5-YEAR REVIEW
March 31, 2004

Species under review: *Hypomesus transpacificus* (delta smelt)

FR Notice: Federal Register 68(148):45270-45271 on August 1, 2003

Lead Field Office: Sacramento Fish and Wildlife Office (916) 414-6700

Name of Reviewer(s): Ryan Olah and Michael Nepstad (916) 414-6625

Cooperating Field Office(s): Not Applicable

Lead Region: California/Nevada Operations Office, Diane Elam, 916/414-6464

BACKGROUND

1. Existing Recovery Priority Number:

The current U.S. Fish and Wildlife Service (Service) Recovery Plan (1996) for delta smelt assigned a recovery potential of 2C. A listed species is assigned a recovery priority number from 1 (highest) to 18 (lowest) according to the degree of threats, recovery potential and taxonomic distinctness. In addition, a species' rank may be elevated by adding a C designation to its numerical rank to indicate that there is some degree of conflict between the species' conservation efforts and economic development associated with its recovery. Recovery priority numbers are based on criteria published the Federal Register Notice (48 FR 43098; September 21, 1983). At the time of listing, Delta smelt was under a high degree of threat from the severe 1987-1992 California drought. The species persisted in small numbers and rebounded to pre-decline levels in 1993, suggesting that its recovery potential is fairly high. The subsequent decline in 1994, a critical water year, to a then all-time low annual abundance index of 102 (Fall Midwater Trawl Survey (FMWT)), however, illustrates the high degree of threat that neutralizes gains in abundance that result from good water years. More recent abundance indices have varied, but overall, the trend is still negative.

2. Most recent Species Status as reported to Congress in the Biennial Report:

The 2003 Species Status as reported to Congress in the Biennial Report (Service 2003a) contained the following information:

2003 Listing Status: T, CH
2003 Population Status: U
2003 Recovery Achieved: 2
2003 Recovery Priority: 2C
2003 Is Recovery Plan Under development: No (Final plan completed 1996)

2003 Active Approved Recovery Team: No

2003 Last Year of Population Survey: There presently is no survey which provides data which can be used for population estimates. All of the surveys described below provide limited data on seasonal distribution and abundance for a portion of the smelt life history.

2003 Controlled Propagation: Yes, for research program, objectives met

Species Comments: Not enough known as population information is based on abundance indices

Recovery Plan Comments: 5 year review ongoing, plan set recovery criteria which are now known to be incorrect, has not met delisting criteria. (See section 11 below and appendix A)

3. Listing History:

a. Original Listing:

The Service was petitioned to list the delta smelt as endangered on June 26, 1990. The Service proposed the species as threatened with critical habitat on September 27, 1991. The species was listed as threatened in Federal Register 58:12863 on March 5, 1993. Critical habitat was designated in Federal Register 59:65256 on December 19, 1994.

b. Revised Listing: Not Applicable

4. Associated Listings: Not Applicable

5. Review History: Not Applicable

6. Recovery Plan or Outline:

The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes was signed and approved on November 26, 1996. A recovery team assisted in the preparation of the plan; Dr. Peter Moyle of the University of California, Davis was the team leader. (See #11 and #12 below for a discussion of the Recovery Plan and Appendix A for recommendations concerning the Recovery Plan).

7. Reference Point Document:

The March 5, 1993 Final Rule (Service 1993) is the most recent comprehensive analysis of the species status and will be used as the reference point document.

The following is the five factor analysis as published in the 1993 Final Rule (Note that the citations in this section are located within Appendix C):

A. The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range.

The delta smelt was one of the most common and abundant pelagic fish caught by California Department of Fish and Game trawl surveys in the Delta during the early 1970's (Stevens and Miller 1983, Moyle et al. 1989, Stevens et al. 1990). Its distribution once ranged from western Suisun Bay upstream to Sacramento on the Sacramento River and to Mossdale on the San Joaquin River (Radtke 1966, Moyle 1976, Moyle et al. 1992). Smelt populations fluctuated a great deal in the past, but after 1981 began a precipitous decline. Over the last 20 years, the population has experienced a ten-fold decline in numbers, and since 1982, has remained at extremely low levels. Recent population abundance indices confirm that the species has not shown any significant signs of recovery (Moyle and Herbold 1989, Moyle et al. 1989, Stevens et al. 1990, Moyle et al. 1992, Sweetnam 1992). This species' pelagic life history, dependence on pelagic microzooplankton, 1-year life span, and low fecundity are characteristics of a fish species that is affected greatly by perturbations to its reproductive habitat or larval nursery areas. Under existing levels of water development, the delta smelt is especially vulnerable during protracted drought periods. Deleterious effects of the present drought period would be exacerbated if additional alterations in hydrology caused by reductions of freshwater inflows to the Delta alter the timing and/or duration of water exports. A weak stock-recruitment relationship (i.e., little evidence of the effect of parent population size on subsequent recruitment) strongly suggests that environmental or habitat factors are severely limiting delta smelt abundance, even during those years when adults may be abundant (Moyle et al. 1992).

Moyle et al. (1989) reported multiple and synergistic causes of the delta smelt decline in the following order of importance: (1) Reduced river outflows, primarily in the Sacramento and San Joaquin Rivers, and their tributaries, (2) extremely high river outflows in years with unusually high rainfall, (3) entrainment mortality caused by water diversion, (4) human and natural perturbations to the smelt's food web, (5) presence of toxic substances in the aquatic habitat (e.g., agricultural and industrial chemicals, heavy metals, etc.), and (6) loss of genetic integrity because of a sharply curtailed delta smelt population. This small delta smelt population may become displaced by the wagasaki, or Japanese smelt (Hypomesus nipponensis), which was inadvertently introduced into reservoirs of the Sacramento River drainage by the California Department of Fish and Game (Moyle 1976).

Delta water diversions and exports presently total up to about nine million acre-feet per year. State and Federal projects presently export about six million acre-feet per year when there is sufficient water available, and in-Delta agricultural uses result in diversion of about three million additional acre-feet per year. Plans currently being prepared propose to greatly increase exports and diversions in the future. The Service is aware of 21 major Central Valley Project, State Water Project, or private organization proposals that will result in increased water exports from the Delta, reduce water inflow to the Delta, change the timing and volume of Delta inflow, or increase heavy metal contamination into the Delta. These proposed projects or actions include but are not limited to: Los Banos Grandes Reservoir, South Delta Water Management Program, South Delta Water Barriers Project, North Delta Water Management Project, West Delta Water Management Project, Coastal Aqueduct proposal, Delta Wetlands Corporation

Water Storage Project, Central Valley Project contract renewals, Los Vaqueros Reservoir, the Central Valley Project and State Water Project wheeling purchase agreement, reactivation of the San Luis Drain, Stanislaus-Calaveras River Basin Water Use Program, Kern Water Bank, Arvin Edison water storage and exchange proposal, and State Water Project Pump additions.

A significant change in in-Delta diversions is unlikely; if anything, a slight decrease in in-Delta agricultural use is probable. The Federal pumping plant has been operated at capacity for many years except for a very few drought years, so increased exports at this plant appear unlikely. The State Water Project pumping plant and the capacity of the State Aqueduct have considerable unused capacity, however. A table of past and projected State Water Project deliveries from Delta sources during the years of 1962 to 2035 are listed in California Department of Water Resources (1992). In the 1980's, deliveries ranged from 1.5 million acre-feet to 2.8 million acre-feet. By 1993, if enough water is available, deliveries could increase to as much as 3.8 million acre-feet. By 2010, deliveries of up to 4.2 million acre-feet are possible.

Since 1983, the proportion of water exported from the Delta during October through March has been higher than in earlier years (Moyle et al. 1992). The timing of these proportionally higher exports have coincided with the delta smelt's spawning season. Federal and State water diversion projects in the southern Delta export, by absolute volume, mostly Sacramento River water with some San Joaquin River water. During periods of high export pumping and low to moderate river outflows, however, reaches of the San Joaquin River reverse direction and flow to the pumping plants located in the southern Delta. The State-operated pumping plant presently exports water at rates up to 6,400 cubic feet per second (cfs). The State is considering proposals to export an additional 3,900 cfs. The Federal pumping plant can export water at rates up to 4,600 cfs. In addition, local private diverters export up to 5,000 cfs from about 1,800 diversions scattered throughout the Delta.

When total diversion rates are high relative to Delta outflow and the lower San Joaquin River and other channels have a net upstream (i.e., reverse or negative) flow, out-migrating larval and juvenile fish of many species become disoriented. Large mortalities occur as a result of entrainment and predation by striped bass at the various pumping plants and other water diversion sites. Net positive riverine flows and estuarine outflows of sufficient magnitude are required for delta smelt larvae to be carried downstream into the upper end of the mixing zone of the estuary rather than upstream to the pumping plants.

In recent years, the number of days of reversed San Joaquin River flow have increased, particularly during the February-June spawning months for delta smelt (Moyle et al. 1992). All size classes of delta smelt suffer near total loss when they are entrained by the pumping plants and diversions in the south Delta. Very few are effectively salvaged at the State and Federal pumping plant screens. The few delta smelt that are transported into water project reservoirs or canals fail to reproduce. This species' embryonic, larval, and postlarval mortality rates also will become higher as reduced western Delta flows

allow increases in the salinity level and relocation of the mixing zone.

The delta smelt is adapted for life in the mixing zone (brackish water/freshwater interface) of the Sacramento-San Joaquin estuary. The estuary is an ecosystem where the mixing zone and salinity levels are determined by the interaction of river outflow and tidal action. Moyle et al. (1992) reported that delta smelt were most abundant in shallow, low salinity water associated with the mixing zone, except when they spawned. Their analysis showed that smelt were collected from water with a mean salinity of 2 parts per thousand (ppt) with a mean temperature of 15 degrees Celsius (C), but were found in salinities ranging from 0-14 ppt at temperatures ranging from 6-23 degrees C. The larvae require the high microzooplankton densities produced by the mixing zone environment. The best survival and growth of smelt larvae occurs when the mixing zone occupies a large geographic area, including extensive shoal regions that provide suitable spawning substrates within the euphotic zone (depths less than 4 m). Sixty-two percent of delta smelt collected in Suisun Bay occurred at 3 sampling stations with depths less than 4 m; the remaining 38 percent were caught at 6 deeper stations.

During periods of drought and increased water diversions, the mixing zone and associated smelt populations are shifted farther upstream in the Delta. During years prior to 1984, the mixing zone was located in Suisun Bay during October through March (except in months with exceptionally high outflows or during years of extreme drought). From April through September, the mixing zone usually was found upstream in the channels of the rivers. Since 1984, with the exception of the record flood outflows of 1986, the mixing zone has been located primarily in the river channels during the entire year because of increased water exports and diversions. When located upstream, the mixing zone becomes confined to the deep river channels, becomes smaller in total surface area, contains very few shoal areas of suitable spawning substrates, may have swifter, more turbulent water currents, and lacks high zooplankton productivity. Delta smelt reproduction very likely is adversely affected now that the mixing zone is located in the main channels of the Delta, east of Suisun Bay (Moyle et al. 1992). In 1982, the decline of the delta smelt population in response to the shifted location of the mixing zone was significant. In all respects, the upstream river channels are much less favorable for the spawning and survival of the smelt. The decline of the delta smelt population since 1981 has been concurrent with an increasing amount and proportion of freshwater diversions that confine the mixing zone to the narrow, deep, and less productive channels in the lower rivers.

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Not known to be applicable; however, the delta smelt may be harvested as a non-target by-catch in commercial bait fisheries for other baitfish species. Some scientific collecting is conducted for the delta smelt; however, these activities do not appear to be adversely affecting this species. Native Americans historically harvested delta smelt for food, but modern Native Americans are not known to be harvesting this fish. No recreational or educational uses of this animal are expected to affect the delta smelt population.

C. Disease or Predation

Not known to be applicable. However, the introduced striped bass may have caused an increase in predation on all size classes of the delta smelt. An effort by the California Department of Fish and Game is underway to compensate for striped bass population mortalities caused by water export projects. The 1991 striped bass stock was very low relative to the population in the 1960's. The striped bass compensation program annually releases 1-2 million juvenile hatchery reared striped bass in the estuary in an effort to rebuild the population. This year the Director of the California Department of Fish and Game decided not to release striped bass because of the potential harm they would cause to the federally threatened Sacramento River winter-run chinook salmon.

D. The Inadequacy of Existing Regulatory Mechanisms

NOTE: This paragraph from the original delta smelt listing is no longer correct. The delta smelt was subsequently listed as threatened under the California Endangered Species Act. *Regulatory mechanisms currently in effect do not provide adequate protection for the delta smelt or its habitat. This species is not listed by the State of California. The California Fish and Game Commission ruled on August 30, 1990, that a petition to the State to list the species was unwarranted, rejecting the California Department of Fish and Game's recommendation to list the delta smelt as a threatened species under State authority (Stevens et al. 1990). State listing would have provided some measure of protection to the species because State agencies would have been required to consult with the California Department to Fish and Game if any project they funded or carried out would adversely affect the delta smelt. However, even if the State of California had listed the delta smelt, the species would not have been protected from the adverse effects of Federal actions.*

Suisun Bay is the best known nursery habitat for this species' reproduction and larval survival, but the habitat has been deleteriously altered because of higher salinities in spring. These higher salinities are caused by the large number of freshwater diversions that allow brackish seawater to intrude farther upstream. At present, there are relatively few periods when freshwater outflow volumes through the Delta and Suisun Bay of any significance are mandated for wildlife or fisheries. Federal and State agencies had planned to increase 1991 and probably 1992 water supplies for out-of-stream uses at the expense of environmental protection of estuarine fish and wildlife resources in the fifth and potentially sixth years of drought (Morat 1991). Because of significantly higher than normal precipitation and subsequent higher instream flows during March, 1991, a State agency request for relaxation of Delta water quality standards was withdrawn. It is likely, should the severe California drought continue, that this water quality relaxation action will be requested again in the near future to favor out-of-stream water use over the need to protect aquatic habitats for fish and wildlife.

Present regulatory processes do not ensure that water inflows to Suisun Bay and the western Sacramento-San Joaquin estuary will be adequate to maintain the mixing zone near or in Suisun Bay to benefit delta smelt and other fish and wildlife. The California

State Water Resources Control Board (Board) has the authority to condition or require changes in the amount of water inflow and the amount of water exported or diverted from the Delta. At the Board's Water Quality/Water Rights Hearings in 1987, a Service biologist testified that the delta smelt had been recommended for addition to the Federal Animal Notice of Review as a category 1 candidate species (Lorentzen 1987). The Board has not taken regulatory or legal action to protect this animal or its habitat during the 4 years since the Service expressed its concern for several species native to Sacramento-San Joaquin estuary. On December 9, 1992, the Board released a copy of Water Rights Decision 1630 (D-1630), San Francisco Bay/Sacramento-San Joaquin Estuary (California State Water Resources Control Board 1992). A meeting to consider adoption of D-1630 is scheduled for January 25, 1993. In whatever form it is finally adopted by the Board, D-1630 will establish minimum levels of public trust uses of the delta for up to 5 years. Subsequently, long-term standards will be prepared and adopted.

Implementation of the draft decision as prepared would result in improved habitat conditions for the delta smelt. The Service is presently in the process of analyzing the draft terms and conditions to determine to what extent delta smelt will be benefited, if the decision is adopted and implemented. However, even assuming immediate adoption and implementation of these interim terms and conditions, their adequacy as a regulatory mechanism to protect the delta smelt remains in question. The Service is aware that the salinity standards currently in effect (D-1485) are inconsistently implemented and frequently violated due to operational constraints. Institutional guarantees of compliance have been lacking in the past and are needed in the future.

Similarly, the Service is currently analyzing the potential effects on the delta smelt and other fish and wildlife resources in California as a result of the recent enactment of the Central Valley Project Improvement Act (Pub. L. 102-575). Two of the stated purposes of this act are to: "protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California" and "to contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary". Section 3406(b)(2) dedicates annually 800,000 acre-feet of Central Valley Project water for various purposes including the benefit of federally listed species. While the Service is reasonably certain that the delta smelt will realize some benefit from implementation of this Act, the magnitude and timeliness of these protections may be inadequate to prevent the endangerment of the delta smelt. For example, many analysts predict that provisions within the Act will take many years for the courts to resolve. Finally, neither adoption of the State Water Resources Control Board's Decision 1630 or the Central Valley Project Improvement Act protect the delta smelt per se, or provide mechanisms to ensure the continued existence of the species.

For the reasons stated above, the Service considers the existing regulatory mechanisms inadequate to assure the long-term existence of delta smelt in Suisun Bay and the Delta.

E. Other Natural or Manmade Factors Affecting its Continued Existence

The delta smelt is highly vulnerable to extinction because of its short life span, present small population size, and restricted distribution. The limited gene pool may result in depressed reproductive vigor and loss of genetic variation.

Poor water quality also may be a threat. All major rivers in this species' historic range are exposed to large volumes of agricultural and industrial chemicals that are applied in the California Central Valley watersheds (Nichols et al. 1986). Agricultural chemicals and their residues, and chemicals originating in urban runoff, find their way into the rivers and estuary. Toxicology studies of rice field irrigation drain water of the Colusa Basin Drainage Canal documented significant toxicity of drain water to striped bass embryos and larvae, medaka larvae, and the major food organism of the striped bass larvae and juveniles, the opposum shrimp (Neomysis mercedis). This drainage canal flows into the Sacramento River just north of the City of Sacramento. The majority of drain water samples collected during April and May 1990 were acutely toxic to striped bass larvae (96-hour exposures), the third consecutive year that the Colusa Basin rice irrigation drain water has been acutely toxic (Bailey et al. 1991). Delta smelt may be similarly affected by agricultural and industrial chemical run-off.

Some heavy metal contaminants have been released into the Delta from industrial and mining enterprises. Although the effects of these contaminating compounds on delta smelt larvae and their microzooplankton food resources are not well known, the compounds could potentially adversely affect delta smelt survival. In addition, increases in urban development in the Sacramento Valley will continue to result in concurrent increases in urban runoff. Finally, a proposal to reactivate the San Luis Drain would result in discharge of high levels of selenium from the San Joaquin Valley into the Delta. Selenium has been shown to cause developmental defects in and mortality of wildlife species.

In recent years, untreated discharges of ship ballast water introduced nonindigenous aquatic species to the Sacramento-San Joaquin estuary ecosystem (Carlton et al. 1990). Several introduced species adversely affect the delta smelt directly. An Asian clam (Potamocorbula amurensis), introduced as veliger larvae at the beginning of the present drought, was first discovered in Suisun Bay during October 1986. By June 1987, the Asian clam was nearly everywhere in Suisun, San Pablo, and San Francisco Bays irrespective of salinity, water depth, and sediment type at densities greater than 10,000 individuals per square meter. Asian clam densities declined to 4,000 individuals per square meter as the population aged during the year (Carlton et al. 1990). Persistently low river outflow and concomitant elevated salinity levels may have contributed to this species population explosion (Carlton et al. 1990). The Asian clam could potentially play an important role in affecting the phytoplankton dynamics in the estuary. It may have an effect on higher tropic levels by decreasing phytoplankton biomass and by directly consuming Eurytemora affinis copepod nauplii, the primary food of delta smelt.

Three non-native species of euryhaline copepods (Sinocalanus doerrii, Pseudodiaptomus forbesi, and Pseudodiaptomus marinus) became established in the Delta between 1978 and 1987 (Carlton et al. 1990), while Eurytemora affinis populations, the native

euryhaline copepod, have declined since 1980. It is not known if the introduced species have displaced E. affinis or whether changes in the estuarine ecosystem now favor S. doerrii and the two Pseudodiaptomus species (Moyle et al. 1989). These introduced copepod species are more efficient at avoiding the predation of larval delta smelt. The introduced copepods also exhibit a different swimming behavior that makes them less attractive to feeding delta smelt larvae. Because of reduced food availability or feeding efficiency causing decreased food ingestion rates, weakened delta smelt larvae are more vulnerable to starvation or predation.

The significantly altered microzooplankton food web now present in the Suisun Bay-Delta estuary may have decreased the gross growth efficiency of delta smelt larvae. Gross growth efficiency is the proportion of weight-specific food ingestion rate that goes to larval fish body growth. When food ingestion rates are low, gross growth efficiency is low. At low gross growth efficiencies, larval fish take much longer to metamorphose to juveniles. Long larval stage durations increase the likelihood that density-dependent mechanisms (e.g., predators, overgrazing of food resources, etc.) and density-dependent mechanisms (e.g., adverse salinities, temperature, absence of zooplankton, water diversion entrainment and impingement mortality, etc.) would develop to adversely affect survival and recruitment. In temperate latitudes, where spawning is temporally and spatially confined, as it is for the delta smelt, both mortality and growth rates tend to be low. Ingestion in temperate species is relatively low compared to tropical species, and larval stage duration is long and potentially highly variable. Under these circumstances, small changes in either mortality rates or growth rates can have significant adverse effects on recruitment potential (Shepherd and Cushing 1980, Houde 1989). Therefore, the timing of spawning and the availability of favorable spawning sites for adults are added critical elements in the recruitment success of the spawned cohort.

The Service has carefully assessed the best scientific and commercial information available regarding the past, present, and future threats faced by this species in this listing determination. The Service acknowledges that available data on the population dynamics of the delta smelt were collected incidental to other investigations and were not intended to provide a population estimate. The Service believes, however, that these data represent the best available information and support the listing of this species. The available data indicate a significant population decline over the last 20 years. Though the current population has remained relatively stable over the last 5 years, it has done so at very low levels. No apparent recovery is occurring. The delta smelt faces threats from a more frequent upstream shift of its aquatic estuarine habitat, and a reduction of available habitat due to drought, replenishment for groundwater overdraft, and water exports and diversions. The shift in location of the mixing zone, as well as the reduced area available to the smelt, is expected to continue in the future. These factors will continue to adversely affect all life stages of the delta smelt. Because the smelt population is at such low levels, this species' 1-year lifespan is also a factor that threatens the species. The failure of a single reproductive season could significantly affect the ability of this species to survive and recover. Based on the evaluation of all available information on population dynamics and threats to this species, the Service has determined that listing as threatened is appropriate at this time.

REVIEW

8. DPS Review - Application of the Distinct Population Segment (DPS) Policy:

The entire population of delta smelt is listed and nothing in the current science suggests that the delta smelt should be listed as a DPS.

Status Review

- **9. Information Review:** Is there new information available that is relevant to this review? Available information is considered to be all information 1) submitted, 2) available to Service employees, or 3) in Service files, during the review.

Yes __X__ (Go to 9. B.) No _____ (End of Review/Go to 14)

9. A. Is there any relevant new information regarding the listed population and/or the species throughout its range with respect to the appropriate application of the DPS policy?

Yes _____ No __X__

Not applicable, as the delta smelt was not listed as a DPS.

9. B. Is there relevant new information addressing the species' biology and status including, but not limited to, population trends, distribution, abundance, demographics, and genetics?

Yes __X__ No _____

Below is a discussion of available new and updated information which addresses delta smelt biology and status.

SURVEYS

The Service is aware of 14 surveys that collect data on delta smelt. See Appendix B for Abundance Indices Tables based on some of the below survey data. The following nine surveys began sampling before the listing in 1993:

(1) California Department of Fish and Game's (CDFG's) Fall Midwater Trawl (FMWT) (1967 to present) (CDFG 2003a). The Fall MWT was initiated by CDFG in 1967 to sample striped bass, a non-native sport fish. In addition to striped bass, CDFG has maintained records of other fish species captured in the samples in most years. This monitoring program currently samples 100 sites from San Pablo Bay in the west to Rio Vista on the lower Sacramento River and to Stockton on the San Joaquin River. Data are collected from September through December using a midwater trawl with a 3.7 square m (39.8 square ft) wide mouth. The FMWT covers the entire range of delta smelt distribution and provides one of the two best measures of delta smelt abundance (Sweetnam and Stevens 1993). The FMWT provides a better measure of abundance than

the Summer Townet Survey (described below) because it catches pre-spawning adult delta smelt (Service 1996). An index based on pre-spawning adults, rather than on juveniles which are vulnerable to high mortality, provides a better estimate of delta smelt stock and recruitment (Service 1996). Although the FMWT was not designed to catch delta smelt and is not as efficient at catching delta smelt compared with the Kodiak trawl (described below), it has been continuously done since 1967 and thus provides a solid base of historical data (Service 1996). Results from this trawl are used to calculate the Delta Smelt Recovery Index as described in the Recovery Plan.

(2) CDFG's San Francisco Bay Midwater Trawl (1980 to present). This trawl catches delta smelt throughout the year in the waters west of the delta seaward to south San Francisco Bay.

(3) CDFG's San Francisco Bay Otter Trawl (1980 to present). This trawl catches delta smelt throughout the year in the waters west of the delta seaward to south San Francisco Bay.

(4) University of California (UC) Davis' Suisun Marsh Otter Trawl (1979 to present). This trawl catches delta smelt in the Suisun Marsh waterways. The Suisun Marsh OT surveys began in 1979 and are conducted by the University of California (UC) Davis as part of a long-term study of the ecology of the entire fish community of the marsh. The survey is funded by California Department of Water Resources (CDWR) in part to determine if management actions in Suisun Marsh are affecting fish communities. The program samples 21 sites monthly in nine sloughs with an otter trawl that drags along the bottom and samples much of the water column in the shallow sloughs. In small sloughs, the trawl samples much of the cross sectional area; in large sloughs, the sampling fraction is smaller. A monthly abundance index is calculated as mean catch per trawl.

(5) Service's Chipps Island Trawl survey (1976 to present). The U.S. Fish and Wildlife Service conducts a sampling program for juvenile salmon in the deep water channel near Chipps Island at the western terminus of the Delta. This trawl also catches delta smelt. A midwater trawl is pulled at the surface for ten 20 minute hauls per day. Data are compiled to produce an index based on the catch per hour of trawling.

(6) Fish salvage at the CVP Tracy Fish Collection Facility (1979 to present) (CDFG 2003b and Service 2003b). This facility salvages smelt throughout the year. The CVP operates fish screening facility to divert fish away from the pump intakes into holding facilities where they are counted, measured, and released. Data collection takes place at two hour intervals when the pumps are operating. Reliable CVP data start in 1979. The pumps are not operated as sampling programs so the amount of "sampling" is related to the amount of water exported, which in turn is related to the amount of water available, water demand, and, in recent years, changes in pump operations to protect migratory salmon, splittail, and delta smelt and to maintain appropriate salinities in Suisun Bay and Marsh. The survival of fish salvaged at the facilities and released into the delta varies by species and environmental factors. At this time, delta smelt mortality from this process is estimated by the Service to be 100%. In addition, the number of smelt salvaged is used to

help determine if an Environmental Water Account (EWA) action needs to be taken. (See 9D below for a discussion of EWA)

(7) Fish salvage at the SWP Skinner Delta Fish Protective Facility in the south Delta (1979 to present) (CDFG 2003b and Service 2003b). This facility salvages smelt throughout the year. The SWP operates a fish screening facility to divert fish away from the pump intakes into holding facilities where they are counted, measured, and released. Data collection takes place at two hour intervals when the pumps are operating. Reliable SWP data start in 1979. The pumps are not operated as sampling programs so the amount of "sampling" is related to the amount of water exported, which in turn is related to the amount of water available, water demand, and, in recent years, changes in pump operations to protect migratory salmon, splittail, and delta smelt and to maintain appropriate salinities in Suisun Bay and Marsh. The survival of fish salvaged at the facilities and released into the delta varies by species and environmental factors. At this time, delta smelt mortality from this process is estimated by the Service to be 100%. In addition, the number of smelt salvaged is used to help determine if an EWA action needs to be taken.

(8) Service's Delta Beach Seine Survey (1976 to present). This survey can catch delta smelt throughout the year. The survey provides the broadest geographical coverage of all of the sampling programs but is focused on outmigrating juvenile salmonids.

(9) CDFG's Summer Townet Survey (1959 to present) (CDFG 2003c). This trawl is operated in the summer, catches juvenile and adult delta smelt, and provides one of the two best measures of delta smelt abundance (Sweetnam and Stevens 1993). The CDFG summer townet survey began in 1959 to provide an index of striped bass abundance. It samples YOY fish twice monthly at 30 sites using oblique tows in mid-channel. Starting and ending dates vary from year to year. Sample sites are located throughout the Delta, Suisun Bay, and San Pablo Bay. Data for species other than striped bass were not regularly recorded until after 1962, but were also not recorded in 1966, 1967, and 1968.

(10) CDFG's Striped bass egg and larval survey (1968 to 1995) (Interagency Ecological Program 1996). This survey sampled in the spring and caught larval delta smelt.

The following five surveys began sampling delta smelt since the listing:

(11) IEP's 20mm survey (1995 to present) (CDFG 2003d). This survey runs in the spring to catch larval and juvenile delta smelt. This survey's information is used to help determine smelt distributions in the delta and to helps determine if an EWA action needs to be taken.

(12) U.S. Army Corps of Engineers' (Corps) Napa River Survey (2001 to present) (Corps 2002 and 2003). This survey catches delta smelt in the Napa River. This survey exists in association with a flood control and ecosystem restoration project in the Napa River. It is performed by consultants under contract to the Corps, and involves a range of sampling techniques including beach seine, purse seine, otter trawl, fyke nets, and a 20 mm (0.8 in)

size class surveys. The Napa River Survey began sampling in March 2001 and has detected smelt (Corps 2002, 2003) but the data are too recent and of too short a term to be useful for an abundance index. The survey is scheduled to be completed in 2007 or 2008, after 7 years of data collection. In addition, the Napa River is less well understood in terms of relationships between outflow, smelt habitat, and smelt production, than are the Central Valley rivers and the Delta (see section 9.I. below).

(13) IEP's Spring Kodiak Trawl (2002 to present) (CDFG 2003e). This trawl, designed specifically to sample delta smelt, is pulled by two boats and samples the upper water column. This survey catches adult delta smelt and can help determine where adult smelt are distributed in the delta.

(14) North Bay Aqueduct Larval Fish Survey (1996 to present) (CDFG 2003f). This trawl samples north delta in the spring for larval delta smelt.

DENSITY DEPENDENCE

Attempts have been made to answer the questions of density dependence and population size for delta smelt, but to date there is no expert consensus on whether delta smelt populations display density dependence or density independence. Density dependence can be broadly defined as the case where more individuals of one life stage do not necessarily result in more adults and implies that there is a finite carrying capacity. There is considerable disagreement among experts over whether the data show that delta smelt exhibit density dependence during part or all of their life cycle (CALFED 2001, 2003a). This question is relatively controversial because of its ultimate potential implication for management of water diversions within the Delta. Bennett used traditional stock-recruitment analysis and calculations of mortality between life stages to conclude that density dependence has regulated delta smelt abundance over the period of record (CALFED 2001). However, Bennett (CALFED 2002a) stated that the available evidence suggests density dependence occurs infrequently and was most evident in the 1970's. Finally, Bennett (2003) stated that density dependant regulation may now be occurring at lower levels of abundance during late-summer than before the population decline.

A preliminary analysis by the California Department of Fish and Game (CDFG) (2003g) strongly suggests that the delta smelt population is largely regulated by density independent factors, particularly spring temperature conditions, the location of X2, and possibly the impact of export losses in dry years. CDFG (2003g) does not believe density dependant mortality currently plays a substantial role in determining annual delta smelt abundance for three fundamental reasons: 1) no credible mechanism for density dependent regulation has been presented; 2) smelt are currently not abundant relative to their past abundance or relative to the other species living in the delta, and; 3) the statistical evidence for density dependence is very weak.

ROLE OF TWO YEAR OLDS

Delta smelt typically live one year, but approximately 3-8% of individuals live two years

(Bennett 2003). Two year old fish have 3 to 5 times the fecundity of 1 year fish. These fish could be important for carrying the population over through years of poor year class strength (fewer individuals). However, there is no information at this time which describes their relative contribution to spawning during years following poor recruitment (CALFED 2003a, CDFG 2003g, and Bennett 2003).

9.C. Is there relevant new information addressing habitat conditions including, but not limited to, amount, distribution, and suitability?

Yes ___X___ (See Section 9D) No _____

9.D. Is there relevant new information addressing conservation measures that have been implemented that benefit the species?

Yes ___X___ No _____

FISH SCREENS

The CALFED Ecosystem Restoration Program has funded the construction of screens on several water diversions within the range of delta smelt, including an agricultural diversion on Hastings Slough, and the City of Sacramento's diversion on the Sacramento River (CALFED 2003b). These screens are designed to help prevent help prevent adult delta smelt from becoming entrained by the physical barrier of the screen as well as sweeping velocities that would carry delta smelt past the point of diversion (CALFED 2003b). While there remain over 1,800 diversions within the range of delta smelt, the Service recognizes that the actions of CALFED to date represent progress towards eliminating entrainment of delta smelt in unscreened diversions (CDWR 1995).

ECOSYSTEM RESTORATION

The CALFED Ecosystem Restoration Program has funded the restoration of multiple habitats at several locations within the range of delta smelt, including Canal ranch, Liberty Island, and McCormack-Williamson Tract (CALFED 2003b). The CALFED Ecosystem Restoration Program has also funded the restoration of shallow water tidal and marsh habitat at several locations within the range of delta smelt, including Fay Island, Franks Tract, Big Break, Lower Sherman Lake, and Prospect Island (CALFED 2003b). The Service recognizes that the actions of CALFED to date represent progress towards enhancing and/or restoring additional habitat for the delta smelt.

WATER MANAGEMENT

Since the listing of delta smelt, our body of knowledge of delta smelt life history and population dynamics has increased. Water and fishery management actions have become more focused on

addressing specific life history requirements rather than prescriptive limitations on exports. Both VAMP and the EWA, described below, are water management tools which are designed to address specific needs of delta smelt. As our scientific understanding of delta smelt increases, we expect that these or similar programs would adapt to our current state of knowledge.

VAMP

It has been postulated that the Vernalis Adaptive Management Program (VAMP) has changed water movement in the southern Delta during the early delta smelt life history (CALFED 2001). The assumptions and information leading to this hypothesis are as follows: 1) since the initiation of VAMP in 1996, modeling and field data demonstrate that April through May net flows in southern Delta channels are more positive than occurred pre-VAMP, with less water movement towards the pumps; 2) since VAMP started, the projects have exceeded the red light take level more often than they would have pre-VAMP; 3) the VAMP flows and pumping restrictions provide better spawning and rearing conditions in the south Delta than was formerly possible; 4) with better rearing conditions, the larvae in the south Delta that are not entrained grow to the size (greater than or equal to 20 mm) that is successfully salvaged and counted at the intakes; 5) taking this model to its logical conclusion, the projects are not removing more fish than they did historically, they are removing more older fish (i.e. in the past the larval fish did not reach the salvageable size and went down the aqueduct without being counted), and; 6) on balance, VAMP effects on delta smelt are likely to be or slightly positive since delaying higher levels of exports may allow more of the oldest fish to avoid entrainment.

ENVIRONMENTAL WATER ACCOUNT

CALFED has undertaken efforts to minimize the take of delta smelt at the SWP and CVP since 2001 water year using their Environmental Water Account (EWA). The EWA is designed to balance two conflicting objectives: (1) to protect federally listed fish and (2) avoid interruptions of water deliveries by the state and federal export facilities. The EWA is built on the premise that water can be obtained and banked until needed. When large numbers of delta smelt are being taken at the state and federal export facilities, pumping is reduced and water stored south of the delta pumps is delivered in place of water not pumped. The effectiveness of EWA is governed by two factors: its ability to acquire sufficient water and the surplus pumping capacity at the state and federal export facilities needed to bank the water (Service 2003c).

EWA is managed by an interagency team which has the responsibility of determining if and when EWA assets are used. The EWA is currently being resized to account for proposed increases in water exports at the state and federal export facilities. In addition, the EWA is currently being reviewed to determine if it was successful in its first 3 years of operation. The current EWA was established as a temporary program, lasting only four years with the ability to be extended in the future. It is expected that the EWA will continue, although it has not yet become a permanent program. EWA actions for smelt are taken to reduce pumping at the CVP and SWP when high numbers of smelt are in the south delta. However, at this time it is unclear what, if any, effect EWA actions have had on the delta smelt population. The last 3 years of survey data show declining numbers of delta smelt (see Appendix B) (CDFG 2003g). However, 3 years of operation are insufficient to determine EWA's impact on delta smelt, for even if abundance indices were to indicate increases, they represent too limited a timeframe to overcome natural variance (Service 2003c). The information currently available is inconclusive, and as a

result we are unable to accurately assess the effects of VAMP and EWA. What is clear is that to the extent flow management affects delta smelt viability, both programs contribute to delta smelt conservation.

9. E. Is there relevant new information addressing species' existing threats status and/or trends since the last review?

Yes __X__ No

New information relating to existing threats include water flow, water diversions, proposed modifications to the water system, and continuing inadequacy of existing regulatory mechanisms. Please refer to section #13 (5 factor analysis) for an in-depth discussion on each issue.

9. F. Is there relevant new information addressing new threats since the last review?

Yes __X__ No _____

New information relating to new threats include the South Delta Temporary Barriers, and possible disease, introduced species, predation, discharge of ballast water, food availability, genetics, and other environmental issues. Please refer to section #13 (5 factor analysis) for an in-depth discussion on each issue.

9. G. Is there relevant new information to suggest a change in species taxonomy?

Yes _____ No __X__

Stanley *et al.* (1995) confirmed that delta smelt is a genetically distinct species. This does not change our understanding of the species as cited in the reference point document.

9. H. Have any improved analytic methods resulted in relevant new information?

Yes __X__ No _____

POPULATION TREND

A number of surveys have been conducted both prior to and since the 1993 listing, as described in section 9B. The data gathered from these surveys provide abundance indices for delta smelt (see Appendix B). The two-year running average of the Delta Smelt Recovery Index for 2003, as determined from the FMWT, is the second lowest since the species was listed (Service 2003d). The Summer Tow Net Survey data show an almost complete disappearance of juvenile delta smelt in the south delta sampling stations by the mid-1970s (CDFG 2003g). Moyle (2003),

stated that the analysis of 22 years of monthly sampling data from Suisun Marsh shows that the delta smelt have still not recovered to their former abundance, although there has been a general increase in numbers since their low point during a long period of drought (Matern *et al.* 2002) (see Appendix B). From these indices, the Service has concluded that the delta smelt abundance has not recovered to its pre-decline (prior to 1982) levels.

In addition, the San Luis & Delta-Mendota Water Authority (2002) submitted an analysis of population trend on delta smelt adults. Based on four analyses (simple moving average, Lowess smoothing, linear splines smoothing, and polynomial trend smoothing) of Fall Midwater Trawl (FMWT) data, they asserted that delta smelt have exhibited an increasing population trend since the mid-1980's. USGS (2003) conducted a peer review of the San Luis & Delta-Mendota Water Authority (2002) submission. Overall, the peer reviewers (USGS 2003) concluded that the authors failed to demonstrate a positive trend in smelt abundance. Rather than demonstrating a positive trend, the USGS review (2003) indicated that large inter-annual variability is notable and that such variability is expected from a species with this life cycle.

In summary, we believe that there is little compelling information which would suggest that delta smelt populations are increasing over pre-decline levels. However, we recognize that the current available scientific information on delta smelt abundance is somewhat imprecise. We anticipate that research efforts will continue to focus on the development of more reliable population estimates for use in population trend analyses.

POPULATION SIZE

Many individuals and organizations have strongly suggested that abundance indices are inadequate to meet management needs and that population estimates should be made for delta smelt. A population estimate for delta smelt may permit more easily justified take limits, better assessments of population dynamics and extinction coefficients, better understanding of the trophic dynamics of the delta, and better public education efforts. However, there are many challenges associated with determining population size for delta smelt (Herbold 1996).

Surveys of abundance in one area can sometimes be generalized over an entire population. Most often in fisheries science, this involves counts of individuals at a point or points where the entire population must pass. For some species such as salmon, fish passage rates at fish ladders or carcass counts on spawning grounds can give reasonably adequate estimates of total population size (Herbold 1996). However, these methods are not possible for use on delta smelt.

Populations that spend at least part of their life cycle in a discrete area permit estimates of total population size. Fish which aggregate in large, monospecific, and concentrated schools can be adequately estimated through hydroacoustic surveys. The small, mixed species aggregations in the entrapment zone, combined with the delta smelt's frequent presence in shallow water habitats

where hydroacoustic gear is least effective; make such estimation procedures unsuitable for delta smelt (Herbold 1996).

Species that are regularly or randomly distributed within a well defined habitat permit counts in part of the habitat to be confidently expanded to the entire habitat. Species, like delta smelt, whose distributional patterns are unknown but which are likely to demonstrate different abundances and distributional patterns in different parts of their range are unlikely to be estimated with any useful degree of accuracy. For example, capture of two delta smelt in July in Suisun Marsh at a salinity of 10 parts per thousand (ppt), conditions under which they have never been abundant, would mean something quite different from a catch of 2 delta smelt at Chipps Island in October at a salinity of 2 ppt. However, our current understanding of delta smelt is insufficient to translate the difference into a population estimate (Herbold 1996).

The difficulties surrounding delta smelt population estimates are independent of the assumptions regarding gear effectiveness or choice of sampling sites. Thus, more effective sampling gear and wider distribution of surveys cannot wholly overcome the statistical difficulties attending the estimation of population size (Herbold 1996). We would anticipate an increase in confidence in delta smelt population estimates as our knowledge of smelt life history and population dynamics increases.

California Department of Water Resources (CDWR) noted that neither the FMWT nor the Summer Townet Survey provide statistically defensible population abundance estimates. Rosenfield (2003) stated that the Fall Midwater Trawl (FMWT) index is highly variable, at least in part because the sampling gear is not well-suited to detecting delta smelt, as it only briefly samples the surface waters where delta smelt are concentrated. According to Rosenfield (2003), the Kodiak Trawl appears to be a much more effective sampling instrument than the FMWT. The Kodiak Trawl collects fish from the top six feet of the water column (where delta smelt generally reside) while the FMWT collects samples by drawing the trawl diagonally through the water column from the bottom of the river to the top (San Luis & Delta-Mendota Water Authority 2003). The FMWT was not designed for sampling delta smelt and is used because it was implemented in 1967 and so can provide a historical context for relative delta smelt abundance. Unfortunately, the Kodiak Trawl has only been employed recently, and there is no historical context with which to interpret data collected with this gear (Rosenfield 2003).

Bennett (2003) believed that there is little confidence in the effectiveness of the sampling gear of the Fall Midwater Trawl (FMWT) and the Kodiak Trawl. For example, he notes, Kodiak Trawls appear to out-fish the traditional Fall Midwater Trawl in abundance per unit volume, but this knowledge is based on only 2 sampling days and 12 concurrent samples in September 1994. Moreover, there is little certainty of which size classes are missed by the various surveys. The lack of an appropriate abundance measure is currently a crucial factor limiting progress in our understanding of the delta smelt population.

The San Luis & Delta-Mendota Water Authority (2002) estimated the population size of sub-adult delta smelt in the late 1990's to be at least 1 million and as many as 12 million. The estimate was derived by using "side-by-side comparisons" of Fall Midwater Trawl (FMWT) and the Kodiak Trawl made in 1994 by the CDFG.

USGS (2003) and Rosenfield (2003) stated that the assumptions and procedures employed by the San Luis & Delta-Mendota Water Authority (2002) in reinterpreting the FMWT data are flawed. They state that the comparison of catches with different gear and scaling of density data to obtain population estimates is unsupportable as are the estimated correction factors used to offset trawl inefficiency. Also, the use of a correction factor for the Kodiak trawl is questionable. They stated that "scaling up of zero values is found unacceptable given the assumptions listed, life history of the fish, and limitations of the gear." After reviewing USGS (2003) and Rosenfield (2003), we have concluded that the population size estimates presented by San Luis & Delta-Mendota Water Authority (2002) are limited by uncertainties associated with the data set and assumptions. Despite any shortcomings in San Luis & Delta-Mendota Water Authority's (2002) approach, we would encourage continuation of future research efforts to develop reliable population estimates.

PROBABILITY OF EXTINCTION

The San Luis & Delta-Mendota Water Authority (2002) used the population estimates discussed above to estimate the probability of extinction of delta smelt. They estimated that if the sub-adult population is 12 million, then the probability of extinction of delta smelt by 2050 is less than one percent. The USGS (2003) peer reviewers indicated that the use of their population estimates conclusions as a basis for estimating extinction probability would result in a severe underestimate.

USGS reviewers (2003) also felt that risk could not be removed from the analysis as San Luis claims. USGS concluded that risks to the population from both the anthropogenic and climatic factors were major concerns in evaluating abundance indices, regardless of the analytical outcome.

In another analysis, Bennett (2003) investigated the likelihood of delta smelt populations falling below an "effective population size" for two consecutive years. He defines this term to be a Fall Midwater Trawl index of less than 100 for two straight years. This index value of 100 was chosen because it reflects an unprecedented low number of delta smelt. He determined that there was a 13% chance that the delta smelt's population size could fall below an effective population size within the next 10 years, and a 33% chance that the delta smelt's population size could fall below an effective population size by 2025.

9. I. Is there any other relevant new information, such as corrections in historic range, nomenclatural changes, or identification of erroneous information in the list?

Yes ___X___ No _____

Delta smelt are now known to spawn in the Napa River (CDFG 2003d; Corps 2002 and 2003), although it is unclear if these delta smelt are self perpetuating or if frequent recolonization from the delta is necessary to maintain a population there. Several more years of study will be needed in order to determine the role that the Napa River plays in maintaining the species.

10. For population listings only, utilizing the updated species information, provide your assessment with respect to the appropriate application of the DPS policy. See attachment to 5-year review - Consideration of the DPS policy during the 5-year review.

Not applicable, as the delta smelt was not listed as a DPS.

11. Does the species have an up-to-date recovery plan with downlisting and/or delisting criteria (and in some cases uplisting criteria for threatened species) that address both the demographics and the threats to the species?

Yes _____ No ___X___

Our Recovery Plan (Service 1996) stated that recovery of delta smelt should be assessed when the species satisfies abundance and distribution criteria. Distribution criteria were based on catches of smelt in various zones throughout the range of the species. Abundance criteria were that (1) smelt numbers or total catch must equal or exceed 239 (based on the Delta Smelt Recovery Index) for 2 out of 5 years and (2) not fall below 84 for more than two years in a row. If distribution and abundance criteria are met for a five-year period that includes two successive extreme outflow years, one of which is dry or critical, the species will be considered restored.

12. Does the relevant new information indicate that the recovery criteria for downlisting/delisting/uplisting have been met?

Yes ___X___ No ___X___

Our Recovery Plan (Service 1996) stated that delisting would be considered when (1) the five-year period includes two successive extreme outflow years with one year dry or critical and (2) legal mechanisms and interagency agreements are in place to manage the Central Valley Project (CVP), State Water Project (SWP), and other water users to meet these criteria.

During the period from 1998 through 2002 the Delta Smelt Recovery Index, as calculated from the Fall Midwater Trawl data, exceeded 239 in 2 out of 5 years, the 2 year running average never

fell below 84, and the distribution criteria were met (Service 2003d). Therefore, the delta smelt met the abundance and distribution criteria in 2002 based on the five year period from 1998 through 2002. However, threats to delta smelt still remain, and sufficient legal mechanisms and interagency agreements are not in place to assure removal of many of the threat (see section 13 below for a discussion of threats). Therefore, the delisting process has not been initiated. It should also be noted that for 2003, the Delta Smelt Recovery Index did not meet the abundance and distribution criteria outlined in the Recovery Plan.

13. 5-Factor Analysis - Threats Assessment

This section describes the current status of threats to delta smelt, using our 5-factor analysis.

(A) The present or threatened destruction, modification, or curtailment of its habitat or range.

WATER OUTFLOW

Our original listing document states that the delta smelt's decline and sustained low abundance is linked to changes in hydrology resulting from water resource development in and upstream of the Delta. Delta smelt continue to be affected by delta hydrology, which is governed by both climatological and anthropogenic factors.

For fishes and most other Delta organisms, moderately high spring outflows are important because they move fish downstream to shallow water areas in and around Suisun Bay, distant from south Delta diversions (Service 1996). This well mixed shallow water habitat encourages production of phytoplankton and zooplankton that are food for plankton-feeding fish such as delta smelt and their larvae (Service 1996). Low outflows maintain fish larvae and juveniles in the deep, narrow channels of the Delta and Sacramento River where productivity of phytoplankton is lower because much of the water is beyond the reach of sunlight (Service 1996). Presumably, if the food supply is inadequate, fish either starve to death or have increased mortality from secondary effects, as a result of poor nutrition (Service 1996).

Strong statistical relationships between outflow and abundances of American shad, Chinook salmon and longfin smelt (Stevens and Miller 1983), were demonstrated, but no such statistically significant relationship was found for delta smelt. Nevertheless, Kimmerer (2002) shows a change in delta smelt abundance as it relates to X2 (i.e., flow) historically, the further upstream X2 was the greater the abundance of delta smelt; and more recently, the further upstream X2 the poorer the abundance of delta smelt (see below for additional discussion of X2).

Years of major delta smelt decline have been characterized not only by unusually dry years with exceptionally low outflows (1987-1991) but also by unusually wet years with exceptionally high outflows (1982-83, 1986, 1998). High outflows are believed to flush delta smelt out of the system along with much of the zooplankton. This means that not only is potential spawning

stock of delta smelt reduced, but its food supply as well. Furthermore, depletion of established populations of invertebrates and fish may have made it easier for exotic species of copepods, clams, and fish to colonize the estuary, which may be detrimental to delta smelt (Service 1996).

Years of high delta smelt abundance were strongly correlated with the springtime location and duration of the 2 parts per thousand (ppt) bottom isohaline (X2) demarcation. There is some evidence that a large part of this relationship rests on the number of days in April when salinities of 2 ppt are between Middle Ground and Roe Island. The higher captures of delta smelt below 2 ppt and in shallow habitats (when waters of 2 ppt are near shallow habitats) suggest habitat selection by delta smelt. The tie between the amount of this habitat and fall abundance of delta smelt also suggests that availability of suitable habitat limits the abundance of this species. In the absence of a significant stock/recruitment relationship or tie to any other environmental variable, availability of nursery habitat may be a limiting factor to abundance of adult delta smelt (Service 1996). Future research efforts will hopefully draw more certain conclusions regarding the relationship between physical habitat and population status.

WATER DIVERSIONS

Water is pumped out of the Delta system mainly by the CVP and SWP to supply California's agriculture and municipal demands (Service 1996). Also, over 1,800 small diversions within the Delta supply water for Delta farms (CDWR 1995). Water is also pumped through power plants for cooling west of the Delta (Service 1996). Delta smelt are caught (entrained) in all these pumping facilities (Service 1996). The early stages of these fish are planktonic and weak swimmers making them susceptible to flow patterns (Service 1996). Large numbers of young delta smelt are entrained at CVP and SWP plants (Service 1996). Efforts are made to rescue a portion of the fish (greater or equal to 20 millimeters (mm) fork length being entrained at CVP and SWP plants by trapping them and trucking them back to the Delta (Service 1996). There are no efforts to rescue or quantify fish below 20 mm, these fish are the most susceptible to entrainment and loss (Service 1996). The effectiveness of the salvage activities have not been well evaluated, however, delta smelt are very fragile and the majority die as a result of the process (Bennett 2003).

During dry years, larvae are concentrated in the river channels making them more likely to be entrained in major and minor diversions. High export pumping in dry years changes the hydraulics of the Delta and small fish are shifted upstream to Delta channels rather than in Suisun Bay where they are relatively immune to entrainment. Studies are currently being conducted to quantify losses of delta smelt and other fishes to these delta diversions. Some delta smelt have been captured in agricultural diversions during the studies, but it appears that season, location and size of the diversion are major factors affecting entrainment of delta smelt. Other major diversions within the habitat of delta smelt are the power generation facilities west of the Delta, near Pittsburg and Antioch. These facilities are believed to entrain large numbers of delta smelt juveniles and larvae. Several million larval and juvenile delta smelt are estimated as lost in State, Federal, agricultural, and cooling diversions each year.

There is consensus among experts that power plants with flow through cooling can impose significant mortality if they are close to fish habitat (CALFED 2003a and Service 1996). In the San Francisco Estuary there are two such plants, one at Pittsburg and one at Antioch, both well within the region of maximum abundance of delta smelt for many months of each year (CALFED 2003a and Service 1996).

The California Department of Fish and Game (CDFG) (2003g) is concerned that entrainment at the CVP and SWP may be a major source of population impacts under certain conditions. The Summer Tow Net Survey data show an almost complete disappearance of juvenile delta smelt in the south delta sampling stations by the mid-1970s (CDFG 2003g). This disappearance followed a trend of increasing combined water exports from the south Delta (CDFG 2003g). They further state that they estimate the losses of delta smelt juveniles to SWP and CVP operations to range between 11 to 46% annually (Kimmerer, pers. comm. as cited in CDFG 2003g).

CDFG (2003g) states that in the pre-decline period, delta smelt were more abundant in the delta and less abundant in Suisun Marsh, and in the post-decline period the delta smelt are now less abundant in the delta and more abundant in Suisun Marsh. CDFG concludes that the water exports since the 1970s removed optimal smelt rearing conditions within the delta (CDFG 2003g).

Based upon years of entrainment data at the CVP and SWP facilities, it is clear that large numbers of delta smelt are subject to mortality each year. However, the net effect of this mortality on the delta smelt population structure is difficult to predict at this time.

The CDWR and the U.S. Bureau of Reclamation (Reclamation) are currently preparing a proposal to replace the temporary barriers with permanent barriers. The change from temporary fish and agricultural barriers to permanent barriers in the South Delta could result in additional effects to delta smelt. The temporary barriers are installed in April of each year and are removed in November, and serve the purpose of maintaining water levels for in-delta diverters. These barriers operate using tidal flap gates, meaning the barriers allow the flood tide flow upstream and then close when the tide ebbs to hold water behind the barriers. These barriers physically prevent smelt movement and can also change delta hydraulics (Service 2001). The proposed permanent barriers operations may include operating during additional periods and may include different operations that may affect delta smelt. Computer simulations by the California Department of Water Resources (2003) have shown that placement of the barriers changes south delta hydrodynamics, increasing central delta flows toward the state and federal export facilities. When delta smelt occur in areas influenced by the barriers, entrainment losses at the state and federal export facilities could increase. However, the operations and effects of the permanent barriers have not yet been fully analyzed.

PROPOSED MODIFICATIONS TO THE WATER SYSTEM

The demands on surface water resources in the Central Valley have increased. The proposed Freeport Regional Water Project would divert up to 185,000 acre-feet(af)/year of water from a point of diversion north of the delta at Freeport (Freeport Regional Water Authority 2003). The

proposed expansion of Los Vaqueros Reservoir would entail an additional 400,000 af of off-stream storage, diverted from the delta using existing facilities as well as new facilities located at Old River and/or Middle River (CALFED 2003c and Reclamation 2003a). Reclamation and CDWR have proposed to increase pumping capacity at the SWP Banks pumping plant from 6,680 cubic feet per second (cfs) to 8,500 cfs and eventually to 10,300 cfs (CALFED 2002b, 2003d). Reclamation and CDWR have also proposed construction of a 400 cfs intertie connecting their aqueducts, which would allow Reclamation to increase the pumping at their Tracy Pumping Plant from 4,200 cfs to 4,600 cfs. The CALFED Bay-Delta Program proposes to expand surface water storage capacity at existing reservoirs and strategically located off-stream sites by 3.5 million af (including the 400,000 af at Los Vaqueros) by: 1) north of the delta off stream storage; 2) Shasta enlargement; 3) Los Vaqueros Expansion; 4) in-delta storage; and 5) additional storage in the Upper San Joaquin (Friant) (CALFED 2002b and Reclamation 2003a). Finally, the City of Stockton proposes to construct a new intake at the southwestern tip of Empire Tract on the San Joaquin River with an ultimate diversion capacity of 371 cfs (Environmental Science Associates 2003). The diversions would likely result in lower delta outflows and increased entrainment.

In summary, the threats under this category as described in the original listing remain. Since the time of the listing, State and Federal agencies together with stakeholder groups have implemented the Delta's Water Quality Standards, VAMP, and EWA, which have helped to ameliorate these threats. It is unclear how effective these management tools will be over time based on available funding and future demands for water.

(B) Overutilization for commercial, recreational, scientific or educational purposes

Our final listing rule (Service 1993) did not identify any threats in this category, and there is no new information concerning threats of overutilization for commercial, recreational, scientific or educational purposes.

(C) Disease or predation

Our final listing rule (Service 1993) did not identify any threats in this category.

Antonio *et al.* (2000) examined infections associated with *Mycobacterium* ssp. in wild and captive delta smelt. *Mycobacterium* ssp. was not detected from any of the fish examined immediately after collection from the Sacramento-San Joaquin Estuary or during captivity of broodstock groups at water temperatures of 9-12°C. However, *Mycobacterium* ssp. was isolated from, and mycobacteriosis occurred in, broodstock held at 16°C during spawning season and in experimental groups maintained at 17°C. *Mycobacterium* ssp. and mycobacteriosis were more prevalent among groups frequently handled for physiological experiments. Broodstock groups that were less stressed exhibited a lower prevalence of the bacterium and the disease. Their findings suggest that *Mycobacterium* ssp. may be present in a latent state in the wild population of delta smelt and infections may progress from asymptomatic to clinical under intensive culture conditions. Swanson *et al.* 2002a concluded that while *Mycobacterium* ssp. may not play a significant role in the ecology of delta smelt (e.g. as the proximate cause of post-spawning

mortality), some aspect of the handling of the fish may have caused this disease to develop. The relevance of *Mycobacterium* ssp. to delta smelt in the wild is unknown at this time.

In the central Delta, recent studies by Grimaldo *et al.* (2000) of tidal wetland and marsh habitats show that introduced fishes dominate. The presence of the introduced water plant, *Egeria densa*, appears to be an important factor at sites in the central Delta. In areas where this plant is abundant, native fishes are extremely rare.

Although many species may prey on adult and juvenile delta smelt, much of the attention to date has focused on inland silversides (CALFED 2001). After their accidental introduction to the Delta in 1975, their population expanded rapidly through the 1990s (CALFED 2001). Estimates of abundance of delta smelt and silversides are negatively correlated, suggesting that inland silversides may be an important predator on larval delta smelt and competitor for copepod prey (CALFED 2001). Silversides often occur in dense schools near shorelines and their occurrence may detract from the value of shallow water habitat created to aid delta smelt restoration (CALFED 2001).

As noted by CDWR (2003), however, since the early 1980's there also have been increases in other potential larval fish predators such as coded-wire-tagged chinook salmon smolts released in the delta for survival experiments and non-native centrarchids. In addition, striped bass appear to have switched to piscivorous feeding habits at smaller sizes than they historically did following severe declines in the abundance of mysid shrimp (CDWR 2003). To address concerns regarding delta smelt, the California Department of Fish and Game completed a Habitat Conservation Plan for their striped bass management program, which includes measures designed to help conserve delta smelt.

Northern pike (*Esox lucius*) have been introduced into Lake Davis, and all attempts at eradication have failed (CDFG 2000). If these fish escape into the Sacramento River system and become established in the delta, the delta smelt population will almost certainly be affected (CDFG 2000).

In summary, the threats of disease and predation have still not been sufficiently studied to determine their effects on delta smelt.

(D) The inadequacy of existing regulatory mechanisms

The operation of the SWP and CVP has been conditioned by the Service's biological opinion (Service 1995). The BO has no provision for the protection of larval delta smelt (<20mm in size) at the facilities. The take is not quantified but assumed to be high in number given the smelt's poor swimming ability. At this time, we do not have information on any correlation or causality between larval delta smelt take and population index.

The discharge of any ballast water into the San Francisco Bay is not prohibited. The U.S. Coast Guard has jurisdiction over ships that discharge ballast water (Service 1996). The Coast Guard requires ships to discharge ballast water before entering U.S. ports, but compliance is voluntary

(Service 1996). A number of non-native species have already been introduced into the Bay-Estuary-Delta from ballast water and without strictly enforced prohibitions on ballast water discharge in the Bay, additional introductions of non-native species can be expected to continue (Service 1996 and Moyle 2003).

(E) Other natural or manmade factors affecting its continued existence

REDUCED PRODUCTIVITY AND FOOD

Jassby *et al.* (2003) found that phytoplankton biomass has declined over the past few decades, partly because of the Asiatic clam invasion. The phytoplankton decline may represent a reduction in the system's capacity to support higher levels of the food web. Lower phytoplankton levels have been linked to declines in key zooplankton populations in the delta, although the evidence for food limitation of fish populations is not as strong as for zooplankton and benthic invertebrates. However, Kimmerer (2002) pointed out that the decline in delta smelt abundance predates the step decline in the base food web.

Our Recovery Plan (Service 1996) stated that another complicating factor is the rise in abundance of the diatom *Melosira*, at some times to the point where it is the most abundant species of phytoplankton. This diatom grows in long chains and is very difficult for zooplankton to graze on; thus the change in composition and abundance of zooplankton may also be tied to the increased importance of this diatom. The causes of increase in *Melosira* are not known (Service 1996).

GENETICS

Genetic analyses have confirmed that delta smelt and wakasagi (*Hypomesus nipponensis*) are distinct species with delta smelt more closely related to surf smelt than wakasagi (Stanley et al. 1995; Trenham *et al.* 1998). While hybridization is possible between delta smelt and wakasagi the threat of introgression at the population level is believed to be low due to the sterility or lack of viability of offspring (Trenham *et al.* 1998). Interbreeding may cause the loss of valuable gametes of delta smelt and hinder the population from recovering (Moyle 2002, 2003). Swanson *et al.* (2000) studied the temperature, salinity, and flow tolerances of delta smelt and the non native wakasagi, and concluded that delta smelt may be at a physiological disadvantage to wakasagi, particularly in habitats with suboptimal environmental conditions. They also concluded that the low abundance of wakasagi in the delta recorded to date may indicate that factors other than temperature, salinity, and flow determine wakasagi distribution.

Trenham *et al.* 1998 determined that delta smelt exhibits very little population subdivision across its range, and that the delta smelt in the Napa River are not a distinct population.

ENVIRONMENTAL FACTORS

Delta smelt are relatively poor swimmers and show lower swimming ability than other sympatric fishes of the Delta (Swanson *et al.* 2000). Delta smelt are unable to swim against the current for any substantial distance, and therefore are more susceptible to impingement and entrainment at major water diversions than other similar sized fish species (Cech and Swanson 1998; Swanson *et al.* 1998, 2002b, and 2003; Young *et al.* 1998, and 2003; and White *et al.* 1998).

The threats of other natural or manmade factors affecting the delta smelt's continued existence as described in the original listing (Service 1993) remain and will increase. The available information indicates that hybridization with wakasagi is not a threat to delta smelt.

14. Outcome:

14.A. Regarding the species' demographic status, does the species now occupy a significant portion of its former range, and within its current range, is the species demographically stable or improving? If not, what is the outlook for expansion of the species into a significant portion of its former range?

The delta smelt currently occupies its historic range; although its abundance in the south delta is considerably lower (CDFG 2003g). Moyle (2002) stated that the pelagic life style, short life span, spawning habits, and relatively low fecundity indicate that a substantial population is necessary to keep delta smelt from becoming extinct.

The two-year running average of the Delta Smelt Recovery Index for 2003, as determined from the FMWT, is the second lowest since the species was listed (Service 2003d). The Summer Tow Net Survey data show an almost complete disappearance of juvenile delta smelt in the south delta sampling stations by the mid-1970s (CDFG 2003g). Moyle (2003), stated that the analysis of 22 years of monthly sampling data from Suisun Marsh shows that the delta smelt have still not recovered to their former abundance, although there has been a general increase in numbers since their low point during a long period of drought (Matern *et al.* 2002)(see appendix B). From these indices, the Service has concluded that the delta smelt abundance has not recovered to its pre-decline (prior to 1982) levels and that the overall trend is negative.

CDFG (2003g) is concerned that entrainment at the CVP and SWP remains be a major source of population impacts under certain conditions, and that the species will remain threatened in the foreseeable future due in part to water exports. Future increases in water exports could increase the population effects to delta smelt. Moyle (2003) states that the delta smelt will never be out of danger of extinction unless there are permanent and reliable changes made to the flow and temperature regimes that favor the smelt.

14.B. What individual threat(s), if any, could result in the extinction of the species within its currently occupied range? What has been done/is being done to abate these threats?

The threats of the destruction, modification, or curtailment of its habitat or range resulting from extreme outflow conditions (reduced outflow or high outflow) and/or the operations of the State and Federal water projects could result in the extinction of the delta smelt (CDFG 2003g and Moyle 2002, 2003). In addition, any one of the many stochastic factors that affect delta smelt, such as predation, invasive species, change in food organisms, toxic substances, disease, competition, and entrainment losses to water diversions can cause their numbers to move towards extinction (Moyle 2002, 2003).

The San Luis & Delta-Mendota Water Authority (2002) submitted to the Secretary of Interior their analysis of population size estimate, population trend and extinction probability for delta smelt. Their analysis was subjected to a peer review by the USGS (2003). The USGS (2003) determined that none of their analysis or assumptions was valid and that their white paper did not constitute new information. Others reviewing their white paper reached the same conclusions as the USGS. (See 9h above)

Moyle (2002) states that it is implicit that the recovery of delta smelt requires the recovery of natural processes in the Sacramento-San Francisco estuary, including outflow. Finding a way to protect the delta smelt without disrupting water supplies (i.e. CVP and SWP operations), was a major reason for the creation of CALFED. The CALFED process set in motion a number of efforts, described in #9D above, toward recovery of delta smelt, although the effectiveness of these measures remains to be seen.

14.C. What combined threats, if any, could result in the extinction of the species within its currently occupied range? What has been done/is being done to abate these threats?

See #14B above.

14.D. If no single threat or combination of threats threatens the species' existence at this time, what single threat or combination of threats could cause a decline toward endangerment?

See #14B above.

FINDING

__X__ The 5-year review does not indicate a change in classification is warranted.

_____ The 5-year review does indicate a change in classification is warranted.

In summary, the threats of the destruction, modification, or curtailment of its habitat or range resulting from extreme outflow conditions, the operations of the State and Federal water projects, and other water diversions as described in the original listing remain. The only new information concerning the delta smelt's population size and extinction probability indicates that the population is at risk of falling below an effective population size and therefore in danger of becoming extinct. Although VAMP and EWA have helped to ameliorate these threats, it is unclear how effective these will continue to be over time based on available funding and future demands for water. In addition, there are increased water demands outside the CVP and SWP which could also impact delta smelt. The increases in water demands are likely to result in less suitable rearing conditions for delta smelt in Suisun Marsh, increased vulnerability to entrainment, and less water available for maintaining the position of X2. The importance of exposure to toxic chemicals on the population of delta smelt is highly uncertain. Therefore, a recommendation to delist the delta smelt is inappropriate.

In addition, many potential threats have not been sufficiently studied to determine their effects, such as predation, disease, competition, and hybridization. Therefore, a recommendation of a change in classification to endangered is premature.

In his August 24, 2003, letter, the foremost delta smelt expert, Dr. Peter B. Moyle, stated that the delta smelt should continue to be listed as a threatened species (Moyle 2003). In addition, in their January 23, 2004, letter, the CDFG fully supported that the delta smelt should retain its threatened status under the Act (CDFG 2004).

15. If the outcome to #14 above indicated that a change is warranted, recommend the appropriate classification.

Not Applicable.

16. List all information and data sources used in this review, and file locations if they will not be filed with the review: All listed documents are filed within the Sacramento Fish and Wildlife Office.

A. Peer Reviewed Literature

Antonio, Dolores B., Christina Swanson, Joseph J. Cech Jr., Randy C. Mager, Sergei Doroshov, and Ronald P. Hedrick. 2000. Prevalence of *Mycobacterium* in Wild and Captive Delta Smelt. California Fish and Game 86(4): 233-243.

Grimaldo, L.F., Peregrin, C., and R. Miller. 2000. Examining the relative predation risks of juvenile chinook salmon in shallow water habitat: the effect of submerged aquatic vegetation. IEP Newsletter, 13(1): 57-61.

Jassby, A.D., J.E. Cloern, and A.B. Muller-Solger. 2003. Phytoplankton fuels Delta food web. California Agriculture, 57(4): 104-109.

Herbold, Bruce. 1994. Habitat Requirements of Delta Smelt. *In*: R. Brown and P. Herrgesell (Eds): Interagency Ecological Studies Program Newsletter, Winter 1994. California Department of Water Resources. Sacramento, California.

Herbold, Bruce. 1996. Why we don't do population estimates for delta smelt. IEP Newsletter, 8(2): 20-22.

Kimmerer, W.J. 2002. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Marine Ecological Progress Series 243: 39-55.

Matern, Scott A., Peter B. Moyle, and Leslie C. Pierce. 2002. Native and Alien Fishes in a California Estuarine Marsh: Twenty-One Years of Changing Assemblages. Transactions of the American Fisheries Society 131: 797-816.

Molye, Peter B. 2002. Inland Fishes of California. University of California Press. 576 pp.

Rosenfield, Jonathan A. 2002. Pattern and process in the geographical ranges of freshwater fishes. Global Ecology & Biogeography 11: 323-332.

Stanley, Scott E., Peter B. Moyle, and H. Bradley Shaffer. 1995. Allozyme Analysis of Delta Smelt, *Hypomesus transpacificus* and Longfin Smelt, *Spirinchus thaleichthys* in the Sacramento-San Joaquin Estuary, California. Copeia 2: 390-396.

Stevens, D.E. and L.W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin River system. North American Journal of Fisheries Management 3: 425-437.

Swanson, Christina, Paciencia S. Young, and Joseph J. Cech Jr. 1998. Swimming Performance of Delta Smelt: Maximum Performance, and Behavioral and Kinematic Limitations on Swimming at Submaximal Velocities. Great Britian. Journal of Experimantal Biology 201, 333-345.

Swanson, Christina, Turid Reid, Paciencia S. Young, and Joseph J. Cech Jr. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered California estuary. Oecologia 123: 384-390.

Swanson, Christina, D.V. Baxa, Paciencia S. Young, Joseph J. Cech Jr., and Ronald P. Hedrick. 2002a. Reduced Swimming Performance in Delta Smelt Infected with *Mycobacterium* ssp. Journal of Fish Biology 61: 1012-1020.

Sweetnam, D.A. and D. E. Stevens. 1993. A status of the delta smelt (*Hypomesus transpacificus*) in California. Report to the Fish and Game Commission. Candidate Species Report 93-DS. 98 pp.

Trenham, Peter C., H. Bradley Shaffer, and Peter B. Moyle. 1998. Biochemical Identification and Assessment of Population Subdivision in Morphologically Similar Native and Invading Smelt Species (*Hypomesus*) on the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 127: 417-424.

B. Personal Communications, Comment Letters, White Papers, Workshop Summaries, Federal Register Publications, and All Other Information

Bay Institute, The. 2003. Comment Letter on the Five Year Status Review of the Delta Smelt. 4 pp.

Bennett, William A. 2003. The Population Ecology of Delta Smelt in the San Francisco Estuary. 44 pp.

Bureau of Reclamation. 2003a. Notice of Initiation of Federal Feasibility Studies. Mid-Pacific Regional Office, Sacramento California.

Bureau of Reclamation. 2003b. Draft Long-Term Central Valley Project Operations Criteria and Plan Biological Assessment. Mid-Pacific Regional Office, Sacramento California.

CALFED Bay-Delta Program. 2001. Delta Smelt and CALFED's Environmental Water Account: Summary of a Workshop held September 7, 2001 at the University of California, Davis. Sacramento, California.

CALFED Bay-Delta Program. 2002a. Workshop Summary Water Operations and Environmental Protection in the Delta: Scientific Issues. Sacramento, California.

CALFED Bay-Delta Program. 2002b. Annual Report 2002. Sacramento, California. 80 pp.

CALFED Bay-Delta Program. 2003a. CALFED's Environmental Water Account: Summary of the Annual Delta Smelt Technical Workshop, Santa Cruz, California, August 18-19, 2003. Sacramento, California.

CALFED Bay-Delta Program. 2003b. Ecosystem Restoration Program Project Evaluation Phase 2 Report. Sacramento, California. 72 pp.

CALFED Bay-Delta Program. 2003c. CALFED Los Vaqueros Reservoir Studies [database on the internet]. Updated on May 27, 2003. Available from http://www.lvstudies.com/default.asp. Accessed on October 10, 2003.

CALFED Bay-Delta Program. 2003d. CALFED Implementation: The Role of the Napa Proposal. Powerpoint Presentation. Sacramento, California.

California Department of Fish and Game. 2000. Risk to California's Fisheries [database on the internet]. Available from http://www.dfg.ca.gov/northernpike/mgpike.htm. Accessed on February 6, 2004.

California Department of Fish and Game. 2003a. Fall Midwater Survey Results [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/mwt/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003b. Fish Salvage Monitoring [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/salvage/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003c. Summer Townet Survey [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/townet/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003d. 20mm Survey [database on the internet]. Available from http://www.delta.ca.gov/data/20mm/2000/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003e. Spring Kodiak Trawl [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/skt/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003f. North Bay Aqueduct Larval Fish Survey [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/nba/catchsummary.asp. Accessed on October 10, 2003.

California Department of Fish and Game. 2003g. Comment Letter on the Five Year Status Review of the Delta Smelt. 6 pp.

California Department of Fish and Game. 2004. Comment Letter on the Five Year Status Review of the Delta Smelt. 2 pp.

California Department of Water Resources. 1995. Sacramento San Joaquin Delta Atlas.

California Department of Water Resources. 2003. Comment Letter on the Five Year Status

Review of the Delta Smelt. 20 pp.

Cech, Joseph J. Jr., and Christina Swanson. 1998. Delta Smelt Environmental Requirements and Tolerance Limits. *In*: Proceedings of the Third Delta Smelt Workshop, Sacramento, California.

Environmental Science Associates. 2003. Stockton Delta Water Supply Project. 25 pp.

Freeport Regional Water Authority. 2003. Draft Environmental Impact Report/Environmental Impact Statement.

Interagency Ecological Program. 1996. Striped Bass Egg and Larval Survey [database on the internet]. Updated March 14, 1996. Available from http://www.iep.water.ca.gov/strip_bass_els/.

Knowles, Noah. 2001. Long-Term Inflow and Salinity Changes. *In*: State of the Estuary 2001 Conference. California.

Moyle, Peter B. 2003. Comment Letter on the Five Year Status Review of the Delta Smelt. 4pp.

Rosenfield, Jonathan A. 2003. Comment Letter on the Five Year Status Review of the Delta Smelt. 3 pp.

San Luis & Delta-Mendota Water Authority. 2002. The Delta Smelt and the State of the Science. 5 pp + Appendices.

Swanson, Christina, Paciencia S. Young, Stephanie Chun, Trilia Chen, Teresa MacColl, Leslie Kanemoto, Timothy Mussen, Rachel Kussow, and Joseph J. Cech Jr. 2002b. Close Encounters with a Fish Screen II: The Emerging Delta Smelt Story. *In*: Proceedings of the Symposium and 36th Annual Meeting of the California-Nevada Chapter of the American Fisheries Society. Tahoe City, California.

Swanson, Christina, Paciencia S. Young, Stephanie Chun, Trilia Chen, Timothy Mussen, Joseph J. Cech Jr., G. Aasen, and Robert Fujimura. 2003. Close Encounters with a Fish Screen: Exploring Applications of Laboratory Studies for Developing Fish Screen Criteria for Delta Smelt. *In*: Proceedings of the CALFED Science Conference 2003. Sacramento, California.

U.S. Army Corps of Engineers, Sacramento District. 2002. Napa River Fisheries Monitoring Program Annual Report 2001. Contract # DACW05-01-C-0015. Prepared by: Stillwater Sciences and Jones & Stokes.

U.S. Army Corps of Engineers, Sacramento District. 2003. Napa River Fisheries Monitoring

Program Annual Report 2002. Contract # DACW05-01-C-0015. Prepared by: Stillwater Sciences and Jones & Stokes.

U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants: Determination of threatened status for the delta smelt. March 5, 1993. **Federal Register** 58(42): 12854-12864.

U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants: Critical habitat determination for the delta smelt. December 19, 1994. **Federal Register** 59(242): 65256-65279.

U.S. Fish and Wildlife Service. 1995. Formal Consultation and Conference on Effects of Long-Term Operation of the Central Valley Project and the State Water Project on the Threatened Delta Smelt, Delta Smelt Critical Habitat, and Proposed Threatened Sacramento Splittail.

U.S. Fish and Wildlife Service. 1996. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. Portland, Oregon. 195 pages.

U.S. Fish and Wildlife Service. 2001. Formal Section 7 Consultation on the South Delta Temporary Barriers Project in San Joaquin County, California. Sacramento, California. 31 pages.

U.S. Fish and Wildlife Service. 2003a. 2003 Species Status as reported to Congress in the Biennial Report. Sacramento Fish and Wildlife Office. Sacramento, California.

U.S. Fish and Wildlife Service. 2003b. Combined Facilities Take Comparison by Month and Water Year type. Sacramento Fish and Wildlife Office. Sacramento, California.

U.S. Fish and Wildlife Service. 2003c. Environmental Water Account Expenditures for Protection of the Delta Smelt in Water Year 2003.

U.S. Fish and Wildlife Service. 2003d. Delta Smelt Recovery Index. Sacramento, California.

USGS. 2003. Editor's Comments-Peer Review of the 2002 San Luis and Delta-Mendota Water Authority White Paper "The Delta Smelt and the State of the Science"

White, D.K., Christina Swanson, Paciencia S. Young, Joseph J. Cech, Jr., and L. Kavvas. 2003. Close Encounters with a Fish Screen: Anatomy of an Impingement. *In*: Proceedings of the CALFED Science Conference 2003. Sacramento, California.

Young, Paciencia S., Christina Swanson, and Joseph J. Cech, Jr. 1998. Delta Smelt Swimming Performance: Effects of Environmental Variables. *In*: Proceedings of the Third Delta Smelt Workshop, Sacramento, California.

Young, Paciencia S., Christina Swanson, Leslie Kanemoto, Trilia Chen, Stephanie Chun, Joseph J. Cech, Jr., Z.Q. Chen, H. Bandeh, and L. Kavvas. 2003. Close Encounters with Two Fish Screens: Responses of Delta Fishes to Simulated Multiple Exposures. *In*: Proceedings of the CALFED Science Conference 2003. Sacramento, California.

C. Literature from the Listing File

Bailey, H.C., D.J. Ostrach, and D.E. Hinton. 1991. Effect of rice irrigation water in Colusa Basin Drain on fertilization success and embryonic development in striped bass. Contract No. 9-169-250-0 Draft Report to California State Water Resources Control Board. 31 pp.

California Department of Water Resources. 1992. Data and computations used to determine 1993 water charges. Bulletin 132-92, Appendix B. California Department of Water Resources, Sacramento, California. 136 pp.

California State Water Resources Control Board. 1992. Draft Water Right Decision 1630, San Francisco Bay/Sacramento-San Joaquin Delta Estuary, December 1992. State Water Resources Control Board, Sacramento, California. 121 pp. + Appendices.

Carlton, J.T., J.K. Thompson, L.E. Schemel, and F.H. Nichols. 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis*. I. Introduction and dispersal. Mar. Ecol. Prog. Ser. 66: 81-94.

Houde, E.D. 1989. Comparative growth, mortality, and energetics of marine fish larvae: Temperature and implied latitudinal effects. Fishery Bulletin, U.S. 87: 471-495.

Lorentzen, E.M. 1987. U.S. Fish and Wildlife Service testimony in the matter of State Water Resources Control Board water quality/water rights proceeding on the San Francisco Bay and Sacramento-San Joaquin River Delta, September 8-10, 1987. U.S. Fish Wildlife Service Exhibits 17-24. 11 pp.

Morat, R.J. 1991. U.S. Fish and Wildlife Service testimony in the matter of State Water Resources Control Board Public Hearing and Board Meeting on consideration of drought-related emergency water rights order and related actions in response to a request for a hearing from the Department of Water Resources, March 15, 1991. U.S. Fish Wildlife Service Exhibit 1. 3 pp.

Moyle, P.B. 1976. Inland Fishes of California. University of California Press, Berkeley, California. 405 pp.

Moyle, P.B. and B. Herbold. 1989. Status of the delta smelt, *Hypomesus transpacificus*. Unpublished final report prepared for U.S. Fish and Wildlife Service, Sacramento Field Office, Habitat Conservation Division, Sacramento, California. 42 pp.

Moyle, P.B., B. Herbold, D.E. Stevens, and L.W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Trans. Amer. Fish. Soc. 121: 67-77.

Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Final report prepared for State of California, Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California. 222 pp.

Nichols, F.H., J.E. Cloern, S.N. Luoma, and D.H. Peterson. 1986. The modification of an estuary. Science 231: 567-573.

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta. Pp. 115-119 *In*: J.L. Turner and D.W. Kelley, eds.: Ecological studies of the Sacramento-San Joaquin estuary, Part 2. California Department of Fish and Game Fish Bulletin No. 136.

Shepherd, J.G. and D.H. Cushing. 1980. A mechanism for density-dependent survival of larval fish as the basis of a stock recruitment relationship. J. Cons. int. Explor. Mer 39: 160-167.

Stevens, D.E., L.W. Miller, and B.C. Bolster. 1990. Report to the Fish and Game Commission: A status review of the delta smelt (*Hypomesus transpacificus*) in California. California Department of Fish and Game Candidate Species Status Report 90-2. 149 pp.

Sweetnam, D. 1992. Delta Smelt Project Update, October 1992. Unpublished report prepared by California Department of Fish and Game, Bay-Delta and Special Water Projects Division, Stockton, California. 7 pp.

17. List all knowledgeable experts and their affiliations used in this review:

The Service received comments from individuals and agencies during our comment period (see Appendix C for a list of commentors). In addition, the Service closely worked with CDFG to coordinate with their review on the status of delta smelt. In their January 23, 2004, letter, CDFG fully supported that the delta smelt should retain its threatened status under the Act.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
SIGNATURE PAGE

Species: *Hypomesus transpacificus*

Recommendation: *No change in listing status.*

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve _____/Date 3/31/04

Do not Approve_____/Date

Lead Field Offices must ensure that all other Field Offices within the range of the species' have been provided an adequate opportunity to review and comment prior to the reviews' completion. For all species where a change in classification is recommended, written concurrence from other Field Offices is required.

Cooperating Field Supervisor, U.S. Fish and Wildlife Service

Concur N/A /Date

Not concur_____/Date

Lead Regional Director, U.S. Fish and Wildlife Service

Concur _____/Date 3/31/2004

Not concur_____/Date

The Regional Director must sign all 5-year reviews, unless the authority has been delegated by the Regional Director to the Field Supervisor.

Cooperating Regional Director, U.S. Fish and Wildlife Service

Concur _____/Date

Not concur_____/Date

The Lead Region must ensure that any other Regions within the range of the species' have been provided an adequate opportunity to review and comment prior to the reviews' completion. For all species where a change in classification is recommended, written concurrence from other Regional Directors is required.

APPENDIX A
to the 5-year review for
Hypomesus transpacificus (delta smelt)

Based upon our review of the best available scientific data, we concluded that the delta smelt should retain threatened status. Many of the original threats to delta smelt identified in the 1993 listing continue to exist, and the population of delta smelt remains substantially below its historical levels. While some important improvements have been made, most threats which were discussed in the original listing remain. Therefore, it is not justified at this time to recommend delisting of the delta smelt.

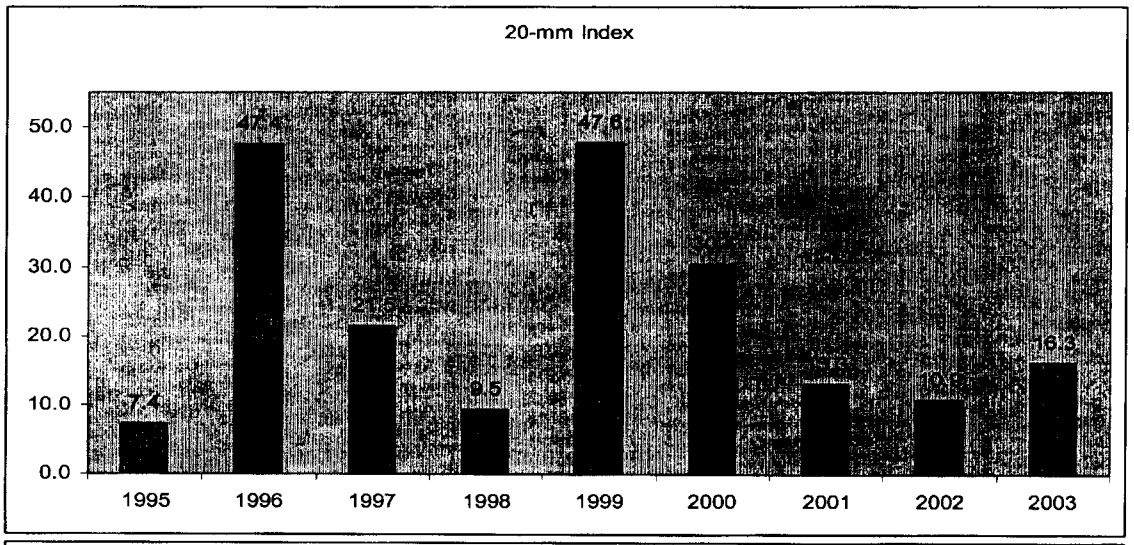
Having reached this conclusion, we nevertheless acknowledge that the San Luis & Delta-Mendota Water Authority's white paper made several important points with which we agree:

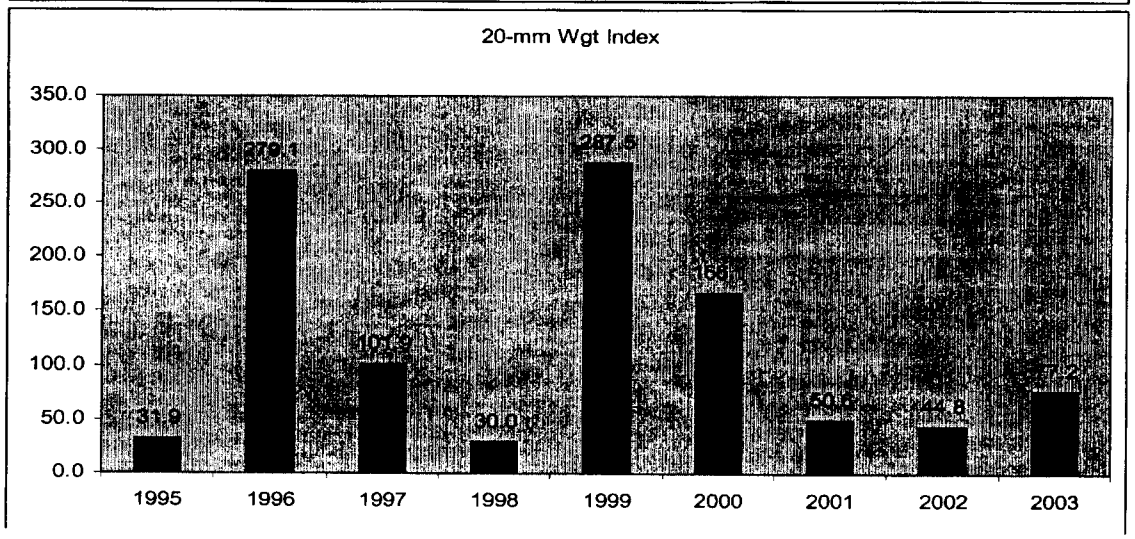
- Since 1996, significant new information has been collected, and therefore some of the original recovery criteria are outdated and in need of revision.
- Some of the data collection and analysis methods are not well suited for monitoring delta smelt abundance or population trends and should be improved.
- The Service should work more closely with you and other interested parties to incorporate updated scientific information into water management decisions.

There has been substantial information gathered since the time of listing concerning the life history and biology of delta smelt. Since the recovery plan was written in 1996 our understanding of how the delta smelt respond over time to changes in environmental conditions does not seem to have been born out. Dr. Peter Moyle (former Delta Native Fishes Recovery Team Leader) in his comments on the notice for this review (Moyle, 2003) suggested that the current numerical criteria for delta smelt are no longer appropriate based on our current understanding of delta smelt biology. Although the numeric criteria in the 1996 recovery plan have been met, it appears that the long-term trend of delta smelt abundance indices has not appreciably changed since the time of listing. There is numerous new data collection and analytical methods that have been explored in order to better understand delta smelt population dynamics these include the 20 mm survey and the spring townet survey. Also analytical methods to try and correlate different data sets for a more predictive estimate of future abundance have been investigated such as relationships between summer tow-net surveys and the fall mid-water trawl. The high degree of variability in the population both in time and space do not appear to be accurately reflected in the current numeric criteria. That is to say the current criteria only use one data set (fall mid-water trawl) and only a sub-set of the data set. There are geographic limitations to the data set in terms of establishing recovery over the known range of the species. The role of environmental variables such as the role of hydrology and climactic conditions in delta smelt population dynamics is not well understood and the temporal nature of the current recovery criteria should be reviewed. Based on the above reasoning and recommendations from experts in the field we recommend that a recovery team be reconvened to review the biology of delta smelt and revise the numeric criteria as appropriate.

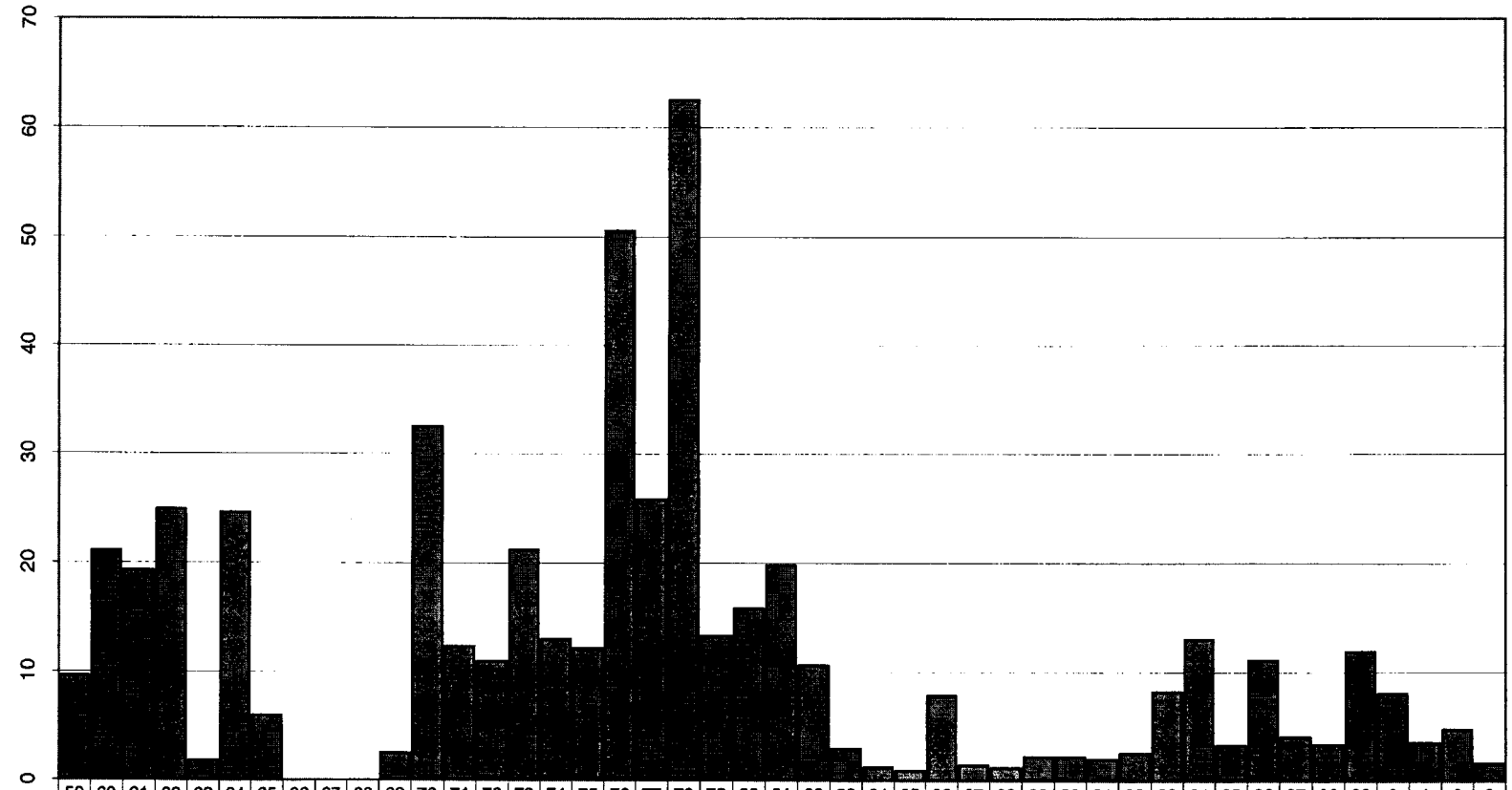
APPENDIX B
to the 5-year review for
***Hypomesus transpacificus* (delta smelt)**
Date

Abundance Index Tables

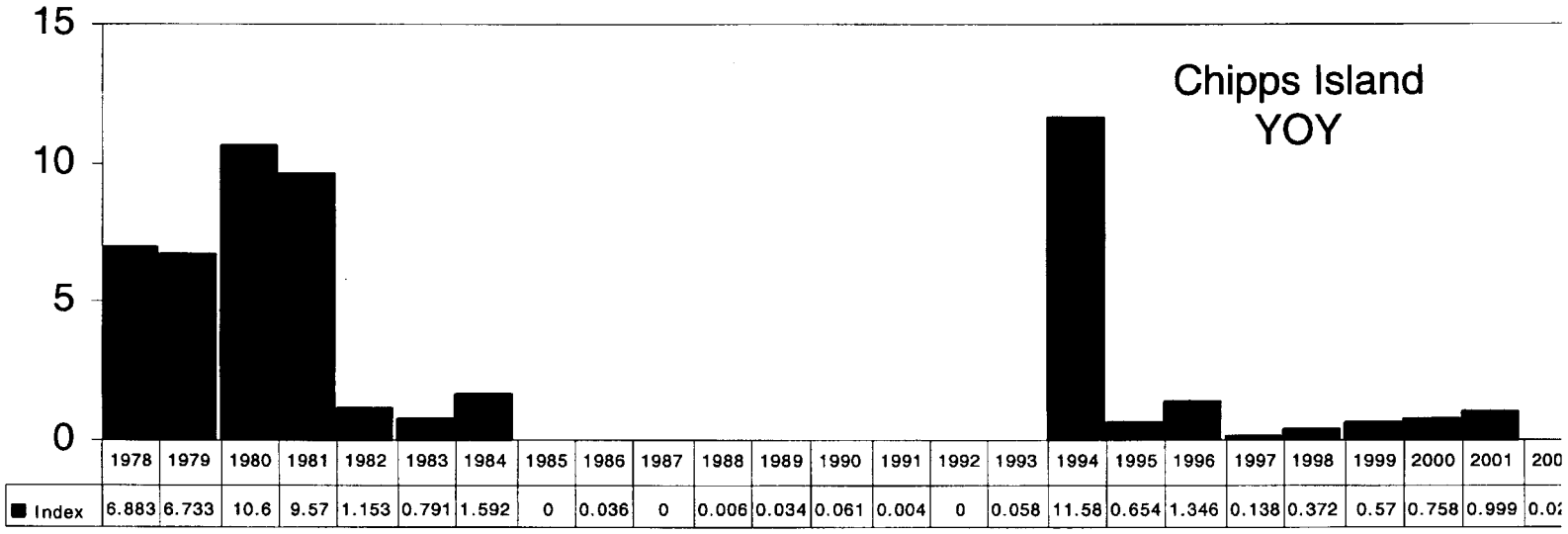

20-mm Index
50.0
40.0
30.0
20.0
10.0
0.0
7.4
47.6
9.5
47.6
16.3
1995
1996
1997
1998
1999
2000
2001
2002
2003


20-mm Wgt Index
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
31.9
279.1
100.9
30.0
287.5
166.1
50.2
44.8
77.2
1995
1996
1997
1998
1999
2000
2001
2002
2003

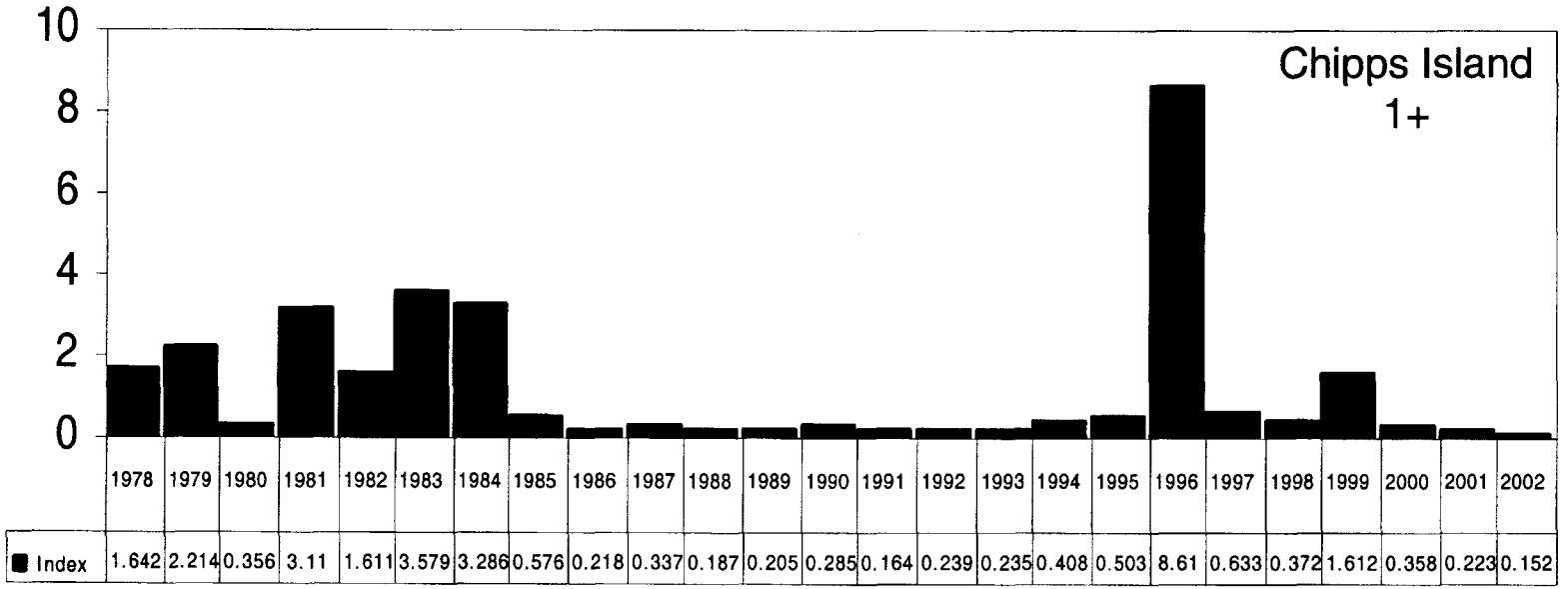
TNS Index



	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	0	1	2	3
Index	9.6	21	19	25	1.8	25	6				2.5	33	12	11	21	13	12	51	26	63	13	16	20	11	2.9	1.2	0.9	7.8	1.4	1.2	2.2	2.2	2	2.5	8.2	13	3.2	11	4	3.3	12	8	3.5	4.7	1.6

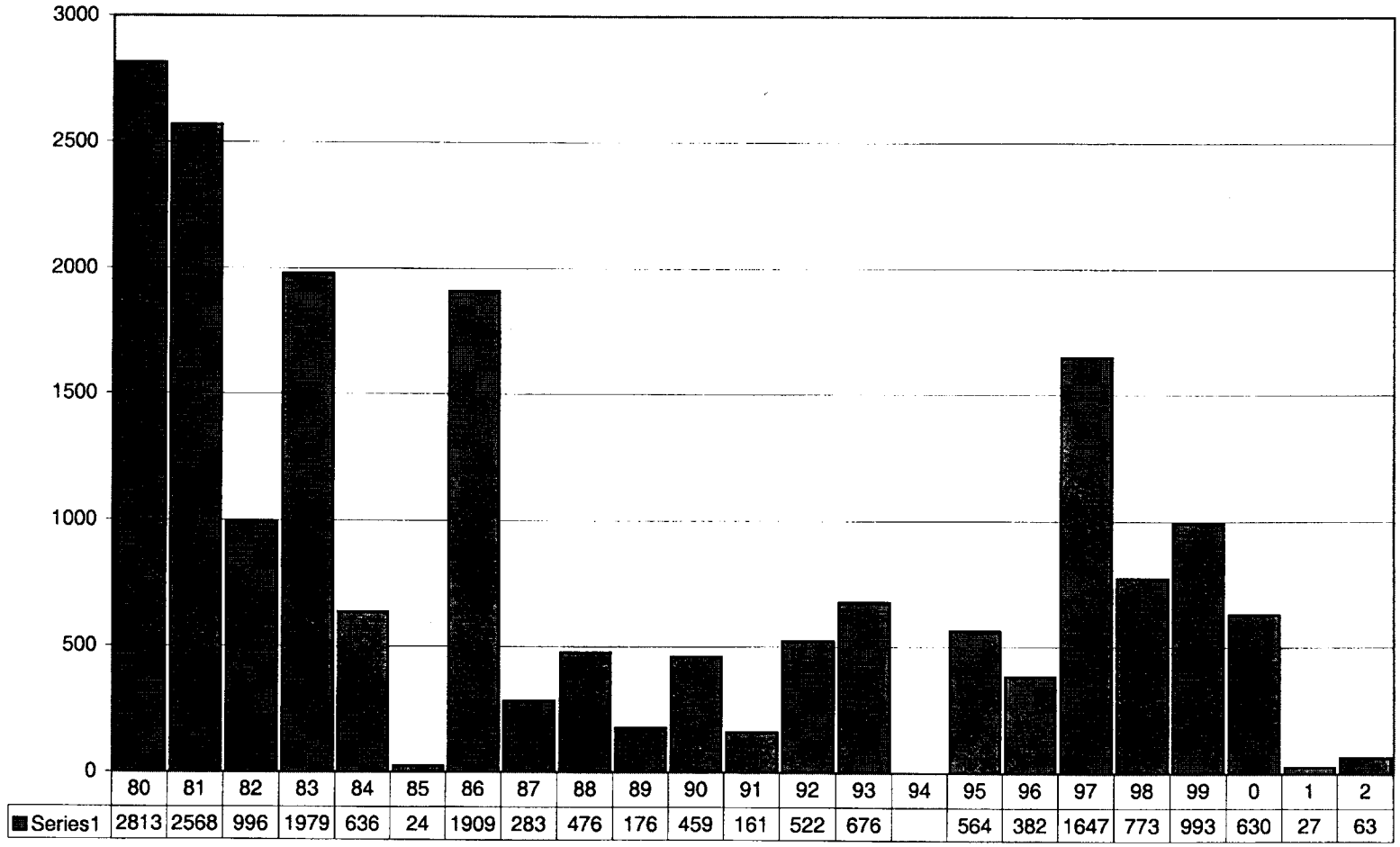


	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	200
Index	6.883	6.733	10.6	9.57	1.153	0.791	1.592	0	0.036	0	0.006	0.034	0.061	0.004	0	0.058	11.58	0.654	1.346	0.138	0.372	0.57	0.758	0.999	0.0



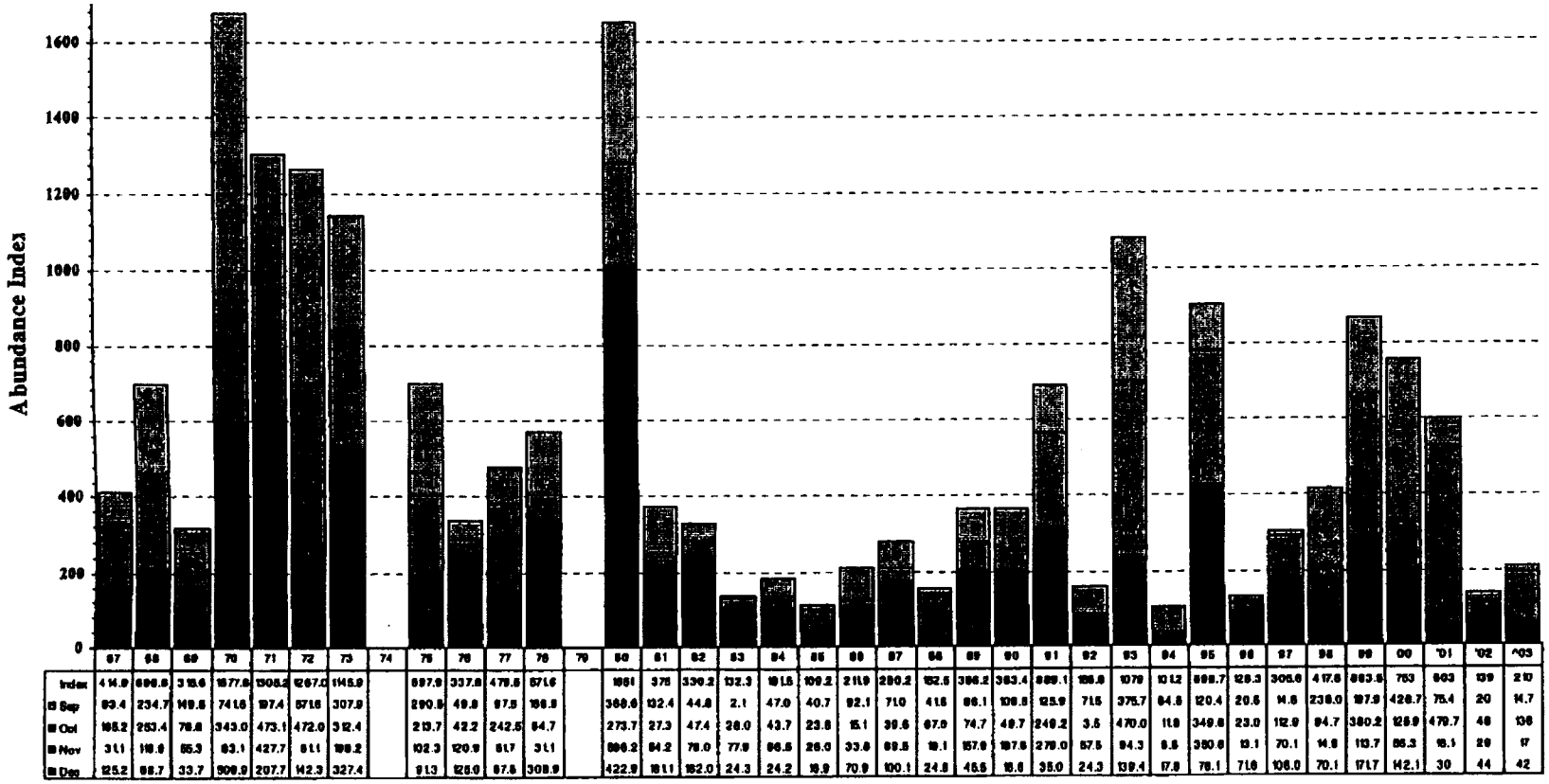
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Index	1.642	2.214	0.356	3.11	1.611	3.579	3.286	0.576	0.218	0.337	0.187	0.205	0.285	0.164	0.239	0.235	0.408	0.503	8.61	0.633	0.372	1.612	0.358	0.223	0.152

Bay Study Delta Smelt YOY Index



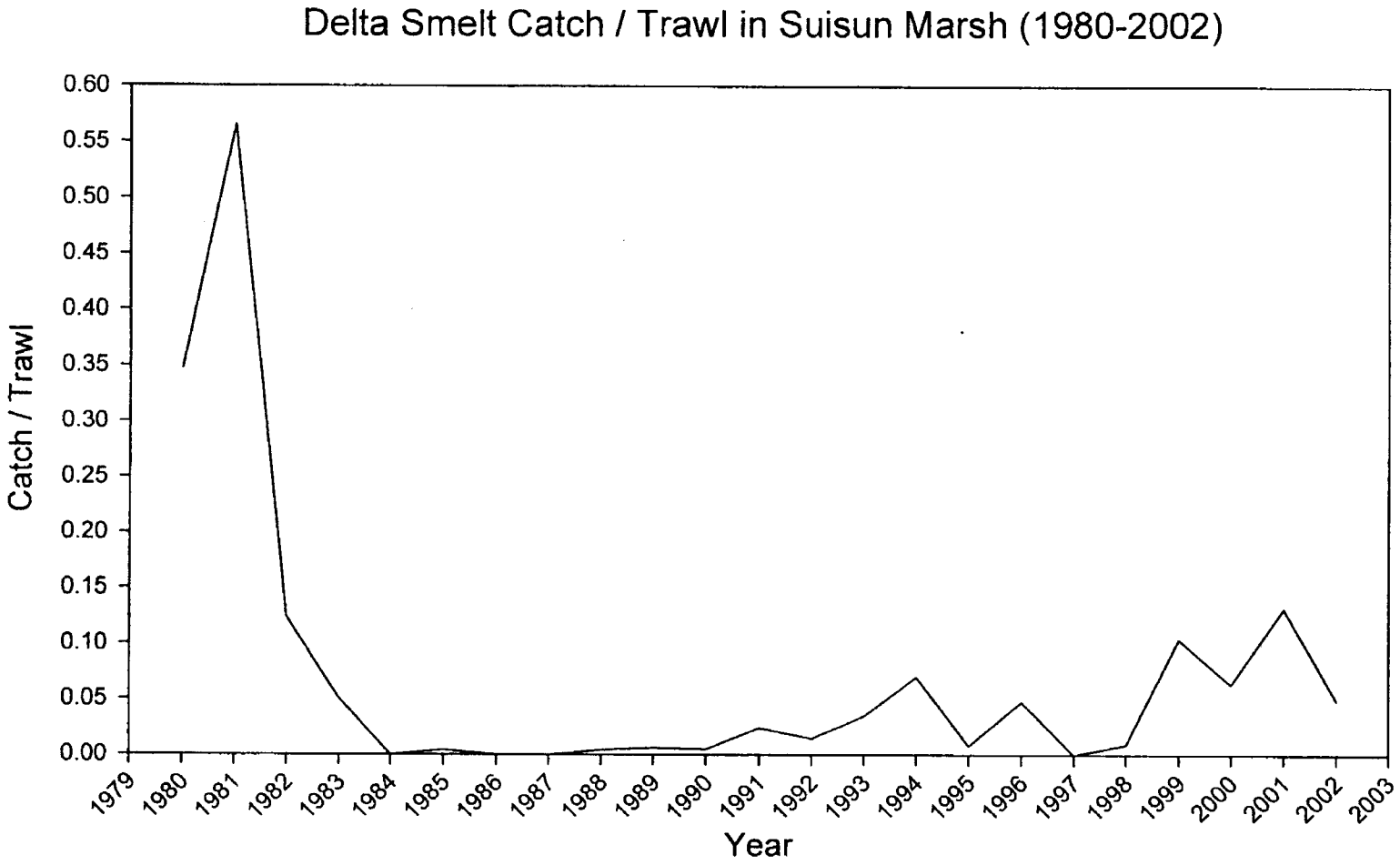
	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	0	1	2
Series1	2813	2568	996	1979	636	24	1909	283	476	176	459	161	522	676		564	382	1647	773	993	630	27	63

Delta Smelt Fall Midwater Trawl Abundance Index

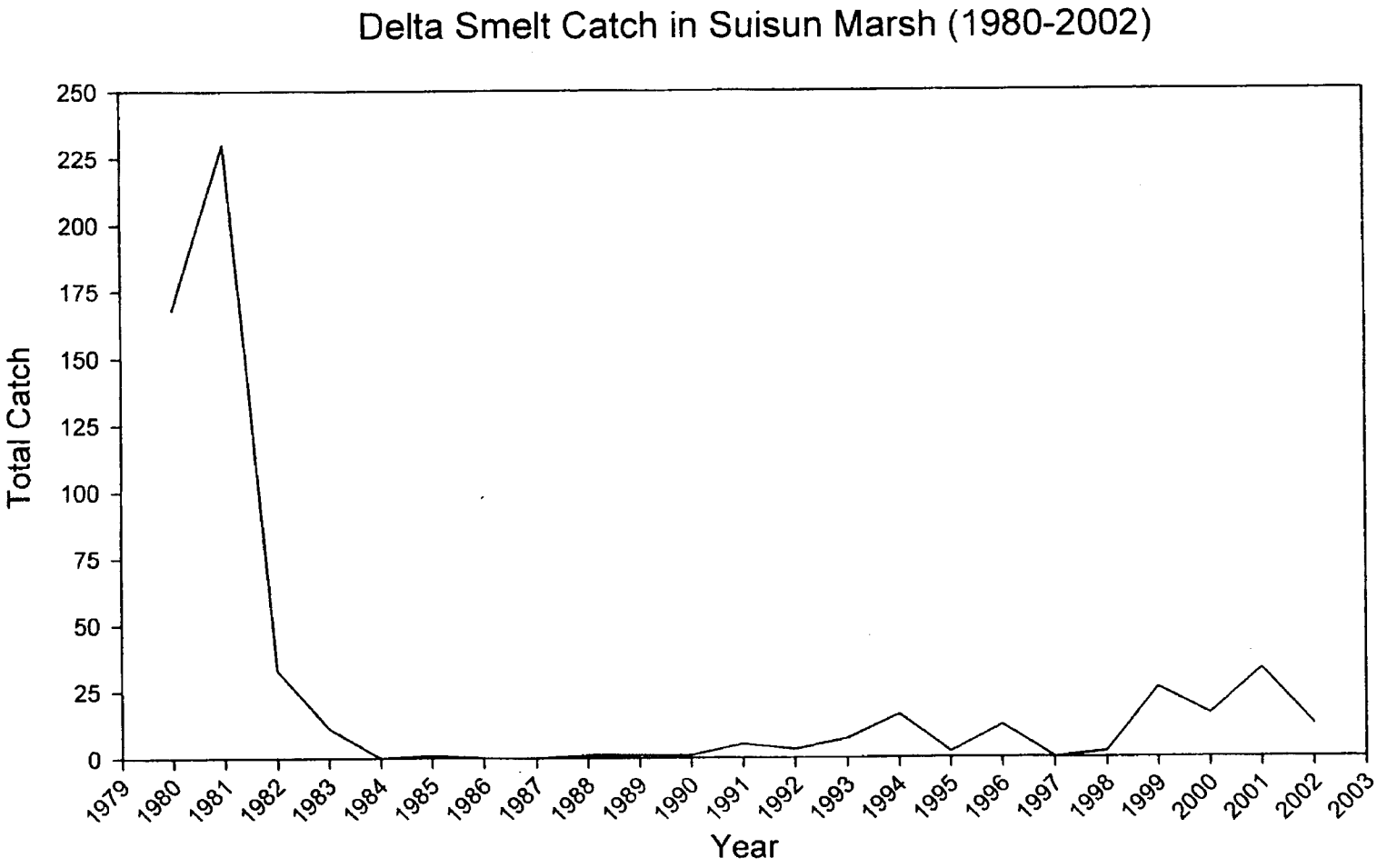


	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Index	414.9	696.6	318.6	1677.8	1308.2	1267.0	1145.9		697.9	337.8	479.5	571.6		1661	376	330.2	132.3	191.5	109.2	211.9	280.2	162.5	366.2	363.4	699.1	166.8	1079	101.2	898.7	129.3	306.6	417.6	883.5	783	603	159	210
Sep	89.4	234.7	149.5	741.6	197.4	571.6	307.9		290.5	49.8	97.5	156.9		368.6	102.4	44.8	2.1	47.0	40.7	92.1	71.0	41.6	86.1	109.5	125.9	71.5	375.7	64.8	120.4	20.5	14.6	238.0	197.9	428.7	75.4	20	14.7
Oct	185.2	253.4	76.8	343.0	473.1	472.0	312.4		213.7	42.2	242.5	84.7		273.7	27.3	47.4	28.0	43.7	23.8	15.1	39.6	67.0	74.7	49.7	249.2	3.5	470.0	11.8	349.8	23.0	112.9	94.7	380.2	125.9	479.7	46	136
Nov	31.1	118.8	85.3	93.1	427.7	91.1	199.2		102.3	120.9	61.7	31.1		896.2	84.2	76.0	77.9	86.5	26.0	33.8	69.8	19.1	157.9	197.8	278.0	67.5	94.3	8.5	360.8	13.1	70.1	14.8	113.7	86.3	16.1	29	17
Dec	125.2	68.7	33.7	909.9	207.7	142.3	327.4		91.3	126.0	67.8	308.9		422.9	161.1	182.0	24.3	24.2	16.9	70.9	100.1	24.8	45.5	16.6	35.0	24.3	139.4	17.8	76.1	71.8	106.0	70.1	171.7	142.1	30	44	42

Year



Data from Peter B. Moyle, Suisun Marsh study



Data from Peter B. Moyle, Suisun Marsh study

APPENDIX C
to the 5-year review for
***Hypomesus transpacificus* (delta smelt)**
Date

Commentors Index

Name	Address	Description
Dr. Peter B. Moyle, Ph.D., Professor	Department of Wildlife, Fish, and Conservation Biology University California at Davis 1 Shields Avenue Davis, CA 95616-8751	38pages includes letter, 3 journal articles co-authored by commenter, and 2 graphs; **"Moyle 2002" cited** [Inland Fishes of California]
Dr. Jonathan A. Rosenfield, Ph.D. Post-Graduate Researcher	Center for Integrated Watershed Science and Management 1 Shields Avenue University California at Davis Davis, CA 95616-8751	13 pages includes letter, journal article by commenter, and list of references
Mr. Perry L. Herrgesell, Chief	Central Valley-Bay Delta Branch California Department of Fish and Game 4001 N. Wilson Way Stockton, CA 94205-2486	6 pages includes letter, 2 cites, data, and graphs
Dr. Joe J. Cech, Jr. Professor	Department of Wildlife, Fish, and Conservation Biology University California at Davis 1 Shields Avenue Davis, CA 95616-8751	50 pages includes 7 abstracts & 4 journal articles
Mr. Stephen W. Verigin, Acting Chief Deputy Director	Division of Environmental Services California Department of Water Resources 3251 S Street Sacramento, CA 95816-7017	20 pages includes letter
Dr. Christina Swanson, Ph.D., Senior Scientist	The Bay Institute 500 Palm Drive, Suite 200 Novato, CA 94949-5006	4 pages
Ms. Florence LaRiviere, Chair	Citizens Committee to Complete the Refuge 453 Tennessee Lane Palo Alto, CA 94306-4149	4 pages 1 citation
Mr. Bill Pauli, President	Farm Bureau Federation 2300 River Plaza Drive Sacramento, CA 95833-3239	10 attachments = 1 1/8" 2 copies
Mr. Daniel J. O'Hanlon, Attorney At Law	Kronick, Moskovitz, Tiedemann, & Girard 400 Capitol Mall, 27th Floor	comments by water contractors 2 ½"