STATE OF CALIFORNIA
The Resources Agency

DEPARTMENT OF FISH AND GAME

STRIPED BASS RESTORATION AND MANAGEMENT PLAN FOR THE SACRAMENTO-SAN JOAQUIN ESTUARY PHASE I

September 1989

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LEGISLATIVE ACKNOWLEDGMENTS

Senator Ellis introduced SB 1032 in 1981 to create the $3.50 striped bass fishing stamp for four years (1982-1985). Proceeds were to be used by the California Department of Fish and Game to "restore the California striped bass fishery."

Assemblyman Costa introduced AB 823 (Section 7360-7361) in 1985 to extend the striped bass fishing stamp for four additional years (1986-1989).

Approximately $15 million will have been made available to the Department of Fish and Game during the eight years from 1982 through 1989. Striped bass stamp funds were used to prepare this plan.

DEPARTMENT OF FISH AND GAME PARTICIPATION IN DEVELOPMENT OF THE

STRIPED BASS RESTORATION AND MANAGEMENT PLAN FOR THE SACRAMENTO-SAN JOAQUIN ESTUARY PHASE I

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STRIPED BASS STAMP FUND ADVISORY COMMITTEE

The public Striped Bass Stamp Fund Advisory Committee, appointed by the Director, helped determine the expenditure of striped bass stamp funds by reviewing and deciding on each proposed project. The Committee also critically reviewed and contributed to the plan. Their dedication and hard work as volunteers deserve high praise.

Committee members, past and present, are listed:

Michael Alvarez - Benicia	*George Iwao - San Francisco
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PARTICIPATION OF OTHERS IN PLAN DEVELOPMENT

Information for this plan was provided by federal and State agencies, cities, counties, private companies, angler organizations, environmental groups and individuals. We must mention the considerable contributions by California Striped Bass Association, United Anglers of California and Associated Sportsmen of California. These groups and their leadership strongly advocated development of a striped bass plan. To attempt to list all other organizations and individuals, however, would result in the inadvertent omission of some. Therefore, no such complete listing is presented, but that cooperation is greatly appreciated and acknowledged.

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DIRECTOR'S FOREWORD

A message from the Director of the Department of Fish and Game to striped bass anglers and others concerned about the future of the striped bass population in the Sacramento-San Joaquin Estuary.

This Striped Bass Restoration and Management Plan has been prepared by the California Department of Fish and Game because it has the statutory responsibility to manage this valuable public resource. However, it draws upon the assembled knowledge of governmental agencies - federal, State and local - businesses, organizations, and private individuals.

Even at one-third the size of what it was 25 years ago, the Bay-Delta striped bass fishery - located amidst a large metropolitan region - is the source of great public wealth: it provides year-round recreational and aesthetic enjoyment for hundreds of thousands of people; and it supports the economic livelihood of thousands of others.

To restore this fishery to its recent historical levels would be an important achievement for all of us to pass on to future generations. The annual recreational and economic benefits would be far greater than today. We believe it is reasonable to expect three to four million adult bass -- where today there are about one million. We believe it is reasonable to have anglers catch 750,000 bass annually -- where today they take 150,000 each year. To achieve that goal will not be easy; it will require hard work and sacrifice. The process, however, will forge a greater appreciation for the natural resources entrusted to all of us.

The extent to which the wild striped bass population of the Sacramento-San Joaquin Estuary is eventually restored depends ultimately on the degree to which five critical things happen: (1) how well we in the Department of Fish and Game do our job of describing and justifying what needs to be done; (2) how well water development agencies, water-user groups, and other parties all work together to solve problems; (3) how well local, State, and federal regulatory agencies establish controls and regulations to benefit aquatic life; (4) how well the public - including angler and environmental groups - communicates its interests to all parties; and (5) how well the Legislature is able to develop legislation, and other aids, to promote fishery restoration.

The Department of Fish and Game cannot, obviously, guarantee restoration of the bass population. If this plan is fully implemented, however, we believe it will provide an environment that should enable the wild striped bass population to regenerate itself.

It is apparent that to activate and realize this plan, increased and new efforts will be required by public and private entities whose actions affect striped bass. In our case, this plan will be the basis for guiding present and future Department of Fish and Game programs.

Dwight D. Eisenhower, former President and General, said "The price of liberty is eternal vigilance." A parallel observation is "Californians must recognize that the price of an abundant, thriving striped bass population is eternal vigilance." Sadly, there will never come a day when everyone can sit back and say "At last -- it's all done." Both government and the people must, forever, commit time, energy and money to perpetuate this valuable natural and renewable resource.

The Department of Fish and Game is committed to meeting this challenge.

Pete Bontadelli

Pete Bontadelli
Director
California Department of Fish and Game

STRIPED BASS RESTORATION AND MANAGEMENT PLAN
FOR THE SACRAMENTO-SAN JOAQUIN ESTUARY
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INTRODUCTION

This plan concerns California's most important striped bass (Morone saxatilis) population and fishery located in the lower Sacramento-San Joaquin rivers, their common delta, San Francisco Bay, and the ocean inshore-area north to Tomales Bay and south to Morro Bay. Bass were first introduced from the New Jersey coast to this area at Martinez in 1879. They quickly multiplied to several million for many decades, but by 1970 the population had become severely depleted.

This plan represents what the Department of Fish and Game (DFG) believes should be done by the DFG and other State, federal and local agencies, and public and private groups and organizations to restore the striped bass population to levels of more than three million adult fish.

This introduction to Phase I of the plan describes the rise and fall of the striped bass population and fishery, bass reproduction and early life history, and DFG (and other) efforts to reverse the fishery decline. The remainder of the plan identifies: (1) DFG fishery goal and specific objectives; (2) problems detrimental to bass and to the human use of bass and their possible solutions; and (3) a restoration and management plan with a Four-Point Program to meet DFG objectives and solve identified problems.

Phase II is the implementation of the plan. Guidelines for conducting Phase II are presented at the end of this plan report.

Rise and Fall of the Striped Bass Population and Fishery

Following the introduction of striped bass from the New Jersey Atlantic coast in 1879, the bass population boomed. By the early 1900's the commercial net catch alone was averaging over one million pounds annually. In 1935 commercial netting of stripers was stopped by law. Except for a brief decline in the mid-1950's, angling success was very good up through the early 1960's. At that time there were about three million adult bass (greater than 16 inches in length) and the annual angler catch approximated 750,000 fish. About then the bass population began to decline.

By the late 1970's, striper fishing had become poor. Fishery investigations revealed alarmingly low adult and juvenile striped bass populations. Estimates suggested that the 1980 adult bass population was no more than one-third, and possibly only one-fourth, that of the early 1960's, and the annual angler catch was down to about 150,000 fish.[1/]

Tagging and creel census projects indicate the average annual percent catch of striped bass is distributed approximately as follows:

	Percent annual catch
San Francisco Bay	35
San Pablo Bay-Carquinez Strait	21
Delta	20
Upstream from Courtland	15
Suisun Bay	6
Ocean	2
Upper San Joaquin	1
	100

Bass Reproduction and Early Life History

Some of the most serious problems that affect striped bass do so because they adversely impact bass reproduction and development of eggs, larvae, and fingerlings. It is important, therefore,

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1/ Other separate striped bass fisheries are:

(1) Lake Havasu on the Colorado River, from Davis Dam downstream 70 miles to Parker Dam. Striped bass were stocked in the early 1960's and they have developed a self-sustaining population; and

(2) the statewide reservoir and aqueduct fisheries consisting of: (a) several reservoirs in which bass are stocked as there is either no or insufficient natural reproduction (includes Camp Far West, Lake Mendocino, Lake Millerton, San Antonio, and Santa Margarita reservoirs); (b) reservoirs and canals of the federal Central Valley Project (CVP), State Water Project (SWP), and Contra Costa Water District that draw water and young striped bass from the Delta (includes San Luis Reservoir, O'Neil Forebay, Pyramid Lake, Silverwood Lake, California Aqueduct, etc.); and (c) New Hogan Reservoir where limited natural reproduction maintains a striped bass fishery.

These California striped bass fisheries will be accommodated in separate plans. A minor saltwater striper fishery near San Diego and in Mission Bay was created from 1974-1985 by annual stocking of yearling stripers. Angler use and catch were low, however, and that program was discontinued in 1986.

to understand the early life-cycle of striped bass in the Sacramento-San Joaquin Estuary.

Striped bass spawn in fresh water where there is moderate to swift current. The section of the San Joaquin River between the Antioch Bridge and the mouth of Middle River, together with other channels in this area, is an important spawning ground. Another important spawning area is the Sacramento River between Sacramento and Colusa. About one-half to two-thirds of the eggs are spawned in the Sacramento River, and the remainder in the San Joaquin River system.

Stripers begin spawning in spring when water temperature reaches 60^{o}F. Most spawning occurs between 61 and 69^{o}F, and the spawning period usually extends from April to mid-June.

Female striped bass usually spawn for the first time in their fourth or fifth year, when they are 21 to 25 inches long. Many males mature when they are two years old and only about 11 inches long. Most males are mature at age three and nearly all females at age five.

Stripers are very prolific. A five-pound female may spawn 180,000 eggs in one season and a 15-pound fish is capable of producing over a million eggs. Because of this great reproductive potential and because environmental conditions were better then, striped bass were able to establish a large population within a few years after their introduction in California.

Striped bass often spawn in large schools. On one occasion, Department of Fish and Game biologists observed a school of several thousand bass at the surface along the bank of the Sacramento River above Knights Landing. Small groups of from three to six bass frequently segregated from this school and splashed and churned in the main current of the river in the act of spawning. At times, five or more groups of bass were observed spawning at once. Usually a large female was accompanied by several smaller males.

During the spawning act, eggs and milt are released into the water. The milt contains microscopic sperm cells which penetrate the eggs and cause them to begin to develop. While the eggs are in the female they are only about 1/25 of an inch in diameter, but after release they absorb water and increase to about 1/8 of an inch in diameter. At this time they are virtually invisible because they are almost transparent.

Striped bass eggs are slightly heavier than water. A moderate current is needed to suspend them while they develop. Without adequate water movement they sink to the bottom and die. The eggs hatch in about two days, although the length of time may be somewhat shorter or longer depending upon the temperature; hatching is quickest in warm water.

The newly hatched bass continue their development while being carried along by water currents. At first, the larval bass subsist on their yolk which contains food stored in the egg, but in about a week they start feeding on tiny crustaceans which are just visible to the naked eye. In about two months, by August, they are about two inches long and are feeding primarily on opossum shrimp (Neomysis mercedis). At this time they are most numerous in the western Delta and Suisun Bay.

The complex, fragile chain of biological events during the first two to three months of a striped bass' existence occur over a large geographical area of river channels and sloughs during a three-month spawning period and expose bass to a number of man-caused problems that are described in detail later in this report.

DEPARTMENT EVALUATION AND MANAGEMENT PROGRAMS

Bay-Delta Project

For 25 years the DFG staffed Bay-Delta Project, which is part of the "Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary" and is funded by several agencies, has worked with the Department of Water Resources (DWR), U.S. Bureau of Reclamation (USBR), other State, federal, and local agencies, and the public, mostly to resolve fishery problems associated with water diversion from the Delta. Most of what is known about California striped bass and their problems is the direct result of biological investigations by this program.

The Bay-Delta Project presently has seven major fishery activities related to striped bass:

1. Determining abundance and requirements of striped bass during their first year of life.
2. Determining abundance of adult striped bass and factors affecting their abundance.
3. Identifying distribution and abundance of plankton, including opossum shrimp, that are important foods of young striped bass.
4. Monitoring the health of adult striped bass following procedures developed by the National Marine Fisheries Service (NMFS).
5. Developing ways to improve fish screening and fish handling at the State Water Project (SWP) and Central Valley Project (CVP) diversions in the Delta.
6. Negotiating with DWR and USBR over operation of various State Water Project and Central Valley Project features, and institution of appropriate fishery mitigation measures.
7. The project has DFG lead responsibilities for preparing and presenting information on striped bass to the State Water Resources Control Board (SWRCB) during the Board's "Bay-Delta Water Rights Hearing."

In the 1970's the program conducted experiments, with advice from a board of engineering/biological consultants, to determine fish screen requirements for several species - including striped bass - at different sizes and times of the year. Complex engineering structures were constructed and tested with live fish at Hood on the Sacramento River.

In recent years the Bay-Delta Project has devoted about $1.7 million annually to striped bass investigations, of which

$120,000 are Striped Bass Stamp dollars, and another $600,000 are other DFG funds. About 58% of the total budget is from the California Department of Water Resources and the U.S. Bureau of Reclamation. Those efforts have resulted in: (1) a much improved understanding of the striped bass stocks and factors affecting them, (2) upgrading of fish screens near Byron at the California Aqueduct intake, (3) restrictions on water exports at key times, (4) minimum flow standards to protect striped bass, (5) additional angling restrictions to reduce total catch, and (6) implementation of mitigation measures, primarily the stocking of hatchery-reared bass, to offset direct losses of striped bass in intakes to the California Aqueduct and Pacific Gas and Electric Company's (P.G.&E.) power plants. Those positive measures did not prevent the bass decline, but all agencies involved continue to seek ways to restore the bass population.

Striped Bass Stamp Project

In 1981 striped bass anglers, principally through United Anglers of California and the California Striped Bass Association, proposed and lobbied successfully for legislation to create a striped bass fishing stamp to generate funds for striped bass restoration. In September 1981 the Governor signed SB 1032 (Ellis) which required all striped bass anglers to purchase a $3.50 stamp in addition to a regular fishing license. This legislation was in effect for four years (January 1982 through December 1985). Stamp revenue was to be used to "preserve and enhance the striped bass fishery in California." In 1985, AB 823 (Costa) was signed into law and it extended the striped bass stamp program another four years, through December 1989. From 1982 through 1988, Striped Bass Stamp sales produced $13 million in revenue for the Department of Fish and Game.

The Director of the Department established a "Striped Bass Stamp Fund Advisory Committee" composed of interested citizens and public angler groups to advise the Department's Striped Bass Stamp Project staff on how to best spend stamp dollars to restore the striper fishery. This Advisory Committee has had an important impact on expenditures, and close to $10 million have been spent.

Since 1982 stamp funds have been used to: (1) stock 5.5 million young striped bass; (2) support a hatchery-bass evaluation project that has implanted 4.5 million magnetic, coded-wire tags in those stocked bass, and conducts a year-round creel census to determine their survival and catch by anglers; (3) help support annual surveys of distribution and abundance of bass eggs and larva; (4) construct and operate an Aquatic Toxicology Laboratory that determines effects of various pollutants on young bass and their important food, opossum shrimp; (5) increase overtime law enforcement patrols on bass law violators, and to purchase boats, night-vision scopes, and other patrol equipment; (6) launch or expand more than a dozen scientific investigations to solve practical problems and to probe the biology and environmental requirements of striped bass; and (7) prepare this Striped Bass Restoration and Management Plan.

Department of Fish and Game Regional Projects

The DFG Region 2 (Rancho Cordova headquarters) and Region 3 (Yountville headquarters) have conducted striped bass projects for many years. Region 2 operates both the Department's striped bass hatchery at Elk Grove and, under contract to DWR, the 1988 striped bass "grow-out" facility at the State Delta Pumping Plant near Byron. Region 2 also oversees annual electrofishing efforts by private aquaculturists to capture wild, spawning bass broodstock in order to rear and sell young bass to the State and others for resource improvement. Region 3 conducts biweekly aerial surveys of San Pablo Bay, Carquinez Strait, Suisun and Honker bays, and the lower Delta during May, June, and July to determine the date of onset, location, magnitude, and duration of the die-off which annually plagues striped bass during their migration from fresh- to saltwater.

Both regions direct Fish and Game warden patrol efforts to enforce bass laws and regulations and assign water quality biologists to investigate pollution incidents to insure continued maintenance of bass habitat. The regions also review land and water development proposals and activities and advocate bass habitat protection measures.

GOAL AND OBJECTIVES

The Department of Fish and Game is committed to the goal of stabilizing, restoring, and then improving the striped bass fishery of the Sacramento-San Joaquin Estuary.

Specific fishery resource objectives are to:

1. Restore a self-sustaining Bay-Delta striped bass population to levels of more than three million adult fish.
2. Provide Bay-Delta striped bass which, when eaten, will not endanger human health due to contamination from chemicals or trace-metals.
3. Provide for striped bass angling, aesthetic, and educational use-opportunities.

PROBLEMS DETRIMENTAL TO STRIPED BASS (AND SOLUTIONS)

The Bay-Delta adult striped bass population has declined to about one-third, perhaps one-fourth, of what it was in the early 1960's. The DFG, the Interagency Ecological Study Team, and consultants have devoted considerable time and effort to determine the cause of that decline. However, gaps and insufficient data in the accumulated scientific knowledge have not allowed development of a universally accepted explanation of the reason(s) for the bass decline.

The scientific exploration to pinpoint the cause(s) of the bass decline has identified 11 problems detrimental to the welfare of striped bass and four problems that restrict public use of bass. The DFG, therefore, is placing higher priority on solving those problems and getting the scientific knowledge necessary to define the relative importance of the various problems. Considering the ecological complexities of the situation and the long history of efforts to identify cause and effect, it is reasonable to expect the investigations to provide important new insights into causes, but not a definitive explanation in the immediate future.

This section identifies the 11 problems detrimental to striped bass and presents possible solutions. The four problems of human use and possible solutions are in the next section.

The DFG believes resolution of these resource problems will provide an environment that will enable the striped bass population to regenerate itself. Solution of some of these problems will, however, be extremely difficult. This list is in general order of priority with the most detrimental problems grouped first. One should not, however, overemphasize the exact numerical order of the list:

I. Delta Water Diversions

Five separate water diversion operations entrain and remove striped bass eggs, larvae, and juveniles from the Delta; reduce the young bass food supply; and disrupt bass migrations. These five water diversions, their detrimental impacts, and possible solutions are:

A. <u>The State Water Project (SWP)</u>, which began operating pumps to draw water into the California Aqueduct near Byron in 1967 with a present pumping capacity of 6,400 cubic feet per second (cfs). The pumping capacity is scheduled to be increased 60 percent, to 10,300 cfs, by the early 1990's, provided certain issues are resolved; e.g., lack of Delta channel capacity, water storage south of the Delta, and lifting of Corps of Engineers pumping limitations. Clifton Court Forebay stores water drafted from south Delta channels and regulates water levels to allow better pumping operations. The CCF started operations in 1969-70.

B. <u>The federal Central Valley Project (CVP)</u>, which began operating the Tracy pumping into the Delta-Mendota Canal in 1951 with a diversion capacity of 4,600 cfs. The present fish screen at the intake was completed in 1957.

Striped bass problems attributable to these State and federal water diversions are: (1) small bass are eaten by larger bass (and other fish) in Clifton Court Forebay (SWP), and at the CVP intake; (2) bass eggs, larvae, and fry are lost through both fish screens into the California Aqueduct (SWP) and Delta-Mendota Canal (CVP); (3) bass salvaged at both State and federal fish screens die during collection, handling, and trucking to Delta release sites; (4) bass salvaged and trucked to Delta release sites by State and federal programs create an unusual abundance of disoriented and stressed young bass that are easy victims of predatory fishes (including larger bass) that congregate at the release sites; (5) the combined State and federal pumping operations create upstream (reverse) flows in much of the Delta east of Antioch which greatly increase the number of bass eggs and young drawn to the pumps, and disrupt migrations of young and adult bass throughout the Delta; (6) bass eggs, larvae, and juveniles that should drift and migrate down the Sacramento River to the western Delta and Suisun Bay are diverted into the Delta Cross Channel (DCC) at Locke, and are carried 30 miles through the eastern Delta to the south Delta pumps (CVP and SWP). These north to south, cross-Delta flows are an integral part of the Delta water diversion operations; and (7) the food supply (plankton) of young bass in the western Delta and Suisun Bay has been reduced by entrainment of plankton into Delta diversions, and by rapid water transport through most major Delta channels.

Reduced Delta outflows cause serious problems for striped bass, and Delta diversions are responsible for part of the flow reductions at Chipps Island. However, upstream water storage projects unrelated to Delta diversions have helped to reduce Delta outflows. Low Delta outflows, therefore, are not caused entirely by Delta diverters; and reduced outflows are addressed more appropriately as the second significant striped bass problem in this planning report.

<u>Solutions to problems caused by SWP and CVP diversions:</u>

i. In December 1986, DWR and DFG signed the Two-Agency Fish Protective Agreement that establishes procedures and guidelines to utilize specific DWR funds to offset direct losses of bass (and other species) caused by the Harvey O. Banks Delta Pumping Plant.

Both agencies consider this agreement one of the most significant positive steps taken to mitigate detrimental impacts of the SWP on striped bass (and other species). An advisory committee of representatives from environmental, conservation, and water development groups provides advice on measures to implement the agreement at bimonthly meetings. Proposed projects are identified, analyzed, and those found to be worthwhile are implemented.

ii. A similar agreement is needed with the U.S. Bureau of Reclamation to offset direct fish losses at the federal Tracy Pumping Plant and fish screen facility. Preliminary meetings have been held and negotiations for such an agreement are underway.

iii. The number of bass eggs and larva drawn to the SWP and CVP diversions needs to be reduced through some combination of changing Delta channels (or flows) to eliminate reverse flows, reducing water exports when young bass appear in great abundance, and increasing river flows to carry bass eggs and young downstream away from these diversions. These solutions are presently being considered by public environmental and angler groups, water users, DFG, DWR, and U.S. Bureau of Reclamation as part of the "Article VII" discussions convened by the Two-Agency Fish Protective Agreement.

iv. DWR is pursuing project planning and preparation of environmental documentation for their proposed North Delta Water Management Program (NDWMP) and South Delta Water Management Program (SDWMP). One of the objectives of the NDWMP is reduction of SWP fisheries impacts, principally through reduction in the intensity and occurrence of reverse flows in the lower San Joaquin River. As currently proposed, the NDWMP would accomplish this change in reverse flows by diverting a large proportion of Sacramento River flow into forks of the Mokelumne River via new or existing channels.

Other likely effects of the NDWMP include reductions in Delta outflow and reductions in lower Sacramento River flows. When combined with the SDWMP, there is a possibility of higher SWP export rates and intensification of reverse flows in lower Old River. The two projects could be operated to reduce exports in spring and summer when conditions in the Delta are critical for young striped bass by increasing exports during periods of high flow.

The net effect on striped bass of changes to the Delta resulting from the NDWMP and SDWMP will be addressed in environmental documentation due to be completed in draft form in late 1989.

v. The DFG has negotiated with the U.S. Bureau of Reclamation and other water agencies for development of Delta Cross Channel (constructed in 1951) operating criteria to help protect striped bass and chinook salmon. When Delta outflows exceed 12,000 cfs in spring and early summer, the SWRCB requires the U.S. Bureau of Reclamation to close the DCC gates for specific time periods to allow bass eggs and larvae to pass down the main Sacramento River. Although the U.S. Bureau of Reclamation is not required to close the gates for the entire period, in practice they have done so as long as outflow exceeds 12,000 cfs. Unfortunately, at lower flows the gates are not closed due to water delivery constraints. A "Catch 22" problem develops with prolonged closure of the DCC and sustained Delta diversions in that water flowing down the Sacramento must eventually be drafted upstream around islands in the western Delta to the State/federal pumps, which creates the serious problem of upstream (reverse) flows described earlier. The DFG is continuing investigations to refine operating criteria needs, and improvements are expected in the near future.

vi. The DWR is investigating Sherman Island needs as part of their West Delta Water Management Program. Two major alternatives for Sherman Island's future that would help striped bass are: (a) to continue as an agricultural producer, in which case some diversions could be consolidated and relocated to areas with low bass egg and larval concentrations; and (b) to convert to a wildlife management area with associated benefits, and with much less water diversion from the Delta.

vii. For many years the DFG considered the Peripheral Canal (PC) to be the best Delta water management alternative to protect striped bass; mainly because it moved major Delta water diversions away from the prime bass nursery area. A proposal to construct the PC was defeated in a public election in June 1982, and little consideration has been given to the PC since then.

viii. Recent evidence indicates that the predatory bass population in Clifton Court Forebay exchanges with the Bay-Delta population. Killing those predators, therefore, would be counterproductive to bass restoration efforts. Two possible solutions are: (a) install fish screens to prevent entrainment of fish into Clifton Court Forebay; and (b) remove and transplant bass in winter and early spring.

ix. Construction of new reservoir "off-stream storage" and related facilities near or south of the major aqueduct intakes (SWP, CVP) could allow pumping to be reduced substantially during periods of high abundance of bass eggs and larvae.

x. Modifications are "on line" at the Skinner Fish Facility to improve fish salvage capabilities. It does not appear likely, however, that additional significant improvements can be made to the existing fish screen complex to save bass eggs, larvae, and bass smaller than 1.5 inches.

xi. Ways to increase bass survival during fish screen salvage and trucking operations are: (a) the fish "collection bucket" should never be overloaded, and fish should not be held in the bucket longer than five minutes; (b) salt (0.4% NaCl concentration) should be added to the fish truck water when directed by DFG biologists; (c) compressed oxygen (4 psi) should be used to maintain proper dissolved oxygen concentrations in the fish truck water; and (d) water venturi aerators should not be used in fish truck tanks.

xii. The "Secondary Fish Screen" at the State John E. Skinner Fish Screen Facility may need to be covered to darken it, thereby reducing predation losses.

C. <u>The Contra Costa Canal (CCC) (part of CVP) intake on Rock Slough</u>, which began operating in the south Delta in 1940 with a diversion capacity of 350 cfs. Detailed problems are: (1) bass eggs, larvae, and young are lost down this unscreened diversion canal; (2) this diversion contributes to the reverse (upstream) flows in the Delta east of Antioch which increase the number of bass eggs and young entrained, and disrupt migrations of young and adult bass throughout the Delta; (3) the food supply (plankton) of young bass in the western Delta and Suisun Bay has been reduced by entrainment of plankton and by the rapid transport of water through Delta channels that supply south Delta diversions.

<u>Solutions to problems caused by CCC diversions:</u>

i. The DFG, Contra Costa County Water Agency, and other appropriate agencies and interests should develop an agreement regarding direct and indirect fish losses caused by the CCC diversion. The intent would be to produce an agreement similar to the one approved by the DWR and DFG in December 1986 to offset direct fish losses caused by the State Harvey O. Banks Delta Pumping Plant.

ii. The loss of bass eggs, larvae, and juveniles into the CCC could be partly resolved by: (a) installing a fish screen at the intake; (b) relocating the intake to an off-stream storage reservoir; or (c) relocating the intake to the existing Clifton Court Forebay. Alternatives b and c might be years in the future, whereas, fish screen development could proceed sooner, but presents major technical difficulties because of the intake location in a dead end channel.

iii. Curtail pumping when bass eggs and larvae appear in great abundance at the intake to the CCC, and provide flows adequate to move eggs and larvae toward the western Delta and Suisun Bay. Efforts to resolve SWP and CVP bass entrainment would greatly aid solution of CCC problems.

D. <u>The Pacific Gas and Electric Company (P.G.&E.) electric power generating plants at Antioch and Pittsburg</u>, which technically do not "divert" Delta water because most water drawn in for cooling purposes is returned to the estuary. Thus, the primary issue is the mortality of fish and plankton entrained in this intake water as it passes through the plants. For the most part, these plants were operating by the mid-1960's with a collective intake capacity of almost 3,100 cfs.

The Contra Costa Plant at Antioch has seven units, five of which began operating between 1951 and 1953, and the last two started in 1964. The collective intake capacity is 1,500 cfs.

The Pittsburg Plant also has seven units, six of which started between 1954 and 1961, and the last began in 1972. The collective intake capacity is 1,600 cfs. Detailed problems are: (1) bass eggs, larvae, and young are entrained and killed by thermal shock and abrasion. Some larger bass die when they are impinged on the fish screens at these intakes; and (2) the food supply (plankton) of young bass in the western Delta and Suisun Bay has been reduced by entrainment of plankton into power plant intakes.

<u>Solutions to problems caused by P.G.&E. diversions:</u>

i. P.G.&E. has changed their physical structures and pumping operations to reduce bass losses by 40% to 80% in relation to losses in the 1970's. This is accomplished primarily by pumping less water when bass egg and larva abundance is high at the intakes.

ii. P.G.&E. purchases hatchery-reared striped bass yearlings to be stocked as mitigation for the remaining entrainment losses. The DFG has been tagging these fish, and its evaluation report is due to P.G.&E. in March 1990. Future mitigation efforts will depend largely on the conclusions of that report.

iii. Further reduction of entrainment mortality is desirable, however, no practical ways appear feasible. The situation should be monitored for potential feasible improvements.

E. <u>The approximately 1,800 private unscreened agricultural diversions in the Delta that have operated for decades.</u> Approximately 2,500 to 4,800 cfs are diverted from May through August by all such Delta agricultural intakes, with lesser amounts diverted at other times.

Detailed problems are: (1) bass eggs, larvae, and young are entrained and killed in these unscreened pumps and siphons; (2) the food supply (plankton) of young bass in the western Delta and Suisun Bay has been reduced by entrainment of plankton into these Delta diversions.

<u>Solutions to problems caused by agricultural diversions:</u>

i. Agriculture diversions should be consolidated and relocated to areas with low bass egg and larval concentrations.

ii. Virtually all of the larger "several hundred" existing agriculture water diversions in the Delta should be screened on a priority basis to keep out bass longer than 1.5 inches.

iii. Screened diversions should be examined to identify desirable improvements.

iv. Establishment of "area-wide" voluntary rescheduling of water diversions should be considered by all parties in selected locations when bass eggs and larvae are at peak abundance during spring and early summer. No infringement or impairment of riparian water rights would be necessary.

v. The DFG, Delta agriculture interests, collectively, and other appropriate agencies should establish (negotiate) future screening needs, and explore new irrigation schemes to protect young bass. Agencies involved include North Delta, South Delta, and Central Delta Water agencies.

vi. Any unavoidable losses of bass in Delta agriculture pumping should be mitigated with hatchery-reared bass, or with habitat improvement projects.

vii. Improved water distribution and use schemes should be developed throughout the Delta to minimize bass losses while meeting water demands.

II. Reduced Delta Outflows

Multiple water diversion and storage projects on each significant tributary to the Sacramento-San Joaquin Estuary, coupled with water exports south of the Delta, have reduced Delta outflows past Chipps Island in spring and early summer. Most upstream water storage projects are unrelated to Delta diversions. Thus, low Delta outflows are the collective result of Delta diversions and upstream diversions and storage by irrigation districts, water agencies, and SWP and CVP reservoirs. Much of the nutrient load that formerly washed down annually into the estuary has been diverted or stored. Some of the stored nutrients have been redirected into reservoir fish production.

Two obvious effects on striped bass, however, are that reduced Delta outflows in spring and early summer sometimes make the lower San Joaquin River saltier than desirable for bass spawning; and they reduce the transport of bass eggs and larvae and thus, spatially, restrict their nursery area. A reduced nursery area curtails the level of fish production.

<u>Solutions to reduced Delta outflows:</u>

i. Delta outflows should be increased past Chipps Island in spring and early summer, even if mainly from the Sacramento River, as they would increase young bass habitat by distributing them farther downstream, thus allowing them to use more of the western estuary, especially Suisun Bay and San Pablo Bay.

ii. The DFG is seeking increased minimum outflows through the Delta by presenting its case to the State Water Resources Control Board (SWRCB) at the Board's Delta Water Rights Hearings.

iii. The DFG (and others) are also seeking increased outflows through negotiations with DWR and USBR. Such negotiations have started pursuant to Article VII of the December 1986 agreement which commits DWR and DFG to seek measures to offset SWP impacts not dealt with in that agreement (see also solutions to Low San Joaquin River Flows).

III. Low San Joaquin River Flows

Low flows in the San Joaquin River near Stockton often combine with agricultural drain water to create an effective dissolved solids barrier to upstream migration and spawning by striped bass. This problem has two causes; upstream water diversions and agricultural waste waters. The basic water quality problem is one of high total dissolved solids (TDS).

A major complication here is that if the dissolved solids barrier is eliminated, adult bass will move much farther up the San Joaquin before they spawn. The resultant eggs and larvae, however, would immediately become vulnerable to ready entrainment into the nearby SWP and CVP pumping plants near Byron.

Solutions to low San Joaquin River flows:

i. Salinity standards in the lower San Joaquin River, downstream from Stockton, must be upgraded to acceptable levels if bass are to ever use the river upstream from the Delta for spawning. At the same time, it is essential that concurrent solutions be developed to avoid entrainment into SWP and CVP pumping plants of eggs and larva produced by bass migrating farther up the San Joaquin.

ii. If and when solutions to entrainment into the SWP and CVP pumping plants are developed, the DFG and the collective San Joaquin Valley and south Delta agriculture interests should develop ways to provide better water quality in agricultural drain discharges into the San Joaquin River.

iii. The DWR, USBR, and South Delta Water Agency agreed (South Delta Agreement) in 1986 to work together to develop mutually acceptable, long-term solutions of water supply problems of the South Delta Water Agency. Objectives of the South Delta Agreement are to improve and maintain water levels, circulation patterns, and quality in the south Delta. Evaluation of multi-purpose alternatives to meet these objectives will also take into account broader objectives of the USBR and DWR, which are to improve: fishery conditions, water supply reliability, efficiency of CVP and SWP operations, navigation, flood protection, and enhance recreational opportunities.

Several alternatives are being considered for achieving water management objectives in the south Delta. Each alternative would have different, specific impacts on striped bass - some neutral, some beneficial, some detrimental. The various possible combinations of these alternatives, therefore, require careful analyses to determine the most desirable conditions for striped bass (and other species). The DFG, and others, will be conducting such evaluations to determine impacts of proposed projects on fish.

Fishery benefits may be provided through a conjunctive use program with New Melones, which would provide additional flow down the San Joaquin River during periods critical to fish. Fishery benefits might also be realized through a winter banking program with use of storage south of the Delta, which may shift some pumping operations from spring and summer (periods critical to striped bass and other species) to winter when bass and other species are less abundant and less vulnerable.

In addition, the Two-Agency Fish Protective Agreement would be renegotiated prior to any increase in exports above existing U.S. Corps of Engineers constraints, with possible inclusion of the federal government in negotiations.

Meetings to implement the South Delta Agreement, and related programs, are attended by public agencies and parties interested in the proceedings. Proposed projects are identified, evaluated, and some are recommended for action. The final environmental document is expected in early 1990.

IV. Water Pollution, Toxic Chemicals, Trace-Metals

Water pollution, including toxic chemicals (petrochemicals pesticides, and chlorinated hydrocarbons) and trace-metals (mercury, selenium, copper, cadmium and zinc) is harmful in many ways to bass of all ages. Dredging and spoil disposal are treated as a separate pollution problem (V.) because of their unique nature and solutions.

Actions by the Regional Water Quality Control Boards have greatly improved water quality since the early 1960's, principally from the standpoint of Biochemical Oxygen Demand (B.O.D.) and some toxics. Similar progress, however, has not been made in reducing many serious toxicants. Toxic chemicals and trace-metals potentially stress, debilitate, or kill bass eggs, larvae, young, and adults and their food (and possibly impact primary productivity) throughout the Sacramento-San Joaquin Estuary. Studies on Atlantic Coast stocks of striped bass show that the combination of toxic chemicals and trace-metals found in those waters significantly decreased survival of young bass. Chronic exposure to toxicants appears universal, and continues today, in Bay-Delta bass.

For example, 67 percent of the 46 adult bass examined in 1987 contained unmetabolized DDT in the liver (public use of the pesticide DDT was banned in 1973).

The complexities of the toxics problem make it difficult to analyze and resolve. Current knowledge provides a relatively narrow view of the myriad of chemicals and possible toxic interactions in the Sacramento-San Joaquin Estuary. State water quality control agencies project increases in the volume and complexity (content) of municipal, industrial, and agricultural waste discharges into the Bay-Delta system. The U.S. Environmental Protection Agency (EPA) has developed several tests for biomonitoring of marine and freshwater discharges for chronic toxicity. Unfortunately, the applicability of these test responses from marine and freshwater organisms to the health of striped bass is unknown, and further work is necessary to be able to link causes with effects.

Nonpoint source run-off of pollutants is one of the largest unresolved problems facing waters of the Sacramento-San Joaquin Estuary. Each year billions of gallons of storm water run-off wash into this estuary carrying toxic and other waste materials from streets, parking lots, and other areas which are often incidental dumping grounds for all kinds of urban waste, trash, and garbage. The costs for assessing and correcting problems, and policing to prevent future problems are enormous.

Due to several mandates regarding underground tank inspections, the San Francisco Regional Water Quality Control Board has reduced its field checking program for regulated waste dischargers. The Board relies heavily upon the Department to assist in field response and data collection during any "spill" incidents. With regard to striped bass and other fishery resources, there is particular concern about the various municipal discharges throughout the estuary. It is common for these operations to have upsets in their treatment systems with the result that large amounts of highly toxic chlorine, and other materials, are discharged directly to the receiving waters. There is a strong need to institute a field checking program using representative estuarine testing organisms for these operations.

The DFG conducts an annual Striped Bass Health Monitoring Program (SBHM) funded by the SWRCB that follows procedures developed by the NMFS. This program is a component of the Regional Effects Monitoring element of the State's Aquatic Habitat Program. The purpose of this component is to monitor the physiological and reproductive condition, and pollutant burdens, of adult bass over a long period of time.

The monitoring, which began in 1978, demonstrates that adult female bass exhibit substantial parasite burdens, have annually variable egg resorption rates, and contain detectable levels of a wide range of potentially harmful pollutants. However, only weak associations between fish condition and pollutant body burdens have been scientifically demonstrated. This lack of strong correlation may be due to the limited scope of pollutant analyses. In addition to parasite enumeration, the current SBHM program measures synthetic organic pesticides, trace-metals and low boiling point (volatile) petrochemicals.

Three classes of dangerous chemical compounds have been detected only recently in organisms from the Sacramento-San Joaquin Estuary. The three chemical classes are polynuclear aromatic hydrocarbons (PAH's), polychlorinated dibenzodioxins (PCDD's), and polychlorinated dibenzofurans (PCDF's). These chemicals may have far worse effects on striped bass health than chemicals currently analyzed.

PAH's, such as napthalene and benzo(a)pyrene, enter waterways in oil refinery discharges, oil spills, municipal sewage discharges, atmospheric fallout, and surface water run-off. Ambient values as low as 5 ppb can be toxic to fish, and PAH's and their metabolites have been associated with liver tumors. Some scientists believe PAH's may present more of a threat to fish than do volatile (low boiling point) petrochemicals such as xylene.

PCDD's and PCDF's can be released by certain industrial processes; e.g., pulp and paper plants, pesticide and wood treatment plants, incinerators, chlorinated power plant discharges, and sewage treatment plants. These compounds have recently been found (through new, expensive procedures) at concentrations of significant health concern in striped bass and rainbow trout from the Sacramento-San Joaquin rivers. An isomer of PCDD, 2,3,7,8, tetrachlorodibenzodioxin, is 10,000 times more toxic to fish than either toxaphene or endrin, with a No Observed Effect Level (NOEL) of less than 0.038 parts per trillion, and a bioconcentration factor of up to 39,000.

<u>Solutions to problems caused by water pollution, toxic chemicals, and trace-metals:</u>

i. Continue to operate the Aquatic Toxicology Laboratory at the DFG Central Valleys Hatchery to determine "effect" and "no effect" levels of specific toxic chemicals, sediments, and point and nonpoint discharges in Delta water on young bass and opossum shrimp. Isolated problems will be directed to the appropriate regulatory agency for corrective action.

ii. Determine relationship in responses among estuarine test species (striped bass and opossum shrimp) and freshwater and marine test species used in monitoring and assessing chemicals and waste discharge requirements.

iii. Since 1978 fish have been collected from the Sacramento and San Joaquin rivers during spring spawning runs, examined physically in detail, and analyzed for a variety of pollutants. It is appropriate now to review program progress and suggest improvements to the monitoring based on data collected thus far. Analysis of PAH's, PCDD's, and PCDF's may be desirable. A review of the monitoring will assure a reliable data base that can be used to determine whether and how pollutants are affecting reproduction and survival of a major fish stock. Previous studies show that pollutants may be contributing to the poor health of the striped bass population, the most important sport fishery in the Bay-Delta. Data developed by the Striped Bass Health Monitoring Program will aid State and regional boards in making water quality management decisions for protection of this fishery.

iv. The Regional Water Quality Control Boards (RWQCB) should strengthen their routine field checking program for regulated waste dischargers. An active field program, with assistance from the DFG and interested volunteer groups, would help in identifying unauthorized waste discharges. In addition, rigorous enforcement of all recorded violations of effluent standards designed to protect fish and aquatic life, including striped bass, is essential.

v. The DFG should continue to participate in the federal EPA Bay-Delta Management Project to better define pollutant effects and necessary programs.

vi. Agricultural pesticides in Delta return drains should be regulated and monitored by appropriate agencies to insure proper fishery safeguards.

vii. The DFG should continue to support SWRCB and RWQCB programs to control point and nonpoint sources of water pollution in the Sacramento-San Joaquin Estuary. Those cooperative efforts should ensure that water quality control plans and water quality objectives adopted by these agencies are adequate to protect striped bass.

viii. Advocate establishing comprehensive monitoring and cause and effect studies through the Interagency Program and Aquatic Habitat Institute.

ix. DFG law enforcement and water quality personnel should continue an aggressive program to detect violations of water pollution laws, improve pollution investigations, and incident response capabilities.

V. Dredging and Spoil Disposal

Dredging for navigation and other purposes, and the required spoil disposal are essentially water pollution problems. These activities are treated separately from other water quality problems because they differ in both operation and control methods.

Dredging and in-bay spoil disposal recirculate toxic chemicals and trace-metals deposited previously in bottom muds whereby they then become concentrated in striped bass, probably partly via the food web. In addition, concurrent turbidity abrades fish gills, reduces phytoplankton, smothers bottom organisms, and interferes with fishing activities.

The practice of slurrying spoil before disposal instead of disposing of the more solidified material from clamshell dredging appears to have exacerbated problems by causing excessive turbidities and enhanced release of toxic materials to the water column. The DFG has documented a serious decline in fishing success in San Francisco Bay over the past few years that has been strongly correlated with spoil disposal turbidities.

The U.S. Army Corps of Engineers constructed the two-mile long Mare Island Training Wall (Dike 12) in 1908 at the southern tip of Mare Island to maintain the channel for ocean-going ships. That wall prevented most dredge spoil or sediment that entered Carquinez Strait from circling around in San Pablo Bay and filling the main channel. Dike 12 is now owned and maintained by the U.S. Navy. Unfortunately, Dike 12 appears to have caused the filling (landfill) of at least five square miles of northern San Pablo Bay and severe shoaling of another five square miles. San Pablo Bay is now likely to be minus a minimum of 10 square miles of high quality, open water bass habitat that existed before Dike 12 was constructed. If that project was proposed today, it might well be rejected because of its environmental damage to San Pablo Bay.

<u>Solutions to problems caused by dredging and spoil disposal:</u>

i. The current practice of in-bay dredge spoil disposal should be discontinued. An ocean disposal site should be selected and used for disposal of spoil from in-bay dredging projects. The ocean site should be in deep water that does not directly support sport or commercial fisheries, and does not support other valued or unusual species or populations of fish or wildlife. The process of ocean site selection is directed mainly by the U.S. Environmental Protection Agency (EPA) and U.S. Army Corps of Engineers and should be designated by 1994.

ii. Until an acceptable ocean disposal site is designated, the RWQCB should incorporate the following conditions in their Water Quality Basin Plan: in-bay spoil disposal should be restricted to small projects that are absolutely essential, that cannot be delayed until the ocean site is available, and for which acceptable on-land disposal sites are unavailable. Such spoil should not be slurried before release. These projects should not discharge spoil into the Bay during the principal recreational fishing season - May through October, inclusive. Projects near Pacific herring spawning grounds should not be dredged or discharged from December through February, inclusive.

iii. On-land spoil disposal sites should be approved only where there is no adverse impact on wetlands or other fish or wildlife habitats or populations.

iv. Before any ocean or Bay disposal of spoils, subject spoils should be tested for toxicity and the presence of toxic or bio-accumulative contaminants. Only spoils found free of toxicity and contaminants should be allowed to be discharged to estuary or ocean waters.

v. Bottom muds of the Bay and Delta should be surveyed cooperatively by federal (U.S. Corps of Engineers, U.S. Geological Survey, etc.) and State agencies to identify areas which contain significant deposits of trace-metals and other toxic materials. The bottom sediment surveys would lead to recognition of potentially detrimental dredging locations and of areas in which dredging might be tolerated under specific control criteria.

vi. The two-mile long Dike 12 of the U.S. Navy at the southern tip of Mare Island may be unnecessary today. Significant spoil disposal in the estuary is no longer acceptable, and the annual sediment load that now passes beneath the Carquinez Bridge is smaller than it was in 1900. Extensive dam and water diversion projects on every significant tributary have cut water and sediment outflows. In addition, it is likely that the State-federal silt/sediment management objectives and methods of 1989 differ from those in 1900 when

Dike 12 was conceived, analyzed, and proposed. The Corps of Engineers' "San Francisco Bay Model" in Sausalito could be enlisted as part of a State-federal investigation to determine the feasibility and desirability of removing Dike 12 to restore the environmental values and fishery and biological production of San Pablo Bay.

VI. Bay-Fill Projects

Obliteration of open water areas by filling Bay and Delta tidelands reduces bass and bass-food habitats by varying degrees. Research reports by San Francisco Bay Conservation and Development Commission (BCDC) reveal that such filling also reduces the estuary's total water volume - its tidal prism; i.e., the water mass that moves in and out of the Golden Gate with the tides. A reduced tidal prism means present estuarine waters are unable to assimilate the same amount of certain pollutants that could be assimilated in previous decades. Thus, each fill project can not only reduce the bass environment, but it can precipitate certain water quality problems which, in turn, can be detrimental to the remaining bass population and its food supply.

State reports document that between 1860 and 1959, 243 square miles of marshlands and tidelands were filled or diked-off out a total of 568 potentially fillable square miles. Bay-fill has been substantially less from 1959 up to the present due to creation of BCDC in 1965. Nevertheless, both water surface area and the tidal prism of the estuary are much smaller today than in the early 1900's.

Solutions to Bay-fill projects:

Continue to work with BCDC and the Corps of Engineers in reviewing bay-fill proposals to: (a) prohibit unnecessary fill and allow fill for only public water-dependent projects such as port development; (b) require complete mitigation and compensation in the form of wetlands, tidal waters, and other waters that are unavoidably filled by water-dependent projects. Such mitigation/compensation must include timely acquisition and full restoration of tidal waters and wetland areas both in terms of tidal prism, surface area, and habitat values affected by the project(s); (c) add or improve public fishing access in minor fill projects; and (d) identify projects which the DFG should oppose because they are overly detrimental to bass and their habitat.

VII. Illegal Take and Poaching

Illegal take and poaching are frequent problems in Bay-Delta waters. Department wardens cite anglers for bass overlimits and undersized fish, and arrest people using illegal nets for striped bass. "Stings" have uncovered marketing of illegally caught bass in the Bay-Delta area. The level of enforcement effort, however, is insufficient to prevent all of the poaching.

Solutions to illegal take and poaching:

i. The general public and anglers should routinely utilize the Cal-Tip program to advise the DFG of poachers, illegal selling of striped bass, and violations of angling regulations. The DFG needs public involvement for effective enforcement.

ii. The DFG will augment night and overtime patrol to apprehend violators of fish and game laws and regulations in Bay-Delta waters. Special equipment to aid striped bass enforcement will continue to be purchased, including night-vision scopes, shallow-water jet boats, deep-water patrol boats, and undercover vehicles.

iii. Courts and prosecutors that judge violations of striped bass laws should be fully informed of the grave plight of the bass resource so that maximum legal penalties will be imposed to deter future violations. Such an informational process could be conducted by the DFG in cooperation with public volunteers.

VIII. Diseases and Parasites

Diseases and parasites stress, debilitate, or kill young and adult bass throughout Bay-Delta waters. The incidence and severity of fish diseases and parasites are influenced by water quality (good or bad) and fish health (good or poor). Bay-Delta bass are more heavily infested with parasites than Atlantic coast bass. This may occur because: (a) there may be different marine parasites on Atlantic and Pacific coasts; (b) California descendants of New Jersey bass may have poor resistance to Pacific parasites; (c) the Bay-Delta environment may be degraded to the point that bass resistance to parasites is weakened; or (d) some combination of all three possibilities.

California striped bass can be infected to varying degrees with the following parasite and disease organisms:

A. Flukes (trematodes) on the body and gills are Gyrodactylus sp. and Cleidodiscus pricei, in the eye Diplostomulum sp., cysts embedded in the flesh may be dormant stages of yellow grub (Clinostomum marginatum) or white grub (Posthodiplostomum minimum);

B. Large external anchor worms (copepods) are Lernea sp.;

C. Flatworms (cestodes) in the gut and body cavity are Lacistorhynchus tenuis which can cause external body lesions, and Tetraphyllidea sp.;

D. Roundworms (nematodes) in the gut, body cavity, and flesh are Anasakis sp., Phocanema sp., Spiroxys sp., and Contracaecum brachyurum;

E. Bacterial infections include gastroenteritis (Aeromonas sp.) and fish tuberculosis (Mycobacterium sp.); and

F. Protozoan infections of the external body and gills (ectoparasites) include Costia sp., Tricophyra sp., Tricodina sp., and Ichthyophthirius multifilis.

Future detrimental water quality changes might aggravate any disease or parasite condition. Fish health is degraded by toxicants, but the health monitoring project does not demonstrate a decrease in health or an increase in parasitism in Bay-Delta bass since 1978 when this monitoring began.

Solutions to diseases and parasites:

i. Continue to conduct the annual monitoring of striped bass "health" to document status and trends of bass parasites and diseases. Such scientific documentation of trends will support the case for instituting measures to improve bass health.

ii. Little likelihood exists for direct control of these problems as is done for humans with individual treatment. Indirect controls, such as improving water quality and introducing parasite-resistant bass from the Atlantic coast (if there are any), might help. While no studies have been conducted to test such hypotheses, these ideas should be explored.

IX. Annual die-off of adult bass

Almost every year there is a summer die-off of adult bass near Carquinez Strait. The severity and location vary annually with observed numbers ranging from several hundred to about two thousand. This has occurred for more than 40 years, and perhaps since the initial introduction of striped bass from Atlantic waters.

As the Delta environment continues to change, it is possible this die-off might escalate to major proportions. Although not a universal phenomenon, die-offs of stripers have occurred on the east coast and in some large reservoirs. The die-off may be genetically influenced, but knowledge of the cause might lead to its elimination.

Solutions to annual die-off of adult bass:

The cause of the die-off is unknown, but ongoing studies by University of California at Berkeley point to liver dysfunction as the major predisposing factor. Both University of California at Berkeley and University of California at Davis will complete a four-year investigation in late 1989 that is funded by the striped bass angling stamp. Studies include: autopsy of dying bass; tissue examination for toxic chemicals and trace-metals; search for internal/ external parasites; examine organs for bacterial, viral, or fungal afflictions; identify various hormone levels in blood; and evaluate environmental parameters. The final reports for these studies will be evaluated to determine whether follow-up investigations are warranted.

X. Commercial Bay Shrimp Fishery

The commercial shrimp fishery in Suisun Bay, and other areas, kills young bass during netting operations. The great value of wild, young bass makes the evaluation of any possible detriment to them a priority activity. The Department first investigated this problem in 1976 and commercial shrimp regulations were changed to better protect young bass in Suisun Bay. In 1984, additional DFG evaluations resulted in regulation changes to further reduce the take of young bass during the shrimp harvest.

Solutions to bass losses by commercial bay shrimp fishery:

In early 1989 the DFG analyzed shrimp and bass data collected by the "Delta Outflow/San Francisco Bay Study" and found that juvenile stripers and market-size shrimp existed together in some areas open to commercial shrimp fishing. Current regulations allow shrimp fishing in areas where large numbers of shrimp and young-of-year (YOY) bass overlap, and this overlap may be greatest during dry years. However, the analysis does not indicate anything about striped bass mortality associated with shrimp trawling operations. Information on such mortality would have to be developed from special field studies. Bass data used in this study do not cover the entire area where the bass population occurs. This is important because it is not possible to project impacts on the overall bass population. Bass can potentially be impacted by shrimp fishing as currently regulated, but the significance of the impacts cannot be determined more precisely than in 1976 without further substantial field efforts involving onboard observers on several shrimp boats. The DFG is reviewing details of a project to place observers on active shrimp boats.

XI. Exotic Aquatic Organisms

For decades there have been continual, unauthorized introductions of worldwide exotic aquatic plants and animals (many microscopic in size) into the Sacramento-San Joaquin Estuary through discharge of ballast water from ships entering San Francisco Bay from foreign ports. Some introductions can have, and may already have begun to have, major detrimental impacts on populations of existing aquatic organisms, including striped bass and their food supplies.

Several species of exotic aquatic organisms, probably introduced via ships pumping ballast water obtained from Chinese and Japanese waters, have become extremely abundant. This is particularly true of the yellowfin goby (*Acanthogobius flavimanus*). It was apparently accidentally introduced in the early 1960's. Since then it has greatly expanded its range and is now abundant in the Sacramento-San Joaquin Estuary and various bays and estuaries along the coast. The yellowfin goby has intruded into freshwater canals and several reservoirs which are directly supplied from the Delta. Like other gobies, it has a voracious appetite and feeds on invertebrates and small fishes. In general, it is an undesirable addition to California waters. These gobies have partially replaced the native longjaw mudsucker (*Gillichthys mirabilis*) and staghorn sculpin (*Leptocottus armatus*), formerly abundant and part of a bait fish industry in this estuary. That bait fish business now also utilizes the yellowfin goby.

The native zooplankter *Eurytemora affinis* is a major food item of young bass. The Chinese zooplankter *Sinocalanus doerii*, from Asian waters, appears to out-compete *Eurytemora* sp. and may be replacing the native species. Preliminary tests suggest *Sinocalanus* sp. may not be an equally acceptable or desirable food for young bass.

The Chinese clam, *Potamocorbula amurensis*, also introduced from Asian waters, has recently and rapidly established large populations in the Sacramento-San Joaquin Estuary. *Potamocorbula* sp. may be feeding on *Eurytemora* sp., which in turn may impact young bass food supplies.

Two other species of zooplankton, *Pseudodiaptomus marinus*, from Japan, and *P. forbesi*, from China, erupted into large populations in 1988 in the Delta.

While some introductions of plants and animals have been beneficial, there are numerous examples, worldwide, of biological disasters caused by both deliberate and accidental introductions of exotic organisms. Certainly it is unwise to permit continuous, indiscriminate, large-scale introductions of aquatic organisms into this estuary from around the world. Predictions of present and future impacts of these ecological changes on striped bass are, as yet, only ominous guesses. Unfortunately, if introductions continue unchecked, such guesses will develop into grave consequences for many species.

Solutions to exotic aquatic organisms:

i. Prohibit discharge of ship ballast water within the Sacramento-San Joaquin Estuary. All ship ballast water emptying and refilling procedures should be conducted in the open sea several miles west of the Golden Gate Bridge.

ii. Examine life cycle and environmental requirements of various undesirable exotic species for the purpose of developing measures to eliminate or adequately control their populations.

PROBLEMS OF HUMAN USE OF STRIPED BASS (AND SOLUTIONS)

Four problems reduce or restrict optimum public use and enjoyment of striped bass: (1) a reduced bass population; (2) public health concerns about mercury and parasites; (3) unsightly lesions, worms, and parasites; and (4) tainting of bass flesh. These problems and their solutions are:

I. Reduced Bass Population

The adult bass population of today is one-third to one-fourth of what it was in the early 1960's. It is not surprising, therefore, that the present annual angler catch of stripers from the Sacramento-San Joaquin Estuary (150,000) is but one-fifth of what it was in the early 1960's (750,000). This reduced catch is due mainly to fewer bass being present. Part of the catch reduction, however, is because angling regulations were changed in 1982 to reduce total catch (minimum size increased from 16" to 18", and the daily limit dropped from three to two).

<u>Solutions to a reduced bass population:</u>

i. Hatchery-reared bass can be stocked to increase the adult population and angler catch. The DFG has been stocking tagged bass since 1982 at different sizes (ages), in several locations and following-up with a Bay-Delta creel census for several years. That program has expanded from annual stocking of 25,000 bass from the DFG Central Valleys Hatchery (CVH), to the current level of tagging and stocking 400,000 yearlings and 600,000 fingerlings and stocking about another 200,000 untagged yearling/fingerling bass each year. These efforts will enable the DFG to identify which stocking strategy produces the best benefit/cost ratio in terms of returns to the anglers' catch and the adult bass population over several years <u>versus</u> costs to produce and stock the fish. The final analysis will be complete in mid-1994, but each year provides more knowledge. Bass are supplied by up to 10 private aquaculture facilities in addition to CVH. P.G.&E. and DWR now purchase bass as a result of mitigation requirements resulting from their Bay and Delta operations.

The DFG favors stocking young striped bass as an interim project, but it recognizes there are several reasons that planting large numbers of hatchery-reared bass forever may not necessarily provide the most feasible or desirable solution of the Bay-Delta bass problem. <u>First of all</u>, stocking hatchery-reared bass will not solve <u>any</u> of the 11 problems detrimental to striped bass. If any planting program is discontinued, there is every reason to believe the bass population would begin another serious decline, unless the problems detrimental to bass are solved. Secondly, other species that may or may not directly impact bass such as *Neomysis*, American shad, starry flounder, *Crangon* shrimp, steelhead, salmon, sturgeon, etc., are also impacted by some of the man-caused problems described earlier - and reliance on stocking bass will not help those species. Thirdly, present hatchery practices produce hundreds of thousands of hatchery bass from only a few parents, and those offspring may not possess the same genetic abilities as wild bass to cope with the ever-changing Bay-Delta environment. The possibility of genetic-based problems being created by existing and greatly expanded stocking programs is being analyzed by a fish geneticist at U.C. Davis with results due in late 1989. Fourthly, the number of hatchery bass required may prove physically infeasible and too expensive; e.g., the present maximum annual production of yearling bass from all sources in California approximates two million. With three million wild yearlings present today, an additional 7.5 million hatchery-reared yearlings would be required to create the 10.5 million yearling stock of the early 1960's. In 1988, 7.5 million yearlings would cost nearly $11.2 million.

Seven and one-half million yearlings equate roughly to 15 million "six-month" fingerlings, and perhaps 150 million "40-day-old" fingerlings. Those are extraordinary numbers of fish to produce by any means.

ii. A plus for bass restoration efforts is the 1988 development of a growout facility to rear wild bass fingerlings salvaged at the State Delta pumping plant. That facility was constructed and is operated with funds allocated by the DWR-DFG Two-Agency Fish Protective Agreement Committee and is staffed by DFG personnel. That project should help solve genetic problems and should increase survival of wild bass. Additional (expanded?) facilities are being considered, and there is a possibility private aquaculturists can be contracted with to rear bass salvaged at SWP and CVP screens at a significant saving.

iii. Angling regulations can maintain, increase, or decrease the anglers' catch of striped bass. Other than with a complete closure, however, the DFG cannot closely control total annual catch as it does not control the number of fishermen or individual fishing-days. There is no indication that Bay-Delta striped bass angling regulations should be changed at this time. The most important evidence supporting this position is that anglers harvest only 15% to 25% of the adult population annually, which is well within safe limits for a typical striped bass population.

If, however, annual DFG estimates of adult bass abundance fall below about 800,000 in two consecutive years, biologists generally believe that more restrictive angling regulations should be considered.

iv. The DFG stocks chinook salmon smolts near Benicia in the Delta. The young salmon sometimes attract large striped bass which are, in turn, caught by anglers in - at times - large numbers. It might benefit striped bass by reducing the heavy catches of them if the salmon were planted at night. Daylight bird predation on salmon would be eliminated. Striped bass stamp funds could be used to pay part of the overtime costs for such night stocking of salmon. Striped bass feed actively at night so this concept should be tested to verify its validity.

II. Public Health Concerns About Mercury and Parasites

The presence of methyl mercury and certain larval roundworms (nematodes) in striped bass pose potential threats to public health. The California Department of Health Services (DHS) has issued, for many years, "health advisories" regarding health hazards from eating fish from the San Francisco Bay and Delta region.

Concerning mercury; all bass collected in 1987 contained mercury, and 18 percent contained mercury levels in muscle tissue greater than U.S. Food and Drug Administration "action levels". The DHS health advisory states "Because of elevated mercury levels, no one should eat more than four meals per month of any striped bass from the San Francisco Bay-Delta region. Women who are pregnant, or may soon become pregnant, nursing mothers, and children under age 6 should not eat fish from the area."

Methyl mercury in striped bass in the Sacramento-San Joaquin Estuary is most likely the result of mercury in bottom sediments being resuspended and recirculated by decades of continuous, repetitious dredging and spoil disposal throughout the estuary. The process of mercury, bacteria, and nutrients interacting to produce methyl mercury in fish is documented in many waters.

Mercury occurs naturally in many California soils, and it was widely used in early gold mining processes. Thus, careless use of mercury in extracting gold from ore, plus the unnatural accelerated soil erosion during and following the Gold Rush days (circa 1850), flooded the estuary with mercury. Hydraulic mining in that period in the Sierra Nevada-Mother Lode devastated the environment of San Francisco Bay. Cubic miles of earth were washed down the rivers; Suisun and San Pablo bays were shoaled by the sediment. One study calculated that in the 41 years following the onset of gold mining (1849-1890), Suisun Bay had received 3.3 feet of deposition on the shoals, and San Pablo Bay had received 2.5 feet.

Solutions to public health concerns about mercury:

i. Curtailment of dredging and prohibition of significant spoil disposal in waters of the Sacramento-San Joaquin Estuary would probably reduce methyl mercury levels in bass (and other fish), but such benefits cannot be estimated quantitatively.

ii. Surveys of mercury presence in bottom sediments in the estuary would identify areas with different levels of mercury. Such surveys could lead to federal/State designation of "unacceptable" and "acceptable" dredging areas.

Concerning larval roundworms (*Anisakis* sp. and *Phocanema* sp.); humans can become infected with these larval nematodes by eating raw fish such as sashimi, salted fish, and marinated fish such as ceviche. The DHS health advisory states "Because of possible infestation (in humans) by parasitic organisms, no fish of any kind from the Bay-Delta region should be eaten raw. Thorough cooking destroys such parasites."

Solutions to public health concerns about parasites:

These roundworms are unlikely to disappear, and no feasible schemes have been developed to eliminate them from fish in the estuary. If people cook their fish thoroughly, there is no threat to humans from eating bass containing these, or any other parasites. Thorough cooking, therefore, is the only present solution.

III. Unsightly Lesions, Worms, Parasites

Anglers throw away striped bass severely infested with unsightly sores, external or internal worms, cysts in the flesh, or protozoan and bacterial diseases. While some "defects" can be cut out, and even though thorough cooking prevents harm to humans, such unappetizing fish detract from and discourage a person's fishing experience.

The abundance of these organisms on individual bass varies from none or few to many. In 1987, 89 percent of the 46 bass collected contained tapeworm larvae, and 62 percent had roundworm larvae.

Actions that reduce these infestations would increase angler use and enjoyment.

Solutions to unsightly lesions, worms, parasites:

These pathogenic organisms are unlikely to vanish, and therapeutic treatment for individual fish is impractical. Although there are exceptions, biologists believe that the cleaner the water - the healthier (parasite-disease free) the fish population.

The goal of reducing severity and frequency of parasite-disease infestations may be attained by upgrading water quality in the Sacramento-San Joaquin Estuary.

IV. Tainting of Bass Flesh

Some striped bass exhibit bad taste or odors during cooking and eating. Such flesh tainting can result from chemical absorption by the fish and by certain algae abundance. While flesh tainting may not kill bass, anglers eventually discard such fish, and this condition detracts from and discourages a person's fishing experience.

The frequency and severity of flesh tainting in striped bass has not been documented. It appears to vary yearly and by area in the estuary.

Actions that reduce flesh tainting would increase angler use and enjoyment.

Solutions to tainting of bass flesh:

The subject of flesh tainting of fishes is not totally understood. Pristine waters do not produce fish that smell or taste of oil/gasoline derivatives. Some unpolluted waters, however, produce fish with bad odor and taste that appear attributable to emergent aquatic vegetation and certain algae.

The goal of reducing severity and frequency of bass flesh tainting may be attained by improving water quality in the Sacramento-San Joaquin Estuary.

RESTORATION AND MANAGEMENT PLAN

As stated earlier, the major plan objective is to restore a self-sustaining Bay-Delta striped bass population to levels of more than three million adult fish. The Department's plan to achieve that objective follows a Four-Point Program:

I. __Develop public participation in plan preparation and implementation.__ To accomplish this the DFG plans to:

A. Submit drafts of the plan to angler, environmental, conservation, water user, and water developing organizations and agencies; including federal, State, and local governments, and other public and private entities interested in and involved with striped bass and water utilization. Meetings will be held with these entities to discuss the plan.

B. Develop recommendations that include tasks to be conducted by public and private agencies, groups, and organizations.

C. Prepare information leaflets and news releases to increase public awareness of problems detrimental to bass and their use, and needed solutions.

D. Develop a plan arrangement and format that will allow future changes without having to rewrite the entire plan report every few years.

E. Designate future dates for the public to consider revision of the plan; e.g., annually for five years, then every two years for six years.

II. __Resolve Problems Detrimental to Striped Bass.__ This major undertaking holds the most promise for permanently restoring the wild bass population. To accomplish this the following actions are needed (some prefer to call these "objectives"; and the means for achieving them, the "how", are described in detail in the solutions presented throughout this plan report):

A. Minimize entrainment losses of bass eggs, larvae, and young in water intake facilities at SWP, CVP, CCC, P.G.&E., and Delta agricultural diversions.

B. Eliminate reverse (upstream) flows in the Delta east of Antioch when bass eggs and larvae are present.

C. Increase Delta outflow at Chipps Island in spring and early summer.

D. Slow the rapid transfer of water through secondary Delta channels (not the main Sacramento and San Joaquin rivers).

E. Reduce quantities of petrochemicals, chlorinated hydrocarbons, pesticides, trace-metals, PAH's, PCDD's, and PCDF's contained in municipal, industrial, and agricultural discharges.

F. Reduce bass losses during fish screen salvage, handling, and fish release operations at SWP and CVP facilities.

G. Install fish screens on a priority basis on the larger Delta agricultural water diversions.

H. Improve any existing fish screens and their operation.

I. Consolidate and relocate Delta agricultural diversions to areas of lower bass abundance.

J. Reduce predation on bass at major water intake structures.

K. Curtail channel dredging and prohibit significant spoil disposal in Bay-Delta waters.

L. Eliminate future Bay-fill projects.

M. Reduce illegal take and poaching.

N. Reduce bass diseases and parasitic infestations.

O. Reduce the annual summer bass die-off near Carquinez Strait.

P. Minimize any kill of small bass by the commercial bay shrimp fishery.

Q. Stock hatchery-reared striped bass to help compensate for losses caused by the problems above, and to possibly contribute naturally spawned offspring to the overall bass population.

III. <u>**Resolve Problems of Human Use of Striped Bass.**</u> To accomplish this the following actions are needed (these may also be considered "objectives"; with detailed solutions described throughout the plan):

A. Continue to stock hatchery-reared bass to increase angler catch and augment the population. Consider substantial expansion of the stocking program.

B. Evaluate new locations to stock tagged striped bass.

C. Evaluate potential of bass "grow-out" facilities, including public and private facilities.

D. Continue to improve pond production of bass at State hatchery.

E. Maintain sport fishing regulations that protect the resource and allow reasonable public angling opportunities.

F. Reduce methyl mercury contamination of adult bass.

G. Reduce bass diseases and parasitic infestations.

H. Reduce tainting of bass flesh.

IV. **Conduct Fishery and Environmental Investigations.** To accomplish this the following actions are needed:

A. Develop techniques to better detect large masses (clusters) of bass eggs and larvae as they drift downstream and approach major water intakes.

B. Continue to survey the annual production of bass eggs, larvae, juveniles, and adults. Determine if large bass, older than six years, are being overharvested or suffering high mortality.

C. Improve annual estimates of larval bass growth and mortality through analysis of daily growth increments on ear bones (otoliths).

D. Survey waste discharges to locate sources of petrochemicals, chlorinated hydrocarbons, trace-metals, PAH's, PCDD's, and PCDF's.

E. Continue testing impacts of various toxicants, discharges, and mixes of Delta waters on young bass and their food organisms such as opossum shrimp and Eurytemora at Aquatic Toxicology Laboratory located at DFG's CVH. Seek to expand such cause and effect studies through the Aquatic Habitat Institute or Interagency Program.

F. Develop a striped bass population model to evaluate factors affecting bass population levels. This is being done by fish population dynamics experts at Oak Ridge National Laboratory in Tennessee.

G. Continue to analyze bass food production (supply) in spring and develop a suite of condition (starvation) indices for larvae to determine if food supply is a limiting factor.

H. Determine comparative toxicology among fathead minnows and striped bass and opossum shrimp and Ceriodaphnia (zooplankton). Fathead minnows and Ceriodaphnia are standard bioassay test organisms. Also, extend the working salinity range for striped bass and opossum shrimp bioassy tests to fill the void between freshwater and marine testing organisms.

I. Improve DFG ability to estimate bass egg and larva entrainment losses in State and federal south Delta pumping plants.

J. Compare suitability of Eurytemora (native copepod) versus Sinocalanus (exotic copepod) as food for young bass.

K. Determine the influence of parentally transferred residues of toxic chemicals and trace-metals on survival of embryos-to-fry bass.

L. Continue monitoring abundance and distribution of selected fishes, invertebrates, and aquatic plants to determine status and population trends. Fluctatuations in the abundance of native and exotic organisms may signal significant ecological changes in the aquatic environment that may be detrimental to striped bass and their food supplies.

M. Evaluate merits of adding east coast bass stocks for improved growth rates, higher fecundity, larger size, greater longevity, better parasite and disease resistance, and to reduce any possible genetic-based problems.

Implementation of Four-Point Program -- Phase II

Implementation of the Four-Point Program is the beginning of Phase II of the Striped Bass Restoration and Management Plan. Phase II represents all of the efforts to follow. The following procedures are guidelines for implementing the solutions and recommendations in this plan.

In January of each year all DFG project leaders involved with striped bass (staff and regions) will convene to identify progress, priority project needs, and annual work plans regarding the basic Four-Point Program. This DFG Striped Bass Working Group will have the following assignments:

A. Critique the previous year's striped bass Four-Point Program to identify results, conclusions, progress, and things that may have gone wrong. This brief annual summary report will preceed the proposed annual work plan.

B. Evaluate and revise, if necessary, the needs detailed in each of the four major points; and establish problem and activity priorities.

C. Develop a detailed work activity schedule for the calendar year. Each activity would be directed to a problem(s) or need(s) identified in the Four-Point Program, and would identify the DFG lead project; e.g., Region 3, Environmental Services; or Bay-Delta Project; or Inland Fisheries Striped Bass Stamp Project; or public volunteer group; etc. Activities scheduled would include efforts planned to: (1) involve federal, State, and local agencies in negotiations to develop agreements on ways to solve fishery resource problems; and (2) prepare reports and testimony for quasi-judicial boards and commissions on fishery restoration.

D. Outline a general work plan for the following calendar year. There would be sufficient detail to indicate the need for any Proposed Program Changes (PPC's) in the budget process.

In February of each year the DFG Striped Bass Working Group will meet with angler, environmental, conservation, water user, and water developing organizations and agencies; including federal, State, and local governments, and other public and private entities interested in and involved with striped bass and water utilization. The purpose will be to review progress and problems and to obtain and develop suggestions on projects desired for the next two years to aid and improve the striped bass population and fishery.

The updated Four-Point Program, with revisions and the annual work plans, will then be submitted to the Director for approval. After the Director approves the program -- and his approval process would include further review by outside entities -- it will be provided to all interested federal, State and local governments, and private and public entities.