geographic separation of spawning habitat.

<u>HABITAT NECESSARY FOR SURVIVAL</u>: Adults need access to cold deep pool habitat to enable them to survive and protect garnete viability over the summer months followed by spawning in early fall months. Adults need access to tributary headwaters where they can be geographically isolated from fall-run. Spring-Run are susceptible to extinction from hybridization with fall-run chinook salmon in the absence of geographic isolation. Spring-Run require adequate water quality and quantity for adult holding, spawning, egg incubation, juvenile rearing, and migration.

<u>FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE</u>: In addition to major salmon losses as a result of habitat loss caused by dam construction in the past, Spring-Run populations today are continuing to decline to critical levels. It is generally agreed by experts from state and federal fishery agencies, as well as by independent fishery biologists, that by far the major impediments to Spring-Run recovery and survival today are the adverse hydrodynamic conditions in the Sacramento-San Joaquin Delta. Other impacts such as ocean harvest and predation and tributary conditions are important but of far less magnitude when compared to the situation in the delta.

DEGREE AND IMMEDIACY OF THREAT: The remaining populations are found only in Mill, Deer, Butte and Big Chico creeks. The Spring-Run have severely restricted range, population decline, low population abundance, and high population fluctuation. The populations are highly susceptible to natural and human-caused impacts.

IMPACT OF EXISTING MANAGEMENT EFFORTS: Currently, the Spring-Run receive no protection from adverse hydrodynamic conditions in the delta. The recent Bay/Delta Agreement calls for mitigation measures for reducing the impacts of water exports only during the months of April through June, with additional measures applying from February through April. However, the Deer and Mill Creek Spring-Run out-migrate through the Delta primarily between November and January, when no protections from the Bay/Delta agreement are in place.

SUGGESTIONS FOR FUTURE MANAGEMENT: The Petition recommends actions to improve access and habitat conditions in the Sacramento River tributaries, as well as specific actions to increase smolt survival in the delta.

AVAILABILITY AND SOURCES OF INFORMATION AND DETAILED DISTRIBUTION MAPS: The Petition provides extensive references to sources of information available in libraries and agency files and provides comprehensive and detailed maps that depict past and present population range and distribution.

As this brief summary illustrates, and as affirmed by the Department's favorable recommendation, the Petition satisfies every element that CESA requires for a Petition to be deemed acceptable under CESA. The Petition contains substantial scientific information sufficient to establish that protection "may be warranted" and demonstrates the need for precisely the kind of detailed comprehensive study that can be effectively conducted only through the Department"s twelve-month candidacy stage status review.

IV. THE SPRING-RUN QUALIFIES AS A SPECIES OR SUBSPECIES UNDER CESA.

An "endangered species" is defined in CESA as

> a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion of, its range due to one or more causes, including loss of habitat, change in habitat, over-exploitation, predation, competition, or disease.

(Cal. Fish & Game Code § 2062.)

Both as a matter of fact and law, the Spring-Run unquestionably qualifies for protection under CESA. First, as set out in the Petition, there is overwhelming biological evidence that the Spring-Run qualifies as an endangered species or subspecies. The Petition provides biological evidence of the phylogenetic relationship of the Spring-Run to other races of chinook salmon endemic to the Central Valley. It states the taxonomic status of the Spring-Run as *Oncorhynchus tshawytscha*.

(Petition, Executive Summary.) The Department's recommendation report summarizes the Petition's material on Spring-Run life-history and reproduction, stating:

> [Spring-Run have a] lower fecundity than fall-run chinook salmon; [they are] differentiated from other chinook salmon races by maturity of fish entering freshwater, time of spawning migrations, spawning areas, and emigration time of juveniles. [There is] reproduction isolation maintained by geographic separation of spawning habitat.

(Department Evaluation Report, at 2 (January 17, 1996).)

The Petition bases its description of the Spring-Run's life-history on a variety of historic and current reports that describe the Spring-Run as one of the four Central Valley chinook salmon races. (Petition, Sec. IX.) References used in the Petition include the report titled, Fish Species of Special Concern, by Peter B. Moyle, Ronald M. Yoshiyama, and Eric D. Wikramanayake, published by the State of California, Resources Agency, California Department of Fish and Game, in 1989. (Petition, Sec. IX.) The Petition describes and incorporates by reference substantial information on the present knowledge of Spring-Run discreteness and uniqueness from other Central Valley chinook salmon races. (Petition, Sec. VI.)[3]

---

[3] As but one example, in Fish Species of Special Concern, Moyle et al. explain:

> The runs of chinook salmon are differentiated by the maturity of fish entering fresh water, time of spawning migrations, spawning areas, incubation times, incubation

Second, as discussed supra, the Department has recommended that the Petition be accepted and the Spring-Run advanced to candidacy. Notably, at the federal level, the National Marine Fisheries Service ("NMFS") has also issued a preliminary decision concluding that the Spring-Run is a separate and distinct species. In a recent letter to the Department, NMFS states that "biological evidence now supports designation of the spring-run population in the Sacramento River as a separate [Evolutionarily Significant Unit]." (NMFS Letter to the Department (March 5, 1996).) Thus, at both the state and federal levels, the expert wildlife agencies have recognized that protection of the Spring-Run is biologically appropriate. These findings alone are easily sufficient to meet the low candidacy threshold prescribed by CESA -- i.e., a "substantial possibility that listing could occur." NRDC, supra.[4]

Third, the California Legislative Counsel has interpreted the "species or subspecies" language of CESA to

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> temperature requirements, and migration of juveniles. Differences in life histories effectively isolate spring chinook salmon from other runs; thus the traits are undoubtedly inherited. Therefore, each run of salmnon must be considered to be genetically distinct, even from other runs in the same stream. (Emphasis added.)

[4] To the extent that any scientific question exists regarding the exact taxonomic status of the Spring-Run, the proper course for the Commission -- as recommended by the Department -- is to address the issue as part of the candidacy status review. Rather than foreclose further study, the Department correctly decided that any unresolved scientific issues on taxonomic data militate in favor of candidacy status where, as here, the biological need and scientific basis for protection of the Spring-Run are so extensive and credible.

protect distinct populations of an endangered species, such as the Sacramento Spring-Run. In an Opinion dated October 17, 1986, the Legislative Counsel explained at length as follows:

> Under the California Endangered Species Act, the Fish and Game Commission may include in the list of endangered species plant or animals a distinct population of a particular species or subspecies even though the entire species or subspecies is not itself endangered . . . .
>
> * * *
>
> [T]he term "species" and "subspecies" are not defined in the Fish and Game Code or elsewhere in the state statutes. However, the term "species" has been defined as a "sort, a kind, a class subordinate to a genus, which is a class embracing many species" (Ballentine's Law Dictionary, Third Ed. (1969), p. 1202). "Species" is also defined as "a category of biological classification randing immediately below a genus or subgenus . . . a group of intimately related and physically similar organisms that actually or potentially interbreed and are less commonly capable of fertile interbreeding with members of other grounds, that ordinarily comprise differentiated populations limited geographically (as subspecies) or ecologically (as ecotypes) which tend to intergrade as points of contact . . ." (Webster's Third New International Dictionary, (1976), p. 2187). The federal Endangered Species Act of 1973 (16 U.S.C. § 1531 et seq.), an enactment on the federal level similar to the act, defines "species" to include "any subspecies of fish or wildlife or plants, and any distinct population segment

> of any species of vertebrate fish or wildlife which interbreeds when mature (16 U.S.C. § 1532(16); 50 C.F.R. 424.02(k))." Thus, for example, under federal law, brown bears and grizzly bears are a threatened species in the contiguous 48 states but not in Alaska (50 C.F.R. 17.11). So too, alligators are threatened only in very specific geographical locations (50 C.F.R. 17.42). Accordingly, both the common definition of "species" and a specialized use of the term in a similar statutory scheme include distinct populations of plants, fish, or wildlife.
>
> Generally, courts will construe a statute in accordance with the common or ordinary meaning of the words used (Madrid v. Justice Court, 52 Cal.App.3d 819, 824). Based on the above-stated definitions of the term "species," it seems clear that this word in both its common and ordinary usage and in a more specialized and related usage is broad enough to include a distinct population of a fish, plant or wildlife.

(Opinion of the Legislative Counsel to the Honorable Robert J. Campbell, at 1, 3 (emphasis added).)[5]

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[5] CESA clearly does not require that a petition necessarily cover the entire population and/or range of a species. See, e.g., Cal. Fish and Game Code § 2062 (defining endangered species to include a species that is in serious danger of becoming extinct throughout "all, or a significant portion of, its range" (emphasis added)). Moreover, it is irrefutable that CESA requires protection of species populations within California regardless of whether other populations of that species may exist outside the state.

Fourth, the Commission has previously listed as endangered another distinct segment of the population of chinook salmon endemic to the Central Valley, the Sacramento River Winter-Run Chinook Salmon ("the Winter-Run"). The Winter-Run is also listed as endangered under the federal Endangered Species Act, 16 U.S.C. §§ 1531 et seq. See also U.S. v. Glen-Colusa Irrigation District, 788 F.Sup.p 1126, 1129 (E.D.Cal. 1992) ("[T]he Winter-Run is a distinct species of salmon found only in the Sacramento River."). This listing of the Winter-Run further supports the candidacy of the Spring-Run in establishing that an individual run is entitled to protection under CESA. For the Commission now to disregard its prior decision would violate the well established principle of administrative law that an agency may not blindly disregard its prior practice. See, e.g., Galster v. Woods (1985) 173 Cal.App.3d 529, 544 (mandate issued against Department of Social Services); Henning v. Industrial Welfare Comm. (1988) 46 Cal.3d 1262, 1278 (mandate issued against Industrial Welfare Commission).

Finally, a contrary interpretation of CESA would violate not only the Commission's prior practice but its Salmon Management Policy:

> It is the policy of the Fish and Came Commission that salmon shall be managed to protect, restore, and maintain the populations and genetic integrity of all identifiable stocks . . . .

(Policies Adopted By the California Fish and Game Commission Pursuant to Section 703 of the Fish and Game Code (1994).) See also Cal. Fish and Game Code §§ 2052, 2055 (stating CESA policy to "conserve, protect, restore, and enhance" species and habitat). This explicit statement of policy with regard to salmon unquestionably mandates that the Commission act to "restore, protect and enhance" the Sacramento Valley Spring-Run by advancing it to candidacy.

For all of these reasons, individually and collectively, we believe that listing of the Spring-Run clearly "may be warranted." Accordingly, the Department's recommendation of candidacy for the Spring-Run must be adopted by the Commission.

V. THE COMMISSION HAS THE AUTHORITY TO ACCOMMODATE ONGOING COLLABORATIVE PROGRAMS THAT ARE CONSISTENT WITH CESA'S FUNDAMENTAL POLICIES.

In the NRDC case, the Court of Appeal rejected as "erroneous" the suggestion of the Building Industry Association that a candidacy listing would operate "to preclude, during the candidate study process, all potential habitat development and land use . . . ." NRDC, 28 Cal.App.4th 1104, 1121, 33 Cal.Rptr.2d, 904, 913 (1994). Indeed, § 2084 of the Fish and Game Code explicitly provides that "[t]he Commission may authorize, subject to terms and conditions it prescribes, the taking of any candidate species." Thus, subject to the fundamental policies of CESA -- e.g., "it is the policy of the state to 'conserve, protect, restore, and enhance any endangered . . . or threatened species and [their] habitat" (Fish and Game Code § 2052) -- the Commission may permit limited take of a candidate species.

Given this authority, there is no merit to the suggestion that ongoing collaborative activities consistent with CESA policies will be precluded, curtailed, or otherwise undermined in any way by acceptance of the pending Petition. To the contrary, as our experience with the California Gnatcatcher and the NCCP in southern California has shown, those collaborative activities may actually be reinforced by the prospect of a future listing of the Spring-Run because such listing provides a powerful additional incentive for cooperation, for funding, for research, and for the development of creative initiatives that, while protecting the species, will serve the interests of all stakeholders. There is absolutely no rational reason why similar activities or initiatives within the ecosystem of the Spring-Run would not also be served, rather than subverted, by compliance with CESA in this proceeding.

Through CESA, the Legislature has established a minimum threshold for protection of our wildlife heritage in California and a § 2084 permitting process for flexibility during candidacy. As the Court of Appeal recognized in <u>NRDC</u> with respect to the California Gnatcatcher, erroneous assertions about the actual impact of a candidacy listing cannot be allowed to subvert that

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legislative intent. For all of the foregoing reasons, the pending Petition must be accepted.

Very truly yours,

Joel R. Reynolds
Senior Attorney

Of assistance: Beatrice Hoffman

cc: Robert Treanor,
Executive Director
California Fish and Game Commission

Senator Tom Hayden, Chair
Senate Natural Resources and Wildlife Committee

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COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION

DEPARTMENT OF WILDLIFE, FISH, AND CONSERVATION BIOLOGY
DAVIS, CALIFORNIA 95616-8751
FAX: (916) 752-4154

23 March 1996

Mr. Kip Wiley
Senate Office of Research
California Legislature
1020 N St., Suite 565
Sacramento Ca 95814

Re: Spring run chinook salmon

Dear Mr. Wiley:

Thank you for asking for my comments on spring run chinook salmon conservation.

I regard the arguments that spring run chinook salmon in the Sacramento River drainage do not deserve special protection because they are not a distinct evolutionary unit (i.e. subspecies, distinct population segment, evolutionary significant unit) as being specious. There are several reasons for this opinion: (1) the populations in Deer, Mill, Butte, and nearby smaller creeks have all the hall marks of being evolutionarily distinct, (2) the alternative to treating spring run chinook salmon as a threatened species is to list all wild runs of Sacramento River chinook together as threatened, and (3) regardless of whether or not spring run chinook fit neatly into one of the human-constructed definitions of an evolutionary unit, they exist and deserve special protection as part of our California heritage.

1. **The populations in Deer, Mill, Butte, and nearby smaller creeks have all the hallmarks of being evolutionarily distinct.** These fish are segregated from other chinook salmon in both space and time. They 'run' up these creeks in the spring, just before the lower reaches become impassable to other salmon. They then hold in deep pools through the summer and spawn as soon as flows and temperatures permit in the fall. Usually spawning takes place in September and early October, well before any fall run chinook are spawning in the lower creek (typically November). Studies by Frank Fisher of CDFG indicate that these adult fish differ from their conspecifics in a number of other broad characters such as fecundity, size at different ages, and age class structure. The juveniles then spend a year in the stream before leaving the system in the winter or spring to migrate out to sea. Such distinctive life history traits must have a genetic basis. Given enough time and a sufficiently stable environment, the distinctive life history pattern that effectively isolates spring run populations from other salmon populations could lead to speciation. The seven

species of Pacific salmon (pink, chum, chinook, coho, sockeye, cherry, steelhead) all had a common ancestor and is quite likely that segregation based on life history differences lead to the evolution of these species. Because the environment is inherently unstable (through climatic change, etc.) most isolation events do not lead to distinct species , but the potential is always there (as it is today with spring run chinook salmon).

I suspect one of the arguments against the above view is that spring run and fall run hybridize in the Feather River hatchery and in the Sacramento River, essentially eliminating the distinction between the runs in the main river. It is possible that some of the hybrid fish may be part of the runs up the tributary streams but even if this is the case the environment will be strongly selecting *against* fall run and hybrid traits and *for* the traits that made spring run chinook once the most abundant run in the state. The result is the persistence of the distinctive spring run chinook life history pattern we now observe.

The genetic basis of the distinctive runs of Central Valley chinook salmon is now under investigation by Dr. Dennis Hedgecock at UCD's Bodega Marine Laboratory. I understand that preliminary results have identified distinct gene (allele) patterns for winter run chinook in the limited portion of the genome that has been investigated. It is likely that similar patterns will be found for spring run chinook. However, even if they are not found in Dr. Hedgecock's investigation, the run could still be genetically distinct because the distinctive parts of the genome were not recognized using techniques available. One way or another, genetic 'programming' is the best explanation for the life history adaptations of the spring run chinook salmon.

These arguments have been examined in great detail in relation to Columbia River chinook salmon; these runs have similar or more severe problems of interbreeding but have nevertheless been protected under the Endangered Species Act. For a good summary of the reasoning that allowed protection see R. S. Waples (1995) "Evolutionarily Significant Units and the conservation of biological diversity under the Endangered Species Act." Pages 8-27 *in* J. L. Nielsen, Editor. *Evolution and the aquatic ecosystem: defining unique units in population conservation.* American Fisheries Society Symposium 17.

2. The alternative to treating spring run chinook salmon as a threatened species is to list all wild runs of Sacramento River chinook together as threatened. My understanding is that there is little question that all Sacramento River fish together form a distinguishable genetic unit, of which the four runs (fall, late fall, winter, spring) are presumably subsets. All four runs, whether individually or together, are in decline. Hatcheries have slowed the decline of fall run (now the biggest remaining run), creating a number of new problems for wild fish in the process, but they have not stopped the decline of salmon overall. Thus an alternative, and highly justifiable, strategy to listing the runs separately would be to list the three unlisted runs together and have a recovery plan would focus on maintaining the genetic and ecological diversity that the four runs represent. Obviously, the consequences to sport and commercial fisheries of this action would be severe.

3. Regardless of whether or not spring run chinook fit one of the definitions of an evolutionary unit, <u>they exist</u> and deserve special protection as part of our California heritage. Spring run chinook once were abundant in all major tributaries to the Central Valley, numbering a million or more fish per year. These huge runs were rather callously sacrificed in order to build big dams to provide cheap water to fuel California's economy. Spring run chinook were clearly marvelously adapted to the unusual flow regimes of Central Valley streams and their distinctness was recognized by Native Americans and 19th century fish biologists. The last remnants of these runs are in a few small tributaries the Sacramento River. They look and behave like the original spring run chinook salmon. To let them disappear because of arcane genetic arguments would be tragic. Considering how many populations of spring run chinook salmon have been lost and how much water has been gained as a consequence, keeping the remaining populations going seems like a small cost for conserving a priceless part of our natural heritage.

Sincerely,

Peter B. Moyle
Professor

cc. B. May, L. Davies, Fish & Game Commission

Status of Efforts to Restore Spring-Run Chinook Salmon

Area	Priority "A" Actions		Priority "B" Actions		Priority "C" Actions		Status of Actions	
	Implemented	Incomplete	Implemented	Incomplete	Implemented	Incomplete	Implemented	Incomplete
Sacramento River and Tributaries	34	102	5	22	4	16	43	140 (75%)
Sacramento-San Joaquin Delta	0	13	0	5	0	2	0	20 (100%)
Ocean	0	1	0	1	0	1	0	3 (100%)
Total	34	116	5	28	4	19	43	163 (79.2%)

Data from DFG's "Status of Actions to Restore Central Valley Spring-Run Chinook Salmon" 2/1/96

Sierra Club California
P. O. Box 256 Philo, CA 95466
707-895-3716 fax 895-3746

April 2, 1996

California Fish and Game Commission
1416 - 9th Street
Sacramento, CA 95815

Re: Spring-run Chinook

Dear Commission Members:

We strongly support candidacy status for Spring-run Chinook Salmon. The Department of Fish and Game has determined that the petition contains sufficient information to conduct a status review, has recommended that the petition be accepted, and that Spring-run be granted candidate status. Combined with the scientific evidence in hand, under these circumstances there does not appear to be any legitimate or legal reason to refuse to confer the candidate status.

Although we understand that the issue of taxonomic status has been raised, the appropriate forum for determining the facts is during the status review under candidacy protection. It would be very foolish to conduct an investigation of this point without providing the interim protection that candidacy status will provide. If the run goes extinct during an unprotected analysis, taxpayer resources, both the cost of the analysis and the public trust resource of the fishery, will have been unnecessarily wasted.

Candidacy status for Spring-run chinook can be granted this year with minimal disruption because of the abundant rainfall. We might not be so lucky next year, and delay in candidacy could result in more severe constraints later. Now is the time to take action.

Thank you for your efforts on behalf of protection for California's important fish and game resources.

Sincerely,

Kathy Bailey

Kathy Bailey
State Forestry Chair

State Capitol
Sacramento, CA 95814

California Legislature

April 3, 1996

Mr. Douglas McGeoghegan, President
California Fish and Game Commission
1416 Ninth Street
Sacramento, California 95814

Dear Mr. McGeoghegan:

Regarding the petition before you to list as endangered the Spring-run Chinook Salmon, we are aware that a handful of other legislators wrote you on March 6, 1996 urging the Commission to make its decision based on factors other than the scientific evidence before you. We believe that the law is clear in forbidding the consideration of any such outside political interference.

As you probably know, the California Endangered Species Act requires the Commission to advance a plant or animal to candidate status if it determines that "the petition provides sufficient information to indicate that the petitioned [listing] may be warranted." (Fish and Game Code section 2074.2) Further, established legal precedent requires the Commission to act on a petition based only on the scientific evidence and other information contained in the petition. (Natural Resources Council v. Dept of Fish and Game, 28Cal. App. 4th 1104, 1118n.11 1994)

We therefore respectfully request that you comply with established law and disregard any entreaties offered to you by Legislators or other interests which address anything other than the scientific evidence of the matter.

Sincerely,

Hon. Michael Sweeney

Hon. Liz Figueroa

Tom Bates

Hon. Tom Bates

Hon. Martin Gallegos

Hon. Wally Knox

Hon. Carol Migden

Hon. Kerry Mazzoni

Hon. Louis Caldera

Hon. Jackie Speier

Hon. Debra Bowen

Hon. Martha Escutia

Hon. John Vasconcellos

Hon. Sheila James Kuehl

Hon. Valerie Brown

NRDC

Natural Resources Defense Council

6310 San Vicente Blvd., Suite
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213 934-6900
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BY FAX -- (916) 653-1856

April 2, 1996

Douglas McGeoghegan, President
Richard Thieriot, Commissioner
Frank Boren, Commissioner,
Ted Dutton, Commissioner
Marjie Phares, Commissioner
California Fish and Game Commission
Box 944209
Sacramento, CA 94244-2090

Re: Petition to List Sacramento Spring-Run Chinook Salmon (Oncorhynchus tshawytscha) As Endangered

Dear President McGeoghegan and Members of the Commission:

On behalf of the Natural Resources Defense Council ("NRDC") and its members,[1] we write in support of the pending petition to list the Sacramento Spring-Run Chinook Salmon as an endangered species under the California Endangered Species Act ("CESA"), Cal. Fish & Game Code §§ 2050 et seq. For the reasons set forth below, and based upon the petition and submissions in support thereof (including testimony offered at the hearings on the petition), we believe that, without question, listing of the Spring-Run Chinook Salmon "may be warranted." Cal. Fish & Game Code § 2072.3.

As the Department of Fish and Game has recommended, therefore, we respectfully submit that the petition must be accepted and the Spring-Run Chinook Salmon listed as a candidate species. In addition, as discussed at Point V infra, we believe

[1] NRDC is a non-profit environmental advocacy organization with approximately 200,000 members nationally and a staff of 165 lawyers, scientists, and resource specialists. Established in 1970, NRDC has advocated for decades on behalf of rare, endangered, and threatened species and enforced endangered species laws both nationally and in California.

that, notwithstanding a candidacy listing, the Commission unquestionably has the authority to accommodate ongoing collaborative programs or other conservation efforts that are consistent with the fundamental policies of CESA. Cal. Fish & Game Code § 2084.[2]

I. BACKGROUND

On October 16, 1995, Senator Tom Hayden, Chair of the California State Senate Natural Resources and Wildlife Committee, submitted a Petition to the California Fish and Game Commission ("Commission") to list the Sacramento Spring-Run Chinook Salmon ("the Spring-Run") as an endangered species under CESA. As required by statute, the Commission referred the Petition to the California Department of Fish and Game ("Department"). (Cal. Fish & Game Code § 2073.)

After evaluating the Petition, the Department found that it contained sufficient scientific information and adequately addressed all required criteria specified in California Fish & Game Code § 2072.3. Accordingly, the Department recommended that the Commission accept the Petition for consideration and list the Spring-Run as a candidate for endangered protection. (Cal. Fish & Game Code § 2073.5.)

Upon receiving this recommendation from the state's own wildlife experts and the record of overwhelming scientific

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[2] In the interest of brevity, we will not attempt to reiterate here the supporting factual information and legal arguments that have been, or will be, introduced into the record from other sources. All such information is incorporated herein by reference.

evidence upon which the recommendation is based, the Commission scheduled and then held a hearing on March 7, 1996 to consider the Petition, the Department's favorable recommendation, and comments received. It then adjourned the hearing to April 4, 1996, and left the hearing record open for further consideration of the subject. Specifically, the Commission sought further consideration of (1) whether the Petition is adequate or complete in light of the criteria prescribed by CESA for acceptance of a petition; and (2) whether the Spring-Run qualifies as a "species" or "subspecies" under CESA.

II. CESA'S CANDIDACY STANDARD

CESA was enacted to afford protection to threatened and endangered species and their habitats. The statute establishes a two-step process by which an interested person may petition the Commission to list a species as endangered. The first step of the process is a determination of "candidacy status": that, based on the scientific information contained in the Petition, protection of the species "may be warranted." (Cal. Fish & Game Code § 2072.3.) The second step, which follows the candidacy finding and completion of a twelve-month status review or study period, is a determination of "listing status": that protection of the species in fact "is warranted." (Cal. Fish & Game Code §§ 2074.6, 2075.5.)

In this proceeding, the Department found that the scientific information contained in the Petition was sufficient for the first-step determination that listing may be warranted. It therefore recommended to the Commission that the Petition be accepted, that the Spring-Run be advanced to candidacy status, and that the status review be initiated.

The Commission must now consider the Petition, the Department's favorable recommendations, and comments received, and make one of two possible findings:

> (1) If the commission finds that the petition does not provide sufficient information to indicate that the petitioned action may be warranted, the commission shall publish a notice of finding that the petition is rejected, including the reasons why the petition is not sufficient.
>
> (2) If the commission finds that the petition provides <u>sufficient information to indicate that the petitioned action may be warranted</u>, the commission shall publish a notice of finding that the petition is accepted for consideration.

(Cal. Fish & Game Code § 2074.2 (emphasis added).) If the Commission determines that the listing "may be warranted," it must designate the species as a candidate species.

Most important, at this stage of the review, the question facing the Commission is <u>not</u> whether listing as an endangered or threatened species <u>is</u> warranted, but whether it <u>may be</u> warranted. Specifically, § 2074.2 of the California Fish & Game Code provides that the Commission must advance a species or subspecies to candidacy status if it determines that "the petition provides <u>sufficient information</u> to indicate that the petitioned [listing] <u>may be warranted</u>." (Cal. Fish & Game Code §

2074.2 (a)(2) (emphasis added); see also 14 Cal. Code Reg. § 670.1(e)(2).)

This "may be warranted" language has recently been interpreted by the California Court of Appeal in an action challenging the Commission's failure to advance the Coastal California Gnatcatcher to candidacy. Natural Resources Defense Counsel v. California Fish & Game Commission, 28 Cal.App.4th 1104, 1119 (1995) ("NRDC"). In NRDC, the Court of Appeal concluded that a "may be warranted" finding (and hence acceptance of the petition) is required where there is such information that "would lead a reasonable person to conclude" that there is a "substantial possibility that the listing could occur." Id. at 1119, 1125. "Substantial possibility" is more than a "fair argument," but less than a "reasonable probability," that a listing will occur. Id. Thus, applied here, the NRDC case makes clear that the only question now before the Commission is whether, based on the Petition, there is a substantial possibility that listing of the Spring-Run could occur.

By establishing this two stage process -- with a low threshold for acceptance at the candidacy stage, followed by a twelve-month status review -- the Legislature clearly envisioned that all scientific uncertainties would not and need not be resolved for a petition to be accepted. Indeed, the intervening status review was intended to provide ample opportunity for the Department to compile and review all available information, conduct such studies as are necessary, and develop a thoroughly informed recommendation on listing for consideration by the Commission. At this stage, CESA requires only that a petition contain each of the prescribed elements and "sufficient scientific information" to conclude that the listing of the Spring-Run "may be warranted" -- a standard plainly met by the pending Petition.

III. THE PETITION CONTAINS EACH OF THE ELEMENTS REQUIRED BY CESA TO SUPPORT A FINDING THAT LISTING OF THE SPRING-RUN AS AN ENDANGERED SPECIES MAY BE WARRANTED.

In its January 17, 1996 Evaluation Report recommending candidacy, the Department correctly found that the Petition contains sufficient scientific information and adequately addresses all the required criteria under CESA. To be sufficient, a petition must contain the following scientific information:

> information regarding the population trend, range, distribution, abundance, and life-history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant.

(Cal. Fish & Game Code § 2072.3.)

The Department's favorable recommendation is thoroughly justified by the Petition, which, as summarized below, satisfies each of the required statutory elements. Briefly summarized, the Petition sets forth, and discusses in detail, at least the following information:

<u>POPULATION TREND</u>: The Spring-Run has undergone a significant long-term decline since historic times because of loss of spawning habitat. More than 20 historically large populations have been extirpated or reduced to nearly zero since 1940.

<u>ABUNDANCE</u>: The Spring-Run was once the most abundant race of salmon in California's Central Valley, producing about one million fish annually, and has been a major cultural, biological and economic asset of the state. The Mill and Deer Creek Spring-Run populations, which represent the most important remaining populations in the Sacramento-San Joaquin River system, have declined by 80% since the 1960s.

<u>RANGE AND DISTRIBUTION</u>: The Spring-Run once occupied 26 streams in the Sacramento-San Joaquin drainage. Their range is now highly restricted from elimination of access to spawning areas by dam construction on the Sacramento-San Joaquin River system. It is widely accepted that pure Spring-Run have been rendered extinct in the mainstream Sacramento River and certain East Valley rivers. Fishery biologists are in general agreement that the true Spring-Run stocks are now limited to spawning in Mill and Deer Creeks, and possibly to Big Chico, Butte and several other East Valley creeks.

<u>LIFE HISTORY AND REPRODUCTION</u>: Spring-run have a lower fecundity than fall-run chinook salmon. They are differentiated from other chinook salmon races by maturity of fish entering freshwater, time of spawning migrations, spawning areas, and emigration time of juveniles. There is reproductive isolation by geographic separation of spawning habitat.

<u>HABITAT NECESSARY FOR SURVIVAL</u>: Adults need access to cold deep pool habitat to enable them to survive and protect garnete viability over the summer months followed by spawning in early fall months. Adults need access to tributary headwaters where they can be geographically isolated from fall-run. Spring-Run are susceptible to extinction from hybridization with fall-run chinook salmon in the absence of geographic isolation. Spring-Run require adequate water quality and quantity for adult holding, spawning, egg incubation, juvenile rearing, and migration.

<u>FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE</u>: In addition to major salmon losses as a result of habitat loss caused by dam construction in the past, Spring-Run populations today are continuing to decline to critical levels. It is generally agreed by experts from state and federal fishery agencies, as well as by independent fishery biologists, that by far the major impediments to Spring-Run recovery and survival today are the adverse hydrodynamic conditions in the Sacramento-San Joaquin Delta. Other impacts such as ocean harvest and predation and tributary conditions are important but of far less magnitude when compared to the situation in the delta.

<u>DEGREE AND IMMEDIACY OF THREAT</u>: The remaining populations are found only in Mill, Deer, Butte and Big Chico creeks. The Spring-Run have severely restricted range, population decline, low population abundance, and high population fluctuation. The populations are highly susceptible to natural and human-caused impacts.

<u>IMPACT OF EXISTING MANAGEMENT EFFORTS</u>: Currently, the Spring-Run receive no protection from adverse hydrodynamic conditions in the delta. The recent Bay/Delta Agreement calls for mitigation measures for reducing the impacts of water exports only during the months of April through June, with additional measures applying from February through April. However, the Deer and Mill Creek Spring-Run out-migrate through the Delta primarily between November and January, when no protections from the Bay/Delta agreement are in place.

<u>SUGGESTIONS FOR FUTURE MANAGEMENT</u>: The Petition recommends actions to improve access and habitat conditions in the Sacramento River tributaries, as well as specific actions to increase smolt survival in the delta.

<u>AVAILABILITY AND SOURCES OF INFORMATION AND DETAILED DISTRIBUTION MAPS</u>: The Petition provides extensive references to sources of information available in libraries and agency files and provides comprehensive and detailed maps that depict past and present population range and distribution.

As this brief summary illustrates, and as affirmed by the Department's favorable recommendation, the Petition satisfies every element that CESA requires for a Petition to be deemed acceptable under CESA. The Petition contains substantial scientific information sufficient to establish that protection "may be warranted" and demonstrates the need for precisely the kind of detailed comprehensive study that can be effectively conducted only through the Department"s twelve-month candidacy stage status review.

IV. THE SPRING-RUN QUALIFIES AS A SPECIES OR SUBSPECIES UNDER CESA.

An "endangered species" is defined in CESA as

> a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion of, its range due to one or more causes, including loss of habitat, change in habitat, over-exploitation, predation, competition, or disease.

(Cal. Fish & Game Code § 2062.)

Both as a matter of fact and law, the Spring-Run unquestionably qualifies for protection under CESA. First, as set out in the Petition, there is overwhelming biological evidence that the Spring-Run qualifies as an endangered species or subspecies. The Petition provides biological evidence of the phylogenetic relationship of the Spring-Run to other races of chinook salmon endemic to the Central Valley. It states the taxonomic status of the Spring-Run as *Oncorhynchus tshawytscha*.

(Petition, Executive Summary.) The Department's recommendation report summarizes the Petition's material on Spring-Run life-history and reproduction, stating:

> [Spring-Run have a] lower fecundity than fall-run chinook salmon; [they are] differentiated from other chinook salmon races by maturity of fish entering freshwater, time of spawning migrations, spawning areas, and emigration time of juveniles. [There is] reproduction isolation maintained by geographic separation of spawning habitat.

(Department Evaluation Report, at 2 (January 17, 1996).)

The Petition bases its description of the Spring-Run's life-history on a variety of historic and current reports that describe the Spring-Run as one of the four Central Valley chinook salmon races. (Petition, Sec. IX.) References used in the Petition include the report titled, Fish Species of Special Concern, by Peter B. Moyle, Ronald M. Yoshiyama, and Eric D. Wikramanayake, published by the State of California, Resources Agency, California Department of Fish and Game, in 1989. (Petition, Sec. IX.) The Petition describes and incorporates by reference substantial information on the present knowledge of Spring-Run discreteness and uniqueness from other Central Valley chinook salmon races. (Petition, Sec. VI.)[3]

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[3] As but one example, in Fish Species of Special Concern, Moyle et al. explain:

> The runs of chinook salmon are differentiated by the maturity of fish entering fresh water, time of spawning migrations, spawning areas, incubation times, incubation

<u>Second</u>, as discussed <u>supra</u>, the Department has recommended that the Petition be accepted and the Spring-Run advanced to candidacy. Notably, at the federal level, the National Marine Fisheries Service ("NMFS") has also issued a preliminary decision concluding that the Spring-Run is a separate and distinct species. In a recent letter to the Department, NMFS states that "biological evidence now supports designation of the spring-run population in the Sacramento River as a separate [Evolutionarily Significant Unit]." (NMFS Letter to the Department (March 5, 1996).) Thus, at both the state and federal levels, the expert wildlife agencies have recognized that protection of the Spring-Run is biologically appropriate. These findings alone are easily sufficient to meet the low candidacy threshold prescribed by CESA -- <u>i.e.</u>, a "substantial possibility that listing could occur." <u>NRDC</u>, <u>supra</u>.[4]

<u>Third</u>, the California Legislative Counsel has interpreted the "species or subspecies" language of CESA to

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> temperature requirements, and migration of juveniles. <u>Differences in life histories effectively isolate spring chinook salmon from other runs</u>; thus the traits are undoubtedly inherited. <u>Therefore, each run of salmnon must be considered to be genetically distinct, even from other runs in the same stream</u>. (Emphasis added.)

[4] To the extent that any scientific question exists regarding the exact taxonomic status of the Spring-Run, the proper course for the Commission -- as recommended by the Department -- is to address the issue as part of the candidacy status review. Rather than foreclose further study, the Department correctly decided that any unresolved scientific issues on taxonomic data militate in favor of candidacy status where, as here, the biological need and scientific basis for protection of the Spring-Run are so extensive and credible.

protect distinct populations of an endangered species, such as the Sacramento Spring-Run. In an Opinion dated October 17, 1986, the Legislative Counsel explained at length as follows:

> Under the California Endangered Species Act, the Fish and Game Commission may include in the list of endangered species plant or animals a distinct population of a particular species or subspecies even though the entire species or subspecies is not itself endangered . . . .
>
> * * *
>
> [T]he term "species" and "subspecies" are not defined in the Fish and Game Code or elsewhere in the state statutes. However, the term "species" has been defined as a "sort, a kind, a class subordinate to a genus, which is a class embracing many species" (Ballentine's Law Dictionary, Third Ed. (1969), p. 1202). "Species" is also defined as "a category of biological classification randing immediately below a genus or subgenus . . . a group of intimately related and physically similar organisms that actually or potentially interbreed and are less commonly capable of fertile interbreeding with members of other grounds, that ordinarily comprise differentiated populations limited geographically (as subspecies) or ecologically (as ecotypes) which tend to intergrade as points of contact . . ." (Webster's Third New International Dictionary, (1976), p. 2187). The federal Endangered Species Act of 1973 (16 U.S.C. § 1531 et seq.), an enactment on the federal level similar to the act, defines "species" to include "any subspecies of fish or wildlife or plants, and any distinct population segment

of any species of vertebrate fish or wildlife which interbreeds when mature (16 U.S.C. § 1532(16); 50 C.F.R. 424.02(k))." Thus, for example, under federal law, brown bears and grizzly bears are a threatened species in the contiguous 48 states but not in Alaska (50 C.F.R. 17.11). So too, alligators are threatened only in very specific geographical locations (50 C.F.R. 17.42). Accordingly, both the common definition of "species" and a specialized use of the term in a similar statutory scheme include distinct populations of plants, fish, or wildlife.

Generally, courts will construe a statute in accordance with the common or ordinary meaning of the words used (Madrid v. Justice Court, 52 Cal.App.3d 819, 824). Based on the above-stated definitions of the term "species," it seems clear that this word in both its common and ordinary usage and in a more specialized and related usage is broad enough to include a distinct population of a fish, plant or wildlife.

(Opinion of the Legislative Counsel to the Honorable Robert J. Campbell, at 1, 3 (emphasis added).)[5]

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[5] CESA clearly does not require that a petition necessarily cover the entire population and/or range of a species. See, e.g., Cal. Fish and Game Code § 2062 (defining endangered species to include a species that is in serious danger of becoming extinct throughout "all, or a significant portion of, its range" (emphasis added)). Moreover, it is irrefutable that CESA requires protection of species populations within California regardless of whether other populations of that species may exist outside the state.

Fourth, the Commission has previously listed as endangered another distinct segment of the population of chinook salmon endemic to the Central Valley, the Sacramento River Winter-Run Chinook Salmon ("the Winter-Run"). The Winter-Run is also listed as endangered under the federal Endangered Species Act, 16 U.S.C. §§ 1531 et seq. See also U.S. v. Glen-Colusa Irrigation District, 788 F.Sup.p 1126, 1129 (E.D.Cal. 1992) ("[T]he Winter-Run is a distinct species of salmon found only in the Sacramento River."). This listing of the Winter-Run further supports the candidacy of the Spring-Run in establishing that an individual run is entitled to protection under CESA. For the Commission now to disregard its prior decision would violate the well established principle of administrative law that an agency may not blindly disregard its prior practice. See, e.g., Galster v. Woods (1985) 173 Cal.App.3d 529, 544 (mandate issued against Department of Social Services); Henning v. Industrial Welfare Comm. (1988) 46 Cal.3d 1262, 1278 (mandate issued against Industrial Welfare Commission).

Finally, a contrary interpretation of CESA would violate not only the Commission's prior practice but its Salmon Management Policy:

> It is the policy of the Fish and Came Commission that salmon shall be managed to protect, restore, and maintain the populations and genetic integrity of all identifiable stocks . . . .

(Policies Adopted By the California Fish and Game Commission Pursuant to Section 703 of the Fish and Game Code (1994).) See also Cal. Fish and Game Code §§ 2052, 2055 (stating CESA policy to "conserve, protect, restore, and enhance" species and habitat). This explicit statement of policy with regard to salmon unquestionably mandates that the Commission act to "restore, protect and enhance" the Sacramento Valley Spring-Run by advancing it to candidacy.

For all of these reasons, individually and collectively, we believe that listing of the Spring-Run clearly "may be warranted." Accordingly, the Department's recommendation of candidacy for the Spring-Run must be adopted by the Commission.

V. <u>THE COMMISSION HAS THE AUTHORITY TO ACCOMMODATE ONGOING COLLABORATIVE PROGRAMS THAT ARE CONSISTENT WITH CESA'S FUNDAMENTAL POLICIES</u>.

In the <u>NRDC</u> case, the Court of Appeal rejected as "erroneous" the suggestion of the Building Industry Association that a candidacy listing would operate "to preclude, during the candidate study process, all potential habitat development and land use . . . ." <u>NRDC</u>, 28 Cal.App.4th 1104, 1121, 33 Cal.Rptr.2d, 904, 913 (1994). Indeed, § 2084 of the Fish and Game Code explicitly provides that "[t]he Commission may authorize, subject to terms and conditions it prescribes, the taking of any candidate species." Thus, subject to the fundamental policies of CESA -- <u>e.g.</u>, "it is the policy of the state to 'conserve, protect, restore, and enhance any endangered . . . or threatened species and [their] habitat" (Fish and Game Code § 2052) -- the Commission may permit limited take of a candidate species.

Given this authority, there is no merit to the suggestion that ongoing collaborative activities consistent with CESA policies will be precluded, curtailed, or otherwise undermined in any way by acceptance of the pending Petition. To the contrary, as our experience with the California Gnatcatcher and the NCCP in southern California has shown, those collaborative activities may actually be reinforced by the prospect of a future listing of the Spring-Run because such listing provides a powerful additional incentive for cooperation, for funding, for research, and for the development of creative initiatives that, while protecting the species, will serve the interests of all stakeholders. There is absolutely no rational reason why similar activities or initiatives within the ecosystem of the Spring-Run would not also be served, rather than subverted, by compliance with CESA in this proceeding.

Through CESA, the Legislature has established a minimum threshold for protection of our wildlife heritage in California and a § 2084 permitting process for flexibility during candidacy. As the Court of Appeal recognized in <u>NRDC</u> with respect to the California Gnatcatcher, erroneous assertions about the actual impact of a candidacy listing cannot be allowed to subvert that

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legislative intent. For all of the foregoing reasons, the pending Petition must be accepted.

Very truly yours,

Joel R. Reynolds
Senior Attorney

Of assistance: Beatrice Hoffman

cc: Robert Treanor,
Executive Director
California Fish and Game Commission

Senator Tom Hayden, Chair
Senate Natural Resources and Wildlife Committee

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Dr. Jennifer L. Nielsen

4/1/96

Robert Treanor, Executive Director
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Dear Mr. Treanor,

I am writing to respond to Dr. Robert Taylor's arguments against sub-specific status for the spring-run chinook in the Sacramento River as stated in his unpublished manuscript: "The Subspecies Concept and Its Application to the Spring-run Chinook Salmon." Dr. Taylor, in quoting me from a recent phone conservation states that I suggested that the current set of discrete runs of chinook salmon in the Sacramento River represent "remnants of a larger population of salmon exhibiting continuous variation across the range of potential habitats and timing of runs." He goes on to interpret my statement to imply that anthropomorphic disturbance over the last century has influenced population levels, "destroying intermediate forms."

Dr. Taylor's statement about my concepts on population structure in the Sacramento River chinook is in part correct, but is also in part incorrect. I do follow the philosophy that the wild Sacramento River chinook populations represent a single, complete meta-population that includes highly variable habitat adaptations, migration timings, and reproductive schedules, including the freshwater maturation schedule that we now identify as unique to the spring-run. To what degree anthropomorphic manipulation of that habitat and supplemental fish production by hatcheries subsequent to the European settlement of the Central Valley has "destroyed many intermediate forms," as stated by Dr. Taylor was not, and is not part of my scientific knowledge of the Sacramento

River chinook populations. Without significant speculation, we cannot judge population structure outside of the context in which we find it. We currently have no scientific evidence to suggest that the spring-run was ever identical genetically or ecologically to the other chinook runs in the Sacramento River. Indeed many studies supply evidence to the contrary, including some of my own.

Dr. Taylor incorrectly identified the spring-run as a "more-or-less" discrete population. Molecular genetic analyses using mitochondrial DNA (mtDNA) done in my laboratory in 1993 and 1994 showed significant genetic separation among the Sacramento chinook races (Nielsen et al. 1994). Follow-up studies in 1995 confirm these results and show no significant year-to-year variation in the mtDNA taken from run-specific chinook samples from the Sacramento River (Nielsen 1995). Using these data, an unbiased estimate of gene flow among the four spawning runs of Central Valley chinook was calculated according to methods given in Barton and Slatkin (1989). Based on simulation modeling and mathematical theory, this estimate (0.45 fish per generation), demonstrates significant genetic separation among the four chinook spawning-runs found in the Sacramento River that could not be a product of genetic drift alone, therefore supporting substantial reproductive isolation for the spring-run. A recent study of the chinook salmon stocks transferred from the Sacramento River to streams and rivers in New Zealand at the turn of the century also confirms the long-term continuity of molecular markers found in the Sacramento River chinook runs (Quinn et al. 1996).

The evolution of the spring-run life history type has been documented in other species of *Oncorhynchus*, and *Salvelinus* including Arctic charr and steelhead trout. The distribution of this type of reproductive strategy in other anadromous fishes suggests an ancient evolution of this unique behavior that derived many times in several independent lineages at some time in the past. My recent microsatellite analyses of the Middle Fork Eel River summer-run steelhead that enter the river in late spring as reproductively immature adults and over-summer in deep pools before maturation in freshwater (much like the Sacramento River spring-run chinook) estimated population separation between the winter- and summer-runs of over 160,000 generations using molecular distance analyses drawn from Goldstein et al. 1995 (J. L. N. unpublished data).

A similar analysis using microsatellites in currently underway in my lab for the Sacramento River chinook. However, mtDNA separation between the Eel River steelhead populations was not as convincing of population substructure as it was in the Sacramento chinook (Nielsen et al 1996), suggesting an even longer estimated genetic distance will be found within the Sacramento River chinook groups. It is my belief that Dr. Taylor, with all good intentions, misinterpreted my comments to suggest a recent separation of chinook populations, not the actual time scales supported by the relevant genetic data on these groups.

Dr. Taylor argues that geographic distance alone defines a species or subspecies. Based on the Darwinian theory of change by descent, all living organisms share, to some degree, a recent common ancestor and even some species could, therefore, be considered as members of a single biological unit. Speciation, however, is a matter of time as well as geography. There are no hard and fast rules on how or when speciation becomes permanently fixed within a population. Reproductive isolation is not necessarily easy to conclude, consider the viable hybrids found to represent crosses between chinook and coho salmon in wild salmonid population in California (Bartley et al. 1990; J. L. Nielsen, unpublished data). Does this mean that coho and chinook should be reconsidered as a single species under CESA?

Evolution and population structure can be recognized on many scales. Determining the most appropriate scale for protection of organisms will require considerable information and complex biological decisions. We currently have the tools and scientific principles to judge relevant time scales that separate unique populations using DNA sequence data. In all such studies to date, the spring-run chinook of the Sacramento River shows statistically significant separation from the rest of the runs and should be considered a unique population segment that represent an important component of the evolutionary legacy of the species. The Sacramento River spring-run chinook, therefore, should be classified as a distinct subspecies under the California Endangered Species Act.

Sincerely,

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Literature:

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