BAY-DELTA OVERSIGHT COUNCIL

DRAFT

BRIEFING PAPER ON BIOLOGICAL RESOURCES OF THE SAN FRANCISCO BAY/ SACRAMENTO-SAN JOAQUIN DELTA ESTUARY

Bay-Delta Oversight Council

September 1993

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Bay-Delta Oversight Council

September 1993

State of California The Resources Agency

Memorandum

Date : September 30, 1993

To : BDOC Members

From : Steve Yaeger, Deputy Executive Officer
Bay Delta Oversight Council

Subject: Briefing Packet on Biological Resources

This section of the two part Draft Briefing Packet on Biological Resources is being provided to the Council for your advance review while the remainder of the packet is still in preparation. This specific section deals with Aquatic Resources. The second section, dealing with Wildlife and Plant Resources is currently being reviewed by the Peer Groups and we expect to provide those papers to you prior to the briefing on that subject -- tentatively scheduled for the November BDOC meeting.

The perspectives papers of the Aquatic Resources section are still in progress despite our best efforts to solicit them from a wide spectrum of biological experts. We will provide these issue papers as soon as they are available. In any event, several of the biological experts will present their perspectives orally at the meeting and be available to answer your questions. We will make written copies of their presentations available for your future use.

SURNAME				

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LISTING OF BRIEFING ITEMS
BDOC BRIEFING ON BIOLOGICAL RESOURCES OF THE SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA ESTUARY

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III. Estuary Aquatic Resources

A. Status, Trends and Factors Controlling the Estuaries Aquatic Resources

1. Status of Selected Fish and Invertebrate Species
2. Factors Controlling the Abundance of Aquatic Resources prepared by Department of Fish and Game

B. Perspectives of State and Federal Agencies

1. U.S. Fish and Wildlife Service
2. Other Resources Agencies

C. Perspectives and Issues of Concern to Agencies and Public Interest Groups (Issue papers prepared by the Agencies and Groups)

1. Fishery Groups
2. Public Interest Groups
3. Others

IV. Estuary Wildlife and Plant Resources

A. Status, Trends and Factors Controlling the Estuaries Wildlife and Plant Resources

1. Status and Trends
2. Factors Affecting Wildlife and Plant Resources

B. Perspectives of State and Federal Agencies

1. U.S. Fish and Wildlife Service
2. Other Resources Agencies

C. Perspectives and Issues of Concern to Agencies and Public Interest Groups (Issue Papers Prepared by the Agencies and Groups)

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INTRODUCTION

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Briefing Materials on Biological Resources of the

San Francisco Bay/Sacramento-San Joaquin Delta Estuary

This briefing package is meant to provide basic information on Estuary Biological Resources. Its two components deal separately with aquatic resources and wildlife and plant resources.

Also to be provided at a future date, are representative spectrum regarding these topics submitted by various affected agencies, and experts in the Estuaries biological resources. Time constraints did not allow for canvassing all agencies and concerned public groups, however, we believe that the coverage provided will encompass a fairly comprehensive identification of the major issues.

The Executive Summary seeks to provide an overview of the material contained herein. It deserves emphasis, however, that the Summary should not be considered a substitute for the full text of the issue papers. Rather, it is meant to provide merely a snapshot of the major points raised since the characterization and flavor of the entire prepared pieces simply cannot be replicated in the Summary.

The first section of the package covers the aquatic resources of the Estuary, and begins with a background paper on the status of the resources. This status paper is followed by a paper which discusses the factors which affect the abundance of aquatic species. These papers are intended to present as objective an overview as possible.

Following the discussion papers, prepared comments will be included, representing particular perspectives and concerns relating to the estuaries aquatic resources as submitted by affected State and Federal agencies, as well as a cross-section of other experts in the field.

The discussion of Wildlife and Plant Resources of the Estuary is similarly organized. Background papers presenting an overview of the status of the resource and factors affecting the abundance of the resource will be followed by papers presenting various perspectives of State and federal resource agencies and other experts in the field.

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

STATUS AND TRENDS OF ESTUARY AQUATIC RESOURCES

■ GENERAL

Highly dynamic and complex environmental conditions exist in the Estuary, which have historically supported a diverse and productive ecosystem.

Over 200 species of fish, shrimp, and crabs are known to inhabit the Estuary. Throughout the food chain, many aquatic species representing varying needs and methods of utilizing the Estuary as a habitat, are in decline, suggesting that the Estuary's ability to maintain aquatic species has decreased.

Many aquatic species living in the Estuary have experienced serious population declines in recent years. While the condition of all species is important in the discussion of the resource, several species are generally recognized as indicator species representing broader groups, and therefore are discussed here, including white catfish, Delta smelt, longfin smelt, Sacramento splittail, sturgeon, Pacific herring, starry flounder, Caridean shrimp, striped bass and chinook salmon.

The Estuary's biological resources have undergone a significant transformation over the last century and a half. Many species of non-native aquatic invertebrates and more than 50 species of non-native fish species have been introduced.

Estuarine species spawn in salinities ranging from ocean concentrations to freshwater, depending on the species. Brackish water habitats typically provide critical nursery areas. As their classifications suggests, freshwater and marine species spend most of their lives in freshwater and salt water habitats respectively.

It is important to note that the observed declines of most, if not all, species under consideration here, were undoubtedly intensified by the recent, historically unprecedented drought. Long-term biological consequences of the drought will require additional study in order to specifically address such effects.

■ PHYTOPLANKTON AND ZOOPLANKTON

- Phytoplankton abundance has declined in the last 20 years in Suisun Bay. Moreover, over the same period, a previously less common species of phytoplankton, which is not a preferred food source for zooplankton, has

become dominant. This is an important factor as phytoplankton converts the energy of sunlight into food and is important to the growth or productivity of other organisms as one of the fundamental building blocks of the food chain.

- Zooplankton abundance has remained constant throughout the Delta since the early 1970's but the species composition has changed dramatically. Generally, native species have dwindled, while non-natives have increased their numbers. In Suisun Bay, a species that serves as an important source of food for bass has declined substantially.

- **BENTHOS**

  - Benthic organisms (benthos) are animals that live in or on the bottom of the Estuary. With few exceptions, all of the common benthic species found in the Estuary have been introduced.

  - In the northern reach of the Estuary, benthic abundance and distribution is significantly affected by salinity variation.

  - The introduced Asian clam (Potamocorbula amurensis) has established itself as the dominant species in Suisun Bay. The impact of this filter-feeding organism on phytoplankton is generally believed to be dramatic, though it has yet to be quantified.

- **FISH**

  - White Catfish --

    - White catfish is a non-native species that supports an important sport fishery. Its abundance has declined severely since the mid-1970s. Catfish reproduction is concentrated in the south and east Delta and replenishment from these areas has greatly diminished since the early 1970's.

  - Delta Smelt --

    - Delta smelt are fast growing, short-lived and feed entirely on zooplankton. They are unique to the Estuary and spawn in freshwater or slightly brackish water. Delta smelt have been collected over an extensive range of the Estuary and up the Sacramento and San Joaquin Rivers.

- Historically, the Delta smelt was widely distributed throughout the Estuary. Recently, they have become heavily concentrated in the lower Sacramento River, between Collinsville and Rio Vista.

- Abundance indicies for the Delta smelt have declined from the 1,000 -- 1,500 range in the early 1970's, to the 300 -- 400 range in the late 1980's and early 1990's. The 1992 index (157) was one of the lowest on record.

- The U.S. Fish and Wildlife Service added the Delta smelt to the Threatened and Endangered Species list in March of 1993. This species has also been listed as Threatened under the California Endangered Species Act.

- Longfin Smelt --

  - Longfin smelt are found in fresh, brackish, and marine waters from San Francisco Bay to Alaska.

  - The Longfin smelt spawn in the lower Sacramento and San Joaquin Rivers, the Delta and the freshwater portions of Suisun Bay. The second year of the life cycle of the longfin smelt, an important component of the estuarine food chain, is normally spent in the Bay.

  - Fluctuations in abundance are closely correlated to freshwater flows between February and May. No such similar relationship exists for Delta smelt.

  - There are petitions presently pending to place the longfin smelt on the federal endangered species list.

- Sacramento Splittail

  - The Sacramento splittail is a large minnow, endemic to the Estuary. Although it is considered a freshwater species, adults and sub-adults have an unusually high salt tolerance.

  - Spawning and nursery habitat have been significantly reduced through land reclamation. The splittail's range has historically covered the Central Valley, from Redding to Fresno. Today, however, they are only found in the lower reaches of the Sacramento and San Joaquin Rivers, the Delta, Suisun and Napa marshes, and tributaries north of San Pablo Bay.

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- Sacramento splittail abundance reached an all time high in 1983 for the period of record starting in 1967, but have since declined dramatically. The splittail is considered a species of special concern by the California Department of Fish and Game and a petition for listing under the federal Endangered Species Act has been submitted to the USFWS.

- Sturgeon
  - White sturgeon and green sturgeon are both anadromous and native to the Estuary, though the latter is much less common. White sturgeon supports an important and growing sport fishery.
  - White sturgeon make less extensive ocean migrations than green sturgeon and spend most of their life in the river and Estuary. Both types of sturgeon spawn in the Sacramento and San Joaquin Rivers, although the white sturgeon is more prevalent in the Sacramento than the San Joaquin. Increasing freshwater flows seems to trigger spawning.
  - Larval movement and dispersal is also dependent on river flow, and nursery areas move further downstream as flows increase.
- Pacific Herring
  - Pacific herring support a large fishery in the San Francisco Bay. Its population has been relatively stable.
- Starry Flounder
  - Starry flounder are native to the Estuary. They range from Santa Barbara north around the arc of the northern Pacific and south to the Sea of Japan.
  - Adults inhabit shallow coastal marine water. Juveniles appear to be estuarine-dependent and seek out brackish water for nursery purposes.
  - Starry flounder supports a moderate sport fishery in California. Overall abundance has been low since 1986.
- Caridean Shrimp
  - There are five relatively abundant species of shrimp in the Bay; four are native and one was introduced from the Orient.

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- These shrimp support a fishery and are primarily sold as bait.

- Each species utilizes the Bay as nursery area to a varying degree. While one species' abundance is strongly related to freshwater outflow in the spring, the other species do better in drier, low flow years. There has appeared to be both a shift in relative abundances of the five species and an overall decline of total biomass during the 1988-90 period.

- Striped Bass

  - Striped bass were introduced as a sport and commercial fish in the late 1800's. By the turn of the century the commercial catch was over a million pounds annually. However, by 1935 commercial fishing for striped bass was prohibited in order to enhance the sport fishery.

  - Striped bass begin spawning in the spring, usually from April to mid-June. They spawn in freshwater, with moderate to swift current, and water temperatures in the range of 61 F to 69 F. Important spawning grounds include the San Joaquin River between Antioch Bridge and the mouth of Middle River, and the Sacramento River between Sacramento and Colusa. About 1/2 to 2/3 of total striped bass eggs are spawned in the Sacramento River. In wet years, some spawning occurs in the San Joaquin River above the Delta.

  - Striped bass are very prolific. A five-pound female may spawn 180,000 eggs in a season, while a 15 pound fish can produce over a million eggs. Even so, population levels have declined substantially since the 1960's. 1990 estimates were at a record low of approximately 590,000 naturally produced adult fish.

- Chinook Salmon

  - Chinook, or "King," salmon spawn in freshwater but spend most of their adult lives in the ocean. Chinook salmon and steelhead rainbow trout are the principal salmonids in the Estuary.

  - There are four distinct salmon runs in the Estuary system; named for the season of their upstream migration. They are the spring, fall, late fall, and winter.

- Today, fall run are the principal run found in the Sacramento and the only run found in the San Joaquin drainage. About 80% of all four runs are produced in the Sacramento basin. Typically, over 90% of all Central Valley spawners are fall run fish.

- Spawning occurs where gravel size, porosity of the gravel bed, water velocity, temperature and oxygen conditions combine to create a good red (nest) spot. Successful incubation (50 to 60 days) requires flows to be strong enough to remove waste and silt but not so strong as to wash the eggs downstream.

- Salmon "fry" (free-swimming young salmon) rear for a few months in riverine or estuarine habitat, feeding on insects and zooplankton. "Smoltification" enables the fish to survive the transition from fresh to salt water, and during this life stage they are called smolts. Central Valley chinook typically remain in the ocean from two to four years before they begin their return to freshwater to spawn and die.

- Natural salmon populations have been augmented by hatchery production. Release of hatchery fish in the lower Estuary instead of releasing them at the hatchery has increased survival and maintained a relatively stable ocean fishery since the 1950's, though with a relatively reduced level of natural stocks.

- Sacramento River Basin

The number of adult fall-run chinook salmon returning to the Sacramento River basin in 1991 was estimated to be 116,900, about the same as 1990 but 36% below the 10-year average of 171,500.

1992 DFG estimates of the late fall-run present in the upper Sacramento River was 10,400.

1992 DFG estimates of the spring-run in the Sacramento River above Red Bluff was fewer than 500. In the late 1960's, the spring-run numbered in the 20,000s.

1992 DFG estimates of the winter-run in the Sacramento was 1,200, down substantially from the 118,000 estimated in 1969, but up from 1991's low of 200. DFG expects low return numbers for the next several years. The winter-run is listed under both the state and federal endangered species acts.

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- San Joaquin Basin

Salmon populations in the San Joaquin have fluctuated widely since the early 1950's when counts were begun.

1991 counts of fall-run chinook salmon produced an estimate of 1,100, well below the 76,100 that returned in 1985.

Traditional indices of salmon populations suggest that most runs of chinook salmon in the Estuary and its watershed have declined significantly in recent years, with little evidence suggesting near-term improvement.

FACTORS AFFECTING THE AQUATIC RESOURCES OF THE ESTUARY

- **THE INFLUENCE OF DELTA INFLOW ON AQUATIC RESOURCES**

  - Freshwater flows into the Delta affect biological resources both in the rivers above the Estuary and in the Estuary proper. Specific examples of this effect include:

    - Striped bass eggs and larvae experience increased survival rates during periods of higher spring flow rates;

    - Minimum flow rates are needed in the Sacramento River system during various time frames to protect salmon in upstream spawning and rearing areas. Many believe flows impact outmigrating salmon in the Delta. A USFWS model, however, identified water temperature and diversion, rather than flow, as the principal controlling factors in the success of outmigrating salmon.

    - It is important to note that needs of the various salmon runs may differ and caution is warranted in making management decisions based on limited observations of particular runs.

    - A strong statistical correlation exists between spring flows of the Tuolumne and Stanislaus rivers and returning runs of adult salmon to those rivers 2 1/2 years later;

    - USFWS, NMFS and DFG advocate minimum spring flows in the San Joaquin River to improve salmon survival in the Delta;

- Seaward fall migration abundance of American shad reacts directly to high flow in the previous spring;

- White sturgeon populations are highest following high Sacramento River flows in the late winter and spring.

IMPACTS OF DIVERSIONS FROM THE SACRAMENTO RIVER

- The principal evidence on effects of diversions relates to salmon outmigrants. Mortality of outmigrating salmon entering the Delta through the Cross Channel and Georgiana Slough is estimated to be twice that of smolts remaining in the Sacramento's main stem. This is also likely true for other fish.

- The impacts of flow splits at Three Mile Slough on salmon outmigrants have not been evaluated. Studies do suggest Three Mile Slough is a major transport route for ocean salts into the interior Delta. If these studies are confirmed, it is also likely a conduit for fish, eggs and larvae from the Sacramento River to the interior Delta.

THE INFLUENCE OF REVERSE FLOWS

- Reverse flows, which occur when total upstream flow exceeds downstream flow as a partial consequence of the influence exerted by operation of the project pumps, tend to move fish and their food supply toward the pumps rather than toward the ocean.

- Flow reversals occur essentially all the time in Old and Middle rivers, and about one-half to three-quarters of the time on the lower San Joaquin River in many years.

- Different methods of addressing reverse flows will have different effects on fish mortality.

- Flow reversals may impede migration and increase mortality of salmon smolts.

LOSSES FROM WATER PROJECT DIVERSIONS

- Intakes at the State and federal pumping plants are screened. Though ineffective for larval fish, they are close to 90% effective for fish several inches long.

- Entrained fish are trucked to the western Delta for release. However, a small to large proportion of these fish die as a result of associated stress and predation at the point of release. (However, this loss is almost 100% for some species.)

- Predation, particular of salmon by striped bass, in Clifton Court Forebay is of significant concern. A major program to remove striped bass from the Forebay is planned for this fall.

- Two major disadvantages of having large water diversions from the south Delta are:

  - No flow can bypass the intake, so all fish must be captured and transported to another location for release, suffering associated stress mortality; and,

  - Since water is being withdrawn from a large "pool" which is a major nursery for some fish and a permanent residence for others, the capacity of the "pool" to support these populations is diminished through effects on the fish and their food supply.

- All fish species are not equally vulnerable to being drawn to the pumps. Migrating fish which follow the downstream flow are more vulnerable than resident fish that reside near the shore.

- High flows may make some vulnerable species less vulnerable by quickly carrying fish downstream.

- Striped bass (before 20 mm stage) losses through entrainment at the project pumps have been estimated by DFG to be more than 70% in dry years and 32% in wet ones.

- There are approximately 20 to 50 million salmon smolt migrating through the Delta which are susceptible to various negative impacts as a consequence of project operations:

  - Losses at project diversions in the south Delta have been estimated to be between 400,000 and 800,000 in recent years, assuming an estimated mortality of 75% in the Clifton Court Forebay.

  - About 2% of spring outmigrants from the Sacramento River are entrained at the project screens, while as many as 20% to 70% of the San Joaquin outmigrants are captured.

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- Experience has indicated that temporarily curtailing or halting diversions within the present configuration of the Delta does little to protect resident fish species, particular Delta smelt, which are easily transported by flow and quickly transported to the pumps when flow resumes.

- **TEMPERATURE IMPACTS**

  - Water temperature has a strong influence on the lives of all fish and their food supply.

  - The principal identified temperature requirement in the Estuary is for cool temperature to maintain salmon survival in the spring.

    - Reservoir operations impact water temperature in upstream tributaries to the Delta.

    - Analyses indicate water temperature in the Delta is generally not influenced by manipulating reservoir releases.

    - The Delta is so far from reservoirs that water and air temperatures have generally reached equilibrium.

- **THE INFLUENCES OF DELTA OUTFLOW**

  - Outflow and Salinity:

    - The magnitude of Delta outflow regulates salt water intrusion into the Estuary.

    - There are conflicting points of view as to whether Delta salinity or outflow is the best variable to manage for ecological benefit. Salinity is more accurately measured than estimates of outflow. However, because outflow estimates are made over time and averaged out, there is little management significance to short-term errors. Regardless, generally the management decisions from either method will be similar.

    - A common opinion held by many biologists who are familiar with the estuary is that biological phenomena of primary interest are driven by flow rather than salinity, with the exception of striped bass spawning which is clearly driven by salinity.

- Physics of Outflow:
  - Freshwater flowing out of the Estuary overrides salt water intrusion caused by tidal action. This results on fresher water near the surface and more saline bottom currents.
  - The entrapment zone (an accumulation of suspended particles) occurs near the location of the upper end of the salinity gradient and is an important fishery nursery area. Production tends to increase when outflows are maintained at a moderate level.
- Bay Fishes and Invertebrates:
  - The magnitude of Delta outflow strongly influences the *distribution* of almost all estuarine fishes and invertebrates, but the relationship of flows to *abundance* for most species is not as well documented. Still, for several species, there is a strong positive relationship between outflows and abundance.
  - Storage and diversion of water during the winter and spring has decreased outflow, probably contributed to the long-term decline of shrimp, starry flounder and longfin smelt populations by decreasing upstream transport to nursery areas.
  - High flows increase survival of longfin smelt by spreading them over a larger area and increasing their food supply.
- Striped Bass:
  - Survival of young striped bass increases in proportion to Delta outflow during April through July.
  - First year conditions appear to determine subsequent abundance of adults.
- Chinook Salmon:
  - Salmon smolts migrate through the lower Estuary faster than net flow would transport them, thus their survival is apparently not related to outflows.

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- **INFLUENCES OF SALINITY**
  - The only fishery regulatory standard which reflects a need clearly dependent on salinity is striped bass spawning in the San Joaquin River.

- **INFLUENCES OF INTRODUCED SPECIES**
  - The shift from native to introduced fish is much greater in the freshwater portion of the Estuary than in the salt and brackish water portions.
  - Several newly introduced species of zooplankton have dramatically changed species composition in the brackish and freshwater portions of the Estuary.
  - A clam introduced in 1986, Potamocorbula amurensis, is now dominating benthic populations.
  - A newly introduced amphipod has become a major food of young bass.
  - The ecological significance of the changes wrought by introduced species is uncertain.
  - With regard to abundance of various fish species, declines in abundance have not coincided with increases in introduced species sufficiently for the introduced species to be the likely cause of observed declines.

- **INFLUENCES OF FOOD LIMITATIONS**
  - Many biologists suspect that food limitations may have played a role in recent declines in fish populations. The abundance of a number of components in the food chain has decreased over the last twenty years even though total zooplankton abundance is about the same.

- **IMPACTS OF TOXICITY**
  - Historically, pollution and its impact on the aquatic environment was fairly obvious. Today, fewer obvious signs of pollution exist. The unanswered question is whether continuing point and non-point discharges have toxic effects on aquatic resources.

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- Toxicant effects are potentially confounded by flow effects because the magnitude of flow dilutes concentrations of toxicants, particularly in the upper portion of the Estuary.

- **THE INFLUENCES OF LEGAL HARVEST**

  - The issue is whether harvest are sufficient to inhibit the population's ability to maintain itself or to be responsible for observed changes in abundance. To date, there has been no evidence correlating declines to harvests.

- **THE INFLUENCES OF ILLEGAL HARVEST**

  - Illegal harvest is more difficult to estimate by its very nature.

  - DFG believes illegal salmon take in the Estuary has no significant impact on the resources, including harvests by foreign fisheries.

  - It is unlikely that the harvest of sub-legal bass is the dominant factor causing the decline in adult bass abundance since 1970.

- **IMPACTS OF LAND RECLAMATION**

  - Historical land reclamation destroyed most of the tidal marshes in the Estuary and seasonally flooded wetland upstream from the Estuary and probably caused the extinction of some species and the decline of the Sacramento splittail.

- **IN-DELTA DIVERSIONS**

  - Diversions onto Delta agricultural lands are made through many small unscreened intakes. These diversions can add up to approximately the same magnitude as the amount of water diverted into the Tracy Pumping Plant .

  - Fish losses occur at cooling water intakes for power plants as well as at the irrigation diversions.

  - Evaluation of fish losses and potential screening methods is underway.

CONCLUSIONS

A host of factors must be considered in formulating a fishery restoration plan for the Sacramento-San Joaquin Estuary. Enough is known to make sound judgements about the potential value of various actions, but not enough is known to design definitive restoration plans for the best known species, much less for the whole ecosystem.

Dealing with the effects of water development should be the cornerstone of any restoration plan. This involves providing adequate flows or salinities for various fishery needs, providing better fish screens and making some structural changes in the water distribution system to deal with adverse effects associated with the nature and location of the major water diversions.

Of the nonwater project related factors, control of toxicants and illegal harvest probably offer the greatest potential for assisting restoration. Prevention of further introductions of fish and invertebrates is important to avoiding additional, potentially harmful changes.