CAL POLY

CALIFORNIA POLYTECHNIC STATE UNIVERSITY
SAN LUIS OBISPO, CA 93407

COASTAL RESOURCES INSTITUTE

June 28, 1995

Dear California hatchery study reviewer:

Attached is our draft, **An Environmental Document on the Culture and Stocking of Resident Trout and Inland Salmon in California,** prepared by a study team of the Cal Poly State University Coastal Resources Institute under contract with the California Department of Fish and Game.

Your comments and suggestions are requested **prior to August 1, 1995,** when we will prepare a final revision and edit for public review. There are a few edit jobs to complete, including completing literature citations, finishing the bibliography, and adding any additional tables/figures or examples which would enhance this work. Additionally, the appendices are not a part of this early draft.

The purpose of this review is to provide peer assessment of the observations and conclusions we have made. Unfortunately, no renumeration is available to offset your effort. However, we will send you a personal copy of our final report as a token of our appreciation for your assistance.

Please send any comments to me at the following address:

Dr. Dianne N. Long
Coastal Resources Institute
Cal Poly
San Luis Obispo, CA 93407

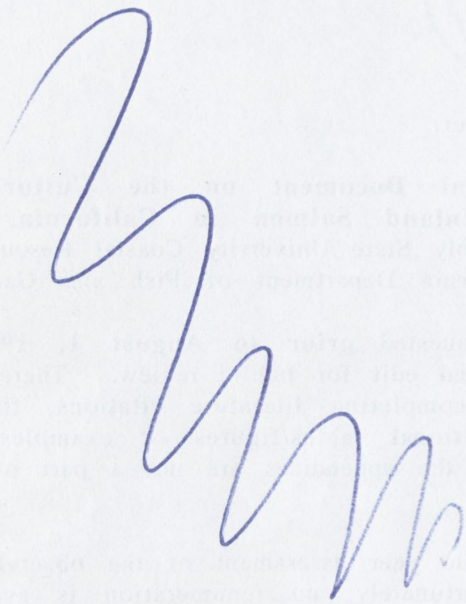
I will be pleased to forward your notes to the appropriate team members. They include: Robert Clover and Royden Nakamura (Biological Sciences), James Vilkitis and Richard Thompson (Natural Resources Management), David Chipping (Geology).

If I can help you in any way, please call me at 805-756-1774 or 805-756-2984.

Your help is sincerely appreciated.

Sincerely,

Dianne N. Long, Research Associate



Coastal Resources Institute

California Polytechnic State University
San Luis Obispo, California 93407

Memorandum

To: California hatcheries study members **Date:** 29 June 1995

From: Dianne Long
Coastal Resources Institute

Subject: Page 8 Missing from An Environmental Document on the Culture and Stocking of Resident Trout and Inland Salmon in California Draft

It has come to our attention that page 8 is missing from the draft document that was sent to you. I have enclosed a copy of page 8 to be placed into the document.

Thank you for your understanding.

AN ENVIRONMENTAL DOCUMENT

ON THE CULTURE AND STOCKING OF RESIDENT TROUT

AND INLAND SALMON IN CALIFORNIA

SUBMITTED BY:

COASTAL RESOURCES INSTITUTE
CALIFORNIA POLYTECHNIC STATE UNIVERSITY
SAN LUIS OBISPO, CALIFORNIA 93407
(805) 756-1774

JUNE 28, 1995

Dawn Johnson
after Aug. 10
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AN ENVIRONMENTAL DOCUMENT
ON THE CULTURE AND STOCKING OF RESIDENT TROUT
AND INLAND SALMON IN CALIFORNIA

TABLE OF CONTENTS

June 28, 1995

Draft/CRI/June 1995
Not for Quotation or Distribution

LIST OF FIGURES

LIST OF TABLES

AN ENVIRONMENTAL DOCUMENT ON THE CULTURE AND STOCKING OF RESIDENT TROUT AND INLAND SALMON IN CALIFORNIA

CHAPTER 1. INTRODUCTION

1.1 PURPOSE AND NEED

An interdisciplinary study team of scientists, resource managers and analysts of the Coastal Resources Institute at California Polytechnic State University, San Luis Obispo, completed a study regarding the culture and stocking of resident trout and inland salmon in California and produced this environmental document. The study focuses on controversial issues identified by the California Department of Fish and Game (DFG) and by Trout Unlimited. The study does not include anadromous fish (salmon and steelhead).

The impetus for the study comes from a Trout Unlimited legal suit against DFG alleging that DFG's trout hatchery program and fish planting programs had not complied with the California Environmental Quality Act (CEQA) because no environmental impact reports had ever been prepared for those programs.

This suit led to an out-of-court settlement in which DFG agreed to prepare an environmental document regarding the effects of rearing and planting trout in California waters.

1.2 DATA AVAILABILITY AND GAPS

DFG provided the project team with data concerning policies and practices, including data on hatchery production. The team did not collect original data but did review additional literature.

The lack of a comprehensive Management Information Systems at DFG caused delays in the project as analysis could not proceed without data. Also, some of the data is "soft" and incomplete. In the opinion of the study team, improvements in a computerized data bank would assist in making future policy choices.

The conclusions drawn reflect DFG data and related information.

AN ENVIRONMENTAL DOCUMENT
ON THE CULTURE AND STOCKING OF RESIDENT TROUT
AND INLAND SALMON IN CALIFORNIA

CHAPTER 2. PROJECT DESCRIPTION

2.1 BACKGROUND

In response to the out-of-court settlement, Trout Unlimited's President and Chief Executive Officer, Charles F. Gauvin, issued a letter from the Washington, D. C. Headquarters office on 28 July 1994, identifying issues of concern. This list established the basis for the issue assessment evaluation and served as the basis for developing the issues for this analysis.

Trout Unlimited identified the following issues in its legal brief:

1. Hatchery trout that survive and interbreed with wild stocks have a detrimental effect on the genetics of wild stocks;

2. Hatchery trout compete with wild stocks for both food and habitat, to the detriment of the wild stocks. The behavior of hatchery trout disrupts wild trout when they are placed together;

3. The operation of hatcheries can cause significant water pollution and localized habitat destruction;

4. The Department of Fish and Game spends too much on hatcheries and not enough on preservation and restoration of critical cold-water fishery habitat;

5. Hatcheries have catastrophic outbreaks of disease, and these disease outbreaks affect wild trout populations. Planted hatchery trout also spread pathogens to other fish; and

6. Catchable trout are planted in roadside waters even if the return rates to the angler are less than the 50% by number of weight as required by DFG Commission policy.

2.2 DFG MEMORANDUM OF UNDERSTANDING

DFG provided the interdisciplinary study team with a list of preliminary issues to be addressed in the environmental document (DFG Memorandum of Understanding with CRI, 1994). They included:

1. The rearing and production of trout and inland salmon by the DFG;

2. Planting of those fish;

3. Their interaction with wetland areas of the river, stream, lake or reservoir [illegible]

4. Planning for [illegible]

The SCDC also identified issues to be excluded from the environmental document. The excluded issues [illegible] fisheries for anadromous salmonids, and [illegible] fish produced and planted by private [illegible].

1.3 SCOPING ISSUES

During the regional scoping meetings, the interdisciplinary team identified the following issues for inclusion in the environmental document:

1. Economic contribution of [illegible] programs.

2. Impacts on urban [illegible] programs.

3. Increase in the harvesting pressure on wild trout populations with no stocking alternative [illegible].

4. Biological impacts.

The study team, in conjunction with DFG, identified two major categories for the environmental document: biological and environmental issues, and programmatic and economic issues.

1.4 STUDY OBJECTIVES

The objectives of the study included: (1) to assess the culture and stocking of resident trout and [illegible] in California; (2) to determine the effects of the existing programs on the [illegible]. The results of the study are expected to enhance DFG's ability to set policy and make appropriate program decisions.

1.5 SCOPING METHODOLOGY

Five statewide public scoping meetings were held throughout the state. The meeting locations ([illegible] Redding, Sacramento, [illegible] and Long Beach) were identified in DFG's Request for Proposals. The Notice of Preparation for the environmental document identified the [illegible]. It was prepared and distributed under the direction of [illegible]. A [illegible]-person team was involved with coordinating the [illegible] and [illegible] the basic information at the meetings.

CRI's interdisciplinary team, in conjunction with DFG, determined the scoping meeting's format. [illegible] at each location. Handouts

3. Their interactions with resident fishes in the river, stream, lake or reservoir; and

4. Fisheries for DFG trout and inland salmon.

The MOU also identified issues to be excluded from the environmental document. The excluded issues related to the production, rearing, and fisheries for anadromous salmonids, and any activity related to fish produced and planted by private aquaculturists.

2.3 SCOPING ISSUES

During the regional scoping meetings, CRI's interdisciplinary team identified the following issues for inclusion in the environmental document:

1. Economic contribution of trout fishing to local economies;

2. Impacts on urban lake put-and-take programs;

3. Increase in the harvesting pressures on wild trout populations with no stocking alternative; and

4. Biological impacts.

The study team, in conjunction with DFG, identified two major categories for the environmental document: biological and environmental issues, and programmatic and economic issues.

2.4 STUDY OBJECTIVES

The objectives of the study include: (1) to assess the culture and stocking of resident trout and inland salmon in California, (2) to determine the effects of the existing programs on the resource base (natural fisheries). The results of the study are expected to enhance DFG's ability to set policy and make appropriate program decisions.

2.5 SCOPING METHODOLOGY

Five statewide public scoping meetings were held throughout the state. The meeting locations (San Rafael, Sacramento, Redding, Bishop, and Long Beach) were identified in DFG's Request for Proposal. The Notice of Preparation for the environmental document identified the scoping meeting's locations. It was prepared and distributed under the direction of Mr. Boyd Gibbons, Director of DFG. A three-person team was involved with conducting the scoping meetings and presenting the basic information to the audiences.

CRI's interdisciplinary team, in conjunction with DFG, determined the scoping meeting's format. The presentation was the same at each location. Handouts

covering the meeting presentation were distributed at the beginning of the meeting to facilitate audience participation. The team leader began by introducing the meeting and the presenters. The introduction included: welcome, format for the meeting, and the audience's role. The audience was informed that both written and telephone responses would be accepted through 30 July 1994. The presentation included: project title, background, scope of the project, lead agency, scoping and document preparation, project description, project objectives, and issues currently identified. Contact names and phone numbers for the responsible individuals within DFG and CRI were provided in the handout.

A transcript of the generic introduction and the materials presented can be found in Appendix A. The members of the audience were encouraged to submit a written statement prior to the presentation. The written comments (hard copy) served as reference material for the later analysis. All statements were recorded on a 27-by-34- inch easel pad for the audience to see. In many cases the speakers were asked to reiterate their statements for clarification. This enabled the team to record all comments clearly and accurately.

After each meeting, the CRI team organized the presenter's statements, and categorized them under one of five categorizes: biological, economic, recreation, social, and political. Appendix A identifies the public's responses. Each statement was given a matrix code and assessed against the following factors: (1) It was within the scope of work, and (2) It has potential for environmental impact. (See Figure 1 in Appendix A.) CEQA Guidelines were used to determine if an issues had potential for significant effects. Potential impacts were identified by code.

2.6 ISSUES IDENTIFICATION

2.6.1 Biological and Environmental Issues

From the scope of the contract and the scoping meetings, a number of issues were identified related to biological impacts on native and wild populations.

Genetic Variability relates to domestic stocks, and interactions of d-catchables with native/wild strains, including inbreeding, drift, assimilation of native populations, and maintaining breeding stock integrity.

Competition includes disruptive behavior of d-catchables and subcatchables, and interspecific competition for food and habitat among d-catchables and native/wild strains.

Predation relates to catchables on native and wild trout juveniles, and native and wild trout on subcatchables and fingerlings

Spread of disease/parasites from hatchery-reared fish includes identification of major diseases/parasites, and effectiveness of control.

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Spread of disease/parasites from hatchery-reared fish includes identification of major disease/parasites and effectiveness of control.

2.6.2 Physical Habitat Issues

Water issues relate to water pollution from hatcheries on downstream habitats and fisheries (RWQCB permits/monitoring of water quality and biological resources), and diversion of flow impacts on source streams, critical habitat and sedimentation.

Habitat degradation looks at critical aquatic and riparian fish habitat and its history of degradation caused by stocking, nonstocking, and the wild trout program, including the control of anglers and other users.

Unique local considerations that exist will also be considered.

2.6.3 Wild Trout Project Issues

Catch and release impacts relate to survival rates of native/wild trout populations, maintaining a self-sustainable trout fishery, and regulations regarding habitat preservation and/or enhancement.

Impacts (+/-) of stocking or not stocking on a) survival of native/wild trout populations, (b) ecological balance (a self-sustaining fishery), (c) inducing/reducing fishing pressure, and (d) diseases and parasites spreading to native/wild populations.

Impacts on endangered and threatened species: those identified to date include eight trout species and two amphibians (Yosemite Toad, Mountain Yellow-legged Frog).

Unique impacts are associated with programmatic trends: native and wild trout populations, and with environmental issues.

2.6.4 Programmatic and Economic Issues

Programmatic and economic issues are associated with the costs and economic considerations of the hatchery/stocking program and implementing the Wild Trout Program, and the management tools that are used to implement the programs. Issues focus on trends in the allocation of resources, efficiency of selected programs, and impacts associated with programmatic trends.

Direction of Major Program Expenditures and Efficiencies: Expenditures and efficiencies for the catchables program, urban put-and-take programs, habitat protection and restoration, and the Wild Trout Program are considered where data is available.

Hatchery Efficiency and Distribution of Stock takes into account costs associated with operating hatcheries against design capacity, catchable trout costs, return to anglers, cost per fish in creel, revenues received per trout in creel, and losses (stocking losses, bird predation at hatchery and at site, diseased fish, poaching).

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Unique legal considerations that exist will also be considered.

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Impacts (+/-) of stocking or not stocking on a) survival of native/wild trout populations; (b) ecological balance (a self-sustaining fishery); (c) attracting/reducing fishing pressure; and (d) diseases and parasites spreading to native/wild populations.

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Advisory Meetings and Document Review provide opportunities for external review of study documents and for technical advice and guidance to the study team. Recommendations for membership came from both DFG and Trout Unlimited (TU). Reviewers provide input on drafts of the study approach and the environmental document.

The primary purposes of the exchange were to identify and clarify important issues and to open communication on study direction and documents. No compensation was available for reviewers; however, members had access to communicate concerns to the interdisciplinary team and to receive all draft and final documents produced. Meetings were held in February, May and July 1995 to allow for face-to-face exchanges. Chapter 7 of the document identifies reviewers.

2.7 LITERATURE REVIEW

DFG provided the literature and data for analysis. The scope of work did not include collection of original data. The team's reference librarian assisted with the identification of relevant documents and published literature. Listings of literature cited appears in the document as appropriate.

2.8 ALTERNATIVES ANALYSIS IDENTIFICATION

The alternatives were developed from an assessment of the major issues and will be addressed from a statewide program perspective. If an issue is unique to a region or area, this anomaly will be noted and/or explained. The alternatives are an attempt to identify, as clearly as possible, the parameters of each program for analysis and evaluation. They are summarized below, and discussed in more detail in Chapter 6.

All references made to fish stocking and associated activities will be in accordance with policy and procedures established in the California Code of Regulations (1994), Fish & Game Code of California (1994), and Fish and Game Operations Manual, Inland Fisheries (1993). Specific codes and policies related to this document can be found in Appendix B.

Each DFG program, whether dealing with catchables, wild or native trout, has a different audience with unique objectives. The various alternatives presented are a mixture or blend of the different programs that are currently in operation.

In implementing programs, the tools of management (such as catchables, subcatchables, fingerlings, strains of fish, etc.) are applied with different emphases related to the demand and environmental conditions under consideration. The impacts (effects) of various programmatic activities expressed in each alternative will be assessed; the tools of management will not.

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In implementing programs, the tools of management (such as catchables, subcatchables, fingerlings, strains of fish, etc.) are applied with different emphasis related to the demand and environmental conditions under consideration. The impacts (effects) of various programmatic activities expressed in each alternative will be assessed, the tools of management will not.

In identifying alternatives, two terms are used to express use. Urban refers to areas with high population centers such as the Southern California counties and the San Francisco Bay areas; high-demand refers to recreational areas that create high-demand pressures, such as Inyo and Mono counties and the Lake Tahoe area. The latter are the areas to which the sporting public from high-population centers go for recreation. When reference is made to the Wild Trout Program (WTP) it includes the programs that involve threatened species.

Alternative 1: Status Quo.

No change in the DFG hatchery and threatened and Wild Trout Programs is called for in Alternative 1. This alternative explains the situation and environmental conditions as they exist today, and assumes that the programs as they exist today will continue into the future. No changes in funding would be required.

Alternative 2: Enhance Trout Stocking Program to meet demand by 2010.

This alternative calls for an increase the catchable trout stocking program in all waters (rivers, streams, lakes, and reservoirs) above the status quo to meet the recreation demands that are anticipated by 2010.

Stocking (catchables and subcatchables) would be primarily in the same waters that are presently stocked, but with more fish. Only waters that cannot sustain a satisfactory fishery without stocking or waters that have a high potential for recreational demand (DFG OM 5340) would be stocked.

Satisfactory waters provide an average of two fish per angler day or one-half fish per angler hour (DFG Policies, III). The WTP would be continued at current funding levels, while additional funds would be required for an enhanced stocking program.

Alternative 2a: Enhance Trout Stocking and WTP Program to meet demand by 2010.

Same as above, with an increase in the Threatened and Wild Trout programs. Additional funds would be required for the WTP enhancement.

Alternative 3: Enhance Threatened and Wild Trout Programs and eliminate the catchable trout program.

The Threatened and Wild Trout programs are primarily directed at managing waters that can sustain a satisfactory sport fishery or protect depleted native species without stocking. Biological and physical inventories would be used to assess the biotic potential for a water and aid in determining its capability for

producing large sizes or numbers of native/wild trout and maintaining a fishery. The decision on how to manage a water rests with the District Biologist, who also determines the species, optimum population size, and harvest rate.

Under this alternative, the state would discontinue its catchable program and redirect these resources to (1) expand the threatened and wild trout programs in waters that can sustain satisfactory fisheries; and (2) develop recreational fisheries by stocking of fingerlings and subcatchables in waters that can sustain a fishery but lack spawning habitat.

All waters that could sustain a satisfactory fishery for threatened/wild trout would be so managed. Management would be directed at protecting threatened and wild trout, and maintaining the health and viability of the fish populations they manage. Under this alternative, it is assumed that waters that can support a sustainable fishery will be stocked with native, threatened, and/or wild populations.

The following water categories and associated management strategies are proposed to stratify fishery habitats in California's inland fresh waters and establish a priority for implementation:

1. Waters that have adequate biotic resources for a sustained fishery and have adequate, self-sustaining wild/native populations would be managed for those populations with no stocking.

2. Waters that have some biotic resources for a sustained fishery but do not have an adequate self-sustaining wild/native population may be managed with a stocking program to produce self sustaining populations or provide satisfactory fishery.

3. Waters that have an adequate biotic potential for a sustained fishery but exhibit environmental degradation that can be restored, will be managed to restore the habitat and establish a self-sustaining population.

4. Waters that lack environmental or biotic resources for adequate reproduction, but are favorable for growth and year-round survival, will be managed with a stocking program utilizing fingerlings and subcatchables.

5. Waters that have favorable environmental or biotic resources for trout seasonally will not be actively managed for salmonids.

Alternative 3a: Enhance Threatened and Wild Trout Programs and expand on stocking activities in urban areas.

Increase the WTP as identified above, and expand on the stocking activities in urban centers by the redirection of catchable-sized trout from high-demand areas.

producing large sizes or numbers of native/wild trout and maintaining a fishery. The decision on how to manage a water rests with the District biologist, who also determines the species, optimum population size, and harvest rate.

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All waters that could sustain a satisfactory fishery for threatened/wild trout would be so managed. Management would be directed at protecting threatened and wild trout, and maintaining the health and viability of the fish populations they manage. Under this alternative, it is assumed that waters that can support a sustainable fishery will be stocked with native, threatened, and/or wild populations.

The following water categories and associated management strategies are proposed to satisfy fishery habitats in California's inland fresh waters and establish a priority for implementation:

1. Waters that have adequate biotic resources for a sustained fishery and have adequate, self-sustaining, wild/native populations would be managed for those populations with no stocking.

2. Waters that have some biotic resources for a sustained fishery but do not have an adequate self-sustaining wild/native population may be managed with a stocking program to produce self sustaining populations or provide satisfactory fishery.

3. Waters that have an adequate biotic potential for a sustained fishery but exhibit environmental degradation that can be restored, will be managed to restore the habitat and establish a self-sustaining population.

4. Waters that lack environmental or biotic resources for adequate reproduction but are favorable for growth and year-round survival, will be managed with a stocking program utilizing fingerlings and subcatchables.

5. Waters that have favorable environmental or biotic resources for trout seasonally will not be actively managed for salmonids.

Alternative 3: Enhance Threatened and Wild Trout Programs and expand on stocking activities in urban areas.

Increase the WTP as identified above, and expand on the stocking activities in urban centers by the redirection of catchable-sized trout from high-demand areas.

Alternative 4: Reduce Hatchery Stocking Program and redirect funds to Threatened and Wild Trout Programs.

This alternative would require reducing hatchery programs except those necessary to maintain low-cost/high-return programs (urban stocking) or those needed for the Threatened and Wild Trout programs.

Under this alternative, the Threatened and Wild Trout programs, as identified under Alternative 3, would continue with the following modifications:

1. Discontinue high-demand catchable program;

2. Maintain the status quo for the urban catchable program;

3. Redirect funds into the WTP; and/or

4. Discontinue the catchable stocking program and the hatcheries that support their use for all waters except those necessary to support the urban catchable program and the native/wild trout programs.

Alternative 5: Limit Wild Trout Program and redirect funds to Urban Catchables Program.

Reduce threatened and wild trout activity to highest priority waters (Category 1 waters in Alternative 3). Emphasis is on satisfying the recreational demand by stocking quality catchables (two fish per pound or larger) to meet increased urban demands.

The quantity and quality of catchables will be increased where recreational fishing demand is greatest. Increased production would be directed at stocking lakes, reservoirs and other waters in high-demand urban areas. Hatchery programs necessary to maintain the WTP (Category 1) and those needed to support demand would remain. Funds will be redirected primarily to the catchable program to meet the urban demand. This alternative differs from the others in that funds would be redirected from the high-demand programs to maximize catchable returns to anglers in high-demand urbanized areas. There would be some cost savings from the reduced WTP activity.

2.9 CEQA REQUIREMENTS FOR AN ENVIRONMENTAL DOCUMENT

The California Environmental Quality Act (CEQA) requires all public agencies in the state to evaluate the environmental impacts of projects that they approve or carry out that may have a potential to significantly impact the environment. Most agencies satisfy this requirement by preparing an Environmental Impact Report (EIR) or Negative Declaration (ND).. However, an alternative to the EIR/ND requirement has been created for state agencies whose activities include the protection of the environment within their regulatory programs. Under this alternative, an agency may request certification of its regulatory program from the

Secretary for Resources, after which the agency may prepare functionally equivalent environmental documents in lieu of EIRs or NDs.

The regulatory program of the Fish and Game Commission has been certified by the Secretary for Resources and the Commission is eligible to submit this environmental document in lieu of an EIR or ND (CEQA Guidelines, Section 15252). Relevant parts of CEQA Guidelines appear below:

"Article 17. Exemption for Certified State Regulatory Programs

15250. General. Section 21080.5 of the Public Resources Code (PRC) provides that a regulatory program of a state agency shall be certified by the Secretary for Resources as being exempt from the requirements for preparing EIRs, Negative Declarations, and Initial Studies if the Secretary finds that the program meets the criteria contained in the code section. A certified program remains subject to other provisions in CEQA such as the policy of avoiding significant adverse effects on the environment where feasible."

The exemption for the certified state regulatory programs is not a blanket exemption from CEQA, as the agency must still comply with CEQA's policies, evaluation criteria and standards. The required environmental review must address all activities and impacts associated with a project.

"15251. List of Certified Programs. The following programs of state regulatory agencies have been certified by the Secretary for Resources as meeting the requirements of Section 21080.5:

(b) The regulatory program of the Fish and Game Commission pursuant to the Fish and Game Code.

15252. Substitute Document. The document used as a substitute for an EIR or Negative Declaration in a certified program shall include at least the following items:

(a) A description of the proposed activity; and
(b) Either:

(1) Alternatives to the activity and mitigation measures to avoid or reduce any significant or potentially significant effects that the project might have on the environment; or

(2) A statement that the agency's review of the project showed that the project would not have any significant or potentially significant effects on the environment and therefore no alternatives or mitigation measures are proposed to avoid or reduce any significant effects on the environment. This statement shall be supported by a checklist or other documentation to show the possible effects that the agency examined in reaching this conclusion."

A cumulative impacts analysis as defined in 15130(b) is not required to be contained within the substitute document prepared under a certified program. "Cumulative impacts need not be considered as a 'cumulative analysis' but recognized as to the

cumulative aspects of a project." What is required is for the certified program to have looked for and in some reasonable manner assessed potential cumulative environmental effects, and to have given sufficient consideration to any such effect it should reasonably have considered to be significant.

"Article 19. Categorical Exemptions

15300. Categorical Exemptions. Section 21084 of the PRC requires these Guidelines to include a list of classes of projects which have been determined not to have a significant effect on the environment and which shall, therefore, be exempt from the provisions of CEQA."

In response to that mandate, the Secretary for Resources has found that the following classes of projects listed in this article do not have significant effect on the environment, and they are declared to be categorically exempt from the requirements for the preparation of environmental documents.

"15301. Existing Facilities.

(j) Fish stocking by the Californian Department of Fish and Game.

15307. Actions by Regulatory Agencies for Protection of Natural Resources. Class 7 consists of actions taken by regulatory agencies as authorized by state law or local ordinances to assure the maintenance, restoration, or enhancement of a natural resource where the regulatory process involves procedures for protection of the environment. Examples include but are not limited to wildlife preservation activities of the State Department of Fish and Game. Construction activities are not included in the exemption."

The notice of preparation from DFG identifies this report as an "Environmental Document for the Culture and Stocking of Resident Trout and Inland Salmon in California."

2.10 INTENDED USES OF THIS DOCUMENT

This document is intended to provide DFG with policy direction regarding programs with focus on the culture and stocking of trout and inland salmon in California. Analysis is designed to give guidance not only in biological and environmental management decisions but also on governmental programmatic and economic decisions.

AN ENVIRONMENTAL DOCUMENT ON THE CULTURE AND STOCKING OF TROUT AND INLAND SALMON IN CALIFORNIA

CHAPTER 3. HISTORICAL PROGRAM OVERVIEW

3.1 INTRODUCTION

In examining DFG trout programs and discussing the various issues, it is important to recognize the significance of the impacts of historical trends and developments in California prior to the turn of the century. The progressive environmental degradation through mining and logging activities, overfishing, damming and diverting of surface waters, and the development of large-scale agriculture all adversely affected the California salmonid fishing resources (Netboy, 1973; Lufkin, 1991) and ultimately influenced the direction of salmonid fish culture and management (Radonski and Martin, 1986; Wydoski, 1986).

It is estimated that only one-third of the nonanadromous freshwater fish found today were found in California's pre-1870 fisheries (McGinnis, 1984) and could be considered "natives." California's natural populations included golden trout (*Oncorhynchus aguabonita*), cutthroat trout (*Oncorhynchus clarki)*, and various other descendants of rainbow trout (*Oncorhynchus mykiss)* including the redband trout (which has no formal taxonomic name).

The state also had one species of char (*Salvelinus*), the bull trout (*Salvelinus Confhentus)*. Several strains of rainbows (*Oncorhynchus mykiss*) existed across much of the state including the anadromous form--the steelhead (*Oncorhynchus gairdneri*) (Behnke, 1980, 1981, 1988, 1992; Moyle, 1976).

3.2 FISH POPULATIONS BEFORE 1870

3.2.1 The Sierras and Northern California

Over the last few thousand years, glaciation prevented fish from inhabiting most of the high Sierran lakes and streams. The eastern slope of the Sierra was formed largely by the inland sea known as Lake Lahontan. This large lake and its drainage supported not only the Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*), but also mountain whitefish (*Prosopium williamsoni*), Tahoe sucker (*Catostomus tahoensis*), mountain sucker (*Catostomus platyrhynchus*), Lahontan redsides (*Richardsonius egregius*), and speckled dace (*Rhinichthys osculus*) (Gerstung, 1995).

In the highly alkaline Eagle Lake in northern California, the specialized Eagle Lake trout (*Oncorhynchus mykiss aquilarum*) can be found. A genetic controversy exists as to whether this species is more a rainbow trout descendent than a Lahontan cutthroat descendent. Golden trout (*Oncorhynchus aguabonita*) are native only to the Kern River basin. Lahontan cutthroats (*Oncorhynchus clarki henshawi*), which are native to

the Lahontan system on the Sierras east slope, and Paiute cutthroats (*Oncorhynchus clarki seleniris*), which are native only to Silver King Creek, Alpine County, were also a part of early California fisheries (Moyle, 1976; Behnke, 1988).

3.2.2 The Owens Valley and Southern California

Out of the Owens drainage, to the west and to the south, various kinds of trout existed. Because the glaciation was not as fish-limiting in the southern region of California, there are remnants of populations of Little Kern golden trout (*Oncorhynchus mykiss whitei*), Volcano Creek golden trout (*Oncorhynchus mykiss aguabonita*), and the Kern River rainbow trout (*Oncorhynchus mykiss*). The latter part of the pre-settlement period saw much damage to California riparian ecosystems, from the destructive practices of hydraulic mining. The effects on fisheries of watershed destruction from this mining method are well-documented, and many streams are even today suffering equilibrium problems as a result of this practice. (Gerstung, 1995)

To the south, in the Owens River Valley, there were no trout. These waters supported populations of Owens River pupfish (*Cyprinodon radiosus*), Owens River tui chub (*Gila bicolor snyderi*), and Owens River suckers (*Catostomus fumeiventris*) (Gerstung, 1995).

3.2.3 Impact of Immigration and the Gold Rush

As populations moved into California in the mid-1800s, much damage occurred to the riverine ecosystems from the destructive practices of hydraulic mining. There are no good records of the impact of mining, logging, and farming activity. However, a large number of salmon appear to have been wiped out when silt, gravel, and debris were pumped into California's rivers, when logging activity polluted waters, when rivers were diverted to prevent flooding of farmlands, and when wetlands were drained to provide fertile fields. The effects on fisheries of watershed destruction are well-documented, and many streams even today have not recovered from the devastation of these practices. (Moyle, 1994)

3.2.4 Early Legislative Response

Legislative response to environmental degradation came upon the heels of statehood (1850). In 1852, California enacted its first salmon law and called on citizens and offices of justice to break down any obstruction to the run of salmon in rivers and streams (Leitriz, 1970). In 1854, the legislature outlawed nets and seines in San Joaquin County, and in 1861 it adopted legislation to protect trout. There is little history to document the impetus for any of these legislative activities; however, it is known that Indian peoples as well as settlers habitually dammed rivers. Additionally, lakes were drained and waters diverted to provide farmlands. (Cohen, 1994) the Lahontan system on the Sierras east slope, and Paiute cutthroats (*Oncorhynchus clarki seleniris*), which are native only to Silver King Creek, Alpine County, were also a part of early California fisheries (Moyle, 1976, Behnke, 1986).

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3.3 INTRODUCTION OF FISH CULTURE 1870-1910

3.3.1 Protective Legislation and Hatchery Starts

The year 1870 marks the passage of legislation in California "to provide for the restoration and preservation of fish in the waters of the state." The legislature created the first Board of Commissioners of fisheries and established the first two publicly owned fish hatcheries (one in San Francisco and the other at the University of California, Berkeley).

From 1870 to 1882, about $40,000 was appropriated for this "preservation and restoration" activity. The 1870 law provided that the three commissioners serve without pay during four-year terms to establish "fish breederies", to stock and supply waters with foreign and domestic fish, to purchase and import spawn and ova, to employ fish culturists and others, to construct fish ladders, to distribute spawn and ova to fish breeders, and to provide for the conservation of fisheries (Leitriz, 1970).

By 1878, the Commission was granted jurisdiction over game as well; in 1909, its name was changed to the Fish and Game Commission. In 1913, the first angling license was required; legislation in the decades that followed concentrated authority for the Commission, and the Department of Fish and Game provided support for its activity. This law established licensing as a source of income for the state's protection and restoration efforts (Fish Bulletin 150).

3.3.2 Legislative Influence

It is important to note that Southern Pacific not only dominated transportation in the state by the completion of the transcontinental railway (1869), but also dominated the legislature and policy-making in California. The new railway and enabling legislation greatly facilitated fish transplants. Planting was intense during the decade following railroad construction, and then gradually tapered off. In 1900, the Lacy Act gave the federal government authority to regulate interstate transportation of fish and wildlife.

Between 1850 and 1900, the most significant change to fish fauna was the draining of Tulare Lake and its companion Buena Vista Lake in the Central Valley. Tulare, a large but shallow lake, occupied the floor of the San Joaquin Valley and supported a large number of fish. The Central Valley was drained for farmland and many of these fishes are lost. The same scenario was true in the San Francisco-Sacramento Delta and the Sacramento River Valley in the 1800s (Moyle, 1994).

3.3.3 Influence of Sportfishing Demand

The demand for new sport fishing species accelerated the development of fish hatcheries and the introduction of fish. Brook trout (*Salvelinus fontinalis*) were introduced into California waters in 1872, and remain today as one of the

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In hatcheries, brook trout had been crossed with other strains of trout for stocking. In the wild, brook trout are known to occasionally hybridize with brown trout, often resulting in a sterile hybrid. Large numbers were planted in fishless waters of California during this time. When they were planted in streams, they tended to displace native fish. Unfortunately, these fish overpopulated the lakes. Because of the long winters in mountain lakes, brook trout tend to be small and considered unsuitable for angling. This situation later led to the practice of poisoning out the brook trout to make room for better angling fish, notably rainbow or golden trout (Moyle, 1976).

Brown trout (*Oncorhynchus trutta*) were introduced to North America in 1883 and to California in 1894 from Scotland, and in 1895 from Germany. Native to Europe and western Asia, they are present to waters throughout the state. While they provide good angling opportunities in California, they have contributed to the decline of other fish in streams (Moyle, 1976).

In this early period, over one hundred hatcheries were established, primarily for experimental purposes, and then abandoned. Many came into being as political "pork" (payoffs for legislative favors), but the locations and climate conditions could not support culture and stocking (Leitriz, 1970). Of the many created in the early years, Shasta (established in 1888) is one of the few remaining.

3.3.4 Proliferation of Hatcheries 1910-1960

Ironically, fish culture became firmly established in North America in the late 1800s and the early 1900s, due to marked scientific and technical advances of fish culturists of the time (Davis, 1958; Bardach, Ryther and McLarney, 1972; Radonski and Martin, 1986). Additionally, various species of California trout ova were shipped to Europe, Japan, Asia, Latin America, and a host of other places. The success of early American fish culturists in the Northeast, the preoccupation with the resulting advocacy of fish culture by the nation's first Interior Secretary, the obvious demise of the aquatic, riparian and salmon resources of the west, and the spread of railroads all served to support the nationwide transplantation of fishes as a partial solution to the changing environment and increasing demands on natural resources.

The economic and legislative interests of the state were changing in the years following 1910. Southern Pacific's influence over legislation gave way to the influence of large land owners, agriculturists, horse racing, shipping, and manufacturing. Immigration in the 1920s and 1940s provided the impetus of economic growth and pressures on California's resources, including waters. Throughout this period, revenues of the state increased to support development of hatcheries, dams, and public projects (some financed with primary sport fishing species in California (McAfee, 1966; Moyle, 1976). Eggs were imported from New Hampshire and Wisconsin and raised at the hatchery at University of California, Berkeley. By 1890, large numbers had been distributed throughout the state (McAfee, 1966; Moyle, 1976).

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In 1947, the state legislature adopted the Wildlife Conservation Act, creating a special board consisting of executive and legislative branch representatives to develop conservation and recreation programs. Also, it appropriated nine million dollars from horse racing funds to the wildlife Restoration Fund. New hatcheries had been constructed and provided the base for the trout hatchery system which now exists. By 1960, 169 hatcheries and stations were constructed (Fish Bulletin 150).

Fisheries' biologists and managers became more scientific and ecologically broader in their approach to fisheries management, and the potential for well-planned stocking programs reemerged with a broadly shared goal among fishery managers to "enhance angling for the widest possible spectrum of anglers, commensurate with the constraints imposed by available habitat." In 1956, the Congress reorganized the Fish and Wildlife Service and focused attention on effective management of natural resources. The recognition of past failures of indiscriminate and ineffectual transplantation of fish stocks slowly was realized and efforts to account for its causes were made (Radonski and Martin, 1986).

In these post-World War II years, experimental stations proliferated to meet demand for fish and to satisfy scientific inquiries of culturists. For example, rainbow ova were removed from stations sited on the tributaries of Lake Almoner and of the lower McCloud and upper Klamath rivers. Until 1938, Lahontan cutthroat trout ova were collected from weirs on the tributaries to Lake Tahoe. In 1959, a station was begun to bring back the Eagle Lake trout, which had adapted to semi-alkaline waters. In 1964, the Kamloops rainbow trout were brought into California and a wild broodstock established in Junction Reservoir, Mono County. This site provided a source of fingerlings for reservoir and cold-water lake planting. In 1981, a station was established on the Cottonwood Lakes in Inyo County to provide golden trout fingerlings for stocking alpine lakes (Gerstung, 1982).

3.4 SCIENTIFIC DEVELOPMENT 1960-1995

3.4.1 Increased Demand

Demand and participation of the U. S. population for recreation fishing opportunities continue to increase (Wydoski, 1986). By the mid-1960s, state fisheries allocated about 25% of their total budgets to fish stocking programs (Stroud and Martin, 1968; Fish Bulletin 150).

Historically, the largest portion (37% in 1974) of inland stocking programs in the U.S. utilized rainbow trout (Wydoski, 1986), the most widely dispersed globally. It is estimated that by the year 2000, the production of hatchery trout will increase to over 505.5 million fish, but would still result in a shortfall of 38 million hatchery-produced fish (Wydoski, 1986).

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While these trends continue, new questions have been raised in recent years regarding stocking programs for salmonids. As a group, the salmonid fishes represent a diverse group of economically important fishes that include species that have been among the most intensely studied in the world. A number of unique features--such as reproduction biology, behavior, tolerance and amenability to direct manipulation by man-- has historically placed them at the forefront of much of what is presently known in the freshwater fisheries biology and fish culture technology. This group also has become a mainstay of recreational fishing, which is widely practiced by an array of different user groups across the nation.

3.4.2 Environmental Protection

The environmental movement of the 1960s and 1970s changed the direction of conservation. The effect was to broaden conservation efforts beyond the traditional management focus.

Congressional legislative efforts resulted in significant wildlife regulation. The Endangered Species Preservation Act (1966) gave the federal government authority to acquire land to protect habitat for species "threatened with extinction." The legislation did not address problems related to managing existing populations. The Endangered Species Conservation Act (1969) extended the federal government's authority regarding wildlife protection. The National Environmental Policy Act (NEPA) defined national policy for environmental protection and required public involvement and preparation of Environmental Impact Statements for federally funded projects affecting the environment.

In response, California's legislature passed a number of legislative mandates focusing on state environmental protection. The Endangered Species Act (1970) established a process for listing rare and endangered species. The California Environmental Quality Act of 1970 (CEQA) set requirements for EIRs for state projects potential affecting the environment adversely.

In 1973, Congress passed the Endangered Species Act, which provided for the listing of endangered wildlife and levied stiff penalties. Amendments to the Act and judicial decisions restricted activity that would negatively impact wildlife. National efforts accelerated protection of nongame wildlife embodied in the Fish and Wildlife Conservation Act (1980). The California legislature strengthened conservation authority in the California Endangered Species Act of 1984 (CESA). The California Wildlife Protection Act (1990), the National Environmental Education Act (1990), and California's Natural Community Conservation Act (1991) instituted a number of educational, management, and regulatory programs.

3.4.3 Managing for Genetic Diversity

Manipulating populations and establishing breeding populations has resulted in concern centered around the loss of genetic diversity in animal and plant

populations. While excessive exploitation and human disturbance of the habitat are often cited, so too are allegations related to the inadvertent and purposeful genetic manipulation of populations. In order to restock steams with fish from pure populations, predatory fish were removed through chemically treating water upstream from a barrier. Restoration activity was stymied by a shortage of pure fish. Also, repopulation delays and cancellations caused negative angler response focusing on chemical treatment. Delays also increased economic pressures to introduce undesired species of trout (as in the case of brown trout) (Gerstung, 1995).

For example, in Bucks Lake (Plumas County), DFG attempted to reduce competition for spawning by removing kokanee salmon, which have overpopulated the lake, and by electrofishing brown trout and transferring the broodstock over a California Conservation Corps barrier. The problem originated with 8,000 kokanee fry planted in 1954. The kokanee quickly increased to over 300,000 by 1973, and trout fishing dropped off dramatically. With intervention, the trout population grew from almost no browns to 300 in five years. Additionally, community groups working with Feather River College constructed a wild trout hatchery to assist in securing eggs to protect resources (Wright, 1982).

Another case of providing for diversity regards the stocking of Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) in the Truckee River-Pyramid Lake area. Here stocking has been successful in providing a sizable commercial and sport fishery since the 1950s. Cutthroat trout historically spawn in the Truckee River and its tributaries. However, Derby Dam water diversion, introduction of exotic salmonids, and water pollution led to Lahontan extinction. The Summit Lake strain (from Summit Lake, Nevada) is now stocked exclusively by the Pyramid Lake Indian Tribe and the U.S. Fish and Wildlife Service. Salmonid spawning is limited to the area from Reno to Lake Tahoe, since hatching success of planted ova is as high as 80%. The lower river has high summer water temperatures and low intergravel dissolved oxygen, causing total mortality of artificially planted eggs. Passage problems, deteriorated habitat, and resident fish populations hamper restoration. And, brown and rainbow trout pose competition for cutthroat (Hassler, 1982).

Today, waters that once held Lahontan are home for brown and rainbow trout. Many of the alpine lakes that were void of trout now hold large populations of brook trout (non-natives). An estimated 60% of High Sierra alpine lakes contain trout; there were few fish historically. The Eastern Sierras, for example, did not have a native trout population, except for Lahontan cutthroat in northern Mono county. The Eastern Sierras are now one of the state's most popular sportfishing regions (Phillips, 1994).

Artificial propagation of Eagle Lake trout and Pit River system native rainbows (*Oncorhynchus mykiss*) is proceeding. The latter natives are resistant to a protozoan (*Ceratomyxa*) and are planted where this protozoan exists (Gerstung, 1995).

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The following management strategies have developed to guide protection of "gene banks":

1. Transplantation of stocks should be avoided.
2. Migration routes and timing of both wild and hatchery stocks must be known.
3. Artificial spawning channels allow fish to make their own matings, and the resultant fry can migrate to natural rearing areas.
4. Hatcheries should be sited to enhance/supplement stocks based on biological considerations, not political issues (Helle, 1982).

3.5 PRESENT SITUATION

3.5.1 Definitions

The transplanting of trout worldwide has caused some confusion in differentiating trout that can be considered "wild", as there can be wild natives and wild non-natives.

Wild fish are members of a naturally produced and maintained population in a natural setting--one hatched and reared in a stream, lake or sea from an egg spawned and deposited (King, 1984). However, wild trout can include hatchery fish that survived and propagate in the wild.

On the other hand, native trout are indigenous fish present in an area prior to European settlement, or fish that have extended their range into an area through means other than human intervention (stocking and habitat alteration). Non-natives are fish introduced to an area through intervention (Trout Unlimited, 1995). Ova from native fish may be transplanted into another area, causing the fish to be considered "non-native" to the area because of the intervention.

Hatchery trout include any trout hatched or raised in a hatchery, including the offspring of wild or native trout. Hatchery trout can be divided into catchable trout, used in put-and-take fisheries, and fingerlings/subcatchable trout, used in put-grow-and-take fisheries (Benke, 1989).

Rainbow and brown trout are popular and widely distributed game fish in California. The demand for them is far beyond the natural reproductive capacities of wild populations, so a considerable portion of DFG's fishing-license revenues goes towards supporting hatcheries that rear domestic strains of rainbow and brown trout for planting on a put-and-take basis (Moyle, 1979; Wingfield, 1995).

Most put-and-take rainbows are planted at 18 to 20 cm and caught within two weeks of planting. These fish are ill-adapted for surviving in streams and are likely to die of starvation or stress within a few weeks. Mortality is highest

when they are planted in relatively small numbers in a stream that also sustains a wild trout population. These smaller planted fish may not be able to break into established dominance hierarchies of larger wild trout. However, if large numbers are planted over a wild trout population, they are likely to disrupt the established hierarchies, making the wild fish more vulnerable to angling. Put-and-take stream may have to be continually planted if any sort of trout fishery is to be sustained (Moyle, 1979; Wingfield, 1995).

The trout's habitat includes the immediate arena in which trout dwell and interact with other organisms. This environment includes all aspects of its surroundings: other organisms, weather, physical-chemical aspects of the water-soils complex, and the shape of the dwelling place (White, 1992)

The DFG has three major trout programs: (1) stocking of catchable trout, (2) the Wild Trout Program (WTP), and (3) preservation of the state's natural/native fish populations.

3.5.2 Catchable Trout Program

California ranks first, nationwide, in freshwater fishing participation. Meeting the recreational demand of sport fisherman is a major concern of the state's trout stocking program. In 1990, some 2.8 million people fished for trout and other cold water species in the lakes and streams of our nation's most populous state. In order to meet this user demand in California, DFG has historically relied heavily on stocked trout, primarily catchables. A catchable trout plant is defined as "fish that are sized, greater than six to the pound."

On average, DFG stocked 19,000,000 trout annually, over the last twenty years. By weight, catchables represent 97% of this total (Fish-Pro, 1994). Only an estimated 5% of California's streams are stocked with catchable trout, mainly in areas where existing populations could not support user demand, such as campgrounds (Deinstadt, 1995). DFG has mandated that waters not be stocked with catchable trout unless 50% or more of the stocked fish (by either number or weight) are expected to be taken by anglers.

The state's fifteen hatcheries are not confined to planting only catchable trout. Most hatcheries can produce and/or stock fingerlings (fish less than sixteen per pound) and "subcatchables" (fish between sixteen and six per pound). A complete listing of all current hatcheries, including a breakdown of their total planting operations, is shown in Appendix B.

3.5.3 The Wild Trout Program (WTP)

DFG is legislatively mandated to compile an annual list that meets the following requirements:

"no less than 25 miles of stream or stream segments and at least one lake that it deems suitable for consideration as catch and release trout fisheries" (State of California, 1994).

when they are planted in relatively small numbers in a stream that also contains a wild trout population. These smaller planted fish may not be able to break into established dominance hierarchies of larger wild trout. However, if large numbers are planted over a wild trout population, they are likely to disrupt the established hierarchies, making the wild fish more vulnerable to angling. Put-and-take streams may have to be continually planted if any sort of trout fishery is to be sustained (Moyle, 1976; Wingfield, 1993).

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The Fish and Game Commission designates certain waters to be managed exclusively for wild trout. These waters are to provide the angler with aesthetically pleasing and environmentally productive waters with trout populations whose numbers or sizes are largely unaffected by the angling process (DFG, 1994). To date, DFG has designated 24 streams (or stream segments) and two lakes as Wild Trout waters. Additionally, nine lakes and 39 stream segments have been designated as catch-and-release (C&R) waters.

About fifty lakes and streams are now WTP-managed; several others are candidates. Designated waters are subject to use and management regulation, including size limits and catch-and-release designation. Hatchery trout may be introduced to supplement natural trout reproduction if needed, but only strains of the wild or semi-wild species can be used. Domestic strains are restricted from designated waters (Lentz, 1995).

Approximately 75% of the funding for the Wild Trout Program comes from the Federal Aid in Sport Fish Restoration Act, with the remaining 25% drawn out of DFG license fees and associated funds. For FY 94-95, the program had an operating budget of $880,100.

3.5.4 Native and Threatened Trout Program

In 1973, DFG recognized that certain species and numbers of fish were declining and in need of special attention. These species include the Lahontan and Paiute cutthroats and the Little Kern golden. A committee was formed to assess the nature of the need and address threatened species. To date, eleven different species or subspecies of trout have been identified by DFG as native trout that are in need of special management.

While many of the state waters have been degraded from channeling, bad management practices, and pollution, stocking remains the primary cause of native trout endangerment. The following is a list of threatened species that have been directly affected (Gerstung, 1995):

Rainbow trout (*Oncorhynchus mykiss*):
Although this native species is the most abundant trout in California, a great deal of displacement is occurring in low-gradient, middle-elevation streams or streams with flow regimes modified by dams. Introduced brown trout are causing most of the displacement. Rainbow trout and its anadromous form, the steelhead, occur throughout California (with the exception of the Mojave Desert, the Great Basin, and the higher elevations in the Sierra Nevada above impassable falls). Most California rainbow trout streams have been stocked with hatchery-reared rainbows, which has greatly affected the genetics of the native species.

Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*):
Natural populations of this subspecies have been eliminated from all but one small stream (ByDay Creek) and one lake (Independence Lake) in California by hybridization with or displacement by introduced trout species, largely of

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Natural populations of this subspecies have been eliminated from all but one small stream (Byday Creek) and one lake (Independence Lake) in California by hybridization with or displacement by introduced trout species, largely of

hatchery origin. The subspecies formerly occurred in Lake Tahoe and several hundred miles of the Truckee, Carson, Walker, and Susan rivers on the Sierra's eastern slope.

Paiute cutthroat trout (*Oncorhynchus clarki seleniris*):
This subspecies is endemic to Silver King Creek, tributary to the East Fork Carson River, where it formerly occupied much of the drainage. As a result of introgression with nonnative, hatchery-reared trout (stocked prior to 1950), the subspecies range was reduced to one small tributary by 1976.

Little Kern golden trout (*Oncorhynchus mykiss whitei*):
This trout formerly occurred throughout the Little Kern River drainage, where it occupied about 90 miles of stream. As a result of ill-advised stocking of hatchery-reared fingerlings during the 1940s, the range of this trout was reduced to eleven miles of tributaries by 1975. The Little Kern golden has been displaced from 89% of its former range following decades of stocking with nonnative rainbows.

Volcano Creek golden trout (*Oncorhynchus mykiss aguabonita*):
This subspecies formerly occurred throughout the South Fork Kern and Golden Trout Creek drainage. Introduction of hatchery-reared trout resulted in the partial displacement of golden trout from the upper half of the South Fork drainage and the total loss of pure stocks due to hybridization in the lower half of the South Fork drainage.

Kern River rainbow trout (*Oncorhynchus mykiss gilberti*):
The Kern River rainbow formerly occurred throughout much of the drainage of the mainstream Kern River. Hybridization with nonnative, hatchery-reared trout has eliminated pure stocks from over 50% of the drainage, and the continued stocking of hatchery trout in several middle reach tributaries poses a threat to the genetic purity of the remainder of the main stem Kern River rainbow trout population.

McCloud River redband trout (*Oncorhynchus mykiss ssp.*):
The stocking of hatchery-reared rainbow trout in the McCloud River and tributaries above Upper Falls has resulted in hybridization with endemic redband trout populations. The degree of introgression is currently being evaluated through DNA analysis. Stocking above the falls was discontinued in 1994, triggering much local opposition. The issue has not been resolved. Pure redband trout may be limited to several isolated tributaries. A similar stocking/redband conflict has occurred in tributaries to Goose Lake. In all, the McCloud River redband trout are known to occur in only 10% of historic habitat.

Bull trout (*Salvelinus confluentus*):
Brown trout introduced to the McCloud River above McCloud Reservoir now occupy the ecological niche formerly occupied by bull trout, California's only native char. Water development also severely reduced the availability of suitable habitat for this fish, which was observed in 1976.

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Paiute cutthroat trout (*Oncorhynchus clarki seleniris*): This subspecies is endemic to Silver King Creek, tributary to the East Fork Carson River, where it formerly occupied much of the drainage. As a result of introgression with nonnative, hatchery-raised trout (stocked prior to 1950), the subspecies range was reduced to one small tributary by 1976.

Little Kern golden trout (*Oncorhynchus mykiss whitei*): This trout formerly occurred throughout the Little Kern River drainage, where it occupied about 90 miles of stream. As a result of ill-advised stocking of hatchery-reared fingerlings during the 1940s, the range of this trout was reduced to eleven miles of tributaries by 1975. The Little Kern golden has been displaced from 88% of its former range following decades of stocking with nonnative rainbows.

Volcano Creek golden trout (*Oncorhynchus mykiss aguabonita*): This subspecies formerly occurred throughout the South Fork Kern and Golden Trout Creek drainage. Introduction of hatchery-reared trout resulted in the partial displacement of golden trout from the upper half of the South Fork drainage and the total loss of pure stocks due to hybridization in the lower half of the South Fork drainage.

Kern River rainbow trout (*Oncorhynchus mykiss gilberti*): The Kern River rainbow formerly occurred throughout much of the drainage of the mainstream Kern River. Hybridization with nonnative, hatchery-raised trout has eliminated pure stocks from over 80% of the drainage, and the continued stocking of hatchery trout in several middle Kern tributaries poses a threat to the genetic purity of the remainder of the main stem Kern River rainbow trout population.

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Bull trout (*Salvelinus confluentus*): Brown trout introduced to the McCloud River above McCloud Reservoir now occupy the ecological niche formerly occupied by bull trout, California's only native char. Water development also severely reduced the availability of suitable habitat for this fish, which was observed in 1975.

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Eagle Lake rainbow trout (*Oncorhynchus mykiss aquilarum*): Eagle Lake is a closed basin that supports the endemic Eagle Lake rainbow, a popular sportfish. In the late 1950s, habitat alteration had reduced the population to just a few adults. Although the population has been restored through artificial propagation, it is suspected to be domesticated, inbred, and introgressed.

CHAPTER 4. BIOLOGICAL AND ENVIRONMENTAL IMPACTS

4.1 LONG-TERM BIOLOGICAL IMPACTS

4.1.1 Biological Aspects: Systemic and Taxonomy

Origins and speciation of salmonid populations have been studied and debated over many decades and a variety of systematic schemes and taxonomic nomenclature proposed (e.g., Stearns and Smith, 1993; Behnke, 1992; McAffee, 1966; et al). The more recent revisions suggest that the present salmonid stocks of western North America are primarily derived from two major groups: *Salmo*, and *Oncorhynchus*. The *Salmo* group diverged from the latter over 50 million years ago, and gave rise to the present Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*) and their allies. A groups of trout not within these lineages and only peripherally salient to this discussion include the chars (e.g., *Salvelinus spp*. such as brook trout, Dolly Varden trout, bull trout), graylings (*Thymallus spp.*) and perhaps the whitefishes (*Coregonus spp.*) The *Oncorhynchus* group ultimately split into the Pacific salmon group and a highly plastic group ancestral to the present three major lineages of trout: the Lahontan populations (cutthroat complex), the red-band trout populations (inland rainbow trout complex) and the coastal rainbow trout complex. Changes within the groups are attributed to major natural geomorphological changes in the environment and the effects of human activities. The latter has become very important since the 1800's with respect to the ultimate development of historic salmonid fisheries management practices. The present status of the many species and populations has been described and, in some instances, protectively classified (listed) under state or federal listing guidelines.

Based on recent analyses, revisions and present consensus among ichthyologists, four major groups of California trout were ultimately derived from the original *Oncorhynchus* group. On the eastern Sierras, there are limited populations of Lahontan and Piute cutthroats (*Oncorhynchus clarkii henshawi, O.c. seleniris*, respectively). The primary obvious distinction is the lack of spotting and historic large size of the latter. The Lahontan was initially listed as endangered and later downgraded to threatened to "legalize angling and facilitate management" in 1975. The original stocks in Pyramid Lake (Nevada), Lake Tahoe and other smaller lakes and their associated drainages became extinct largely due to poor water resource management, environmental degradation, overfishing by commercial and sports fisheries, and the introduction of other species. A population from Walker Lake (Nevada) has been maintained in hatcheries since the late 1940s. Populations still exists in Independence Lake (California) and have been used to establish populations in other areas (e.g., Heenan Lake, California). It is suggested that Summit Lake (N.W. Nevada) and its associated stream still contain "pure"

Lahontan cutthroat. Introgressed populations are thought to exist in California's Cascade Lake, Martis Creek and Dundenberg Creeks.

The Piute cutthroat trout (*O. c. seleniris*), historically one of the largest of all the inland trouts, is thought to have been derived from the original lineage of Lahontan cutthroat trout (*O. c. henshawi*) with a very limited distribution. The drainage most associated with this species is the East Carson River in Alpine County. Other natural populations have been described particularly along Silver King, Corral Valley and Coyote Valley Creeks, all part of the Carson River drainage. Populations have been introduced in several areas, including Cottonwood Creek (Mono County) and in Cabin, Sharktooth and Stairway Creeks in Eastern California. One of the most thoroughly documented introductions occurred in Pyramid Lake, Nevada (Coleman and Johnson, 1988), which resulted in much information of potential use to managers working with this species, and perhaps the Lahontan cutthroat trout in California.

The coastal cutthroat occurs in the north coastal areas of California also. Its origins are related to the Columbia River populations that moved south along the coast. It is reported to be uncommon, and its status is unclear.

There are three major groups of rainbow trout: the coastal rainbow trout, inland redband trout and the golden trout. The first include both resident and steelhead forms of rainbow trout and are thought to have penetrated far into the Sacramento Basin (Sacramento/San Joaquin River drainages) both naturally and through stocking activities. Early stocking efforts in California are believed to have involved inadvertently hybridized coastal steelhead strains of rainbow trout moving into the McCloud River drainage, and resident inland redband trout of the area (Needham and Behnke, 1962).

Other populations of plantings utilized coastal rainbow stocks from the San Francisco Bay area (a.k.a. the California brook trout) (Behnke, 1992). Because of these activities, discreet populations in the Sacramento Basin cannot be clearly identified or characterized. Populations of the coastal rainbow trout (*Oncorhynchus mykiss irideus*) display the widest zoogeographical range of all the rainbow trouts, extending further north, south and inland than any other species.

A species of particular concern to some is the Eagle Lake Rainbow Trout, sometimes classified as *Oncorhynchus aquilarum*. It appears to have no meristic, morphological or electrophoretic differences to separate it from other rainbow trout. It is thought that this is the result of a mixture of coastal and redband trout (see below) gaining access to Eagle Lake after the demise of the Lahontan cutthroat due to geomorphological and climate changes associated with the old Lake Lahontan and flow changes in the Pitt river system. The Eagle Lake rainbow trout is distinguished by its large size and ability to do well in an alkaline environment. The former is thought to be an artifact of the population's reliance on piscivory.

The redband trout group has been to a large extent hybridized with and/or replaced by the Coastal Rainbow group. However, there is a population in Northern California in the McCloud River System, and perhaps in the Pitt

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River System. The extant species or subspecies of this group is the Sacramento redband trout (*Oncorhynchus mykiss stonei*).

The golden trout group are thought to be directly derived from the redband trout group. These exist primarily in the topographically semi-protected parts of the Kern River system. The species/subspecies have been debated in the past. The most conservative assessment is that there are three subspecies: the California golden trout (*Oncorhynchus mykiss aguabonita*), Kern River golden trout (*O. m. gilberti*), and the Little Kern golden trout (*O.m. whitei*). The latter two are federally listed as threatened, under the name *O.m. whitei*.

While earlier pure populations were thought to exist only in a few headwater creeks (Upper Soda Springs, Deadman and Wet Meadows Creeks), efforts have been made to establish new populations in parts of the Little Kern River drainage. The Kern River golden trout may be synonymous with the Kern River redband trout, depending on which systematic scheme is followed.

4.1.2 Biological Aspects: Ecological Relationships and Management Approaches

Because trout are ameanable to artificial propagation, rearing and confinement, a large volume of literature and significant scientific information has been accrued on many aspects of the group. Much of the fundamental biological information on physiology (e.g., metabolism, bioenergetics), nutrition, disease, reproductive biology and behavior, were derived from genetically manipulated and/or artificially confined individuals or sub-populations. While of great value scientifically, there are limitations to which certain types of information may be applied to questions regarding ecological and genetic interactions of salmonid fishes in the natural environment.

Ecological extrapolations based solely on controlled experiments in artificial environments have similar constraints. Laboratory (hatchery) and field observations are not always easily linked. Nonetheless, it is these possible differences between wild and manipulated hatchery stocks that are the basis of concern to many.

Ecological studies on interspecific or interpopulation interactions have often focused on trophic interactions. Fish in both natural and artificial environments will alter their food preferences and feeding behavior under conditions of sympatry, as exemplified by early classic descriptions of this phenomenon termed "interactive segregation" of trout (Nilsson, 1955), "separation of food spectra" (Nikolsky, 1963) or "indices of (food) electivity" (Ivlev,1961).

Subsequent works on interspecific trophic interactions of trouts have been extensive and varied with respect to species, approach, and experimental design. Much of the information is based on experiments in artificial or semi-artificial environments. Field studies on interactions between stocks have generally suggested negative outcomes for both hatchery stocks (e.g., poor

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Subsequent works on interspecific trophic interactions of trouts have been extensive and varied with respect to species, approach, and experimental design. Much of the information is based on experiments in artificial or semi-artificial environments. Field studies on interactions between stocks have generally suggested negative outcomes for both hatchery stocks (e.g., poor survival) and wild stocks (displacement, submissive behavior, lower foraging frequency, etc), depending on what aspects were being observed. There is no question that interactions occur. Regarding the significance of the interactions in the natural environment, it is difficult to unequivocally establish and quantify causal relationships, because not all variables are controllable, direct observations become more difficult, and increasingly reliance must be placed on information extracted from creel census and field surveys.

Certain other variables or situations may be difficult to quantify or are not considered in designing and interpreting field experiments or surveys. For example, is the cover or food resource quantitatively limiting and how does this affect the interaction and outcome?

Although such limitations or weaknesses in a study make it difficult to draw conclusions without equivocation, perusal of the literature uncovers numerous examples in which it appeared that:

1. One species had negatively impacted another species under sympatric conditions,

2. A population or subspecies of the same species group negatively impacted another, and

3. A hatchery-propagated population adversely impacted another to reduce escapement.

Actual mechanisms may be debated or the scientific rigor of studies be critiqued. Still, the ubiquity of examples warrants recognition that there are many correlations between a given population parameter (e.g., size/density or yield) and the presence or absence of an introduced stock of hatchery fish or allopatric population of the same species. These correlations need to be factored into any management scheme. The earliest management schemes for trout in California were attempts to mitigate losses of salmonid populations that had been caused by ongoing and pervasive environmental degradation and water resource mismanagement.

Subsequent recognition of failures of indiscriminate trout planting as a panacea for losses, and the rise of more scientific approaches, apparently resulted in changes in practices. At the same time, the goals began to change. During the 1950s, a broadly shared goal of U.S. fisheries resource managers was increasing and "enhancing angling opportunities for the widest possible spectrum of anglers commensurate with constraints imposed upon by available habitat" (Radonski). Practices in California in the 1950s and 1960s appear to have been consistent with this appraisal. For example, the advent of and strong support for "catchable trout" plantings are reflective of this general philosophy, although it was also recognized that such programs in California were entirely focused on recreational goals rather than more recent goals of conservation and preservation (Butler and Borgeson, 1966).

dominant) and wild stocks (displacement, submissive behavior, lower foraging frequency, etc.) depending on what aspects were being observed. There is no question that interactions occur. Regarding the significance of the interactions in the natural environment, it is difficult to unequivocally establish and quantify causal relationships, because not all variables are controllable, direct observations become more difficult, and increasingly reliance must be placed on information extracted from creel census and field surveys.

Certain other variables or situations may be difficult to quantify or are not considered in designing and interpreting field experiments or surveys. For example, is the cover or food resource quantitatively limiting and how does that affect the interaction and outcome?

Although such limitations or weaknesses in a study make it difficult to draw conclusions without equivocation, perusal of the literature uncovers numerous examples in which it appeared that:

1. One species had negatively impacted another species under sympatric conditions,

2. A population or subspecies of the same species group negatively impacted another, and

3. A hatchery-propagated population adversely impacted another to reduce recruitment.

Actual mechanisms may be debated or the scientific rigor of studies be critiqued. Still, the ubiquity of examples warrants recognition that there are many correlations between a given population parameter (e.g., abundance or yield) and the presence or absence of an introduced stock of hatchery fish or allopatric population of the same species. These correlations need to be factored into any management scheme. The earliest management schemes for trout in California were attempts to mitigate losses of salmonid populations that had been caused by ongoing and pervasive environmental degradation and water resource mismanagement.

Subsequent recognition of failures of indiscriminate trout planting as a panacea for losses, and the rise of more scientific approaches, apparently resulted in changes in practices. At the same time, the goals began to change. During the 1950s, a broadly shared goal of U.S. fisheries resource managers was increasing and "enhancing angling opportunities for the widest possible spectrum of anglers commensurate with constraints imposed upon by available habitats (Radonski). Practices in California in the 1950s and 1960s appear to have been consistent with this appraisal. For example, the advent of and strong support for "catchable trout" plantings are reflective of this general philosophy, although it was also recognized that such programs in California were narrowly focused on recreational goals rather than more recent goals of conservation and preservation (Butler and Borgeson, 1965).

4.1.3 Biological Aspects: Population Dynamics and Genetic Integrity

Historically, much of what is known on population dynamics and interactions of salmonids arose from intensive efforts relating to predicting yields from various species and/or stocks based on fecundity, growth, age, size, class composition, catch rates and other parameters. Efforts to identify or confirm individual populations or stocks relied primarily on simple and inexpensive meristic or morphological analysis. Eventually, biochemical analysis in the form of immunology and protein electrophoresis were utilized. The latter has been used to determine genetic introgression among a wide variety of species, ranging from Pacific salmon to minnows.

While some success was attained in these efforts, the subsequent application of even more sophisticated, and very expensive, DNA biotechnology resulted in a surge of interest and research activity in the population genetics of fishes. This technology was applied more slowly among fish researchers than among many other organismal groups, for a variety of reasons not mentioned here. Nonetheless, previously asked questions on species/population genetic integrity are now being examined with increased resolution and precision in many quarters.

Given this recent surge in the application of biochemical genetics to fisheries resources, the genetic profiles and genetic integrity of many salmonid and other fish populations (including some California stocks) have been described, but much more needs to be done, as studies have been scattered. The intense but scattered efforts reflect the tendency to respond to highly specific perceived crises with particular species, populations or localized management practices. Longer-term organized or systematic efforts may prove to be more efficient, given the expense of the applications. In the case of California trout populations, further efforts need to be made in the area of genetic characterization of selected wild, endemic and hatchery populations, particularly if hatchery stocking of riverine systems is to continue and the often-suggested recommendation for close genetic profiling and matching is followed to any extent. Similarly, analyses of relative genetic contributions in mixed or perceived mixed stocks require such efforts.

4.1.4 Biological Aspects: Ecological/Population Genetic Interactions

The large body of information on ecological interactions between species (e.g., introduced vs. native) or populations (e.g., hatchery vs. wild populations) often has indicated marked differences in aspects of territorial and agnostic behavior, field survival, post-migratory reproductive success, responses to competition, etc. However, some information may be debatable (e.g., whether certain hatchery fish behavior is learned or genetic; transiency of certain behavior in hatchery fish; physiological outcomes of interspecific interactions). References have been made to studies where F-1 generations of hatchery-reared wild trout survived better than F-1 generations of domesticated trout of the same species, produced higher yields, or displayed

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Although this may shown easily for certain physiological traits, it is more difficult to ascertain for behavioral traits associated with specific ecological interactions. Many behavioral traits that are related to spacing and foraging may well be learned and perhaps transient in the wild. An important question is whether or not these are heritable. There appears to be an informational gap regarding this aspect.

Irrespective of informational gaps or difficulties in linking population genetics to behavioral/ecological interactions, current perceptions of differences in biological traits of hatchery-produced stocks compared to wild and/or native populations tend to be negative in the context of hatchery fish utilization in natural environments. The same holds true for exotic strains or subspecies introductions into natural, fertile habitats containing existing populations of wild non-native or indigenous salmonids. Some studies have shown no adverse affects of hatchery produced fish on wild populations of the same species (e.g., Petrosky and Bjornn, 1988).

4.2 MANAGEMENT ASPECTS

4.2.1 Fish Hatchery Function: Practices, Diseases, and Effluents

Many modern fish culture practices are well over a hundred years old, and are inextricably tied to the salmonid fishes due to some unique biological attributes that made this group particularly amenable to human manipulation. At virtually every point of culturing fish (e.g., brood stock selection, egg-taking, artificial fertilization, egg incubation, alevin maintenance, fry/parr maintenance, etc.), there is some form of overt as well as inadvertent artificial selection occurring.

The traditional intensive culture approaches, geared to provide high densities/biomass per unit volume water flow or surface area to maximize stock and harvest size, do not preserve genetic integrity and diversity. Brood selection, matings, and artificial fertilization procedures in salmonid hatcheries have historically been non-random.

Recent concerns about genetic integrity of introduced and indigenous wild populations and the need for genetic matching of target populations in stocking projects indicate the necessity for considering non-traditional modes relating to brood stock selection and artificial propagation. These include keeping brood stock size above minimum effective reproducing populations size (Ne), increasing the breadth of brood stocks to include individuals representing all size and age classes, and using systems that promote random matings of brood stock.

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Similarly, total reliance on traditional incubation systems (e.g., tray and jar incubation devices) needs to be re-examined with the possibility of incorporating systems that simulate natural conditions (e.g., deep or shallow matrix gravel incubators, spawning channels, etc.) thereby minimizing inadvertent artificial selection for subtle traits (e.g., elevated yolk sac fry activity and metabolism in tray/trough systems vs. gravel incubation systems).

Hatcheries are the primary focal point of disease epidemics because the intensive production approaches provide ideal conditions for outbreaks, which have been observed directly. Fish disease epidemics in the natural environment are not as well documented for a number of reasons, including the fact that these are difficult to document (proper diagnosis of fish mortalities requires live or moribund specimens and immediate transfer to a limited number of fish disease laboratories for bioassays and histological examination) and are rarely observed.

Healthy natural or wild habitats are seldom ideal locations for environment disease epidemics, as such outbreaks are usually associated with physiological stress associated with high-density conditions that are the rule in most hatcheries. This is not to say they cannot occur; however, little of what we have observed and know about fish diseases has come from the natural environment simply because they are not a common occurrence. Disease problems are anathema to fish hatchery managers and pose a significant threat to their operations.

There are some federal and state guidelines for inspection and certification of fish and eyed eggs. Historically, these guidelines have been of questionable value, particularly with respect to viral diseases. Prevention through improved practices and protocols involves movement towards increasing intrinsic population brood stock variations in morphology, growth and reproduction, use of random matings, low-density rearing, and more natural egg incubation apparatus. Vigilance against contaminated brood stocks or eyed egg sources should be maintained through good referencing and archiving of stocks.

The problem of waste discharge from hatcheries has been debated in the past, particularly with the emergence of increased federal and state concerns in recent years. During the 1970s, the matter was debated between the EPA and state agencies. The EPA relinquished some jurisdiction over the issue, so regulations vary by state and region. Whether there are specific state regulations for hatcheries per se (i.e., other than the conventional generic regulations for effluent discharges in waterways), or the extent to which any regulations are enforced as appropriate to circumstances, has not been determined.

4.2.2 Other Management Aspects

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4.2.2 Other Management Aspects

Because of California's history of resource over-exploitation and environmental degradation, it is important to place current concerns on salmonid fish management in a historical context. Many early fish cultural practices were driven initially by factors such as the early successes of fish culturists in the Northeast, strong government advocacy of fish culture by the first Secretary of Interior, the proliferation of railroads in the West and the infamous "fish cars," recognition of environmental degradation and fishery resource loss in the West, and an overly optimistic view of fish culture as a panacea to loss of fishery resource. The single-resource mentality was chronically pervasive, and still occurs today. This led to a highly fragmented approach to managing resources that were and are inextricably connected (e.g., water and fisheries).

The early lack of focus on definitive goals and accountability stocking practices did not begin to change until the 1930s or 1940s, when managers recognized past failures or ineffectiveness and sought explanations. By the 1950s and 1960s, fishery managers had become better trained and more scientific in their approach towards assessing and managing fisheries resources. Some aspects of this can be seen in reviewing the assessment and monitoring of certain DFG stocking programs during the late 1960s (e.g., Region 1 synopses of several streams, creeks and lakes with wild populations) where quantitative approaches were utilized and recommendations for reductions in stocking were made in response to changes in statistical indices of fishing effort by anglers. The policies and goals of the California Fish and Wildlife Plan (1965), in which extensive and detailed documentation and categorization of all wildlife and fisheries resources were made, including projections for future utilization of trout resources up through the 1980s, appear to be consistent with more recent national projections of future use of trout resources. The previously cited 1950s+ national goal of providing and enhancing angling opportunities for the public appears to hold true today in California, although with a rapidly changing and more diverse mix of user groups (e.g., fly-fishers, bait-fishers, lure fishers, wild trout fishers, trophy trout fishers, etc.). While the strong demand for wild trout conservation and special fisheries is laudable, if only from an environmental perspective, providing equitable access and availability of fisheries resources to all of the public will be a growing problem if projected high levels of shortfalls of trout production by the year 2000 hold true and the number of anglers increases as population rises in the state. The changing demographics of the angler population will need to be factored into any future overall trout stocking program. Socioeconomic and cultural differences (e.g., attitudes towards the outdoor environment, significance of fisheries resources in an aesthetic-vs-consumptive context, and economic status) must be considered if equitable access and availability to fisheries resources is to be obtained. Other differences in the angler population that should be considered in planning and implementing trout management programs include angling preferences (fly vs. lure vs. bait) and level of angler expertise. Meeting the demands of the various user groups (as summarized in a recent Chico State University Report for the State Parks Division) poses a major challenge. Public awareness and cooperation through education will be as critical as political and financial support.

A chronic problem with California salmonid fisheries resource management has been the fragmentation of resource jurisdictions and an apparent lack of salmonid fish management in a historical context. Many early fish cultural practices were driven initially by factors such as the early successes of fish culturists in the Northeast, strong government advocacy of fish culture by the first Secretary of Interior, the proliferation of railroads in the West and the infamous "fish cars," recognition of environmental degradation and fishery resource loss in the West, and an overly optimistic view of fish culture as a panacea to loss of fishery resource. The single-resource mentality was chronically pervasive, and still occurs today. This led to a highly fragmented approach to managing resources that were and are inextricably connected (e.g., water and fisheries).

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In recent years, there has been a notable shift away from single-species or single-resource management toward the so-called whole ecosystem or habitat approaches. This shift is evident in many government resource agencies, including the DFG. Habitat protection, enhancement or restoration per se is not a new idea; the DFG has made past efforts in this direction, albeit on a limited scale (Calhoun, 1966). This approach requires clearer definition of multijurisdictional agency responsibilities and an integrated and coordinated approach to formulating management strategy and policy (Born, 1989, 1990). Increased emphasis on this approach is evidenced by the use of detailed categorical and systematic compilation of guidelines for habitat restoration (e.g., Flosi and Reynolds, 1991), which includes a wide array of aspects ranging from habitat classification to construction. This is a working manual for the DFG inland fisheries biologist involved in habitat restoration. Such guidelines were developed in response to legislation that made habitat restoration a major component of fisheries management policy (Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988).

Thirteen states, including California, use “special resource” designations or an “Exceptional Waters” (EW) approach to protect and conserve fisheries resources, e.g., Wild Trout Rivers, Wild River Programs. Such strategies commonly lean heavily towards an integrated and coordinated, multidisciplinary and multijurisdictional process for managing fisheries resources. In a multistate comparison of criteria and components used to designate such special resources as special wild trout fisheries, California shows a marked lack of interagency cooperation in water fisheries/water resource programs (Born, 1990). Special designations such as EW approaches require good habitat classification systems and prioritization procedures. In California, these latter aspects are already in places (e.g., standard use of Calif. Salmon Stream Habitat Restoration Manual, DFG, 1991) Continued efforts of this type need to be promoted for the salmonid species and stocks in a variety of salmonid fish-bearing drainages.

4.3 LONG RANGE ENVIRONMENTAL IMPACTS

4.3.1 Genetic Diversity

The genetic impacts of superimposing hatchery fish on wild populations can be detrimental, benign, or beneficial. Few studies have measured the long-term genetic response of wild stocks to hatchery stocking. Negative consequences have been stressed in the scientific literature: the disruption of adaptive genes or gene combinations (coadapted systems; Reisenbichler, 1984, 1986b; Chilcote et al, 1986; Taggart and Ferguson, 1986); genetic homogenization caused by the swamping of native gene pools (Temple, 1978; Utter, et al., 1989); and interspecific hybridization (Behnke, 1972; Busack and Gall, 1981; Leary et. al., 1984; Allendorf and Leary, 1988).

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Genetic risks to wild stocks increase whenever nonadaptive traits are selected in the hatchery stock, or genetic variation within the hatchery stock is small relative to the wild stock (Lannan and Kapuscinski, 1984). The extent to which wild stocks are affected depends on the level of genetic dissimilarity, the reproductive contribution of hatchery and wild fish, the amount of interbreeding, and the relative fitness of progeny. Hatchery fish can influence genetic structure through interbreeding, and can effect genetic change through their interaction with the ecosystem, especially as competitors and predators (Krueger and Menzel, 1979).

Genetic variation has been positively correlated with survival for hatchery stocks (Altukhov, 1983). Large differences in the genetic structure of hatchery and wild stocks can potentially lead to lower survival (Altukhov, et al., 1980; Altukhov and Salmenkova, 1987) and undesirable alterations of the wild gene pool (Allendorf and Ryman, 1987). Genetic variation, its distribution among stocks, and the need to use hatchery fish that are genetically similar to wild stocks are important elements of hatchery programs. Some hatchery stocks have been found to be more closely related to each other than to local wild stocks (Stahl, 1983; Hjort and Schreck, 1982; Taylor, 1986).

4.3.1.1 Inbreeding Depression

Inbreeding occurs when spawning pairs of fish are more closely related to each other than to other individuals in the population (Gall, 1987). A potential cause of loss of genetic variability at both the individual and population level, inbreeding is promoted by directional and unintentional selection and the use of small numbers of fish to establish and perpetuate the hatchery stock. Gall (1987) discussed the theory of inbreeding as it applies to hatchery management.

Inbreeding has long been recognized as a potential problem in hatcheries, but only recently have studies documented its negative effects on salmonid stocks (Ryman and Stahl, 1980; Allendorf and Phelps, 1980; Gall, 1983). Kincaid (1983) reviewed a number of studies in which inbreeding depression (an increase in the percentage of individuals that are homozygotes for recessive deleterious alleles) had a detrimental effect on fitness measures such as survival, reproductive capacity, physiological efficiency, and the occurrence of deformities in hatchery stocks. However, empirical evidence of deleterious alleles being introduced into wild stocks from hatchery planting has not been demonstrated. Likewise, the reduced genetic variation found at some loci in hatchery stocks has not been linked to reduced fitness for fish in natural stream conditions (Nielsen, et al., 1994).

Hatchery rearing programs using either (1) a large random population sample of 50 or more adult pairs (Allendorf and Ryman, 1987), (2) systematic line crossings to eliminate mating of full sibs (Krueger et al., 1981), or (3) repeated introductions of unrelated brood stocks to cross with existing brood stocks (Kincaid, 1983), will cause inbreeding, and its deleterious effects will continue to be exhibited in hatchery-reared fish (Kincaid, 1976).

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4.3.1.2 Outbreeding Depression

Introductions of large numbers of hatchery fish into waters inhabited by relatively fewer, well-adapted wild fish would be expected to reduce the average fitness of the resulting population due to the slim probability that genetic combinations selected for in hatchery conditions would preadapt planted fish for a unique local ecosystem. Swamping of small wild populations has been documented to occur by both interspecific (Behnke, 1972; Allendorf and Leary, 1988) and intraspecific hybridization (Altukhov, 1981; Campton and Johnston, 1985; Gyllensten and Wilson, 1987; Allendorf and Leary, 1988) between hatchery-reared fish and the wild population.

4.3.1.3 Artificial Selection in Hatcheries

A certain amount of unintentional selection is unavoidable in fish-rearing operations, including hatchery programs and facilities used for supplementation (Hynes, et al., 1981). There is evidence that many of the observed changes are maladaptive in a natural environment. Performance data from six studies reviewed by Wohlfarth (1986) and one by Mason, et al. (1967) generally show that short-term survival and growth of pure strain hatchery fish was worse than that of hybrid (progeny of hatchery-reared and wild parents) and wild fish (Mason, et al., 1967) Hybrid progeny of cutthroat and brook trout had greater viability, in terms of better short-term survival, faster growth or both, relative to purebred hatchery and wild stocks.

Kapuscinski and Philipp (1988) concluded that more study of the long-term genetic effects of hatchery planting is needed before concluding that introductions of genetic variants by hatchery-produced fish different from the wild populations is desirable. The assumption that maximizing short-term growth, survival, or reproductive success is equivalent to maximizing the long-term viability of the stock may be untenable, since additional factors are probably involved on an evolutionary time scale.

Steward and Bjornn (1990) were unable to locate any published studies in which the fitness of progeny of hatchery x wild matings was measured over multiple generations and compared with the fitness of the original hatchery and wild parental stocks. Chilcote, et al. (1986) presented evidence that the survival to smolt age of naturally spawned progeny of hatchery steelhead trout was approximately 28% that of offspring from wild spawners. Krueger and Menzel (1979) and Wishard, et al. (1984) also documented poor reproductive success among hatchery brook trout and rainbow trout.

Hatchery rearing practices will continue to produce hatchery fish selected for aggressiveness, slow reaction times, inappropriate territorial, feeding, avoidance and sexual behavior, and resistance to some diseases. When introduced into waters with wild fish, predators, anglers, diverse habitats and variable physical environmental components, these fish will often be poorly suited for survival and reproduction. They will continue to be a threat to wild fish populations by bringing disease organisms to which they are resistant, but wild fish are not.

4.3.1.4 Gene Flow and Genetic Load

Gene flow from a hatchery stock might have beneficial consequences when the wild stock has become so small that it has lost or is threatened with the loss of genetic variation through inbreeding, genetic drift, or population bottlenecks. Under these circumstances, hybridization of genetically divergent hatchery and local stocks may constitute the best management option. In these circumstances, genetic diversity is promoted at the population level, but is lost at the species level: "... the effect of gene exchange between subpopulations is to increase the variance within groups, decrease the variance between groups, and decrease the total variance" (Nelson and Soule, 1987).

Introduced fish tend to stray more frequently than wild fish stocks, increasing gene flow to unintended areas (Waples, 1991). As more fish either disperse to or are introduced into existing, wild trout populations that are adapted to the physical and biological components of their environment, the proportion of genes in the resulting population that contribute to maintaining or increasing the overall population fitness will decrease and the proportion of genes that influence development, growth, and behavior traits that are less appropriate for the environment will increase. As fish carrying less appropriate genetic materials breed with those carrying more appropriate genetic information, their offspring may be less well adapted to the environment than would be the offspring of two wild fish. This genetic load is always present in any population, since the environment is always changing, but introductions of fish with different combinations of genes that have been selected in a hatchery environment would most likely increase the genetic load.

4.3.1.5 Genetic Drift

All finite populations, hatchery and natural, might experience some genetic drift (the direction of change is random but may include permanent losses of rare alleles) due to natural genetic processes that occur in each generation. In hatcheries, the potential for random fixation of alleles increases whenever too few or too closely related individuals are chosen for breeding. Genetic material can be replenished only through mutation or infusions of fish from outside the hatchery.

The rate at which genetic variability is lost in a hatchery stock depends on the number, relative reproductive contribution, and genetic similarity of individuals used for breeding purposes. The proportion of fish that are heterozygous (having two different alleles at the same locus), within a population of size N decreases at the rate of 1 - (1/2N) in each generation, assuming that each individual spawns successfully. For example, where a large number (100 or more) of individuals are randomly mated, a reduction of less than 0.5% of the original genetic variation is expected after one generation. All else being equal, no more than 5% of the heterozygosity would be lost in

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large populations after 10 generations. When 10 fish are used as broodstock, 5% of the initial heterozygosity would be expected to be lost in the first generation alone, and 40% would be lost after 10 generations.

Loss of genetic variability is also reflected by the reduction in the mean number of alleles per locus, expressed as a percentage of the alleles originally present (allelic diversity; Denniston, 1977). The potential reduction in allelic diversity is most dramatic (up to 50%) at moderately polymorphic loci when the number of breeding individuals is small.

Although genetic diversity is generally low in salmonids (Allendorf and Ryman, 1987; Davidson, et al,. 1989), reductions in genetic variability within hatchery stocks can be 20-30% below wild stock levels. However, Thompson (1985) observed levels of genetic variation in hatchery stocks of cutthroat and rainbow trout that were in some cases greater than that present in wild stocks.

Because not all fish within a stock have equal reproductive capacities, the effective population size (Ne - the number of successfully reproducing adults) rather than the total population size actually determines how much genetic variation is lost from one generation to the next. Age, fecundity, fertility, sex, and the degree and magnitude of environmental variations affect the reproductive contribution of each individual relative to other fish in the stock.

Effective population sizes that have been recommended to maintain genetic diversity vary widely (Ryman and Stahl, 1980; Allendorf and Phelps, 1980; Hynes, et al., 1981; Krueger, et al., 1981; Allendorf and Ryman, 1987; Kapuscinski and Jacobson, 1987); the minimum acceptable value probably depends on the environment and the reproductive biology of the species (Simon, et al., 1986). Theory (Allendorf and Ryman, 1987) and empirical evidence (Verspoor, 1988) suggests that little (<1 %) genetic variability will be lost in most salmonid species if Ne of the founding population is >50. Conservative Ne values recommended by two groups of fish population geneticists are higher: Kapuscinski and Jacobson (1987) suggest 100 fish, whereas Allendorf and Ryman (1987) recommend 200 individuals, split evenly by sex, as a lower population bound for hatchery stocks that are used to supplement wild stocks.

4.3.1.6 Disruption of Coadapted Genetic Structures

Gene coding for traits selected for in the hatchery environment may be part of larger coadapted gene complexes (Dobzhansky, 1970). Hatchery-mediated selection may disrupt these systems, leading to reduced genetic variance and population fitness (Strickberger, 1976; Reisenbichler, 1984, 1986b; Chilcote, et al., 1986). This type of genetic disturbance, as yet undocumented in hatchery stocks, merits future research.

Introducing hatchery-reared fish, which are adapted to a hatchery environment, into streams where wild fish are adapted to more variable physical and biological environmental conditions could reduce the fitness of large populations after 10 generations. When 10 fish are used as broodstock, 5% of the initial heterozygosity would be expected to be lost in the first generation alone, and 40% would be lost after 10 generations.

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Introducing hatchery-reared fish, which are adapted to a hatchery environment, into streams where wild fish are adapted to more variable physical and biological environmental conditions could reduce the fitness of the resulting combined populations. A larger proportion of the fish in the combined population will have alleles that have not been screened by natural selection in that particular environment, and will contribute to the genetic load of the population.

4.3.1.7 Summary

Although the potential for genetic destabilization within hatchery stocks and hybridization between hatchery and wild stocks is clear, there is little conclusive evidence of genetic damage among wild stocks that is directly attributable to hatchery planting. Gene flow from hatchery to wild stocks has been studied, (e.g., Campton and Johnston, 1985; Taggart and Ferguson, 1986; Altukhov and Salmenkova, 1987; Gyllensten and Wilson, 1987) and examples of genetic swamping through interspecific hybridization have likewise been documented (Behnke, 1972; Allendorf and Leary, 1988), but compelling evidence of genetic harm is not evident. More disturbing are the few known cases where hatchery introductions are thought to have caused the effacement of native gene pools at the intraspecific level (Altukhov, 1981; Campton and Johnston, 1985; Gyllensten and Wilson, 1987; Allendorf and Leary, 1988).

There is no conclusive evidence to suggest that wild stocks have genetically benefited from hatchery plantings. Stewart and Bjornn (1990) speculated on the reasons more definitive evidence of genetic impact - good or bad - has not been obtained:

- Genetic differences between many hatchery and wild stocks may be small; hatchery practices may not have appreciably altered historic genetic compositions in the comparatively short time that anadromous salmon and trout have been cultured,
- The extent of genetic differences and subsequent introgression has not been assessed or cannot be discerned using available technology,
- Hypothesized cause-and-effect relationships involving genetic changes and stock viability have not been subjected to rigorous experimentation,
- The effects of gene flow cannot be distinguished from changes prompted by natural selection or genetic drift,
- Interbreeding and gene flow may not be extensive, owing to poor survival of hatchery fish, strong and rapid selection against unfit genotypes, and genetic and life history mechanisms that help to buffer the wild genome against deleterious change.

Wild stocks are at greater risk of genetic harm when subjected to environmental stress, because more, hatchery fish are produced that can interact with wild fish to compensate for the higher mortality rates in the wild stocks (Steward and Bjornn, 1990). If wild spawners breed with and are greatly outnumbered by spawners of hatchery origin, genetic instability and the resulting combined populations. A larger proportion of the fish in the combined population will have alleles that have not been screened by natural selection in that particular environment, and will contribute to the genetic load of the population.

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Wild stocks are at greater risk of genetic harm when subjected to environmental stress, because more hatchery fish are produced that can interact with wild fish to compensate for the higher mortality rates in the wild stocks (Cleveland and Bjornn, 1990). If wild spawners breed with and are greatly outnumbered by spawners of hatchery origin, genetic instability and degradation may ensue. The results of fish stocking, even if hatchery fish are genetically equivalent to the native stock, may remain unsatisfactory unless the factors responsible for the decline of wild fish are removed. If hatchery introductions are to succeed, equal consideration must be given to restoring degraded ecosystems to some semblance of their former state (Ryder, et al., 1981).

Environmental perturbation, if severe enough, can result in the partial or total reproductive failure of a stock, with corresponding genetic effect. Wild stocks are susceptible to overexploitation when hatchery fish are abundant. If stocks are depleted to low levels, the loss of genetic variation becomes a major concern (Nelson and Soule, 1987). Even moderate levels of exploitation may result in the selective loss of certain phenotypes and a concomitant genetic response (Ricker, 1958, 1973, 1981; Larkin, 1963; Paulik, et al., 1967; Loftus, 1976; Ferguson, 1989). Traits most likely to be affected would be those most desirable to the fishery, such as rapid growth (large fish) and high catchability (Favro, et al., 1979; Ricker, 1982). When intense selection is applied over several generations, genetic variability within and between stocks can be expected to decline, potentially lowering the viability of the affected stocks.

4.3.2 Ecology and Behavior

Marnell (1986) has summarized impacts of hatchery-reared fish on wild populations in several categories, including introductions of pathogens, genetic alterations, and population and community structure alterations.

Once released from the hatchery, trout may interact with their environment in several processes: competition and predation between salmonids and other organisms, dispersal, and habitat selection. Environmental factors that influence system productivity and habitat characteristics may exert complex and variable control over each of these processes. Few studies have been explicitly designed to evaluate the effects of hatchery releases on the ecology of wild fish. In most studies, the post-release behavior, food habits, growth and survival of hatchery fish have been compared against the ecological attributes of wild trout.

4.3.2.1 Competition

Competition between individuals of one or more species ensues when the demand for a resource in the environment exceeds its actual or perceived availability (Larkin, 1956). The potential for intra- and interspecific competition between hatchery and wild stocks depends on the degree of spatial and temporal overlap in resource demand and supply. Hatchery fish, especially those reared in the hatchery for several months, were found to be less efficient than wild salmonids in exploiting and defending limiting resources, and therefore at a competitive disadvantage (Clady, 1973; Butler, 1975; Krueger and Menzel, 1979; Reisenbichler and McIntyre, 1977; Vincent, 1972, 1975, 1987; Petrosky and Bjornn, 1988). Direct competition with wild degradation may ensue. The results of fish stocking, even if hatchery fish are genetically equivalent to the native stock, may remain unsatisfactory unless the factors responsible for the decline of wild fish are removed. If hatchery introductions are to succeed, equal consideration must be given to restoring degraded ecosystems to some semblance of their former state (Ryder, et al., 1981).

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The capacity for hatchery fish to significantly alter the behavior, growth and survival of wild fish via competition remains a controversial subject. Hatchery planting can lower wild stock production if large numbers of hatchery fish are released (Snow, 1974; Thuember, 1975; Bjornn, 1978; McMullin, 1982; Vincent, 1975, 1987; Nickelson, et al., 1986; Kennedy and Strange, 1986; Petrosky and Bjornn, 1988).

4.3.2.2 Displacement

A wide range of results has been reported for wild-hatchery fish interactions as measured by dispersal. Wild fish may be competitively displaced by hatchery fish early in life, especially when the latter are more numerous, of equal or greater size, and have taken up residency before wild fry emerge from redds (Chapman, 1962; LeCren, 1965; Mason and Chapman, 1965; Lister and Genoe, 1970; Stein, et al., 1972; Elliott, 1989; Chandler and Bjornn, 1988).

Wild rainbow trout did not migrate differentially from heavily stocked sections versus unstocked sections of an Idaho stream (Petrosky and Bjornn, 1989), but movement of wild brown trout in a creek in Montana increased substantially with the introduction of hatchery rainbow trout. The fraction of brown trout moving up to 400 m increased from an average of 19% in non-stocking years to 33% in stocking years. Brown trout moving over 400 m increased from 2% to 10% for the same periods (Vincent, 1987).

4.3.2.3 Behavioral Ecology

Differences in the behavior of hatchery and wild fish that seem to affect competitive interactions, habitat use, growth, and survival have been found (Sosiak, et al., 1979; Dickson and MacCrimmon, 1982). Ersbak and Haase (1983) have identified several behaviors that were successful in hatcheries, but maladaptive in the wild: (1) a lack of wariness and a surface or mid-water orientation (Vincent, 1960; Moyle, 1969; Sosiak, et al., 1979; Legault and Lalancette, 1985; Dickson and MacCrimmon, 1982), (2) an inability to form social hierarchies or hold positions in the natural stream environment (Chapman, 1966; Bachman, 1984), (3) excessive activity (Moyle, 1969), and (4) high levels of aggression (Fenderson, et al., 1968). Sub-optimal foraging strategies could probably be added to this list. Some of these behavioral differences may be genetically based, but are more likely environmentally induced (Suboski and Templeton, 1989).

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Physiological and behavioral characteristics of hatchery fish may predispose them to loss of feeding time, excessive use of energy, and increased exposure to predators" (Fenderson, et al., 1968). Bachman (1984) came to much the same conclusion, suggesting that excessive energy expenditures were primarily responsible for the high mortality of hatchery brown trout he observed in a Pennsylvania stream. Petrosky (1984) described the behavior of hatchery rainbow trout and resident wild cutthroat trout in a natural stream, noting that when released, hatchery rainbow trout formed aggregations in generally deeper and swifter water in midstream than that preferred by cutthroat trout. "Most hatchery trout remained in groups segregated from wild cutthroat trout. These aggregates had no apparent hierarchy. During infrequent feeding, several group members pursued and fought over single items drifting past the group... Hatchery rainbow trout charged, drove, and nipped each other proportionately more often than wild cutthroat trout."

Behavioral ecology studies conducted by Bachman (1984), Petrosky (1984), and Petrosky and Bjorrn (1985) documented the inefficiency of hatchery trout in competing for foraging sites compared to wild trout. Hatchery trout were more aggressive in initial encounters and when food might be present in temporary abundance, exhibiting hyperactivity in "scrambling" for available food resources. Wild trout appeared to be better competitors in obtaining prime foraging sites prior to food becoming available there. By selecting and defending optimal feeding sites, native fish excelled in contest competition in which they chased introduced hatchery trout away from sites that had no obvious (to hatchery trout) value, but where the predictability of feeding opportunities was high.

Hatchery salmonids are apparently less adept at conserving energy, and they do not perform as well as wild fish in stamina tests (Vincent, 1960; Reimers, 1956; Miller, 1955, 1958; Green, 1964; Bams, 1967; Cresswell and Williams ,1983). Horak (1972), working with rainbow trout, found hatchery fish had more stamina than wild fish. Hatchery-reared fish examined by Phillips, et al. (1957) and Green (1964) had more fat and poorer muscle tone than wild fish. Nutritional deficiencies, notably imbalances in fatty acid composition, were suggested as a cause of reduced viability among hatchery fish by Bolgova, et al. (1977).

The high level of aggressive behavior observed among hatchery fish following stocking (Fenderson, et al. 1968; Moyle, 1969; Fenderson and Carpenter, 1971; McLaren, 1979; Dickson and MacCrimmon, 1982; Swain and Riddell, 1990) may be misleading. Aggressive encounters between wild fish begin immediately after emergence and occur as needed to establish and maintain dominance hierarchies or territories. Natural aggressive tendencies of salmon and trout may be suppressed in the hatchery, and the high level of aggression observed following release should not be unexpected when the fish are placed in an environment where there is diversity of habitat and food for which to compete (Steward and Bjornn, 1990).

Competitive bouts between hatchery and wild fish were usually more intense or prolonged than similar encounters between wild individuals (Fenderson, et al., 1968; Dickson and MacCrimmon, 1982). Excessive visual and social contact between "unfamiliar" hatchery and wild fish may elicit high levels of excitement and aggression in both groups (Li and Brocksen, 1977).

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Behavioral ecology studies conducted by Bachman (1984), Petrosky (1984), and Petrosky and Bjornn (1985) documented the inefficiency of hatchery trout in competing for foraging sites compared to wild trout. Hatchery trout were more aggressive in initial encounters and when food might be present in temporary abundance, exhibiting hyperactivity in "scrambling" for available food resources. Wild trout appeared to be better competitors in obtaining prime foraging sites prior to food becoming available there. By selecting and defending optimal feeding sites, native fish excelled in contest competition in which they chased introduced hatchery trout away from sites that had no obvious (to hatchery trout) value, but where the predictability of feeding opportunities was high.

Hatchery salmonids are apparently less adept at conserving energy, and they do not perform as well as wild fish in stamina tests (Vincent, 1960; Reimers, 1956; Miller, 1955, 1958; Green, 1964; Horak, 1967; Cresswell and Williams, 1983). Horak (1972), working with rainbow trout, found hatchery fish had more stamina than wild fish. Hatchery-reared fish examined by Phillips, et al. (1957) and Green (1964) had more fat and poorer muscle tone than wild fish. Nutritional deficiencies, notably imbalances in fatty acid composition, were suggested as a cause of reduced viability among hatchery fish by Belgova, et al. (1977).

The high level of aggressive behavior observed among hatchery fish following stocking (Fenderson, et al. 1968; Moyle, 1969; Fenderson and Carpenter, 1971; McLaren, 1979; Dickson and MacCrimmon, 1982; Swain and Riddell, 1990) may be misleading. Aggressive encounters between wild fish begin immediately after emergence and occur as needed to establish and maintain dominance hierarchies or territories. Natural aggressive tendencies of salmon and trout may be suppressed in the hatchery, and the high level of aggression observed following release should not be unexpected when the fish are placed in an environment where there is diversity of habitat and food for which to compete (Steward and Bjornn, 1990).

Competitive bouts between hatchery and wild fish were usually more intense or prolonged than similar encounters between wild individuals (Fenderson, et al., 1968; Dickson and MacCrimmon, 1982). Excessive visual and social contact between "unfamiliar" hatchery and wild fish may elicit high levels of excitement and aggression in both groups (Li and Brocksen, 1977).

Although hatchery-reared fish are able to switch to a natural diet despite being raised on an artificial diet of pellets (Paszkoskie and Olla, 1985), malnutrition and starvation are frequently the result of introductions (Bachman, 1984). Ersbak and Haase (1983) hypothesize that hatchery trout may have greater difficulty in detecting and exploiting increasing densities of certain forage items than do wild trout.

4.3.2.4 Habitat Selection

The use of habitat by hatchery trout and salmon is often indistinguishable from that of wild fish, particularly when the hatchery fish are stocked as eggs, fry, or young parr (Bjornn, 1978), but may differ from that of wild fish if the hatchery fish have been kept in the hatchery for an extended period. Divergence in habitat use may be caused by behavioral conditioning that occurs in the hatchery and by competition-related interactions after release. Pollard and Bjornn (1973) observed that stocked rainbow trout congregated in deeper water than did native steelhead trout in an Idaho river, as did Hillman and Chapman (1989), who found the hatchery rainbows in pools and wild steelhead in riffles, runs, and cascades. In both studies, hatchery and wild rainbow trout were spatially segregated. Observations of introduced catchable-size hatchery rainbows indicated that hatchery fish did not use the same habitats as native cutthroat and wild rainbow trout (Petrosky and Bjornn, 1988). Bachman (1984) observed that hatchery brown trout used less energy-efficient foraging sites than did wild brown trout.

4.3.2.5 Foraging Behavior

The foraging success of hatchery fish following their release into the wild depends on their experiences, feeding opportunities, and habitat quality. Dietary overlap and competition between hatchery and wild trout is influenced by differences in microhabitat use, differences in foraging tactics and abilities, and size-dependent differences in prey selection. There is no evidence that the diet or feeding habits of wild fish are unaffected by the introduction of hatchery fish. Theoretically, the amount of food available to individual fish should decrease with supplementation, but that depends on how well the hatchery fish adapt to feeding in the natural environment.

Hatchery trout have little opportunity to capture live prey while confined in hatchery raceways and ponds. Nevertheless, hatchery-reared fish appear capable of switching to a natural diet following release (Lord, 1934; Raney and Lachner, 1942; Jenkins, et al., 1970; Ware, 1971; Bryan, 1973; Ringer, 1979; Vinyard, et al., 1982; Paszkowski and Olla, 1985a, 1985b), and trout previously fed only hatchery pellets soon select wild prey over artificial food when offered a choice (Bryan, 1973; Paszkowski and Olla, 1985b).

Some hatchery fish suffer malnutrition and starvation in the wild (Klak, 1941; Miller, 1951; Reimers, 1963; Ersbak and Haase,1983; Bachman, 1984), despite an apparent ability of hatchery fish to switch to natural foods following release.

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Some hatchery fish suffer malnutrition and starvation in the wild (White, 1941; Miller, 1951; Reimers, 1963; Ersbak and Haase,1983; Bachman, 1984), despite an apparent ability of hatchery fish to switch to natural foods following release.

Success in foraging and survival appears to be a function of the length of time reared in hatchery conditions. Hatchery fish released early in life (eggs, fry, young parr) usually adapt to feeding in the wild and grow naturally (Bjornn, 1978). Hatchery fish that had spent significant time in the hatchery appear to be inefficient foragers that exist on suboptimal natural diets (KIak, 1941; Reimers, 1963; Fenderson, et al., 1968; Moyle, 1969; Elliot, 1975; Sosiak, et al., 1979; Shustov, et al., 1981; Bachman ,1984; Marnell, 1986). Hatchery trout may have greater difficulty in detecting and exploiting increasing densities of certain forage items than do wild trout (Ersbak and Haase, 1983) and may have difficulty adapting fully to life in a stream, especially in relatively infertile streams where food likely limits production of fish.

4.3.2.6 Numerical Responses to Introductions

Several studies have shown declines in wild populations associated with introductions (Marnell, 1986). Vincent (1975, 1987) cited a 49% decline in wild trout numbers following introductions of hatchery rainbow trout to a previously unstocked section of creek in Montana. Likewise, several studies have noted that wild fish populations increase upon cessation of introducing hatchery trout. Negative correlations between numbers of introduced fish and numbers of wild fish could be attributed to competition for limited resources, predation, habitat alteration, or some combination of these. However, behavioral studies have suggested the competitive mechanism by which such numerical declines could be explained

Long-term effects of competitive pressures exerting biomass and numerical responses by wild fish populations involve displacement from preferred habitats or complete extirpation. Brown trout are notorius for displacing wild brook trout populations (Cooper, 1970; Kaeding, 1980; Fausch and White, 1981; Waters, 1983).

4.3.2.7 Biomass and Growth Responses to Introductions

Although wild trout appear to have greater longevity than introduced trout (Flich and Webster, 1976; Mason, et al., 1967), the effects of introducing hatchery-reared trout on growth rates of wild fish are not consistent (Marnell, 19xx). Vincent (1975, 1985) has shown that numbers and biomass of wild trout increased dramatically after stocking of hatchery fish was discontinued, implying a competitive effect on survival, reproduction, and growth. Later, he measured a decline in the annual growth rates of several age classes of wild brown trout after catchable-size rainbow trout were stocked in Montana streams (Vincent, 1987). However, Petrosky and Bjornn (1988) reported that growth of wild rainbow trout was not reduced when catchable-size rainbow trout were stocked at a rate that doubled the density of wild fish in a productive Idaho stream. If survivorship of hatchery trout is quite low following their introduction, there may be a neglible impact on growth rates or survival of wild fish.

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A number of studies have documented the relatively poor survival of hatchery reared fish (Needham and Slater, 1944: Heimer, et al., 1985; Petrosky, 1984). Factors affecting survivorship include nutritional status and season of introduction (Mason, et al., 1967), structural heterogeneity of the stream (Bilby and Bisson, 1987; Odonera and Ueno, 1961), and selection of suboptimal habitats by introduced fish (Vincent, 1960; Petrosky and Bjornn, 1988).

4.3.2.8 Age and Size of Introduced Fish

Several studies suggest that the longer fish are raised in hatchery environments, the more inappropriate their behavior when introduced, and the greater the chance they will negatively impact wild fish in the area immediately, but their chances of surviving to reproduce are lessened (Steward and Bjornn, 1990). On the other hand, hatchery fish introduced as eyed eggs or small fry stand a better chance of competing successfully with wild fish and surviving to reproduce.

4.3.2.9 Predation

Predation is difficult to observe, particularly when the life history stages being preyed upon are eggs and larvae, so few clear examples of introduced fish impacting wild populations are available (Moyle, et al., 19xx).

Direct effects of introducing hatchery fish depend to a large extent upon the relative sizes of introduced fish and wild fish. Fish released from hatcheries at sizes larger than the wild residents are potential predators, whereas fish stocked as smaller individuals are potential prey (Steward and Bjornn, 1990).

Taylor, et al. (1984) reviewed several instances in which introduced brown trout have preyed on other salmonids to the extent they have caused significant declines in population numbers and local extinctions. Cannibalism of smaller wild fish by introduced stocks was believed responsible for dramatic reductions in the Feather River (Sholes and Hallock, 1979). Hatchery fish may, on the other hand, be food for larger wild fish, thereby offering numerical protection for smaller, less numerous wild fish (Millard and MacCrimmon, 1972). The relative sizes of introduced hatchery fish and wild fish probably determine which group is most adversely affected (Mead and Woodall, 1968).

Hatchery fish may be more susceptible to predation than wild fish because of inappropriate avoidance and foraging behaviors, an inability to accurately assess predation risks, secondary stress effects, and unfamiliarity with their new surroundings (Steward and Bjornn, 1990).

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In some cases, introductions of brown trout might directly lead to the demise of less aggressive wild trout populations, as brown trout prey on the brook trout (Taylor, et al., 1984).

Numerical Responses:
Introductions of large numbers of hatchery fish may inflate the rate of predation on wild fish as they are displaced from secure habitats to suboptimal habitats and territories by the aggressive, frenetic hatchery fish (Wood, 1984). Such introductions may also stimulate a numerical and functional response among predators (including fishermen) by attracting them to introduction sites and affecting both introduced hatchery fish and the native population.

A history of stocking in a particular area may lead to a stable food source for predators of both hatchery and wild fish that would not otherwise exist there. Stocked fish may be responsible in some sites for maintaining populations of kingfishers, osprey, northern squawfish (Thompson, 1959; Buchanan, et al., 1981). Continuation of the existing stocking program will continue to sustain such predator populations. It is not clear whether such predation has long-lasting effects on wild trout populations or whether predators affect wild trout population dynamics differentially.

Functional Responses:
Some predators are believed to respond to density changes in prey populations by altering their individual rates of predation on a particular prey group (Holling, 1973). Underwater observations of predation by large rainbow trout on outmigrating hatchery and wild chinook salmon by Hillman and Mullan (1989) showed that the trout preferentially preyed on wild chinook fry in 22 of 23 attacks. However, others have found no difference in preference for wild or hatchery-reared fish by predators (Hvidsten and Lund, 1988) and some have found higher rates of predation on hatchery-reared smolts compared to wild smolts. There is no clear-cut pattern that emerges from the literature to indicate whether planted or wild trout are more susceptible to predation. Losses to predation for hatchery fish may be higher than for wild fish due to inappropriate avoidance and foraging behaviors, an inability to accurately assess predation risks, secondary stress effects, and a general unfamiliarity with their new surroundings. Several studies have shown intense post-release mortality among hatchery-reared fish (Piggins, 1959; Larsson, 1985). Also, experimental removal of fish predators from pools prior to introductions of hatchery fish resulted in a doubling of the survival rate of the hatchery fish (Horner, 1978).

Introduced trout may be relatively more susceptible to angling than wild trout in many situations (Parker, 1986; Marnell, 1986). In other circumstances, wild trout may be disproportionately caught due to their quicker reaction time and attack on lures (Hillman and Chapman, 1989).

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4.4 PHYSICAL IMPACTS: IMPACTS OF HATCHERY EFFLUENT ON STREAMS

4.4.1 Water Quality Effects

Studies indicate that passing river water through fish farms causes some deleterious effects on water quality. Measured chemical and biological oxygen demands were measured in the inlet and outlet waters of Norwegian trout farms and were found to be equivalent to that of sewage (Bergheim and Silverstein, 1981). In a survey of British fish farms along the Solway Firth, there were a wide range of quality changes associated with the effluent, when compared to the influent flow. In the vast majority of cases, reductions in water quality were recorded, although in some cases there were actual improvements in water quality. Quality varied over time; deterioration was greatest when the weight of fish carried was large, and flow through the farms was large (Tervet, 1981).

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4.4 PHYSICAL IMPACTS: IMPACTS OF HATCHERY EFFLUENT ON STREAMS

4.4.1 Water Quality Effects

Studies indicate that passing river water through fish farms causes some deleterious effects on water quality. Measured chemical and biological oxygen demands were measured in the inlet and outlet waters of Norwegian trout farms and were found to be equivalent to that of sewage (Bergheim and Silverstein, 1981). In a survey of British fish farms along the Solway Firth, there were a wide range of quality changes associated with the effluent, when compared to the influent flow. In the vast majority of cases, reductions in water quality were recorded, although in some cases there were actual improvements in water quality. Quality varied over time; deterioration was greater when the weight of fish carried was large, and flow through the farms was large (Terver, 1989).

In spite of the lower water quality, there does not appear to be any serious impacts on the live in the receiving waters. A study of hatcheries in Georgia, North Carolina and South Carolina indicated that the numbers and kinds of both benthos and fish increased downstream of fish hatcheries, and that pollution-intolerant benthic organisms were not lost from the fauna below hatchery outfalls. No detrimental changes in the fish communities were apparent (Primmer and Clugston, 1975). Norwegian studies showed that, although decreased oxygen concentrations and increased concentrations of total-N and total-P were measured, salmonid stocks in the river were not affected by the trout farm (Bergheim and Selmer-Olse, 1978). There was an increase in the production and energy consumption of brown and rainbow trout downstream of a Danish fish hatchery (Rasmussen, 1986).

4.4.2 Role of the State Water Quality Control Board

As the California fish hatcheries discharge into open waters, the discharges are under the scrutiny of the State Water Quality Control Board. The Board has set up discharge standards for each hatchery, and each hatchery is routinely monitored for compliance. Although there are times when the standards are exceeded, they are generally few and are associated mainly with tank cleaning operations that dump pulses of settleable material into the effluent stream. Compliance has been made possible by constructing settling ponds downstream of the facility, where the particulate matter can be reduced and where biological activity and oxygenation can reduce some other pollutants. The only hatchery with a significant record of non-compliance with discharge standards is the San Joaquin facility, which is monitored by the Central Valley Regional Water Quality Control Board. This facility lacks a settling pond, but a pond is currently under construction and future compliance can be expected.

4.4.3 Conclusions

The hatchery system appears to have little impact on local streams. Substrate studies have shown that biodiversity is somewhat reduced in the immediate area of discharge to the river system, but the distance affected is apparently small.

Literature Cited

Bergheim, A. and A.R. Selmer-Olsen. 1978. River pollution from a large trout farm in Norway: Aquaculture, v.14, p. 267-270.

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AN ENVIRONMENTAL DOCUMENT ON THE CULTURE AND STOCKING OF RESIDENT TROUT AND INLAND SALMON IN CALIFORNIA

CHAPTER 5. PROGRAMMATIC AND ECONOMIC IMPACTS

5.1 INTRODUCTION

This section describes and analyzes the economic impacts of the Department of Fish and Game's (DFG) current Inland Trout management programs. These programmatic activities will be analyzed and assessed in light of the legislative mandate of DFG, which is expressed in their mission statement:

> "The mission of the California Department of Fish and Game is to manage California's diverse fish, wildlife and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public."

As this mission statement reveals, the DFG has a mandate to manage natural resources, in part, to provide fish and game for recreational sport purposes. The resource in question here is California's freshwater (inland) trout and DFG's trout stocking program. Such resource management can yield significant contributions to the state's economy. If, however, in the process of providing these and other *economic benefits* significant *economic costs* are incurred (e.g., environmental damage, inefficient resource use, harm to native salmonids, etc.), then DFG's trout stocking program could be improved to enhance recreational net benefits and better conserve natural resources.

To assess the *economic impacts* (which include not only dollar impacts but also environmental and social ones), it is important to describe and analyze the contribution of DFG's trout stocking program to the state's economy. The DFG has three primary programs within its Inland Trout budget area: stocking trout (mainly catchable) for put-and-take angling, managing and restoring wild trout habitat in support of both put-and-take and catch-and-release angling, and management and protection of waters that contain species of special environmental concern (e.g., T&E species and native species). Since DFG's trout stocking program is the primary supply for these activities and the industries that support them, it is important to review the funding and budget levels and trends for these programs.

Perhaps the central part of the economic impact study is the analysis of the costs of supplying the catchable trout and the demands that they satisfy. Satisfying recreational fishing demands is clearly part of DFG's legislative mandate. If it were determined, however, that this role was being accomplished in a manner that is economically inefficient or conflicted with its resource conservation mandate, then opportunities exist to suggest changes that will result in a more sustainable management of recreational inland trout fishing.

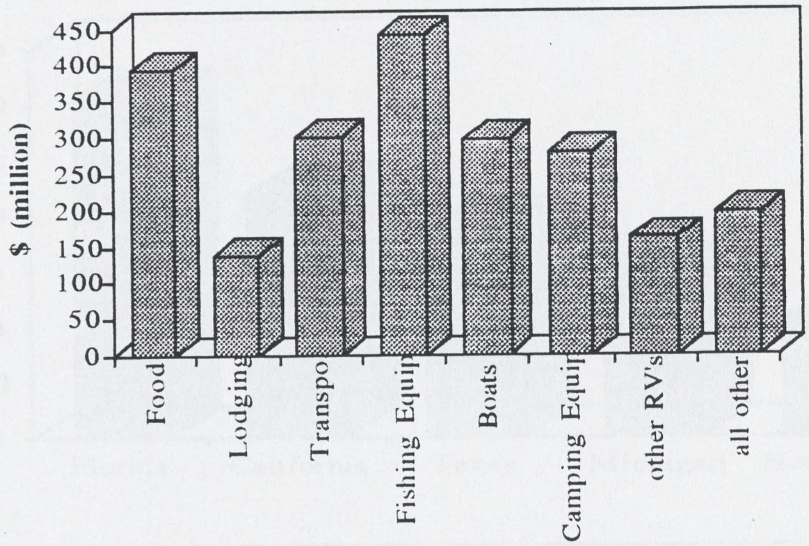
The last major part of this section is an economic description and analysis of the current programs that support DFG's wild trout program (WTP) and threatened trout (sensitive) program. DFG's efforts to "restore" waters that are viable habitat for wild trout will be assessed. Ultimately, restoration activity must address the economic efficiency concerns of society. Not all waters in California have the same potential for restoring such habitats and restoration activities will incur increasingly higher marginal costs and lower marginal benefits as the WTP is expanded.

After the above descriptive analysis is completed, a final overall assessment of the status quo from an economic perspective will be made.

5.2 ECONOMIC CONTRIBUTION OF THE INLAND TROUT FISHERY RESOURCE

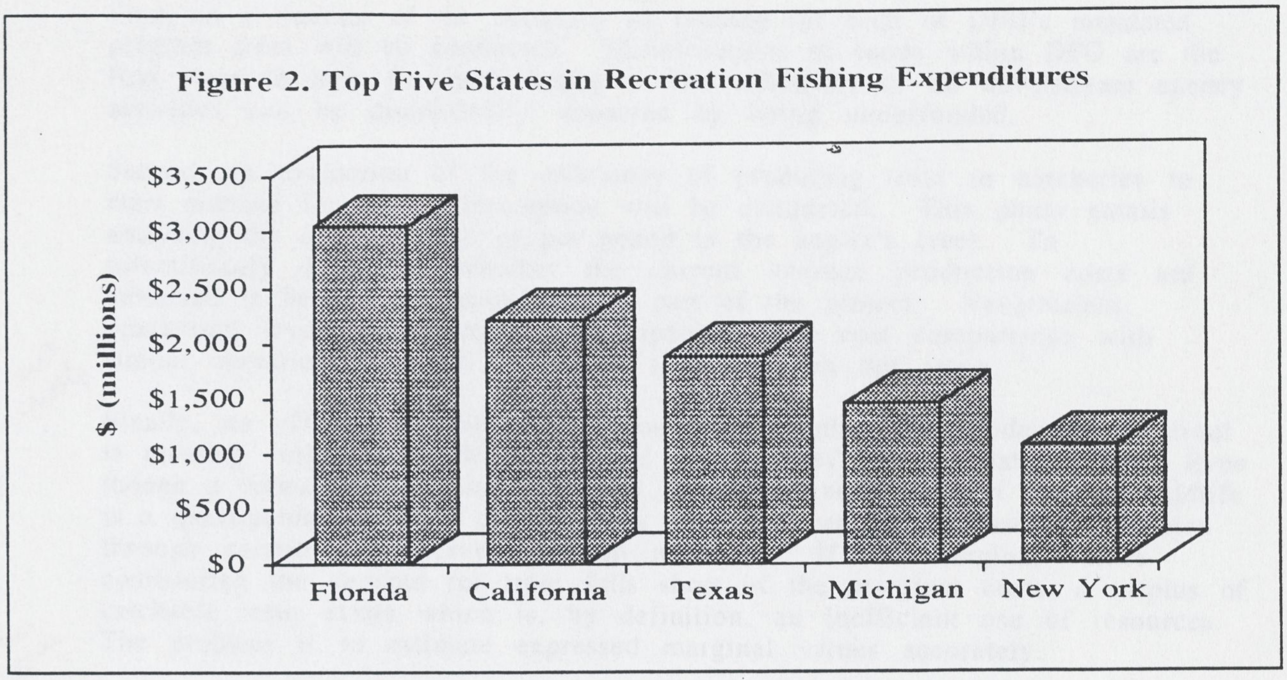
Recreational inland trout fishing and related activities make a substantial contribution to California's economy. Trout fishing, in a state as large and with as a diverse an array of waters as California possesses, involves considerable direct expenditures (about $2.2 billion) on travel, lodging, food consumption, sporting gear, boating and other more indirect activity (see Figure 1). This in turn generates nearly $5.7 billion in direct and indirect business (value-added) activity, or almost 1% of California's domestic product. In turn, this activity creates over 153,000 jobs that provide nearly $5 billion personal income , representing around 1% of total state's employment and personal income (McWilliams and Goldman 1995). With approximately 1.5 million licensed anglers providing around 30 million angler-days per year, this economic contribution amounts to around $190 per angler-day (assuming 16 angling-days per angler, Anderson 1990). Direct expenditures alone account for about $75 per angler-day. Considering those expenditures that can most directly be attributed to fishing activity -- food, lodging, transportation and fishing equipment, nearly $1.2 billion is spent or about $40 per angler-day.

Figure 1. Expenditures for Recreational Fishing in Calif., 1985



Source: McWilliams and Goldman 1995.

Figure 2 illustrates the relative direct economic significance of recreational fishing among the top five states, placing California second among all the states according to expenditures. Much of this economic clout can be attributed to the productivity of California's waters, many of which exceed 150 lbs/acre; waters in the West average only about 50 lbs/acre using a conversion of 8.92 lbs/ac per 1 g/m2 (Platts and McHenry 1988).



Source: McWilliams and Goldman 1994.

The contributions of the inland trout resource that are measurable in dollar terms are substantial and must be recognized, but are only part of the picture when considering its full economic *value* to California and the rest of North America. Other economic values provided by a healthy and thriving trout resource include the option values arising from foregone opportunity costs of lost species and genetic strain, the values that result from the ecosystem niche or function served by salmonids, and the intrinsic value of existence for any species. Because option and existence values are both difficult to measure and controversial in theory, can be incorporated in this study only through subjective reasoning and anecdotal reference.

The cumulative effect of these economic values justifies a careful scrutiny of the management of this natural resource and the role the DFG serves.

5.3 ANALYSIS OF DFG BUDGET ALLOCATIONS AND TRENDS

Efficiency analysis is an investigation that seeks to identify and quantify *waste*. An activity is said to be efficient if it allocates resources and employs the best available technology in a manner that minimizes costs without creating undue waste. For the purpose of this study, the efficiency analysis will be conducted in the following three phases.

First, an evaluation of the adequacy of funding for each of DFG's mandated program areas will be conducted. Misallocations of funds within DFG are the first place to look for inefficiencies. The efficiency of all downstream agency activities can be dramatically impacted by being underfunded.

Second, an evaluation of the efficiency of producing trout in hatcheries to meet demand for trout consumption will be conducted. This phase entails analyzing the cost per fish or per pound in the angler's creel. To scientifically determine whether the current average production costs are minimum is beyond the scope of this part of the project. Nevertheless, production levels in comparison to capacities and cost comparisons with similar operations in other states can shed light on this issue.

Finally, an efficiency analysis must consider whether the production of trout is creating surpluses or deficiencies in the "market" for catchable trout. Even though a formal market does not exist for these goods (in part because wildlife is a quasi-public good), a demand does exist and can be expressed or revealed through certain non-market valuation methods. If the marginal values constituting the demand for trout falls short of the marginal costs, a surplus of catchable trout exists which is, by definition, an inefficient use of resources. The problem is to estimate expressed marginal values accurately.

5.4 DFG PROGRAM FUNDING

Funding for DFG programs is a mixture of many sources, the least of which is the state's General Fund. Figure 3a illustrates that DFG funding is tied to federal matching funds (17% of DFG's funding), which has a certain inertia within the state's budgeting process (e.g., Natural Heritage resources, threatened and endangered species, and oil spills) (DFG, July 1994). Nevertheless, almost half (47%) of DFG's funding comes from the sale of hunting and fishing licenses. These dollars depend upon the supply of game wildlife and catchable trout. Prospects for other sources of funding are increasingly being discussed, but at this stage remain highly uncertain. Only 2% of DFG's funding comes from the state's General Fund, and that small amount is quite vulnerable in these tight fiscal times.

In 1993-94, DFG had a total budget of $159,779,000, and employed 1,600 permanent and roughly 400 seasonal people (DFG, July 1994). This is not a large amount when one considers the jurisdictional area and the diversity of fish and game resources DFG must regulate. Due to this resource diversity, DFG has developed a wide variety of programs to achieve its mission, as illustrated in Figure 3b. Inland Fisheries' budget is just over $48 million (30% of the total budget) making it the largest program area. Enforcement and Wildlife Management/Natural Heritage each account for 19% of the total.

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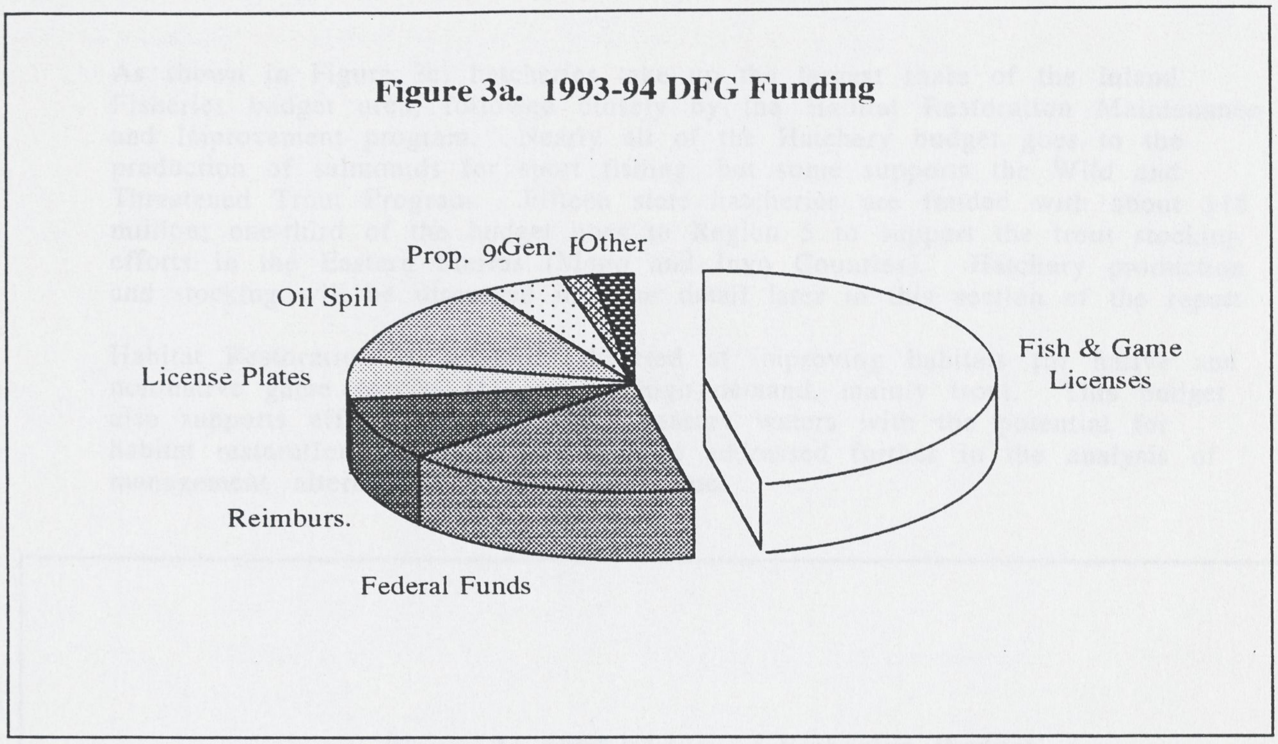
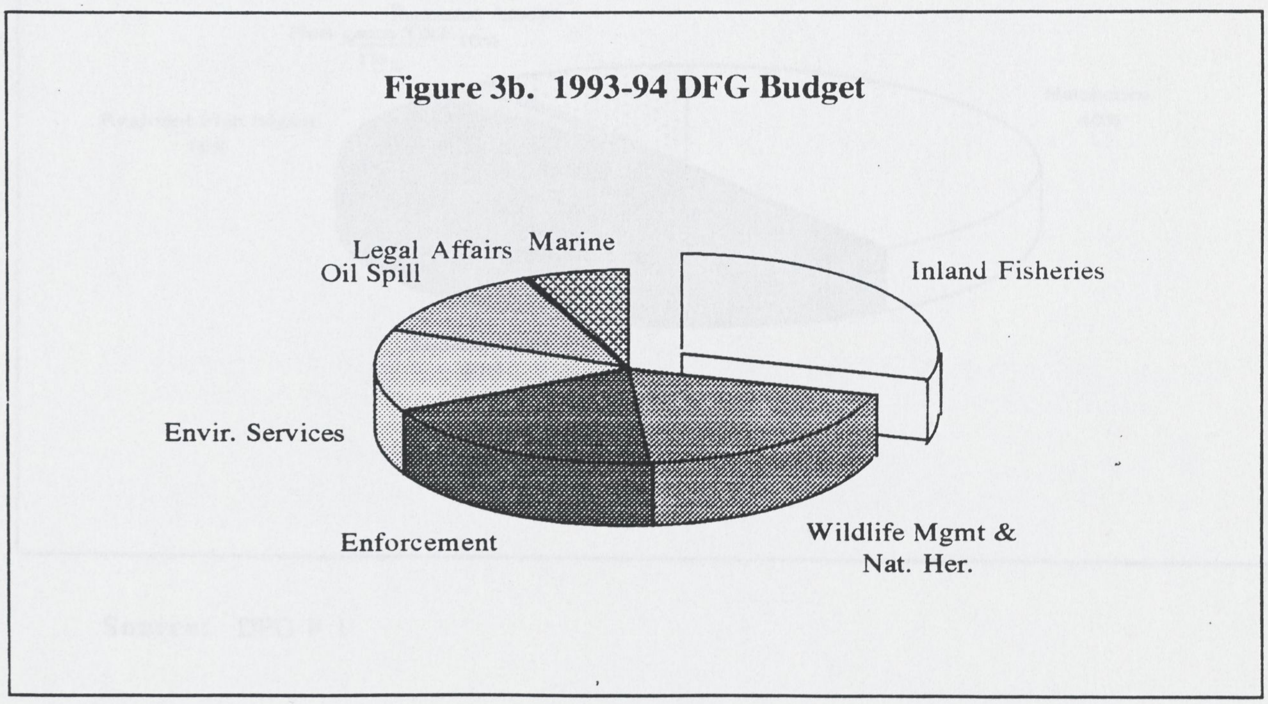




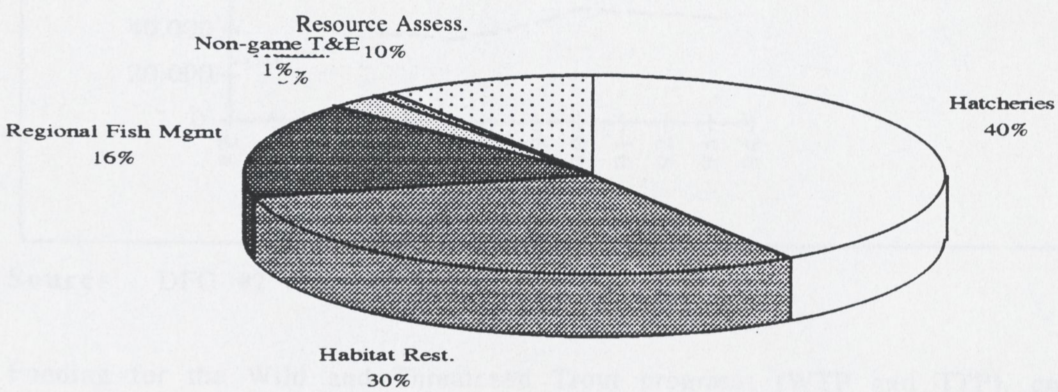
Source: DFG, July 1994.

Draft/CRI/June 1995
Not for Quotation or Distribution

As shown in Figure 3c, hatcheries take up the largest share of the Inland Fisheries budget area, followed closely by the Habitat Restoration Maintenance and Improvement program. Nearly all of the Hatchery budget goes to the production of salmonids for sport fishing, but some supports the Wild and Threatened Trout Program. Fifteen state hatcheries are funded with about $15 million; one-third of the budget goes to Region 5 to support the trout stocking efforts in the Eastern Sierras (Mono and Inyo Counties). Hatchery production and stocking will be discussed in more detail later in this section of the report.

Habitat Restoration is primarily directed at improving habitats for native and non-native game species that are in high demand, mainly trout. This budget also supports efforts to study and inventory waters with the potential for habitat restoration, an issue that will be addressed further in the analysis of management alternatives to the status quo.

Figure 3c. 1992-93 Inland Fisheries Budget

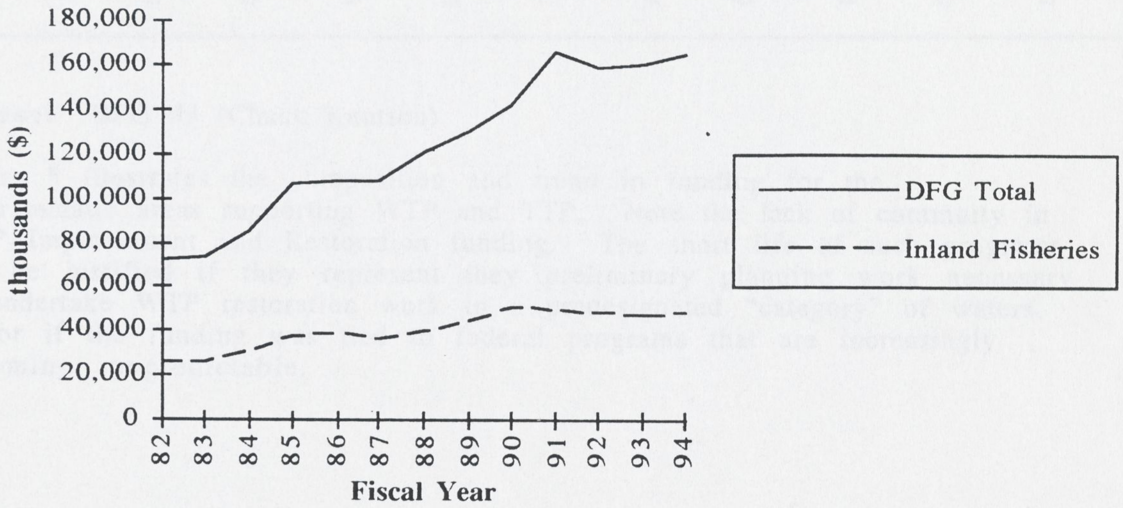


Source: DFG # 1

To further understand the programmatic directions of the DFG. it is useful to evaluate the trends in the budgets for these programs, illustrated in Figure 3d.

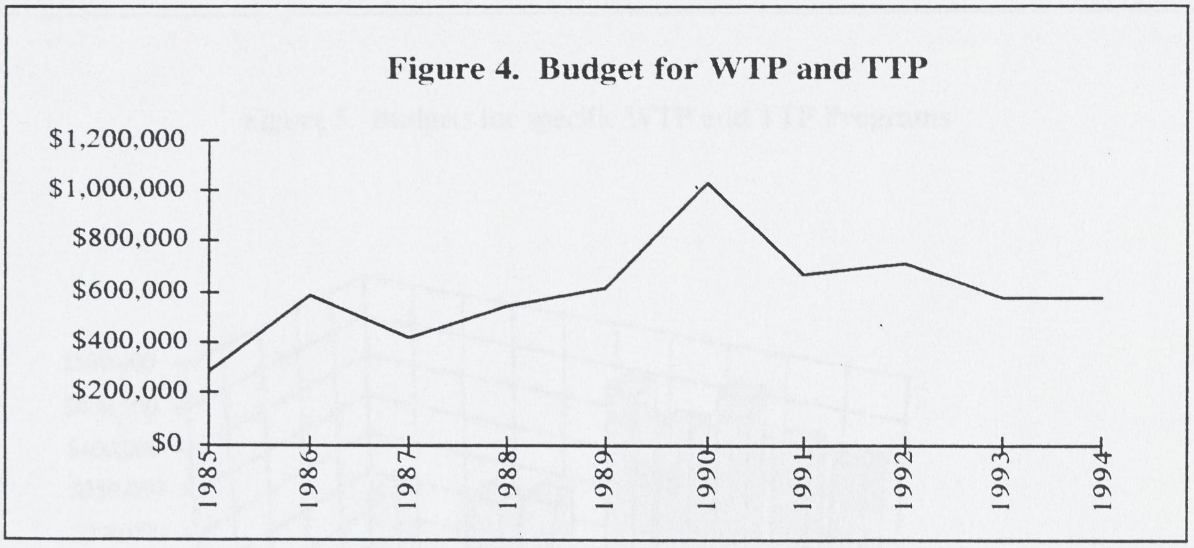
There has been a more rapid growth in ***other budget areas*** than in Inland Fisheries. Whether dictated by law or funding sources, this trend does not bode well for the future. A study by Mayo Associates (1988) commissioned by DFG, projected that in the year 2000, hatchery budgets and production would be increasing at a rate that would have roughly matched the "high" demand projection. Since that study, hatchery production rates have leveled off, leaving in doubt DFG's ability to play its role in meeting the sport fishing demands of the next century. In 1988, DFG hatcheries absorbed a 20% reduction in operating budgets, which has not yet been restored. (Advisory Council minutes, 5/12/95).

Figure 3d. DFG Budget Trends



Source: DFG #2 (Fleming letter, 5/17/95)

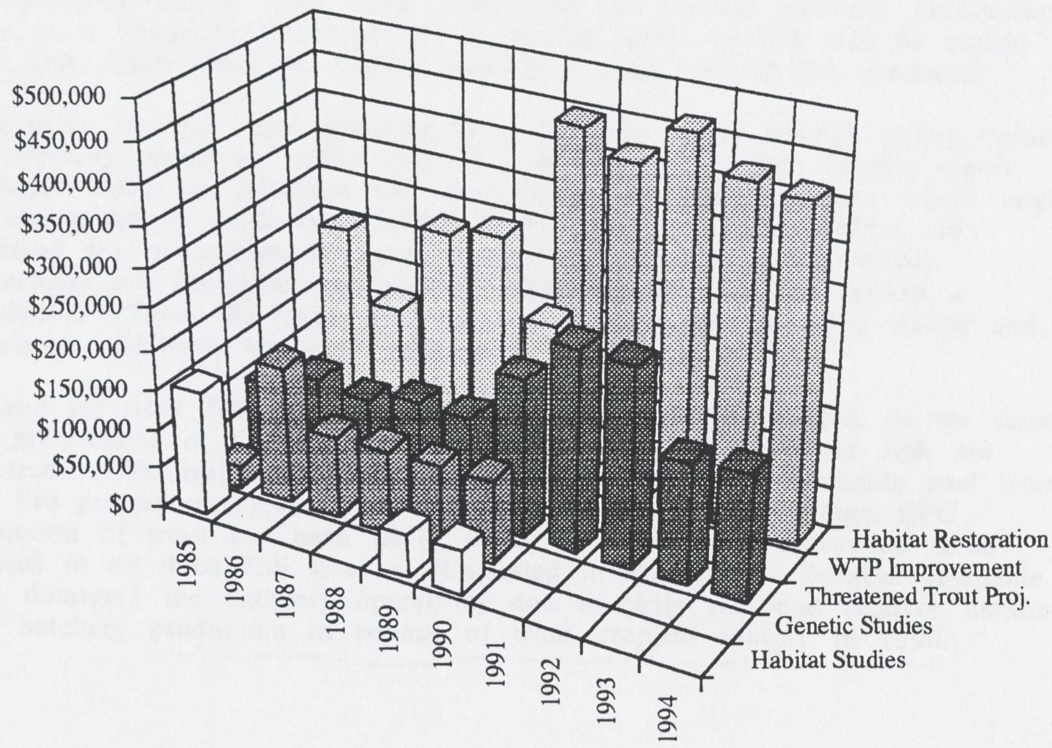
Funding for the Wild and Threatened Trout programs (WTP and TTP), contained in the Inland Fisheries Division, essentially began in 1985. Funding has steadily increased but, due to the federal matching funds component of these programs, that growth has been somewhat erratic. Now the funding for these programs is just under $600,000 (Figure 4), representing just over 1% of the Inland Fisheries budget.



Source: DFG #3 (Chuck Knutson)

Figure 5 illustrates the composition and trend in funding for the programmatic areas supporting WTP and TTP. Note the lack of continuity in WTP Improvement and Restoration funding. The short life of such programs can be justified if they represent they preliminary planning work necessary to undertake WTP restoration work in a predesignated "category" of waters, and/or if the funding was tied to federal programs that are increasingly becoming unpredictable.

Figure 5. Budgets for specific WTP and TTP Programs



Source: DFG #3 (C. Knutson, 1995)

To summarize the analysis of the efficiency of DFG funding and allocations, several preliminary conclusions can be drawn. First, DFG, along with most other state and federal agencies, has an increasing array of laws to obey and problems to address with decreasing funds, or flat budgets at best. Second, DFG funding is heavily dependent upon hunting and fishing licenses and is vulnerable to the vagaries of federal funding support. Third, Inland Fisheries budgets appear to be steady with modest increases in recent years, but

hatchery budgets have been flat. Fourth, programs and budgets for the Wild and Threatened Trout program activities are relatively small and erratic.

5.5 DFG HATCHERY PRODUCTION AND STOCKING

The efficiency issues of the DFG hatchery system involve both the standard costs of production at the hatchery and the distribution of the hatchery stock in California waters. To better understand the current hatchery production costs, it is important to review the production levels by fish size by region over time, since costs are heavily dependent upon size of fish produced.

In general, the fish size produced by a hatchery is set through policy, which is ultimately driven by public demand. As discussed earlier in this report, catchable trout are produced for the purpose of stocking waters where anglers are anticipated to catch them within a few months. Subcatchables are produced for put-and-grow waters, waters that have a better habitat. Fingerlings are produced for stocking better waters that can sustain a population. Thus, the three fish sizes are produced for differing waters and, to a degree, different angling preferences.

Demand for trout fishing is growing but the demand has shifted, or the tastes and preferences of anglers have been better recognized: larger fish are preferred. DFG responded to this in 1990 by changing its catchable goal from 3 to 2 fish per pound (DFG #4, 3/13/95). Except for this one change, DFG production of trout has been fairly steady (with a slight downward trend evident) in all three fish sizes as illustrated in Figure 6a. Because catchable trout dominate the hatchery operations due to their size and relative number, total hatchery production in pounds of trout dropped sharply in 1990.

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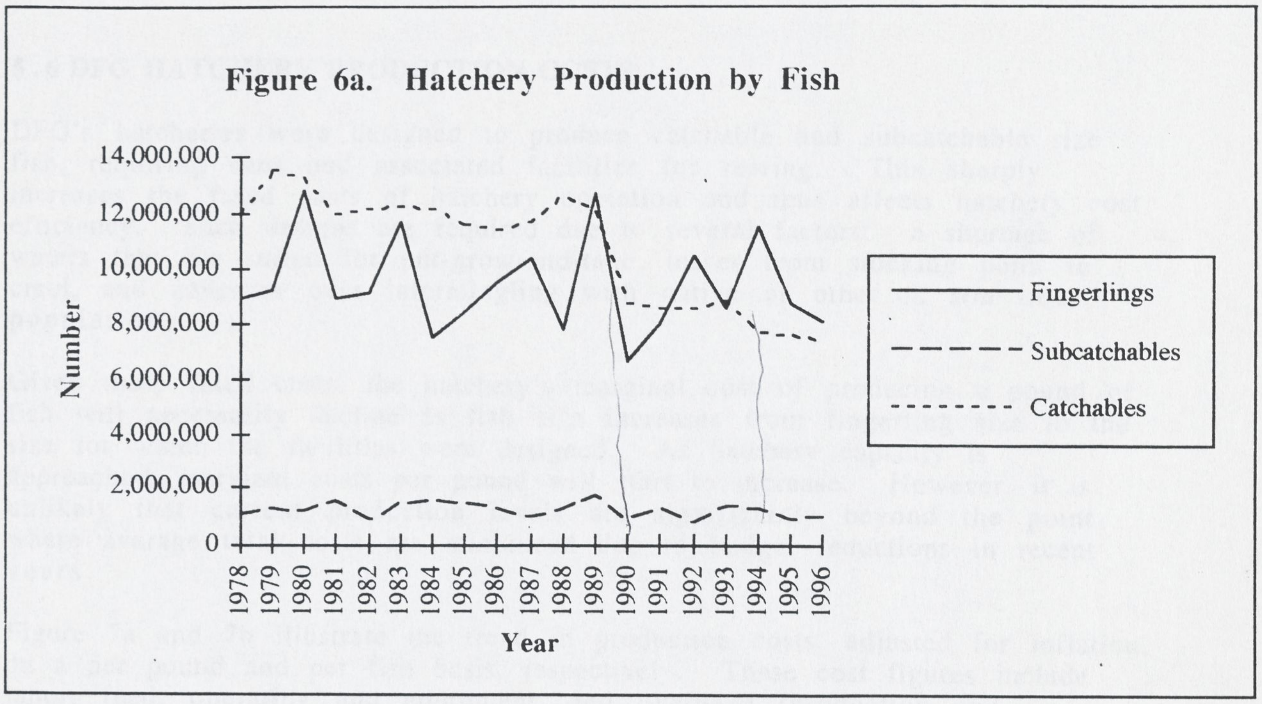
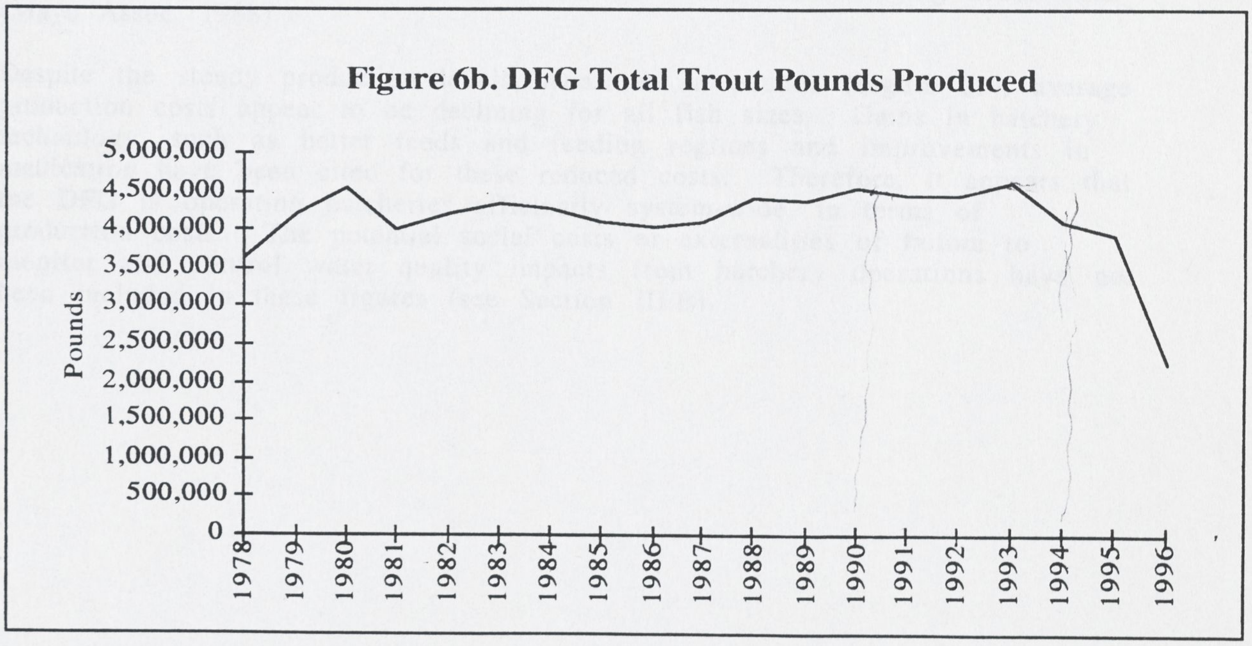




Source: DFG #5, Regional Annual HOC Reports, 1978 - 1995.
Note: In 1987, DFG changed catchable production goals from 3 fish/lb. to 2 fish/lb., resulting in a shift in the number of catchables produced (DFG #4, 3/13/95).

5.6 DFG HATCHERY PRODUCTION COSTS

DFG's hatcheries were designed to produce catchable and subcatchable size fish, requiring runs and associated facilities for rearing. This sharply increases the fixed costs of hatchery operation and thus affects hatchery cost efficiency. Such designs are required due to several factors: a shortage of waters that are suited for put-grow-and-take, losses from stocking point to creel, and concerns over intermingling with native or other *in situ* trout populations.

Given these fixed costs, the hatchery's marginal cost of producing a pound of fish will necessarily decline as fish size increases from fingerling size to the size for which the facilities were designed. As hatchery capacity is approached, marginal costs per pound will start to increase. However, it is unlikely that current production levels are significantly beyond the point where average total costs are minimized due to budget reductions in recent years.

Figure 7a and 7b illustrate the trend in production costs, adjusted for inflation, on a per pound and per fish basis, respectively. These cost figures include labor, feed, operating and equipment, and overhead (production and administrative costs estimated to be attributable to hatchery operations). Labor costs accounted for the largest share of the total, averaging about 40% (Mayo Assoc. 1988).

Despite the steady production levels, measured in pounds (Figure 6b), average production costs appear to be declining for all fish sizes. Gains in hatchery technology, such as better feeds and feeding regimes and improvements in medication have been cited for these reduced costs. Therefore, it appears that the DFG is operating hatcheries efficiently system-wide, in terms of production costs. The potential social costs or externalities of failure to monitor and control water quality impacts from hatchery operations have not been included in these figures (see Section III.B).

Figure 7a. Trout Production Costs per lb in constant $ (1988=100)

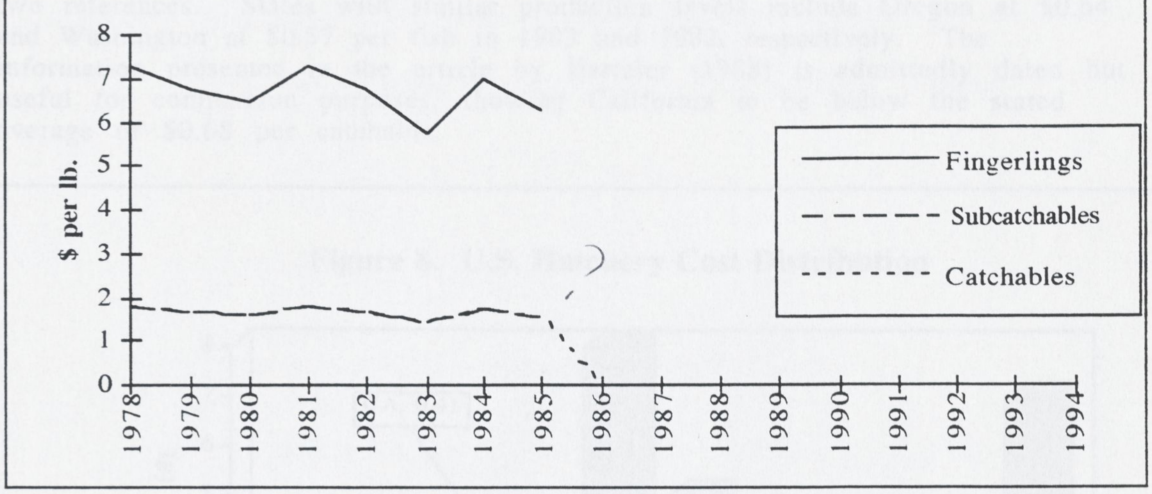
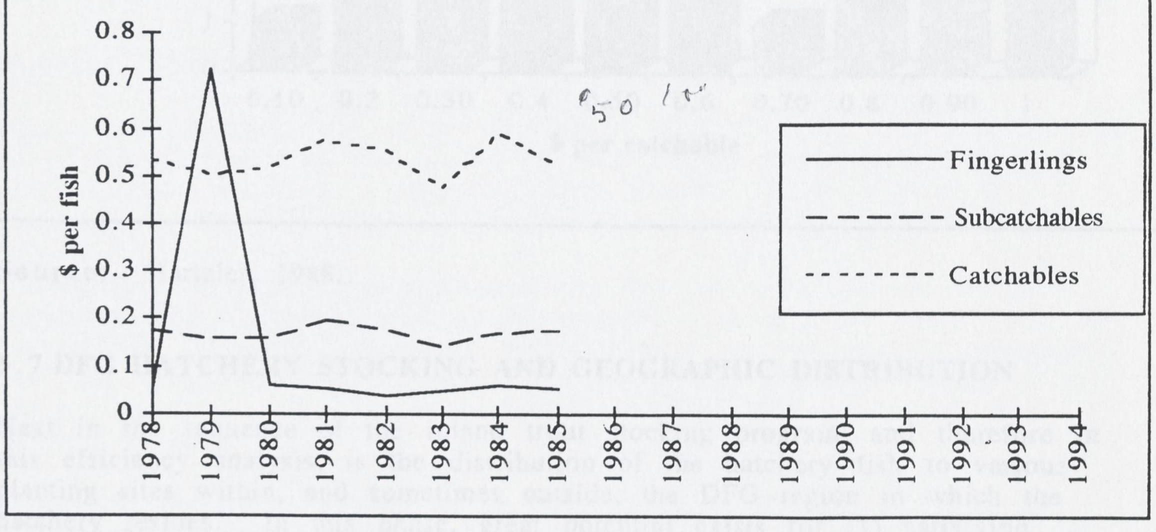


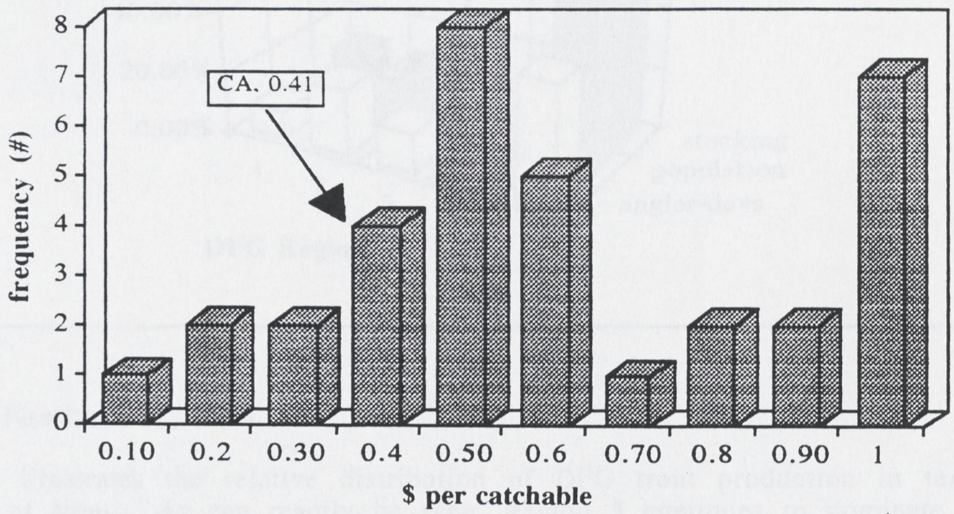
Figure 7b. Trout Production Cost per fish in constant $, (1988=100)



Source: Mayo Associates 1988.
Note: Cost figures are "loaded" to include appropriate fixed costs, excluding planting costs; current dollars adjusted for inflation using the GDP Implicit Deflator (Dept. of Commerce. 1994).

Concluding that the DFG is operating its hatcheries in a fiscally efficient manner is corroborated by comparison to other states, as illustrated in Figure 8. Adjusting the data presented in Figure 7b back to current dollars, $0.46 per catchable fish in 1983 results creating a very close agreement between these two references. States with similar production levels include Oregon at $0.64 and Washington at $0.57 per fish in 1983 and 1982, respectively. The information presented in the article by Hartzler (1988) is admittedly dated but useful for comparison purposes, showing California to be below the stated average of $0.68 per catchable.

Figure 8. U.S. Hatchery Cost Distribution



Source: Hartzler, 1988.

5.7 DFG HATCHERY STOCKING AND GEOGRAPHIC DISTRIBUTION

Next in the sequence of the inland trout stocking program, and therefore in this efficiency analysis, is the distribution of the hatchery fish to various planting sites within, and sometimes outside, the DFG region in which the hatchery resides. In this phase, great potential exists for (1) satisfying existing and latent demand for recreational trout fishing, (2) impacting local and regional tourism-dependent economies, and (3) impacting native trout, established wild trout and many threatened and endangered species populations (an economic externality). Historic DFG trout stocking and distribution patterns creates an economic inertia that is difficult to alter without greatly disrupting their economies.

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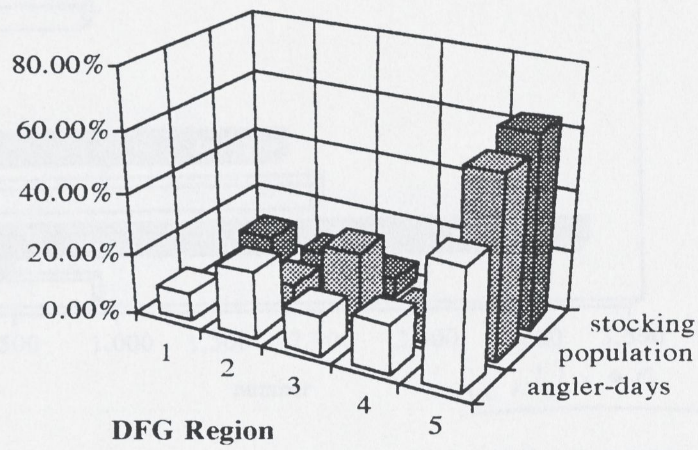
According to DFG in 1990, about 45% of the demand for trout and 40% of DFG trout planting occurred in Region 5, especially in Mono and Inyo Counties (see Figure 9). Regions 2 and 4 appear to be net importers of anglers, while Region 5 is clearly a net exporter.

Figure 9. Fishing Demand & Stocking by DFG Region



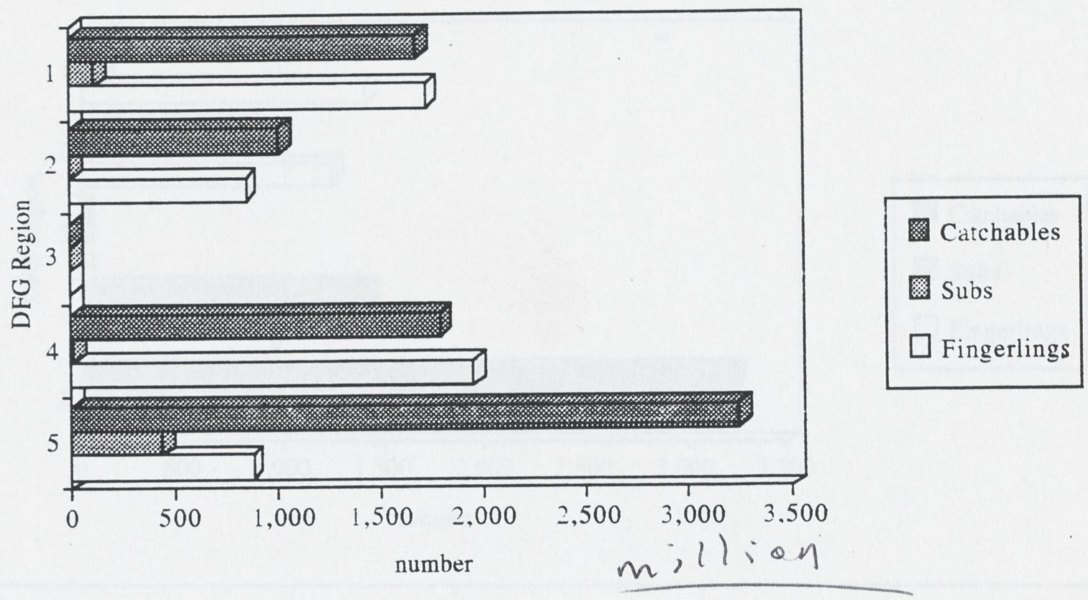
Source: FishPro, Inc., 1994.

Figure 10a illustrates the relative distribution of DFG trout production in terms of number of trout. As can readily be seen, Region 5 continues to dominate DFG hatchery production. Converting these data to pounds of trout (2 catchables per pound) further emphasizes the dominance of Region 5.

According to biologists, the Eastern Sierras did not have a native trout population and its habitat tends to be seasonal, making these waters ideal for put-and-take programs. However, these counties are not heavily populated and lack diverse economies (mainly agricultural and tourism). Much of the tourist industry in these counties has arisen from the recreational trout supplied by DFG.

Fingerling production appears to be emphasized in Regions 1 (Northern California) and 4 (Central Western Sierras), implying a significant habitat potential for a put-and-grow objective in those areas.

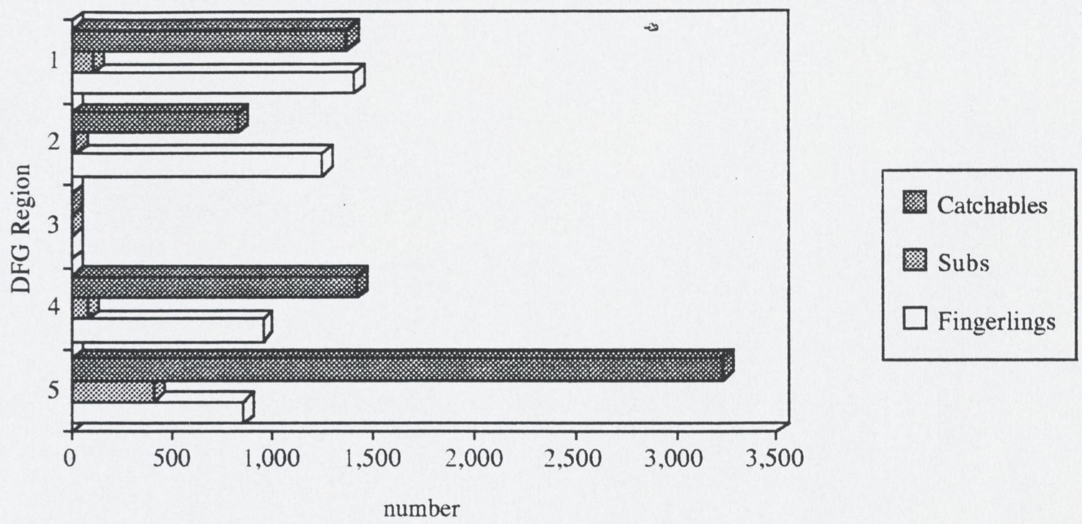
Figure 10a. 1994 Trout Production



Source: DFG #5, 1995

Figure 10b illustrates the projected 1996 production, which shows a fairly dramatic shift in emphasis, wherein all DFG regions receive lower production targets, except for catchables in Region 5. These changes are caused primarily by reduced budgets. Another reason could be the growing awareness of the environmental impacts of stocking catchables and subcatchable in waters near or within migration distances of waters containing established wild trout or native/threatened trout and other species.

Figure 10b. 1996 Target Production



Source: DFG #5, 1995

Figure 11 illustrates the potential for interaction between catchable and subcatchable trout stocked for put-and-take and Wild and Threatened Trout Program waters that are managed in accordance with DFG's mandate to conserve habitats for indigenous species.

[**Figure 11**. map showing regions and sensitive/native-wild trout waters]

It is difficult to draw any conclusion regarding the fiscal efficiency of the DFG's trout distribution and planting activities. Many constraints affect the locations to which any one hatchery takes its stock, one of which is the location of the hatchery itself. These locations are difficult to site given the resource needs and potential environmental impacts. In their 1988 report, Mayo Associates concluded that these constraints made it unlikely that newly designed hatcheries could be constructed to if the decision were made to close any or all of the existing ones (Mayo p.3.15). Stock distribution decisions also depend on programmatic changes regarding size of trout, suitable waters, restoration activities, etc. Given this background, it is appropriate only to address the system-wide planting costs which, according to Mayo Associates, averaged $0.42 per pound in 1988 (Mayo p.3.17). Planting costs generally comprise 20% of the total "loaded" costs to produce and plant catchable trout.

In Chapter 6, an assessment will be made regarding the potential efficiency impacts of a reorientation of the DFG hatchery production and distribution policies.

5.8 COST EFFICIENCY ANALYSIS OF CATCHABLES-TO-CREEL

This section of the economic impact study analyzes and assesses the total cost to the angler of a catchable-size trout in the creel. The average total costs per catchable trout in the creel, both fixed and variable, will be estimated. It also involves the final phase from water to creel, requiring consideration of angler demand for catchable trout and their success rates. These figures will be weighed against estimated benefits generated from recreational trout angling, and later in the alternatives assessment.

Data presented in Figures 7a and 7b showed that it cost roughly $1.40 in the mid-1980s ($1.50 in 1988 dollars) to produce a catchable trout in the hatchery. Adding the $0.42 for distribution and planting cost, an estimate of close to $2 per pound results. In a letter from Assistant Chief Fleming (DFG #4, 3/13/95), the DFG's estimate for producing and planting catchable trout in 1993-94 was $2.065 per pound or $1.03 per trout (based on the 2-trout-per-pound goal). This evidence demonstrates that production and planting costs not only have remained quite steady, but have declined when considering inflation. Included in this estimate were all variable costs "plus costs for fish health laboratory (fish pathologists) and headquarters' hatchery support personnel and Department administrative overhead (23%)." (DFG #4, 3/13/95). After investigating the controversies surrounding assignment of overhead costs, Mayo Associates (1988) used a figure of 14% for production and administrative overhead.

For comparison, a thorough analysis of similar cost data was reported in a very recent article on the economics of catchable trout in Colorado (Johnson, et al., 1995). Table 1 presents these estimates in comparison to figures reported by the DFG for 1993-94 (DFG #4, 3/13/95) and the approximate $2 per pound estimated by Mayo Associates for 1988:

Table 1. Comparison of Hatchery-to-Waters Cost for Catchables

Item	California (1)	Colorado (2)
	- - - - - $ per catchable pound - - - - -	
Hatchery Personnel		0.89
Feed & supplies		0.45
Avg. Variable Costs	1.53	1.34
Admin. Overhead	0.47	0.19
Subtotal Avg. Total Costs	2.00	1.53
Other Support Services	*0.20*	0.44
Capital Replacement	*0.50*	1.48
Avg. Total Costs	2.70	3.45

1. 1993-94 cost estimates provided by DFG (Fleming, 3/13/95) were adjusted to 1988 dollars using GDP Implicit Delfator. Admin. Overhead applied at 23% of Subtotal ATC ($1.27/(1-0.23)). Costs in italics represent estimates.

2. 1988 cost estimates based on information provided by the CO Dept. of Wildlife. Other Support Services and Cap. Replacement figures were estimated by Johnson, et al. using DOW data. "Other Support" includes research, mgmt., engineering, license collection, purchasing & warehousing, insurance, etc. "Cap. Repl." costs include an estimate of the depreciated value of assets associated with catchable trout production (e.g., hatcheries) and are treated as opportunity costs of public assets annuitized @ 8%.

It is difficult to make item-by-item comparisons between different studies of this nature, due to reporting differences between state agencies. Nevertheless, Table 1 provides a reasonable basis for consideration of other costs that are potentially attributable to managing and financing such a public agency, namely "Other Support Services" and "Capital Replacement" costs. Proper economic analysis requires that allocation and cost of capital assets be reflected in long-run decisions.

As footnote #2 in Table 1 indicates, "Other Support Services" was included to capture the proportionate costs of activities needed to support hatchery operations. Capital Replacement costs reflect the opportunity costs of public resources devoted to state hatcheries -- scarce financial resources that could have been utilized by the public in other ways. Both of these issues are appropriate to consider and include in estimating the true economic costs of producing and planting catchable trout. However, differences in reporting make direct application from the Colorado study to California problematic. For instance, the large difference in administrative overhead is more likely to reflect reporting differences than lower fixed costs in Colorado. The $0.19 per pound for overhead in Colorado represents only 12.4% of the Subtotal ATC, a

remarkably low figure for such a public agency, as contrasted to the reported 23% by DFG (DFG #4, 3/13/95). It is reasonable to assume that a portion of the $0.44 per pound for "Other Support Services" in Colorado includes some of the costs reported in the DFG's administrative overhead. Therefore, to properly construct an Average Total Cost estimate for DFG catchables, the Colorado "Other Support Services" estimate was reduced by about half.

As for Capital Replacement costs, it is difficult to know how comparable are the asset values of Colorado facilities to California's and the authors' methodology. Johnson, et al. indicate that the Colorado DOW estimates facility depreciation at $0.21 per pound (based on a book value of $7.4 million), which they conclude is too low given the "value of assets in catchable trout production" of $33 million according to some fair market value estimate. The authors appear to have annuitized their estimate of fair market value in perpetuity using 8% and then divided that figure by current catchable production to arrive at $1.48 per pound for "Capital Replacement." First, use of federal rate for water projects to analyze privatization alternatives is flawed. Current, private sector rates of return tend to be lower. Second, their analysis assumes the alternative use of the land would be for a privately run hatchery, which may not be the highest and best use. Finally, their estimate is highly sensitive to production levels and could drop dramatically if production levels were maximized or additional runs added.

Mayo Associates (1988) concluded that even though such asset values are important to consider, they are "not transferable or marketable." To value these public assets at a fair market value is questionable. Under a scenario of privatization of hatcheries, transfers would be sold at fair market value, but the proceeds would represent a capital gain -- a benefit created through DOW's public fiduciary role. Carrying this argument to its logical extreme would mean that many public assets would be privatized due to the opportunity costs of lost privatized values (e.g., national parks, national forests, or government buildings in downtown areas).

It seems more appropriate to conclude, as did Mayo Associates, that such land and facility assets are not out-of pocket costs and should be treated as opportunity costs to other agencies, but not the hatcheries. Therefore, the depreciated value reported by Colorado DOW seems more fitting for proper economic analysis. To be conservative, a capital replacement cost of $0.50 per pound was used, double the DOW's depreciation cost.

As a result of analysis of these cost considerations, the average total cost to produce and plant a catchable trout should be about $2.70 per pound in 1988 dollars. Allowing for the controversy over the opportunity costs of fixed public assets, an estimate of perhaps $3 per pound in 1988 should be acceptable. On a per trout basis, using the DFG goal of 2 trout per pound, this estimate becomes $1.50 per catchable. Converting this estimate to a cost-to-creel basis requires adjustment for catch-and-keep rates by California anglers.

Return-to-creel rates reported in the literature appear to fairly stable, averaging around 60 - 65% (Johnson, et al. used 60%, DFG reports 65% for remarkably low figure for such a public agency, as contrasted to the reported 25% by DFG (DFG et al., 1992). It is reasonable to assume that a portion of the $0.44 per pound for "Other Support Services" in Colorado includes some of the costs reported in the DFG's administrative overhead. Therefore, to properly construct an Average Total Cost estimate for DFG catchables, the Colorado "Other Support Services" estimate was reduced by about half.

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California in FishPro, 1994). Using the more conservative lower estimate, the average total cost-to-creel estimate should not exceed $2.50 per trout in 1988 dollars.

5.9 COST-BENEFIT ANALYSIS OF PUT-AND-TAKE FISHING

Now that the average total costs to deliver a catchable trout to an angler's creel have been analyzed and estimated, we can consider the benefits that these public expenditures generate. These direct and indirect economic benefits were introduced in Part 2 of this section. Here, a finer analysis will be made of benefits attributable to put-and-take sport fishing; then, the role of license fees and the quantity of recreational fishing's sensitivity to changes in those fees will be analyzed.

5.9.1 Costs to Creel

Recreational fishing is a non-commodity, aesthetic good or service. Fisherman do not look upon fishing as a means of obtaining food; otherwise, no one would sport fish because it would be cheaper to obtain fish at the grocery store. Another issue related to estimating the benefits of recreational fishing is the role and pricing of license fees for fishing. License fees are not, as some have suggested, the value of sport fishing (e.g., Anderson, 1990). Such fees are merely an inexact and indirect means by agencies such as the DFG to extract revenue from those demanding the good or service. Any cost-benefit analysis that treats license revenues as a significant part of the benefits is incorrect.

What is the value of such a recreational resource and how should it be estimated? Resource economists have studied the value of non-marketable goods and services, such as recreation, for decades now. Fundamentally the issue is one of estimating one's willingness-to-pay (hereafter referred to as wtp, not to be confused with WTP for the Wild Trout Program). Willingness-to-pay describes the demand function for a good or service. It can be defined as the potential revenue available if recreation fees could be collected from users equal to the maximum amount they would pay at any level of use -- the entire area under the demand curve.

Two non-market valuation techniques have been designed to capture or estimate wtp. One approach to estimating the value - the revealed preference method - is to observe consumer's behavior; the other approach - the expressed preference method - is to ask consumers to express their wtp.

A number of revealed preference techniques have been developed; for recreational resources. the most prominent over the last three decades has been the Clawson-Knesch Travel Cost Method (TCM), adapted from Harold Hotelling's theory (Randall 1987). This technique reveals wtp (the demand curve) by quantifying all costs (direct and indirect expenditures) necessary to enjoy the recreational experience. for example. preparation costs such as equipment purchases; travel costs to and from the site; expenses at the site,

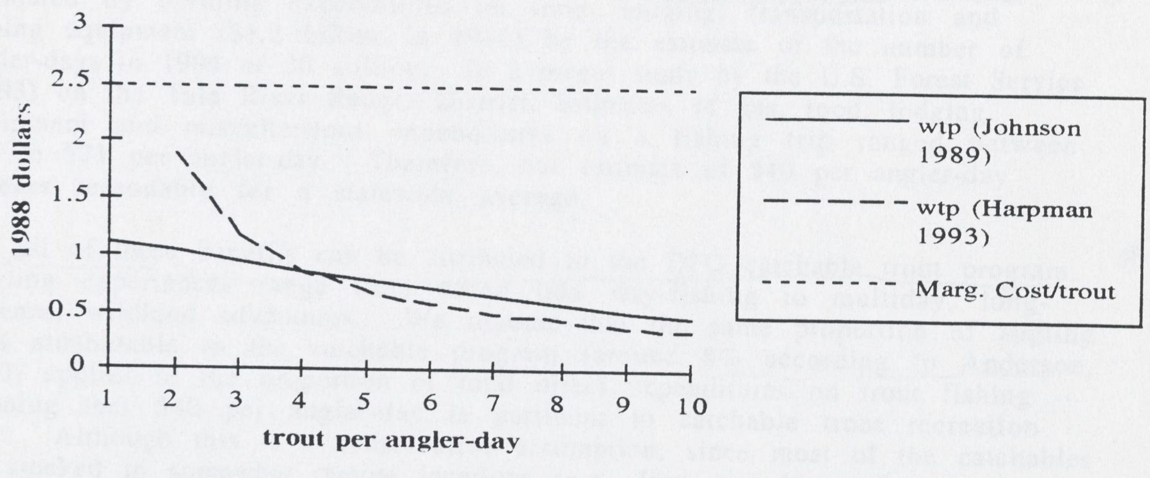
carryel

including license or gate fees; opportunity costs of time; and such non-tangibles as anticipation of the trip, enjoyment of viewsheds, and recollection of the experience. Put in demand terms, TCM assumes that if a person is willing to pay $100 to go 200 miles to a recreational site, if he lived 100 miles closer to the site, travel expenses could be reduced to $70, and the $30 saved is a consumer surplus that could be applied to a day-use fee (fishing license). Ultimately, those visiting the site most frequently are those living the closest and the number of visits made per year would be determined by when the marginal cost (travel, etc.) equals its marginal utility.

The only expressed preference technique to consider is the Contingent Valuation Method (CVM). This method uses a carefully designed survey instrument to elicit wtp estimates from the consumer directly, while attempting to compensate for strategic bias and lack of sincerity, issues that deal with the problem that "actions speak louder than words."

If one were to use CVM and ask anglers what they would be willing to pay for different numbers of trout in their creel, the result would be an estimate of the marginal value of catching trout. This was done in the study of anglers by Johnson, et al., 1995 on the Cache la Poudre River near Ft. Collins, Colorado. Their results, illustrated in Figure 12, indicated that the marginal value of the first trout in the creel was $1.11, with marginal values falling off as expected from theory. In a similar study on the Taylor River in southwestern Colorado, Harpman, et al. (1993) used a CVM technique with results somewhat higher than Johnson et al. (1985) (see Figure 12). Both curves in Figure 12 represent a demand function for catching trout once at the site.

Figure 12. Supply and Demand for Sport Fishing



Sources: Johnson, 1995; Harpman, 1993; Mayo Assoc., 1988; DFG #4.
Note: Here wtp refers to willingness to pay for a resource.

Comparing these demand functions to the supply function (assumed to be a constant marginal cost equal to the average total cost of $2.50 per trout in creel), it appears that no net benefits result. In fact, it seems clear that the costs outweigh the benefits generated. Such a study is useful to understand the marginal value of different levels of fishing success, but this can mislead the reader in thinking that that is all there is to sport fishing.

In the Johnson article, a clue is given as to why it is misleading: "Although there have been numerous studies of the economic value of a trout fishing trip, very few have attempted to estimate the marginal economic benefits of catching trout . . ." One reason this is true is that the vast majority of the benefits of catching trout are generated by the experience of the travel, the enjoyment of the setting, and other associated social values. In a study by Fletcher and King (1988), "beauty of the surroundings" was the number one factor in a good fishing experience, followed by "type of fish caught" and third the "travel distance from home." "Size and number of fish caught" were the least important factors.

CVM estimates of the value of catching trout represent measures of consumer surplus after having already paid to arrive at the site, enjoy the site, and return home, as well as all associated non-pecuniary benefits. Thus, conducting a CVM to express the value of catching a fish greatly underestimates the true benefits that accrue to the angler.

In keeping with the concept of the Travel Cost Method, lacking any studies on this specific recreational value in California, one could conservatively use direct expenditures on inland trout fishing presented in Figure 1 at the beginning of this economic impact analysis. Coming full circle in this economic impact section, we return to the estimate of $40 per angler-day estimated by dividing expenditures on food, lodging, transportation and fishing equipment ($1.2 billion in 1994) by the estimate of the number of angler-days in 1994 of 30 million. In a recent study by the U.S. Forest Service (1993) on the Tule River Ranger District, estimates of gas, food, lodging, equipment and miscellaneous expenditures on a fishing trip ranged between $39 to $71 per angler-day. Therefore, our estimate of $40 per angler-day appears reasonable for a statewide average.

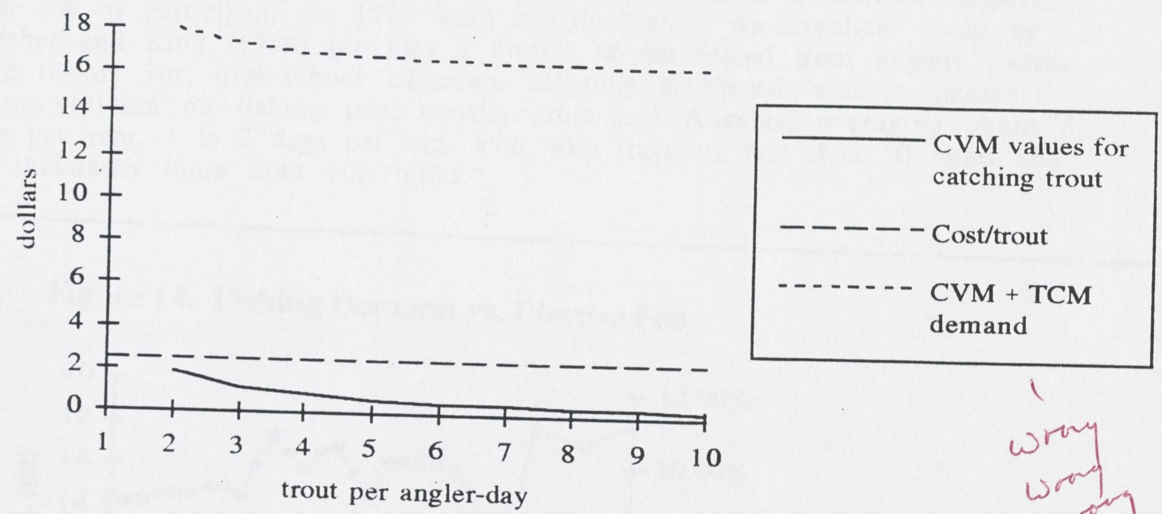
Not all of these benefits can be attributed to the DFG catchable trout program. Angling experiences range from urban lake day-fishing to multiday, long-distance, wildland adventures. We assume that the same proportion of angling days attributable to the catchable program (around 8% according to Anderson, 1990) applies to the proportion of total direct expenditures on trout fishing -- meaning that $40 per angler-day is pertinent to catchable trout recreation only. Although this is a conservative assumption, since most of the catchables are stocked in somewhat remote locations (e.g., Inyo and Mono Counties) and greater expenditures result from longer trips, we will continue to use the $40 per day figure for catchable angling recreation.

These expenditure estimates constitute what anglers are directly willing to pay to participate in this recreational activity -- prices (opportunity costs) that

equate to the marginal utilities in equilibrium. Using data provided by FisPro (1994, p. 37), around 3 catchable trout are estimated to be caught per angler-day. This results in a at least $16 per trout in the creel of average not marginal values, leaving an average net benefit to put-and-take sport fishing of at least $13 per trout-in-creel.

Considering both the TCM estimate of sport fishing benefits and the CVM estimate of consumer surplus, a much different cost-benefit (quasi supply and demand) picture emerges. Figure 13 illustrates that a considerable net marginal return-to-creel benefit per angler-day exists when considering both value estimates.

Figure 13. Supply and TCM based Demand for Sport Fishing



Sources: same as Figure 12 plus analysis of Travel Cost Method (TCM) values.

5.9.2 Demand Elasticity and Projections

This static analysis of the costs and benefits of catchable trout angling leaves much to be considered as alternatives to the status quo are considered. To lay the foundation for analysis of these alternatives, some of the issues involved in travel-based recreation need to be explored.

Alternatives that would move the recreational site closer to users does not necessarily generate higher demands and higher consumer surpluses, since the aesthetics of the travel and site are a major portion of the benefits package for anglers. This creates a long-run demand function for recreational fishing equate in the marginal utilities in equilibrium. Using data provided by Fletto (1994, p. 37) around 3 catchable trout are estimated to be caught per angler-day. This results in at least $16 per trout to the creel of average not marginal values, leaving an average net benefit to put-and-take sport fishing of at least $15 per trout-in-creel.

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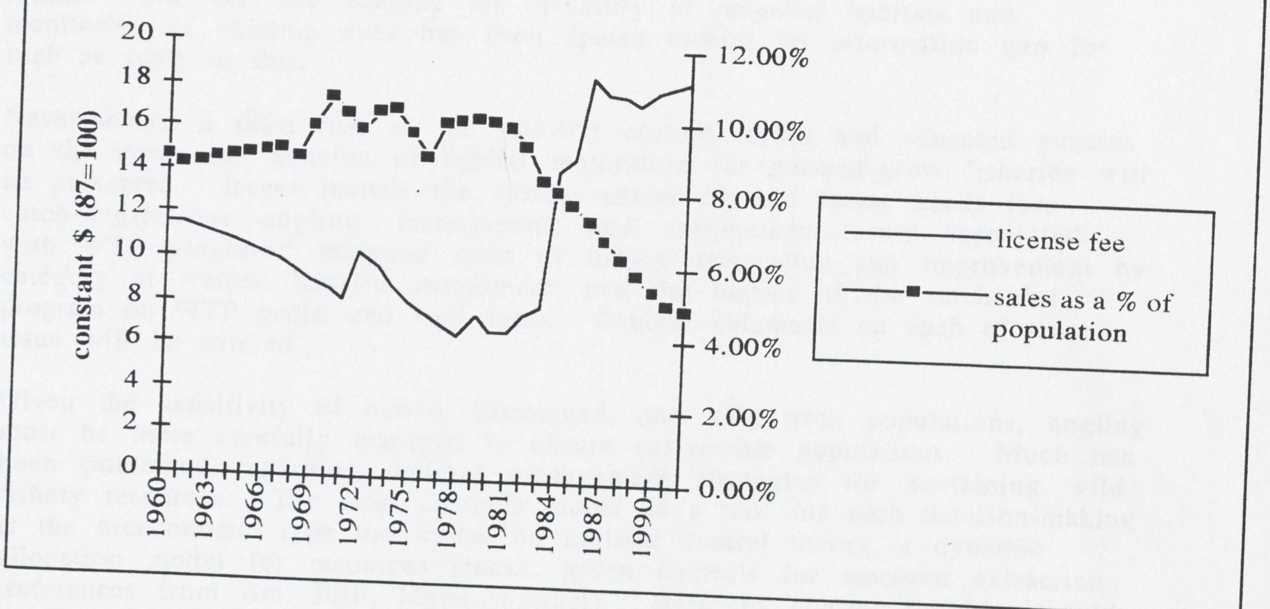
To better understand the concept and relevance of elasticity to this study, it is useful to analyze the simple response by anglers to changes in license fees -- simple because such fees represent a small part of the benefits generated by recreational sport fishing. In 1992, about 1.5 million licenses were sold to California residents (about 5% of the population). In the 1960s, that percent was about double. During the intervening years, license fees have gone from $3 to over $20 in current dollars, but adjusting for inflation, anglers enjoyed a declining real fee and only felt the increase beginning in the early 1980s.

Describing the characteristics of trout fishing demand is very difficult without recent definitive studies on the demographics of such anglers. From FishPro (1994) we learn that 24% of angling participation is by non-licensed individuals (increasing the angling population to almost 2 million anglers). Over 3% of participants in 1990 were non-residents. An excellent study by Fletcher and King (1988) provides a profile of the inland trout angler: white male in his 30s, high-school educated, full-time employed, modest income, taking children on fishing trip, usually from Los Angeles, averaging about 5 trips per year, 1 to 2 days per trip, with 40% traveling less than 50 miles and the remainder more than 100 miles.

Figure 14. Fishing Demand vs. License Fee



Source: FishPro, Inc. 1994

The notion of elasticity is that the quantity demanded (or supplied) of a good or service responds to changes in its price. A good is said to be elastic in demand if the percentage change in quantity demanded is greater than the percent change in its price. Upon analysis of the data presented in Figure 14 (adjusting for population changes in California), it appears that the demand for recreational fishing, as measured by license purchases, is inelastic with respect to the license fee (E_d is about -0.5). If this is so, then DFG can expect to revenues to remain fairly steady if it were to increase the fishing license fee. This conclusion is supported by Hill (199?) and older studies on price elasticity of recreational fishing (e.g., Adams, et al., 1973).

This is an important issue if one is to believe DFG forecasts of greater demand for recreational trout fishing. Continued increases in fishing license fees will likely not erode revenues. However, moving the stocking sites for catchables nearer to the angler's home would reduce the travel costs but also diminish the aesthetic (non-pecuniary) values such that the net effect is a net reduction in demand.

5.10 WILD AND THREATENED TROUT PROGRAMS

Having looked fairly intensively at the cost efficiency and costs and benefits of the DFG's catchable program, it would be good to do likewise with their Wild and Threatened Trout programs. However, far less is known about the impacts and opportunities for restoration and improvement of such trout habitats. As we saw in Figures 4 and 5, budgets for these programs have been small and erratic. The fact that funding for inventory of potential habitats and monitoring of existing ones has been sparse creates an information gap for such as study as this.

Nevertheless, a discussion of the relevant current issues and educated guesses on the costs and benefits of habitat restoration for put-and-grow fisheries will be presented. Issues include the current extent of, and future needs for, catch-and-release angling; management and enforcement costs associated with WTP programs; marginal costs of habitat restoration and improvement by category of waters; benefits assessment; and the impact of the catchables program on WTP goals, and vice versa. General judgments on each of these issue will be offered.

Given the sensitivity of native, threatened, and wild trout populations, angling must be more carefully managed to ensure sustainable populations. Much has been published regarding optimal management strategies for sustaining wild fishery resources. The most common model as a tool for such decision-making is the bioeconomic type that relies on optimal control theory, a dynamic allocation model for resources stocks, given controls for resource extraction (references from Am. Fish. Mgmt. journal). Here the control variables would involve the degree of harvesting and catch-and-release angling. Since implementation of management strategies requires carefully designed control on use rates, higher enforcement and monitoring costs result (DFG #6, Knutson, 1/7/95).

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The degree to which these sustained fisheries can be established depends heavily on the habitats available and the costs of establishing them. Currently, it seems that the WTP has been established for nearly all the waters that the DFG has designated as "blue ribbon", meaning Category 1 waters that had pre-existing habitat to grow healthy, sustainable populations (DFG #6, Knutson, 1/7/95). Naturally, the costs associated with establishing this category of waters is as low as can be achieved. There has been virtually no work on habitat improvement or restoration, due to concerns over the effectiveness, costs and impact on the existing ecosystem.

For this status quo analysis, perhaps the most important issue is the impact that the catchable program has on the DFG's efforts to preserve habitats of native trout or those suitable for designation as WTP. Figure 11 illustrated the geographic juxtaposition of the following three DFG program areas: waters stocked with catchables, waters designated as WTP, and waters of a sensitive nature or special concern (e.g., natives or T&E species). The greater the geographic overlap of the catchable stockings on the other two types of waters, the greater the risk of interference and degradation of wild and threatened trout populations -- a very real economic issue called an externality. Externalities are essentially impacts for which costs are not accounted. If all costs and benefits are reflected in market or quasi-market prices, then theoretically resources are being allocated efficiently. When a significant amount of the social and environmental costs are unaccounted for, then serious inefficiencies can arise -- resources are wasted and ecological damage ensues.

From the map shown in Figure 11, it appears that the intrusion of the catchable stockings near WTP and other sensitive waters is occurring in sufficient quantities and regularity so as to warrant concern that such externalities are occurring. Although the analysis up to this point has generally indicated that the DFG is conducting its production and planting in a fiscally efficient manner, these externalities imply that they are not being managed in an economically efficient manner. The extent and magnitude of this economic inefficiency is not identifiable without more information on this specific issue. Nevertheless, it is an impact of the DFG status quo de facto policy that bears notice.

5.11 CONCLUSIONS AND IMPLICATIONS

California's inland trout fishery clearly contributes significantly to the state's economy. Opportunities to expand this contribution are many and portend a bright future. The state's diverse ecosystems, of which the fisheries resource is a part, are highly productive, but that productivity can be rapidly diminished or even lost if the design and implementation of trout stocking is conducted carelessly or without full knowledge of the impacts.

The DFG's catchable trout are being produced at a reasonable cost in the hatchery. Distribution and planting costs are also acceptable given the number of hatcheries and the geographic area and conditions serviced by

The degree to which these sustained fisheries can be established depends heavily on the habitats available and the costs of establishing them. Currently, it seems that the WTP has been established for nearly all the waters that the DFG has designated as "blue ribbon", meaning Category I waters that had pre-existing habitat to grow healthy, sustainable populations (DFG #6, Kamman, 1993). Naturally, the costs associated with establishing this category of waters is as low as can be achieved. There has been virtually no work on habitat improvement or restoration, due to concerns over the effectiveness, costs and impact on the existing ecosystem.

For this status quo analysis, perhaps the most important issue is the impact that the catchable program has on the DFG's efforts to preserve habitats of native trout or those suitable for designation as WTP. Figure 11 illustrated the geographic juxtaposition of the following three DFG program areas: waters stocked with catchables, waters designated as WTP, and waters of a sensitive nature or special concern (e.g., natives or T&E species). The greater the geographic overlap of the catchable stockings on the other two types of waters, the greater the risk of interference and degradation of wild and threatened trout populations -- a very real economic issue called an externality. Externalities are essentially impacts for which costs are not accounted. If all costs and benefits are reflected in market or quasi-market prices, then theoretically resources are being allocated efficiently. When a significant amount of the social and environmental costs are unaccounted for, then serious inefficiencies can arise -- resources are wasted and ecological damage ensues.

From the map shown in Figure 11, it appears that the intrusion of the catchable stockings into WTP and other sensitive waters is occurring in sufficient quantities and regularity so as to warrant concern that such externalities are occurring. Although the analysis up to this point has generally indicated that the DFG is conducting its production and planting in a fiscally efficient manner, these externalities imply that they are not being managed in an economically efficient manner. The extent and magnitude of this economic inefficiency is not identifiable without more information on this specific issue. Nevertheless, it is an impact of the DFG status quo de facto policy that bears notice.

5.11 CONCLUSIONS AND IMPLICATIONS

California's inland trout fishery clearly contributes significantly to the state's economy. Opportunities to expand that contribution are many and portend a bright future. The state's diverse ecosystems, of which the fisheries resource is a part, are highly productive, but that productivity can be rapidly diminished or even lost if the design and implementation of trout stocking is conducted carelessly or without full knowledge of the impacts.

The DFG's catchable trout are being produced at a reasonable cost in the [illegible] number of hatcheries and the geographic area and conditions serviced by each hatchery. Thus fiscal efficiency of the catchable program is reasonably being achieved. However, it is likely that policy decisions on planting locations have not considered the full economic (environmental and social damage) impacts. This is of special concern for wild and threatened trout populations (and other species of special concern) that exist in proximity to waters stocked with catchables.

Much research is still needed to better understand the biological, genetic and ecological impacts of stocking hatchery-raised fish near wild populations whose genetic makeup is already somewhat precarious. Even more research is needed on the economic contribution of these wild and native fisheries resources in California and the net benefits to the state of put-and-take. put-grow-and-take, and catch-and-release angling. Solid scientific information and inventories are needed of waters for trout habitats, monitoring of current management practices, and costs and benefits of restoration and improvement for various categories of waters.

Any policy redirection that would consider reducing the resources devoted to producing and stocking catchables and redirecting them to habitat restoration for establishing sustainable wild trout fisheries must consider the marginal costs of various levels of restoration arising from varying habitat potentials of California waters. For any development to be sustainable, the investments in establishment must create a perpetual net benefit flow to society. Infusions of taxpayer funds are acceptable to society only if it can be shown that the funding is short-lived and will provide a net present economic return commensurate with other important uses for those scarce public resources.

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CHAPTER 6. ANALYSIS OF ALTERNATIVES

6.1 INTRODUCTION

From a review of the information obtained from Trout Unlimited, the five regional scoping meetings, and letters received by mail, it appears that the major concerns are divided between environmental issues related to the impacts of programs on native and wild trout populations, and programmatic and economic issues relating to the allocation of DFG funds and efficiency of hatchery and stocking programs.

Biological and environmental issues are associated with the direct, indirect, and cumulative impacts (biological, physical, and recreational) of stocking associated with implementing the hatchery program. These include the Wild Trout and Threatened Salmonids projects, and endangered and threatened species that may inhabit the stocking areas. Since cumulative impacts can be associated with both programmatic and environmental categories, it will be a category unto itself.

6.2 STATEMENT OF ALTERNATIVES

The alternatives were developed from an assessment of the major issues, and will be addressed from a statewide program perspective. In situations where an issue is unique to a region or area, the anomaly will be noted and/or explained. The potential environmental and programmatic impacts associated with each alternative are assessed below.

All references made to fish stocking and associated activities are in accordance with policy and procedures established in the California Code of Regulations (1994), Fish & Game Code of California (1994), and Fish and Game Operations Manual, Inland Fisheries (1993). Specific codes and policies related to this document can be found in Appendix B.

Each DFG program (catchables, wild or native trout) has a different audience with unique objectives. The various alternatives presented are a blend of the different programs that are currently in operation. The alternatives are an attempt to identify, as clearly as possible, the parameters of each program for analysis and evaluation. Table 1 lists the various alternatives and program variables.

In implementing programs, the tools of management (such as catchables, subcatchables, fingerlings, strains of fish, etc.) are applied with different emphases related to the demand and environmental conditions under consideration. The impacts (effects) of various programmatic activities expressed in each alternative will be assessed; the tools of management will not.

In identifying alternatives, two terms are used to express use. Urban refers to areas with high population centers, as the Southern California counties and the San Francisco Bay areas: high demand refers to recreational areas that create high-demand pressures, such as Inyo and Mono counties and the Lake Tahoe area. The latter are the areas to which the sporting public from high population centers go for recreation. When reference is made to the wild trout program (WTP), it includes the programs that involve threatened species.

6.2.1 Alternative 1: Status Quo.

This alternative assumes no change in the DFG hatchery and Threatened and Wild Trout programs. It explains conditions as they exist today, and assumes that existing programs will continue into the future. If there is no change to the current program of stocking hatchery-reared fish to waters occupied by wild fish, there will continue to be a variety of ecological and genetic effects, whose nature and magnitude will depend upon particular genetic, environmental and hatchery characteristics, and the specific timing of introductions. No changes in funding would be required.

6.2.1.1 Genetic Diversity

The introduction of hatchery-reared fish into wild fish populations generally is expected to reduce the degree to which the resulting fish populations are adapted to the wild environment, since cultured fish typically represent gene pools that differ from the natural populations with which they are put in contact. Continuation of hatchery operations will continue to risk inbreeding depression and consequent losses of genetic variation, both in hatchery stocks and wild populations, as they are swamped by large numbers of planted hatchery fish. Hatchery stocks will continue to undergo artificial selection that makes them more fit for hatchery life but more likely to exhibit lower survival, poor stamina, poor disease resistance, and inappropriate territorial, hiding, and sexual behavior when introduced to streams and lakes. Hatchery fish that are genetically resistant to some diseases can carry pathogens to which they are resistant to planting sites where wild fish may be affected.

Continued introductions of hatchery fish into areas with viable wild populations is likely to introduce genes that are unsuitable for the particular local environment. To the extent that hatchery fish are successful in breeding, they add to the genetic load of the combined population, making it less fit than it would be otherwise.

Introduction of new genetic materials to a wild population may result in heterosis (hybrid vigor), particularly in small wild populations where genetic drift may have led to the random loss of some genetic diversity (Williams, et al., 1988). However, the majority of studies suggest that the larger problem is the introduction of large numbers of genetically homogeneous stocks, derived from very few sources, which have been artificially selected for hatchery environments, and which are not well suited for the variety of wild

environments to which they are introduced. The large numbers of introduced "clones" may swamp relatively small numbers of wild fish, resulting in their complete elimination. Finally, the heterosis effect often lasts only one or two generations, with subsequent generations losing fitness due to breaking up of coadapted genes (Williams, et al., 1988; Meffe, 1987). Generally, any introduction of exogenous genes can be expected to have a negative effect on population performance; in some cases, severe population reductions have followed introductions of cultured fish (Hindar, et al., 1991). Genetically based immune systems may be impacted by hybridization between hatchery and indigenous stocks, reducing the capacity of the indigenous population to resist infectious pathogens (Marnell, 1986).

6.2.1.2 Ecology and Behavior

Displacement:
Specific introductions of hatchery-reared trout may result in the spatial displacement of existing wild trout populations, or even their local extinction. Introduction of brown trout, for example, has a relatively high likelihood of displacement or local extinction of wild brook trout populations.

Ecological Interactions:
Introductions of large numbers of hatchery trout into waters inhabited by wild fish will continue to cause decreases in numbers of wild fish through various mechanisms (below) almost all of which are related to the fact that food and habitat resources are finite, and local wild fish populations can be overwhelmed by the sheer numbers of fish introduced. Depending upon a variety of factors (stream or lake productivity, season of introductions, structural heterogeneity of environment, density of wild fish population, size of introduced fish), wild fish may exhibit a range of responses from no effect on survivorship to significant reductions in survivorship and density.

Behavioral Ecology:
Introduced hatchery fish can be expected to interfere with normal wild fish behavior patterns, causing greater expenditures of individual fish energy reserves. Although wild fish generally can be expected to persevere in competition due to selecting and defending better feeding, nesting, and cover microhabitats, survivorship, fecundity, and growth rates may decline due to expenditure of limited energy reserves at critical times of the year.

Introductions of larger, older hatchery fish will generally result in their poor survivorship due to a "hardening" of inappropriate behaviors than their younger counterparts. When larger fish are introduced, their immediate impact on wild trout will be greater, but shorter in duration than when younger fish are introduced. Introductions of younger fish might be expected to have longer-lasting competitive impacts on wild populations, and will contribute more to genetic impacts identified above.

Age and size effects:
Introductions of large numbers of fish that are larger than the average wild fish can have significant impacts on the wild fish population. Introductions

environments to which they are introduced. The large numbers of introduced "clones" may swamp relatively small numbers of wild fish, resulting in their complete elimination. Finally, the heterosis effect often lasts only one or two generations, with subsequent generations losing fitness due to breaking up of coadapted genes (Williams, et al., 1988; Waller, 1987). Generally, any introduction of exogenous genes can be expected to have a negative effect on population performance; in some cases, severe population reductions have followed introductions of cultured fish (Hunter, et al., 1991). Genetically based immune systems may be impacted by hybridization between hatchery and indigenous stocks, reducing the capacity of the indigenous population to resist infectious pathogens (Marnell, 1986).

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Age and size effects:
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of large, hatchery-reared fish that are likely to be aggressive and hyperactive would have immediate impacts on the wild fish, and could lead to spatial displacement to less favorable areas (and lower survival and growth rates). When relatively small fish are introduced, wild fish can be expected to prey on them, but the survivors will be more likely to integrate into the social structure of the wild fish population than would larger hatchery plants.

Biomass and Growth Responses:
In any particular stream and stocking situation, the impacts of stocking on growth rates and survivorship will depend on a complex interaction among many factors. Upon introduction of large numbers of hatchery fish, both wild and introduced fish generally experience intensified competition for food and feeding sites. In streams with limited food resources, wild fish experience reduced food intake, and increased interaction with introduced fish and concomitant increased energy expenditures will usually reduce individual growth rates. In productive streams, impacts on growth rates of wild fish may be negligible.

6.2.1.3 Predation

If there is no change in hatchery stocking programs, predator and prey populations will exhibit various numerical responses to artificially high fish population levels, and individual predators may focus on trout, both introduced and wild, at the introduction sites. The risks of negative interactions among wild fish populations and hatchery fish will continue to exist and be exhibited. Some predators may continue to receive a food subsidy as a result of hatchery operations.

6.2.2 Alternative 2: Enhance Trout Stocking Program to meet demand by 2010.

This alternative focuses on increasing efforts in urban and high demand fisheries (including catchables and maintaining the present level of effort in Wild Trout Programs. It assumes increasing the catchable trout stocking program in all waters (rivers, streams, lakes, and reservoirs) in all areas to meet the recreation demands that are anticipated by 2010. Stocking (catchables and subcatchables) would be primarily in the same waters that are presently stocked, but with more fish. Only waters that cannot sustain a satisfactory fishery without stocking, or waters that have a high potential for recreational demand (F&GOM 5340), would be stocked. "...Satisfactory is an average of two fish per angler day or one-half fish per angler hour" (Fish and Game Policies, III). The Threatened and Wild Trout programs would be continued at their current funding level; additional funds would be required for an enhanced stocking program.

This alternative represents an extension of DFG's current catchable stocking policy wherein catchables and subcatchables are planted in waters throughout the state where recreational access is high and the seasonal habitats are adequate. As indicated in the status quo analysis, such a policy is

currently conducted efficiently, except for the problem of externalities. These externalities arise primarily from the potential impacts on other natural resources (e.g., native and wild trout in situ populations and other T&E species). Another type of externality results from influencing recreational pressures by the very act of stocking waters, which encourages increased fishing in the stocked waters. The unpaid costs of impacting the quality of water where the hatcheries are located is another externality. By expanding the stocking program as currently designed, these externalities will be exacerbated and economic efficiency will decline.

This alternative assumes that DFG and/or private hatcheries could be expanded to satisfy this anticipated demand. This is not likely given the extreme cost and difficulty in building new hatcheries or expanding existing ones (Mayo Associates, 1988). The higher funding levels necessary to support a net programmatic increase are also highly unlikely in the current and near-term economic and socio-political climate.

This alternative will help meet projections of recreational trout shortfalls for the high demand and urban fishing areas, but leaves at risk certain limited populations of specific species and subspecies, such as golden trout, Lahontan cutthroat trout, or limited populations of redband strains of rainbow trout. Depending on location of planting activities and population, risk of stock loss or amalgamation remain and may even be increased for some wild trout and/or native trout populations. Except for urban fishing programs, which are usually conducted in marginal-to-unsuitable habitats, short-term overloads on the natural carrying capacity in high-demand fisheries may occur, depending on magnitude of stocking, location and associated existing populations. There also may be increased risks associated with incidence of disease in hatchery stocks, simply because increased overall densities in rearing facilities and increased output into the field raises the probability of carriers and pathogens being released.

These increased risks can be reduced if associated protocols, practices and methods are modified to address the source of the risk and strictly adhered to, particularly in hatchery management, brood stock selection and planting site analyses (including resident populations).

6.2.2.1 Genetic Diversity

Enhancement of the hatchery stocking program could increase the various risks of reducing genetic variation or fitness in wild fish populations, including inbreeding depression, outbreeding depression, artificial selection in hatcheries, gene flow, genetic load, and disruption of coadapted genetic structures.

6.2.2.2 Ecology and Behavior

Competitive Interactions:
Enhanced hatchery activity would increasingly displace wild fish, reduce their numbers, and reduce growth rates of wild fish. Enhanced hatchery

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Competitive Interactions:
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activity involving introductions of eyed eggs and young fry could increase the long-term impacts of hatchery fish on the population, since fish introduced at young ages tend to survive and integrate into the local environment better than older fish.

The degree to which stocking of domestic catchable trout will impact wild fish populations depends upon the relative sizes of fish in the two populations. Larger hatchery fish will aggressively interact with smaller wild fish, and will prey on much smaller wild fish. However, larger introduced fish will generally not survive as well as younger introduced fish. Genetic and economic implications of introducing larger fish should be taken into account.

Enhanced hatchery activity often can depress individual wild trout growth rates, due to increases in competitive interactions among planted and wild trout competing for a finite food supply and limited number of foraging sites.

The impacts of increased levels of stocking on population dynamics will be magnified under this alternative. Survivorship, fecundity, and growth rates may decline as fish increase their expenditure of limited energy reserves at critical times of the year.

Increases in local stocking efforts will increase the risk of wild trout being displaced and driven to local extinction.

6.2.2.3 Predation

Direct Effects:
Increased levels of hatchery stocking will increase the risk of cannibalism of smaller wild trout by larger stocked fish. If smaller hatchery fish are introduced, the impacts may be reversed, but some studies have shown that introductions of food (for larger wild trout, in this case) tend to destabilize the community and result in unpredictable consequences.

Numerical Responses:
Enhanced hatchery activity would be expected to stimulate numerical responses on the part of predator populations, potentially increasing predation on wild fish as well. Some endangered or rare fish predators might be subsidized by stocking programs, helping to sustain their populations. However, higher levels of stocking could just as likely draw predators to stocking sites where other rare species might be preyed upon to their detriment.

Functional Responses:
Higher levels of stocking is expected to stimulate predators to develop a search image for stocked fish, likely leading to disproportionate predation of stocked fish compared to wild trout. However, the overall impact of functional and numerical responses of predators to a larger fish population could be to reduce numbers of wild trout below the levels at which they currently maintain their population.

Other outcomes may include stimulation of growth of the recreational fishing population, with concomitant changes in socioeconomic and cultural composition consistent with demographic trends in California. An increased angler population intuitively implies a wider appreciation of aquatic resources and associated environments. However, an increased and diverse recreational fishing population based solely on hatchery-based trout production is biased towards the consumptive angler rather than the "sports angler," which may reduce attention to wild and unique indigenous populations in the long term. This latter trend may be exacerbated as the population of highly skilled trout fishermen who have traditionally made up the wild, trophy or fly fishing trout user groups ages.

6.2.3 Alternative 2a: Enhance Trout Stocking and WTP Program to meet demand by 2010.

The situation has the same outcomes as above, with an increase in the Threatened and Wild Trout programs. Additional funds would be required for the WTP enhancement.

This alternative takes the status quo policies to the maximum. It expands the catchable stocking program as discussed in Alternative 2 and the current native and wild trout programs. Assuming that there is an interaction between the stocking of catchables and subcatchables in seasonal waters and native and wild trout populations, further expansion of these wild trout populations will only intensify the interactions and worsen the externalities that could occur at present. The only mitigating factor in this alternative could be that expansion of the WTP could occur in waters more "remote" relative to the current catchable stocking program waters and, therefore, would not necessarily result in more intensified interactions. Nevertheless, the extreme increases in funding needed to support this alternative makes it unrealistic, and the potentially greater externalities makes it undesirable.

Wild Trout programs, which would have lowered risk of stock loss or amalgamation for species of concern and habitat protection, would be increased. Designated "wild trout" and/or "Blue Ribbon" quality locations would increase, with a likely increase in the population of wild trout recreational fishers among traditional and non-traditional user groups. Increased extent and use of fisheries resources associated with Wild Trout Programs will require reexamination of regulations, with increased efforts in enforcement and public education.

By designating and managing more streams as Wild Trout Streams, emphasis would be put on restoring streams to more natural conditions and on implementing catch-and-release policies. At the same time, an increase in the level of stocking would supplement the WTP by putting catchable fish in areas subject to heavy fishing pressure, and by selectively placing smaller fish in areas that might develop sustainable wild populations.

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6.2.3.1 Genetic Diversity

Inbreeding Depression:
An increase in wild trout programs would reduce the likelihood of introducing inbred strains carrying homozygous combinations of alleles from the same source and associated abnormal physical and behavioral phenotypes; inbreeding depression might be more likely in areas where hatchery stocking is more intense.

Outbreeding Depression:
Without large numbers of hatchery-reared fish being introduced at one time into local waters, swamping of local gene pools by fish carrying hatchery-selected traits would not be as likely to occur in areas being managed as part of the WTP. The risk of swamping local wild population gene pools would be increased in hatchery stocking sites.

Artificial Selection in Hatcheries:
Although a number of steps could be taken to reduce the likelihood and magnitude of artificial selection occurring in hatchery rearing environments, some selection will undoubtedly continue. Increased funding for hatchery operations could be applied to reducing some the risks of producing homogenous fish stocks that are selected for hatchery environments instead of wild environments, rather than on producing larger numbers of hatchery fish.

Gene Flow and Genetic Load:
Enhanced hatchery stocking would increase the risks associated with introducing different genetic combinations into local populations, including increased genetic load levels in areas where stocking occurs. Enhancement of the WTP would reduce the likelihood of such impacts in areas where the program is applied.

Disruption of Coadapted Genetic Structures:
A WTP emphasis in more waters would, for those waters, minimize disruptions of coadapted genetic combinations through introductions of genetically different fish adapted to survive in hatchery conditions. In waters where stocking takes place or is enhanced, and which are inhabited by wild fish adapted to their local environment, the chances of disrupting coadapted genetic structures would be enhanced. By focusing hatchery operations in fewer areas where impacts on locally adapted wild trout would be minimized, it may be possible to meet angling demands while encouraging establishment of sustainable wild populations where they currently are threatened or do not exist.

6.2.3.2 Ecology and Behavior

Competition:
Enhancing WTA should reduce the risks associated with introductions of competitors and hatchery related pathogens. More wild trout populations

would have an opportunity to adapt to the temporal and spatial aspects of their environment without the added stress of reacting to massive introductions of hatchery fish. Enhancement of hatchery operations in other sites would potentially magnify the various impacts identified in the issues section of this document.

Numerical Responses:
Where the WTP is implemented, wild fish would develop a more stable relationship with their physical and biological environment and be less likely to experience lowered winter survival due to excessive consumption of energy in interactions with planted fish.

6.2.3.3 Predation

Direct Effects:
Implementing more WTP activities would reduce predation by larger introduced fish from hatcheries and reduce the frequency of introducing potentially destabilizing pulses of food in the form of small hatchery-reared fry. Where hatchery programs are enhanced, however, the reverse reaction would be expected.

Numerical Responses:
Wild trout would not receive occasional food supplements of small hatchery fish and exceed their carrying capacity as a result of temporary infusions of hatchery fish. Neither natural predators nor anglers would be expected to congregate in WTP sites, since hatchery plantings would not artificially inflate the temporary availability of prey for them.
In sites where the hatchery program is emphasized, wild trout might be advantaged in terms of survival and reproduction as a result of introductions of smaller hatchery fish.

Functional Responses:
Without hatchery plantings, predators and anglers would not increase their consumption rates of fish at particular sites as they "learned" of a temporary availability of prey. Where hatchery programs are emphasized, the functional responses of predators identified in the issues and status quo alternative would be expected to be more likely to occur.

6.2.4 Alternative 3: Enhance Threatened and Wild Trout Programs and eliminate the catchable trout program.

The Threatened/Wild Trout programs are primarily directed at managing waters that can sustain a satisfactory sport fishery or protect depleted native species without stocking. Biological and physical inventories would be used to assess the biotic potential for a water and aid in determining its capability for producing large sizes or numbers of native/wild trout and maintaining a fishery. The decision on how to manage a water rests with the District Biologist, who also determines the species, optimum population size and harvest rate.

would have an opportunity to adapt to the temporal and spatial aspects of their environment without the added stress of reacting to massive introductions of hatchery fish. Enhancement of hatchery operations in other sites would potentially magnify the various impacts identified in the issues section of this document.

Numerical Responses:
Where the WTP is implemented, wild fish would develop a more stable relationship with their physical and biological environment and be less likely to experience lowered winter survival due to excessive consumption of energy in interactions with planted fish.

6.2.3.3 Predation

Direct Effects:
Implementing more WTP activities would reduce predation by larger introduced fish from hatcheries and reduce the frequency of introducing potentially destabilizing pulses of food in the form of small hatchery-reared fry. Where hatchery programs are enhanced, however, the reverse reaction would be expected.

Numerical Responses:
Wild trout would not receive occasional food supplements of small hatchery fish and exceed their carrying capacity as a result of temporary infusions of hatchery fish. Neither natural predators nor anglers would be expected to congregate at WTP sites, since hatchery plantings would not artificially inflate the temporary availability of prey for them.
In sites where the hatchery program is emphasized, wild trout might be advantaged in terms of survival and reproduction as a result of introductions of smaller hatchery fish.

Functional Responses:
Without hatchery plantings, predators and anglers would not increase their consumption rates of fish at particular sites as they "learned" of a temporary availability of prey. Where hatchery programs are emphasized the functional responses of predators identified in the issues and status quo alternative would be expected to be more likely to occur.

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Under this alternative, the state would discontinue its catchable program and redirect these resources to:

1) expand the Threatened and Wild Trout programs in waters that can sustain satisfactory fisheries; and

2) develop recreational fisheries by stocking fingerlings and subcatchables in waters that can sustain a fishery but lack spawning habitat.

Funds would be directed at:

1) habitat restoration and enhancement and maintenance of Threatened and Wild Trout research and management programs; and

2) providing satisfactory recreational fisheries by stocking wild strains of fingerlings and subcatchables.

Ending the catchables program would create a significant demand deficit for recreational trout fishing. Ultimately, fewer waters with less fish would exist given the higher marginal costs of improving or restoring habitats for sustainable wild trout populations (water categories 2 and 3). Replacing the current catchables program with an expanded Wild Trout Program would not increase the supply of catchable trout back to the current supply levels. Dissatisfaction among consumptive recreational fishermen would create a deleterious impact on the support for DFG programs and funding. A marginal increase in trout resources for catch-and-release, high-end sport fishing would result.

Local economies that are dependent upon recreational trout fishing tourism would be severely impacted, causing a decline in resources committed to improvement and maintenance of the rural infrastructure. The residual sport fishing (i.e., high-end take and catch-and-release) from enhanced wild trout resources would be negatively impacted by loss of services in nearby tourism-dependent communities.

Expenditures on enforcement of fishing regulations would increase greatly due to the vulnerability of wild trout populations to the unmet demands of highly frustrated sport fishermen. Management of wild trout fisheries would require greater management and monitoring expenditures to ensure that yields are sustained. The result of all of these likely outcomes would be a policy course that would be unsustainable due to the lack of fiscal resources for DFG, unmet recreational demands and the countervailing social/political forces.

All waters that could sustain a satisfactory fishery for threatened/wild trout would be so managed. Management would be directed at protecting threatened and wild trout, and maintaining the health and viability of the fish populations being managed. It is assumed under this alternative that waters that can support a sustainable fishery will be stocked with native, threatened, and/or wild populations.

The following water categories and associated management strategies are proposed to stratify fishery habitats in California's inland freshwaters and establish a priority for implementation:

1. Waters that have adequate biotic resources for a sustained fishery and have adequate, self-sustaining wild/native populations would be managed for those populations with no stocking.

2. Waters that have some biotic resources for a sustained fishery, but do not have an adequate self-sustaining wild/native population, may be managed with a stocking program to produce self-sustaining populations or provide a satisfactory fishery.

3. Waters that have an adequate biotic potential for a sustained fishery, but exhibit environmental degradation that can be restored, will be managed to restore the habitat and establish a self-sustaining population.

4. Waters that lack environmental or biotic resources for adequate reproduction, but are favorable for growth and year-round survival, will be managed with a stocking program utilizing fingerlings and subcatchables.

5. Waters that have favorable environmental or biotic resources for trout seasonally will not be actively managed for salmonids.

6.2.4.1 Genetic Diversity

Inbreeding Depression:
An increase in wild trout programs would reduce the likelihood of introducing inbred strains carrying homozygous combinations of alleles from the same source and associated abnormal physical and behavioral phenotypes.

Outbreeding Depression:
Without large numbers of hatchery-reared fish being introduced at one time into local waters, no swamping of local gene pools by fish carrying hatchery-selected traits would occur.

Artificial Selection in Hatcheries:
Enhancement of the WTP alone would limit the extent to which the existing hatchery program would result in artificial selection for traits that are likely to be non-adaptive upon release.

Gene Flow and Genetic Load:
Eliminating the catchable trout program would be expected to have minimal to moderate impacts on reducing gene flow and adding to the genetic load, since most fish planted at larger sizes would not have been expected to survive well enough to breed and contribute to hybridization between hatchery and wild trout.

Disruption of Coadapted Genetic Structures:
A WTP emphasis in more waters would, for those waters, minimize disruptions of coadapted genetic combinations through introductions of genetically different fish adapted to survive in hatchery conditions. Without disruptions due to hatchery introductions, wild trout populations would be expected to react to natural selection pressures in a way that could emphasize development and refinement of coadapted gene complexes.

6.2.4.2 Ecology and Behavior

Competition:
Enhancing WTA should reduce the impacts associated with introductions of competitors. The risks associated with introductions of competitors and hatchery-related pathogens would be reduced. More wild trout populations would have an opportunity to adapt to the temporal and spatial aspects of their environment without the added stress of reacting to massive introductions of hatchery fish.

Numerical Responses:
Where the WTP is implemented, wild fish populations would be expected to develop a more stable relationship with their physical and biological environment and be less likely to experience lowered winter survival due to excessive consumption of energy in interactions with planted fish.

6.2.4.3 Predation

Direct Effects:
Implementing more WTP activities would reduce predation by larger introduced fish from hatcheries. The frequency of introducing potentially destabilizing pulses of food in the form of small hatchery-reared fry might be expected to continue, affecting trout populations in stocked areas in unique and complex ways at each site.

Numerical Responses:
Wild trout would not be preyed upon by catchable stocked trout in areas where the WTP is expanded and stocking of hatchables is discontinued. Other predator populations would not be elevated to artificial levels due to a stocking food subsidy.

Functional Responses:
Natural predators and anglers would not be drawn to WTP areas due to temporary population explosions resulting from stocking and would not be expected to hunt or fish longer when they do visit those areas since returns are unlikely to be inflated.

6.2.5 Alternative 3a: Enhance Threatened and Wild Trout Programs and expand on stocking activities in urban areas.

Increase the WTP as identified above, and expand on the stocking activities in urban centers--primarily Los Angeles and San Francisco--by the redirection of catchable-sized trout from high-demand areas, like the Eastern Sierras and Tahoe.

This alternative attempts to address the supply deficit for consumptive recreational trout fishing by redirecting a portion of the current hatchery catchable production to localities in California near high population centers. Such an alternative would seemingly mitigate the negative impacts from unmet trout fishing demands. However, the cost-to-creel would almost certainly increase. DFG hatcheries were located to support the current stocking policy. Redirecting hatchery stock to more distant urban locations would increase transportation costs and loss rates.

The loss of the aesthetic wildland experience to recreational trout fishing would likely dampen demand for the trout stocked near urbanized areas. The residual unmet demand relative to current and anticipated consumptive trout sport fishing demand would remain high, but not as high as under Alternative 3. Therefore, reduced willingness-to-pay for trout in urbanized waters and the increased cost-to-creel would greatly reduce the economic efficiency of such a stocking policy to a point where net benefits would be quite marginal.

Under this alternative, local tourism-dependent economies would be negatively impacted as described under Alternative 3, with the concomitant effects on the residual sport fisheries. This alternative would also require higher DFG funding levels, as did Alternative 2, which is highly unlikely to occur. The combined effect of (1) higher costs (arising from the higher marginal costs of restoration), (2) increased DFG funding, (3) partially unmet recreational fishing tastes and preferences, and (4) higher costs-to-creel make this alternative inefficient and unrealistic.

If hatchery stock planting programs were decreased, risks to specific populations of wild trout and native fish stocks arising from hatchery trout planting programs would be reduced (e.g., possible introgression and loss of genetic integrity, increased spread of diseases). Increased mortality would occur in existing locations and populations in marginal and high demand areas utilized by fishers who previously relied on hatchery stock planting programs.

Decreased plantings may cause a shortfall of resources relative to public demand in rural areas with high fishing pressure, for all catchable trout programs including urban fishing. Secondary negative effects may include increased potential for habitat degradation due to user group dissatisfaction and/or perception that the environment is of marginal or little value.

Wild trout programs and locations would benefit directly through increased resource allocation to fishery resource protection, and habitat preservation and/or protection. Wild trout and indigenous species may undergo population

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Decreased plantings may cause a shortfall of resources relative to public demand in rural areas with high fishing pressure for all catchable trout programs including urban fishing. Secondary negative effects may include increased potential for habitat degradation due to user group dissatisfaction and/or perception that the environment is of marginal or little value.

Wild trout programs and locations would benefit directly through increased resource allocation to fishery resource protection, and habitat preservation and/or protection. Wild trout and indigenous species may undergo population increases of unknown magnitude. Major shifts in the number of fishers at streams containing wild trout may create unprecedented increases in fishing pressure due to a lateral shift of anglers who previously relied on hatchery-planted stocks. Increased enforcement and new regulations would probably be required to absorb a lateral shift of fishers from traditional hatchery-stock-planting-based fisheries to wild-trout-associated fisheries. Increased efforts in public education would be required.

Increasing WTP and urban fishing could result in the protection of wild and indigenous populations from direct loss and/or genetic introgression correlated with stocks of planted hatchery fish. Fish populations in high-use rural areas would be subject to increased fishing pressure and possible marginalization of habitat and resource due to angler perception or dissatisfaction with fish stock and its immediate environment. Increased pressure on wild-trout-associated resources would probably increase, with increased requirements for new regulations, enforcement and public education.

Urban fishing programs would benefit with increased resource allocation. Increased interest in recreational fishing outside of urban-fishing-based resources would probably occur.

6.2.5.1 Genetic Diversity

Inbreeding Depression:
Enhancement of wild trout programs in some areas would reduce the likelihood of introducing inbred strains carrying homozygous combinations of alleles from the same source and associated abnormal physical and behavioral phenotypes. Stocking in urban areas would be expected to inflate the impacts of inbreeding depression where hatchery stocking is intensified.

Outbreeding Depression:
Without large numbers of hatchery-reared fish being introduced at one time into local waters, swamping of local gene pools by fish carrying hatchery-selected traits would not be as likely to occur in areas being managed as part of the WTP. The risk of swamping local wild population gene pools would be increased in urban stocking sites. It should be recognized that urban areas contain unique wild populations of trout (e.g., Malibu Creek in Los Angeles County, Nielsen, et al., 1995) whose gene pools should be preserved, since they represent unique responses of urban wild populations to decades of human disruption and environmental degradation.

Artificial Selection in Hatcheries:
Although a number of steps could be taken to reduce the likelihood and magnitude of artificial selection occurring in hatchery environments, some selection will undoubtedly continue. Increased funding for hatchery operations could be applied to reducing some the risks of producing homogenous fish stocks that are selected for hatchery environments instead of wild environments, rather than on producing larger numbers of hatchery fish.

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Although a number of steps could be taken to reduce the likelihood and magnitude of artificial selection occurring in hatchery environments, some selection will undoubtedly continue. Increased funding for hatchery operations could be applied to reducing some the risks of producing homogeneous fish stocks that are selected for hatchery environments instead of wild environments, rather than on producing larger numbers of hatchery fish.

Gene Flow and Genetic Load:
Enhanced hatchery stocking in urban areas would be expected to increase the risks associated with introducing different genetic combinations into local populations, including increased genetic load levels in areas where stocking occurs. Enhancement of the WTP would reduce the likelihood of such impacts in areas where this program is applied.

Disruption of Coadapted Genetic Structures:
A WTP emphasis in more waters would be expected to minimize disruptions of coadapted genetic combinations because of introductions of genetically different fish adapted to survive in hatchery conditions. In urban waters, where stocking takes place or is enhanced and which are inhabited by wild fish adapted to their local environment, the chances of disrupting coadapted genetic structures in local populations would be enhanced.

By focusing hatchery operations in fewer areas where impacts on locally adapted wild trout would be minimized, genetic impacts would be minimized, and angling demand might be met. At the same time, the WTP could encourage establishment of sustainable wild populations where they currently are threatened or do not exist.

6.2.5.2 Ecology and Behavior

Competition:
Enhancing WTP should reduce the risks associated with introductions of competitors and hatchery-related pathogens. More wild trout populations would have an opportunity to adapt to the temporal and spatial aspects of their environment without the added stress of reacting to massive introductions of hatchery fish. Enhancement of hatchery operations in urban sites would potentially magnify the various impacts identified in the issues section of this document.

Numerical Responses:
Where the WTP is implemented, wild fish would develop a more stable relationship with their physical and biological environment and be less likely to experience lowered winter survival due to excessive consumption of energy in interactions with planted fish.

6.2.5.3 Predation

Direct Effects:
Implementing more WTP activities would reduce predation by larger introduced fish from hatcheries and reduce the frequency of introducing potentially destabilizing pulses of food in the form of small hatchery-reared fry. Where hatchery programs are enhanced, however, the reverse reaction would be expected.

Numerical Responses:
Wild trout would not receive occasional food supplements of small hatchery fish and exceed their carrying capacity as a result of temporary infusions of hatchery fish. Neither natural predators nor anglers would be expected to congregate in WTP sites, since hatchery plantings would not artificially inflate the temporary availability of prey. In urban sites where stocking activities are enhanced, predator and angler populations would be expected to increase.

Functional Responses:
Without hatchery plantings, predators and anglers would not increase their consumption rates of fish at particular WTP sites as they "learned" of a temporary availability of prey.
Where hatchery programs are emphasized, the functional responses of predators identified in the issues and status quo alternative would be expected to be more likely to occur.

6.2.6 Alternative 4: Reduce Hatchery Stocking Program and Redirect funds to Wild Trout Program.

This alternative would require reducing hatchery programs, except those necessary to maintain low-cost/high-return programs (urban stocking) or those needed for the threatened and wild trout programs. This alternative is essentially a "no net funding increase" version of Alternative 3a. To generate the funds needed to enhance the wild and threatened trout programs (water categories 2 and 3), hatcheries would be closed except those needed to support consumptive trout fishing near urbanized areas. This alternative potentially eliminates some of the negative effects for such programmatic shifts described in alternative 3a, but retains the problems of (1) harming tourism-dependent economies, (2) restructuring and recomposing recreational trout fishing demand, and (3) the costs and uncertainties regarding habitat restoration for WTP expansion.

Under this alternative, the threatened/wild trout program, as identified under Alternative 3, would continue with the following modifications:

1. Discontinue high-demand catchable program.

2. Maintain the status quo for the urban catchable program.

3. Redirect funds into the WTP.

4. Discontinue the catchable stocking program and the hatcheries that support their use for all waters except those necessary to support the urban catchable program and the native/wild trout programs.

Numerical Responses:
Wild trout would not receive occasional food supplements of small hatchery fish and exceed their carrying capacity as a result of temporary infusions of hatchery fish. Neither natural predators nor anglers would be expected to congregate in WTP sites, since hatchery plantings would not artificially inflate the temporary availability of prey. In urban sites where stocking activities are enhanced, predator and angler populations would be expected to increase.

Functional Responses:
Without hatchery plantings, predators and anglers would not increase their consumption rates of fish at particular WTP sites as they "learned" of a temporary availability of prey.
Where hatchery programs are emphasized, the functional responses of predators identified in the issues and status quo alternative would be expected to be more likely to occur.

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1. Discontinue high-demand catchable program.

2. Maintain the status quo for the urban catchable program.

3. Redirect funds into the WTP.

4. Discontinue the catchable stocking program and the hatcheries that support their use for all waters except those necessary to support the urban catchable program and the threatened/wild trout programs.

6.2.6.1 Ecology and Behavior

Competition:
Enhancing WTP should reduce the risks associated with introductions of competitors and hatchery related pathogens. More wild trout populations would have an opportunity to adapt to the temporal and spatial aspects of their environment without the added stress of reacting to massive introductions of hatchery fish. Reductions of hatchery operations would potentially reduce the various impacts identified in the issues section of this document.

Numerical Responses:
Where the WTP is implemented, wild fish would develop a more stable relationship with their physical and biological environment and be less likely to experience lowered winter survival due to excessive consumption of energy in interactions with planted fish. Increases in competitive interactions and associated impacts resulting from stocking operations would be expected to be reduced with a smaller hatchery stocking program.

6.2.6.2 Predation

Direct Effects:
Implementing more WTP activities would reduce predation by larger introduced fish from hatcheries and reduce the frequency of introducing potentially destabilizing pulses of food in the form of small hatchery-reared fry. As hatchery programs are downsized, the extent to which stocking activities result in either food subsidies for wild populations or additional levels of predation by larger hatchery fish would be concomitantly downsized.

Numerical Responses:
Wild trout would not receive occasional food supplements of small hatchery fish and exceed their carrying capacity as a result of temporary infusions of hatchery fish. Neither natural predators nor anglers would be expected to congregate in WTP sites since hatchery plantings would not artificially inflate the temporary availability of prey for them. If stocking activities are reduced, the response of predator and angler populations would be expected to decrease as well.

Functional Responses:
With fewer hatchery plantings and a greater emphasis on WTP, predators and anglers would not be expected to increase their consumption rates of fish overall. However, at particular stocking sites, anglers might exhibit a more intense individual response to a temporary availability of planted fish.

6.2.7 Alternative 5: Limit Wild Trout Program and redirect funds to Urban Catchables Program.

Reduce threatened and wild trout activity to highest priority waters (Category 1 blue ribbon waters in Alternative 3). Emphasis is on satisfying the recreational demand by stocking quality catchables (two fish/pound or

larger) to meet increased urban demands. The quantity and quality of catchables will be increased where recreational fishing demand is greatest. Increased production would be directed at stocking lakes, reservoirs and other waters in high demand urban areas. Hatchery programs necessary to maintain the WTP (Category 1 blue ribbon waters) and those needed to support demand would remain. Funds will be redirected primarily to the catchable program to meet the urban demand. This alternative differs from the others in that funds would be redirected from the high-demand programs to maximize catchable returns to anglers in high-demand urbanized areas. There would be some cost savings from the reduced WTP activity.

This alternative addresses the externalities resulting from the current hatchery stocking program by keeping the WTP at status quo levels but redirecting catchable stocking away from the wildland toward isolated areas of high demand where interaction with in situ native and wild trout populations is minimal. Net funding increases would not likely occur. Closing hatcheries no longer needed to support catchable stocking in some areas would free financial resources to be used to expand production in the high-demand/ urbanized areas, e.g., Mono and Inyo counties, and areas proximate to Los Angeles and the Bay Area. This alternative represents an enhancement of the threatened and wild trout programs, in that the externalities from intermingling catchables would be greatly reduced.

This alternative still retains the problems of restructuring and recomposing consumptive trout fishing demand and the costs and uncertainties surrounding construction and/or expansion of hatcheries needed to support catchable stocking in high demand/urbanized areas. Assuming these problems are tractable, the costs-to-creel of catchables could be reduced and willingness to pay could remain relatively high. Some local tourism-dependent economies would be negatively impacted. Therefore, under this alternative, net efficiency gains are possible but still uncertain.

If hatchery trout planting programs were reduced and WTP associated with fisheries resources were enhanced, a likely outcome would include benefits to populations of wild and indigenous trout species by promoting habitat preservation and restoration and non-consumptive use of trout. Reductions in hatchery stock plant-based fisheries would reduce risks to wild and indigenous populations of concern by reducing short-term carrying capacity overloads, and by minimizing risk of disease transmission and spread as well as the potential for loss of genetic integrity. There would likely be increased potential impacts on wild trout resources and habitats due to a lateral shift of angler population from hatchery planted trout-based fisheries. New regulations, or expanded regulations with concomitant increase in enforcement and public education, would be required.

If urban fishing programs increased and WTP was limited with stocking in high-demand rural locations, then wild and indigenous stocks would be at increased risk due to loss of resources and workforce to ensure preservation and conservation rather than direct biological effects associated with hatchery plant stocks. Losses or other negative effects would be mediated primarily through neglect of habitat or marginalization of habitats to

accommodate other uses or activities. Additional impacts may be manifested through increased fishing pressure and use of wild trout populations and habitats. This shift would be mainly from users of high-demand fisheries stocks in rural areas. Fishers of these stocks also tend to be more reliant on bait and barbed hook lures, which result in higher fish mortalities even after intentional release. Thus impacts beyond fishing pressure will occur. (This aspect applies to all alternatives mentioned above in which lateral shifts of anglers from hatchery-based to wild or trophy-based fisheries occurs.)

Urban fishing program users tend to be consumptive, short-term (day trips) users with common objectives relating to providing first-time fishing experience to children or teenagers. This user group is less apt to directly impact the wild trout-based programs, but rather utilize high-demand rural areas on an irregular basis. The impacts of increasing urban fishing may be manifested in subsequent increased utilization of hatchery and grow-out facilities for planting catchables, in the event of significant growth and demand for urban fishing programs.

6.2.7.1 Genetic Diversity

This alternative would be expected to reduce overall genetic diversity as the negative impacts on diversity would be emphasized and the opportunities for maintaining diversity in wild trout populations are reduced. The likelihood of increased hatchery stocking disrupting coadapted gene complexes would be greater.

Inbreeding Depression:
Impacts of inbreeding depression in urban areas where hatchery stocking increases occur would not change in nature, but the number of sites where hatchery stocking occurs would be expected to increase the overall impacts of inbreeding depression.

Outbreeding Depression:
With more hatchery-reared fish being introduced at one time into local waters, swamping of local gene pools by fish carrying hatchery-selected traits would be more likely to occur.

Artificial Selection in Hatcheries:
Although a number of steps could be taken to reduce the likelihood and magnitude of artificial selection occurring in hatchery rearing environments, some selection will undoubtedly continue. Increased funding for hatchery operations might improve the ability of hatchery managers to implement any such steps, so the risks of producing homogenous fish stocks that are selected for hatchery environments rather than wild environments could increase or decrease, depending upon how the hatchery program is implemented.

accommodate other uses or activities. Additional impacts may be manifested through increased fishing pressure and use of wild trout populations and habitats. This shift would be mainly from users of high-demand fisheries stocks in rural areas. Fishers of these stocks also tend to be more reliant on bait and barbed hook lures, which results in higher fish mortalities even after intentional release. Thus impacts beyond fishing pressure will occur. (This aspect applies to all alternatives mentioned above in which lateral shifts of anglers from hatchery-based to wild or trophy-mixed fisheries occurs.)

Urban fishing program users tend to be consumptive, short-term (day trips) users with common objectives relating to providing first-time fishing experience to children or teenagers. This user group is less apt to directly impact the wild trout-based programs, but rather utilize high-demand rural areas on an irregular basis. The impacts of increasing urban fishing may be manifested in subsequent increased utilization of hatchery and grow-out facilities for planting catchables, in the event of significant growth and demand for urban fishing programs.

6.3.7.1 Genetic Diversity

This alternative would be expected to reduce overall genetic diversity as the negative impacts on diversity would be emphasized and the opportunities for maintaining diversity in wild trout populations are reduced. The likelihood of increased hatchery stocking disrupting coadapted gene complexes would be greater.

Inbreeding Depression:
Impacts of inbreeding depression in urban areas where hatchery stocking increases occur would not change in nature, but the number of sites where hatchery stocking occurs would be expected to increase the overall impacts of inbreeding depression.

Outbreeding Depression:
With more hatchery-reared fish being introduced at one time into local waters, swamping of local gene pools by fish carrying hatchery-selected traits would be more likely to occur.

Artificial Selection in Hatcheries:
Although a number of steps could be taken to reduce the likelihood and magnitude of artificial selection occurring in hatchery rearing environments, some selection will undoubtedly continue. Increased funding for hatchery operations might improve the ability of hatchery managers to implement any such steps, so the risks of producing homogenous fish stocks that are selected for hatchery environments rather than wild environments could increase or decrease depending upon how the hatchery program is implemented.

Gene Flow and Genetic Load:
Increased levels of hatchery stocking would be expected to increase the risks associated with introducing different genetic combinations into local populations.

Disruption of Coadapted Genetic Structures:
Higher rates of stocking in waters that are inhabited by wild fish adapted to their local environment would increase the chances of disrupting coadapted genetic structures.

6.2.7.2 Ecology and Behavior

Competition:
Reducing the WTP and enhancing the urban catchable programs should enhance the risks associated with introductions of competitors and hatchery related pathogens. More wild trout populations would be affected by the added stress of reacting to massive introductions of hatchery fish. Enhancement of hatchery operations in urban sites would potentially magnify the various impacts identified in the issues section of this document.

Numerical Responses:
Enhancement of the urban catchables program will increase environmental impacts, particularly regarding the added levels of stress on existing wild trout populations into which hatchery trout are introduced.

6.2.7.3 Predation

Direct Effects:
More urban catchable planting activities would increase predation by larger introduced fish from hatcheries on existing wild trout.

Numerical Responses:
Wild trout would not receive occasional food supplements of small hatchery fish and exceed their carrying capacity as a result of temporary infusions of smaller hatchery fish. Natural predators and anglers would be expected to congregate in hatchery planting sites to take advantage of the inflated temporary availability of prey.

Functional Responses:
With more hatchery plantings, individual predators and anglers would probably increase their consumption rates of fish at particular stocking sites as they "learned" of a temporary availability of prey.

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CHAPTER 7: CONSULTATIONS

The study team consulted with representatives of DFG, hatchery personnel, and interested organizations and individuals. Three levels of consultation and review were used:

1. **Technical consultation** was provided by representatives of DFG, including central office policy makers, regional biologists, hatchery managers, and former personnel familiar with issues. Both DFG and Trout Unlimited suggested individuals who provided data, policies and procedure information, and judgments on operations.

2. **Advisory consultation** was provided by representatives of Trout Unlimited, Cal Trout, the American Fisheries Society, the American Sportfishing Association, and other angler groups. Both DFG and TU suggested scientists and individuals who could provide advice and review documents. An early copy of the draft environmental document was circulated to reviewers prior to a public review.

3. **Public comment** was provided according to state procedures.DFG then initiated a broader consultation by distributing a notice of preparation (NOP) that announced the intent to prepare the final document. The NOP requested submittal of views on the scope and content of the information. The notice was distributed to members of the public and interested organizations was had expressed prior interest in the study. The notice also was provided to the State Clearinghouse for distribution to appropriate responsible and trustee agencies.

Issues raised in response to the NOP will be described in this section.