PETITION TO THE STATE OF CALIFORNIA FISH AND GAME COMMISSION AND SUPPORTING INFORMATION FOR LISTING THE

DELTA SMELT (*Hypomesus transpacificus*)

AS AN ENDANGERED SPECIES UNDER THE CALIFORNIA ENDANGERED SPECIES ACT

U.S. Fish and Wildlife Service photo

Submitted To: California Fish and Game Commission
1416 Ninth Street
Sacramento, CA 95814

Submitted By: The Bay Institute
Center for Biological Diversity
Natural Resources Defense Council

Date: February 7, 2007

EXECUTIVE SUMMARY

The Bay Institute, Center for Biological Diversity, and the Natural Resources Defense Council formally request that the California Fish and Game Commission change the state listing of the delta smelt (*Hypomesus transpacificus*) from threatened to endangered under the California Endangered Species Act, on an emergency basis. In the past few years, the delta smelt population has plummeted to the lowest levels ever recorded and, based on population viability analysis, the species is in imminent danger of extinction, the criterion for endangered status. Recent surveys indicate that environmental conditions in the delta smelt's critical habitat, the upper San Francisco Bay/Sacramento-San Joaquin Delta Estuary, have also declined, rendering large areas of the delta smelt spawning and rearing habitat lethal to the fish and threatening the planktonic food web upon which the species depends. The magnitude and frequency of occurrence of multiple known threats to the species are also increasing. The petitioners are conservation organizations with an interest in protecting the delta smelt and its estuarine habitat.

Delta smelt are endemic to the upper reaches of the San Francisco Bay Bay-Delta Estuary. The species requires specific environmental conditions (freshwater flow, water temperature, salinity) and habitat types (shallow open waters) within the estuary for migration, spawning, egg incubation, rearing, and larval and juvenile transport from spawning to rearing habitats. Delta smelt feed exclusively on plankton and most individual fish live only one year. Although they are restricted to a relatively small geographic range, delta smelt use different parts of the estuary at different life history stages. Throughout most of their life span, delta smelt inhabit low salinity habitat, at the interface of inflowing fresh water from the Sacramento and San Joaquin Rivers and salt water from the Pacific Ocean. Spawning adults, larvae, and young juveniles are found further upstream in the Delta, where they are vulnerable to lethal entrainment into federal, state, industrial, and local agricultural water diversion and export facilities.

As recently as thirty years ago, the delta smelt was one of the most common and abundant of the pelagic fishes in the estuary. In the early 1980s, its population declined by more than 80%, leading to threatened listings under both the federal and state Endangered Species Acts in 1993. During the 1990s, delta smelt abundance fluctuated and then increased in response to improved habitat conditions following the 1987-1992 drought. In 2002, the species' abundance again declined drastically, dropping more than 80% in just three years. For the past three consecutive years, delta smelt population abundance levels have been the lowest on record: in 2005 delta smelt abundance was the lowest ever measured, just 2.4% of the abundance measured when the species was state and federally listed in 1993, and the 2006 and 2004 abundance levels were the second and third lowest, respectively.

Population viability and extinction risk analyses indicate that delta smelt has fallen below its estimated "effective population size", with its present low abundance rendering the species vulnerable to inbreeding and genetic drift. The analyses, completed three years ago, predicted a 50% chance that the population would fall below its effective population size within two years, a prediction fulfilled by recent measurements of the species' record low abundance in 2004, 2005 and 2006. Other analyses using the most conservative extinction criterion predicted a 26-30% probability that the delta smelt population would fall to just 800 fish (compared to the present record low population of an estimated 35,000 fish) in the next 20 years. These high probabilities of extinction for delta smelt exceed criteria established by the International Union for Conservation of Nature and Natural Resources for an "endangered" species.

There are multiple environmental and anthropogenic threats to the species, including: reductions in freshwater inflow to the estuary; loss of larval, juvenile and adult fish at the massive state and federal water export facilities and urban, agricultural and industrial water diversions; direct and indirect impacts of non-native species on the delta smelt's planktonic food supply and habitat; lethal and sub-lethal effects of toxic chemicals; and, as a result of their present low population size, potential loss of the species' genetic integrity.

The recent decline of the species coincides with significant increases in Delta water exports by the state and federal water projects (seasonal water exports in the 2000s are as much as 49% higher than in the early 1990s), higher incidental take of delta smelt by the pumps, and concomitant increased alterations in internal Delta flow patterns. New analyses have demonstrated statistically significant relationships between delta smelt population abundance and both Delta freshwater outflow and export rates: low freshwater outflows and/or high levels of water exports consistently correspond to low delta smelt population abundance. Hydrodynamic analyses of Delta flows and exports indicate that all larval and juvenile delta smelt present in the southern regions of the Delta, that part of the species' critical habitat closest to the pumps, are likely to be entrained and lost. Based on these analyses, current water management operations in the Delta are contributing to the current critically low numbers of delta smelt and are incompatible with recovery of the species.

Ecological conditions in delta smelt habitat have also deteriorated. Reduced freshwater outflows have shifted the location and degraded the low salinity habitat seasonally used by the fish. The invasive clam *Corbula amurensis* (formerly *Potamocorbula amurensis)* has reduced the abundance of the delta smelt's zooplankton food supply. All life history stages of the species are at least periodically exposed to lethal or sub-lethal concentrations of herbicides and pesticides discharged and transported from upstream into their habitat.

Current state and federal management and protective regulations have proved inadequate to protect delta smelt and their estuarine ecosystem. The current export criteria in the water rights permits issued by the State Water Resources Control Board regulations allow export operations at levels that exceed those necessary to maintain healthy delta smelt populations. Dedications of water for the environment and of money for supplemental acquisitions of environmental water mandated in the 1992 Central Valley Project Improvement Act intended to reduce the negative impacts of the federal water project on fish and wildlife have not been fully or aggressively implemented. The CALFED Bay-Delta Program has been largely ineffective in addressing environmental problems in the

Delta, and its future status is highly uncertain. The most recent Biological Opinion by the U.S. Fish and Wildlife Service (USFWS) for protection of the species relies nearly exclusively on the CALFED Environmental Water Account, an experimental fish protection tool that, after six years of implementation, has failed to provide detectable benefits for delta smelt or any other fish species. Despite precipitously declining populations of delta smelt (and other Delta fish species), the agencies charged with protecting the species under the state and federal Endangered Species Acts are in the process of approving the South Delta Improvements Program, which would increase Delta water exports and install permanent tidal barriers that further modify Delta flow patterns and habitat.

Less than three years ago, the USFWS completed a 5-year status review for delta smelt. Based on that review, the USFWS rejected a proposal to de-list the species, reaffirmed the threatened status of the species, and reported that the threats to the species had been neither eliminated nor mitigated. Since then, the condition of the species has worsened dramatically and threats to its continued existence have multiplied and escalated. The survival of delta smelt is threatened by the present and threatened modification of its habitat; human-related activities such as water diversions, entrainment and toxic chemicals; and predation, competition and other direct and indirect impacts of non-native species. The delta smelt, a potent indicator of the ecological health of the west coast's largest estuary, is at imminent risk of extinction and merits immediate listing under the California Endangered Species Act as an endangered species.

NOTICE OF PETITION

The Bay Institute
500 Palm Drive, Suite 200
Novato, CA 94949
Contact: Christina Swanson, Ph.D.
Phone: (530) 756-9021
Fax: (530) 756-9021
E-mail: swanson@bay.org

Center for Biological Diversity
1095 Market Street, Suite 511
San Francisco, CA 94103
Contact: Jeff Miller
Phone: (415) 436-9682 x303
Fax: (415) 436-9683
E-mail: jmiller@biologicaldiversity.org

Natural Resources Defense Council
111 Sutter Street, 20th Floor
San Francisco, CA 94104
Contact: Katherine S. Poole
Phone: (415) 875-6100
Fax: (415) 875-6161
E-mail: kpoole@nrdc.org

Petitioners the Bay Institute, Center for Biological Diversity, and Natural Resources Defense Council formally request that the California Fish and Game Commission (Commission) reclassify the listing of the delta smelt (*Hypomesus transpacificus*) from a threatened species to an endangered species under the California Endangered Species Act (CESA), Fish and Game Code §2050-2068.

Under 14 CCR s 670.1(i)(1)(C) a threatened species may be uplisted to endangered if its continued existence throughout all or a significant portion of its range is in serious danger of becoming extinct by any one or any combination of the factors listed in subsection 670.1(i)(1)(A); 1) present or threatened modification or destruction of its habitat; 2) overexploitation; 3) predation; 4) competition; 5) disease; or 6) other natural occurrences or human-related activities.

Petitioners further request that the Commission review whether the species warrants emergency listing, and if so, that the Commission use its authorities to list the species as endangered on an emergency basis. The Commission may adopt a regulation that adds a species to the list of threatened or endangered species at any time if the Commission finds that there is any emergency posing a significant threat to the continued existence of the species (Fish and Game Code §2076.5).

The delta smelt is currently designated as a threatened species under the CESA. However, the recent and continuing population decline and new information published in peer-reviewed literature, and presented at scientific meetings and CALFED Bay-Delta Program workshops described in this petition demonstrate that the species' listing should immediately be changed to endangered – at risk of extinction. Evidence to support the listing change presented in this petition includes: record low population abundance in the last two years; current population levels below the "effective population size" for the species cited by the U.S. Fish and Wildlife Service (USFWS) in their most recent 5-year review (USFWS 2004); evidence for a significant stock recruitment relationship for the species; population viability and extinction risk analyses that indicate that the species is at high risk of extinction (Bennett 2003, 2005); and new information regarding the effects of Delta water exports on delta smelt population abundance. Due to this extreme situation, the threats documented in this petition constitute an emergency.

The Bay Institute is a non-profit organization that works to protect and restore the ecosystems of San Francisco Bay, the Sacramento-San Joaquin Delta, and the rivers, streams, and watersheds tributary to the Estuary, using a combination of scientific research, public education, and advocacy. The Center for Biological Diversity is a nonprofit, science-based environmental advocacy organization that works to protect endangered species and wild places throughout the world through science, policy, education, citizen activism and environmental law. Natural Resources Defense Council is a nonprofit, environmental organization that works to restore the integrity of the elements that sustain life – air, land and water – and to defend endangered natural places. The Bay Institute, Center for Biological Diversity, and Natural Resources Defense Council submit this petition on their own behalf and on behalf of their members and staff, with an interest in protecting the delta smelt and its habitat.

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I. NATURAL HISTORY AND STATUS OF THE DELTA SMELT

A. NATURAL HISTORY

1. Description

The delta smelt (*Hypomesus transpacificus*) is a small (50-80 mm in length for most adults), nearly translucent, steely-blue, osmerid fish endemic to the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, in California. The delta smelt was described as follows by Moyle (2002):

> …slender-bodied fish that typically reach 60-70 mm SL *(standard length; 2.36—2.76 in)*, although a few may attain 120 mm *(4.73 in)* SL. The mouth is small, with a maxilla that does not extend past the mid-point of the eye. The eyes are relatively large; the orbit width contained approximately 3.5-4 times within head length. Small pointed teeth are present on the upper and lower jaws. The first gill arch has 27-33 gill rakers and there are 7 branchiostegal rays. The gill covers lack strong concentric striations. The pectoral fins reach less than two-thirds of the way to the bases of the pelvic fins. There are 8-11 (usually 9-10) dorsal fin rays, 8 pelvic fin rays, 10-12 pectoral fin rays, and 15-19 anal fin rays. The lateral line is incomplete and has 53-60 scales along it. There are 4-5 pyloric caeca. Live fish are nearly translucent and have a steely-blue sheen to their sides. Occasionally there maybe one chromatophore (a small dark spot) between the mandibles, but usually there is none.

2. Taxonomy

Delta smelt is one of six species currently recognized in the *Hypomesus* genus (Saruwatari et al. 1997; as cited in Bennett 2005) and genetic analyses have confirmed that it is a well-defined species with a single intermixing population (Stanley et al. 1995; Trenham et al. 1998). Within the genus, delta smelt is most closely related to surf smelt (*H. pretiosis*), a species common along the western coast of North America. In contrast, delta smelt is a comparatively distant relation to the wakasagi (*H. nipponensis*), which was introduced into Central Valley reservoirs in 1959 and is now sympatric with delta smelt in the estuary. Delta smelt and wakasagi can also be distinguished using morphometric and pigmentation characteristics (Moyle 2002).

The U.S. Fish and Wildlife Service (USFWS) has repeatedly concluded the delta smelt is a distinct species: in an October 1991 proposed listing (56 FR 50075 50084), a March 1993 determination of threatened status (58 FR 12854 12864), a January 1994 revised critical habitat determination (59 FR 852 862), a December 1994 critical habitat determination for the species, and a 2004 5-Year Status Review for the species (USFWS 2004).

3. Range and Distribution

Delta smelt are restricted to the upper reaches of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. The species' overall distribution extends from San Pablo Bay upstream to Sacramento on the Sacramento River and Mossdale on the San Joaquin River (Radtke 1966; Moyle et al. 1992; Moyle 2002), with the actual location of the population varying seasonally and with freshwater outflow (Figure 1). The fish are found typically in shallow (<3 m) and/or surface waters in bays, river channels and sloughs, including in the Sacramento River, the Mokelumne River system, the Cache Slough region, the Delta, Montezuma Slough, Suisun Bay, Suisun Marsh, Carquinez Strait, the Napa River, and San Pablo Bay.

Critical habitat for the delta smelt, designated in 1994 (59 FR 65256 65279), encompasses the areas of all water, all submerged lands below ordinary high water, and the entire water column bounded by and contained in Carquinez Strait, Suisun Bay, Goodyear, Suisun, Cutoff, First Mallard and Montezuma Sloughs, and the Sacramento-San Joaquin River Delta (as defined in Section 12220 of the California Water Code). The area designated by USFWS as critical habitat does not encompass all areas within the estuary in which delta smelt have been found in the past or in which they are have been reported in recent years: for example, in most years with high winter and/or spring freshwater outflows, some portion of the delta smelt population spawns in the Napa River and larvae and juveniles rear in San Pablo Bay (including 2006; California Department of Fish and Game [CDFG] 20 mm Survey results, available at http://www.delta.dfg.ca.gov/data/20mm/). Throughout their life cycle, the fish use different areas and habitat types within their critical habitat at different life history stages (Moyle et al. 1992; Bennett 2005; and see Life History below). For spawning, delta smelt require fresh waters as well as suitable substrate for their adhesive eggs (probably rock or submerged vegetation, although spawning microhabitat is unknown; Bennett 2005). Juveniles and sub-adults use brackish water areas in the estuary, which, depending on freshwater outflow conditions, may be located in the Delta, Suisun Bay, or San Pablo Bay.

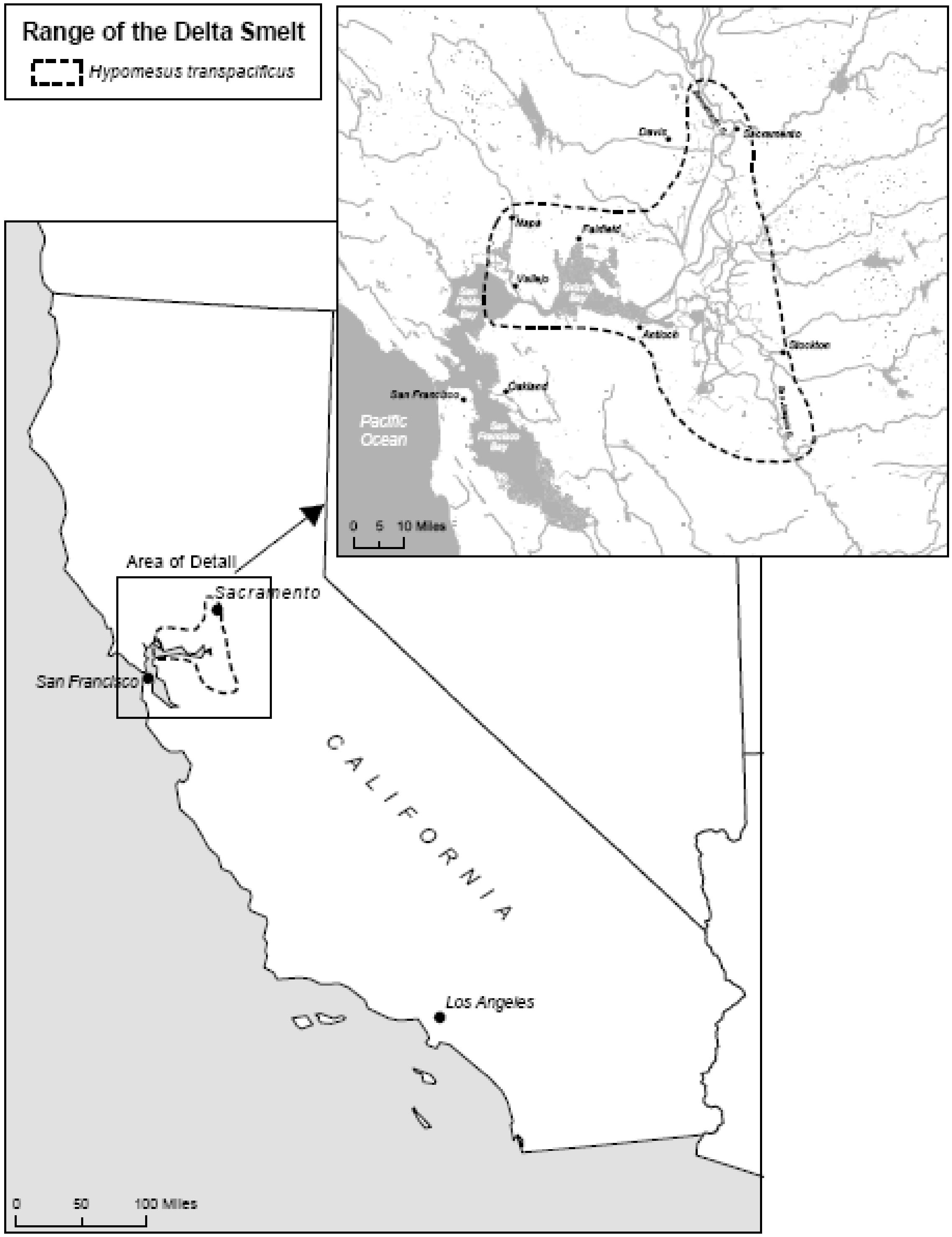

Figure 1. Distribution of delta smelt in California's Sacramento-San Joaquin Estuary. Map modified from Bennett 2005.

4. Habitat Requirements

Delta smelt are moderately euryhaline (capable of tolerating a wide range of salt water concentrations) and eurythermal (adaptable to a wide range of temperatures). The fish are found generally in brackish water (<10-12 psu [practical salinity units]), a range that corresponds well with measured salinity tolerance limits for the species (0 to 19 psu; Swanson et al. 2000). Except during the winter spawning season, most fish reside in the "low salinity zone" (0.2-2.0 psu; Bennett 2005). Delta smelt tolerate water temperatures from approximately 6ºC to 25ºC (depending on thermal acclimation history; Swanson et al. 2000). Temperature does not appear to control delta smelt distribution in the estuary, although temperatures >25ºC may constrain delta smelt habitat during the summer and early fall (Bennett 2005).

The USFWS (1994) described the specific habitat conditions required by each life stage of delta smelt:

> *Spawning Habitat* - Delta smelt adults seek shallow, fresh or slightly brackish backwater sloughs and edgewaters for spawning. To ensure egg hatching and larval viability, spawning areas also must provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emergent vegetation). Specific areas that have been identified as important delta smelt spawning habitat include Barker, Lindsey, Cache, Prospect, Georgiana, Beaver, Hog, and Sycamore sloughs and the Sacramento River in the Delta, and tributaries of northern Suisun Bay. The spawning season varies from year to year and may start as early as December and extend until July.
>
> *Larval and Juvenile Transport* - To ensure that delta smelt larvae are transported from the area where they are hatched to shallow, productive rearing or nursery habitat, the Sacramento and San Joaquin Rivers and their tributary channels must be protected from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g. water diversions that result in entrainment and in-channel barriers or tidal gates). Adequate river flow is necessary to transport larvae from upstream spawning areas to rearing habitat in Suisun Bay. Additionally, river flow must be adequate to prevent interception of larval transport by the State and Federal water projects and smaller agricultural diversions in the Delta. To ensure that suitable rearing habitat is available in Suisun Bay, the 2 ppt isohaline must be located westward of the Sacramento-San Joaquin River confluence during the period when larvae or juveniles are being transported, according to the historical salinity conditions which vary according to water-year type. Reverse flows that maintain larvae upstream in deep-channel regions of low productivity and expose them to entrainment interfere with those transport requirements. Suitable water quality must be

provided so that maturation is not impaired by pollutant concentrations. The specific geographic area important for larval transport is confined to waters contained within the legal boundary of the Delta, Suisun Bay, and Montezuma Slough and its tributaries. The specific season when habitat conditions identified above are important for successful larval transport varies from year to year, depending on when peak spawning occurs and on the water-year type. The Service identified situations in the biological opinion for the delta smelt (1994) where additional flows might be required in the July-August period to protect delta smelt that were present in the south and central Delta from being entrained in the State and Federal project pumps, and to avoid jeopardy to the species. The long-term biological opinion on CVP-SWP operations will identify situations where additional flows may be required after the February through June period identified by EPA for its water quality standards to protect delta smelt in the south and central Delta.

Rearing Habitat- Maintenance of the 2 ppt isohaline according to the historical salinity conditions described above and suitable water quality (low concentrations of pollutants) within the Estuary is necessary to provide delta smelt larvae and juveniles a shallow, protective, food-rich environment in which to mature to adulthood. This placement of the 2 ppt isohaline also serves to protect larval, juvenile, and adult delta smelt from entrainment in the State and Federal water projects. An area extending eastward from Carquinez Strait, including Suisun Bay, Grizzly Bay, Honker Bay, Montezuma Slough and its tributary sloughs, up the Sacramento River to its confluence with Three Mile Slough, and south along the San Joaquin River including Big Break, defines the specific geographic area critical to the maintenance of suitable rearing habitat. Three-Mile Slough represents the approximate location of the most upstream extent of tidal excursion when the historical salinity conditions described above are implemented. Protection of rearing habitat conditions may be required from the beginning of February through the summer.

Adult Migration - Adult delta smelt must be provided unrestricted access to suitable spawning habitat in a period that may extend from December to July. Adequate flow and suitable water quality may need to be maintained to attract migrating adults in the Sacramento and San Joaquin River channels and their associated tributaries, including Cache and Montezuma sloughs and their tributaries. These areas also should be protected from physical disturbance and flow disruption during migratory periods.

5. Life History

The life history of delta smelt has been extensively described by Moyle et al. (1992), Moyle (2002), Bennett (2005), and the most recent Biological Opinion for the species (USFWS 2005). Briefly, delta smelt is an annual species although there is evidence that, at least in some years, a small percentage of the population (<10%) survives to two years and may spawn in one or both years (Bennett 2005). Compared to other annual species, delta smelt exhibit relatively low fecundity with most females producing fewer than 3,000 eggs (Bennett 2005; Mager 1996). Spawning occurs in fresh water during the winter and spring (February-June; peak spawning April-May) and at water temperatures between 12ºC and 18ºC, with the larger adults maturing, arriving in the Delta, and spawning earlier (i.e., February-April) and at cooler temperatures than smaller, younger fish (Bennett et al. 2006; Herbold et al. 2006). Hatching occurs approximately 8-14 days later depending on water temperature. Newly hatched larvae are small (4.5-6 mm) and, after yolk-sac absorption and development of the jaw and mouth parts, they begin feeding on unicellular algae, rotifers, and/or sub-adult copepods. As the fish grow, their diet shifts nearly exclusively to copepods. Larval and juvenile fish move and/or are transported by flow and tides downstream from freshwater areas in the upper Delta (and, in some years, the Napa River and upper Suisun Marsh) to the brackish low-salinity zone where they rear for the summer and fall. In late fall and early winter, maturing adults begin their diffuse upstream migration to freshwater spawning areas.

Delta smelt exhibit a significant stock recruitment relationship. Using data from California Department of Fish and Game (CDFG) surveys that measure the abundance of juvenile and sub-adult/adult delta smelt (see Historic and Current Abundance, below), correlation and regression analyses show that the abundance of juvenile fish is significantly and directly related to the abundance of the adults that produced them (Figure 2 and Equation 1).[1]

[1] Population abundance of delta smelt is monitored by two California Department of Fish and Game surveys. The Summer Tow Net Survey (TNS), conducted during June and July, measures the abundance of juvenile delta smelt. The Fall Mid Water Trawl (FMWT), conducted from September to December, surveys sub-adult and adult delta smelt. From each of these surveys, delta smelt population abundance is calculated as an annual abundance "index". Because the FMWT and TNS abundance index data are not normally distributed, for these and other statistical analyses, the indices were $\log_{(10)}$ transformed (similar to the approach used by Bennett 2005).

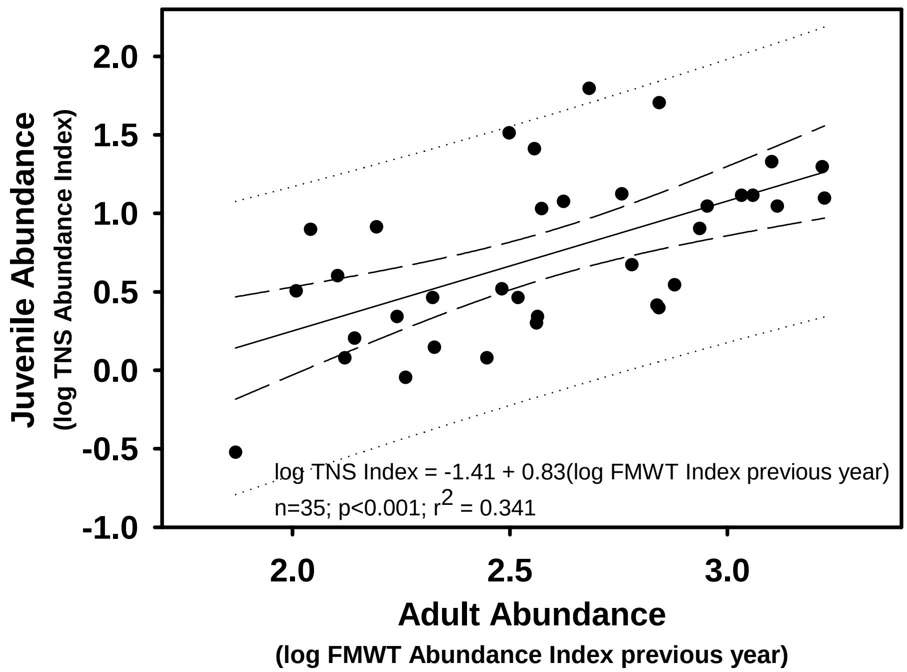

Figure 2. The relationship between the abundance of juvenile delta smelt (log TN Index) and the abundance of the adult fish that produced them (log FMWT Index for the previous year). Data are for 1969 to 2005. Regression equation and associated statistics are shown with the graph and are provided in the text. Data source: California Department of Fish and Game.

Log TNS Index = -1.41 + 0.83(log FMWT Index previous year) **(Equation 1)**
n=35; $p<0.001$; $r^2=0.341$
where: log TNS Index is abundance of juvenile delta smelt; and
log FMWT Index is the abundance of sub-adult/adult delta smelt.

Similarly, the abundance of adult fish measured the following fall is significantly and directly related to the abundance of the population as juveniles measured earlier in the year (Figure 3 and Equation 2).

Log FMWT Index = 2.21 + 0.46(log TNS Index) **(Equation 2)**
n=35; $p<0.001$; $r^2=0.337$

There is considerable disagreement among experts regarding the possible influence of density dependence (i.e., regulation of the size of the population by mechanisms that are themselves controlled by the size of that population, such as availability of food resources) on delta smelt population dynamics and abundance. Bennett (2003, 2005) suggested that the abundance of adult fish might be limited by density dependent effects on juveniles. The CDFG (2003) disagreed in their comment letter to the USFWS for the recent 5-year status review for delta smelt (USFWS 2004), citing lack of credible mechanism(s), the recent low abundance of delta smelt, and the weakness of the statistical evidence for density dependence. The fact that delta smelt are not currently abundant relative to their recent past abundance or relative to the other species living in the Delta suggests that the species has not exceeded the carrying capacity of its habitat and that its abundance is not limited by density dependent effects. Regardless, Bennett's (2005) analysis indicated that, since the early 1980s, density dependent effects did not occur at population abundance levels lower than 400-450 (as measured by the Fall Water Trawl Abundance Index; and see Historic and Current Abundance below), levels that are roughly comparable to or somewhat lower than the recovery criteria identified for the species (Moyle et al.1996).

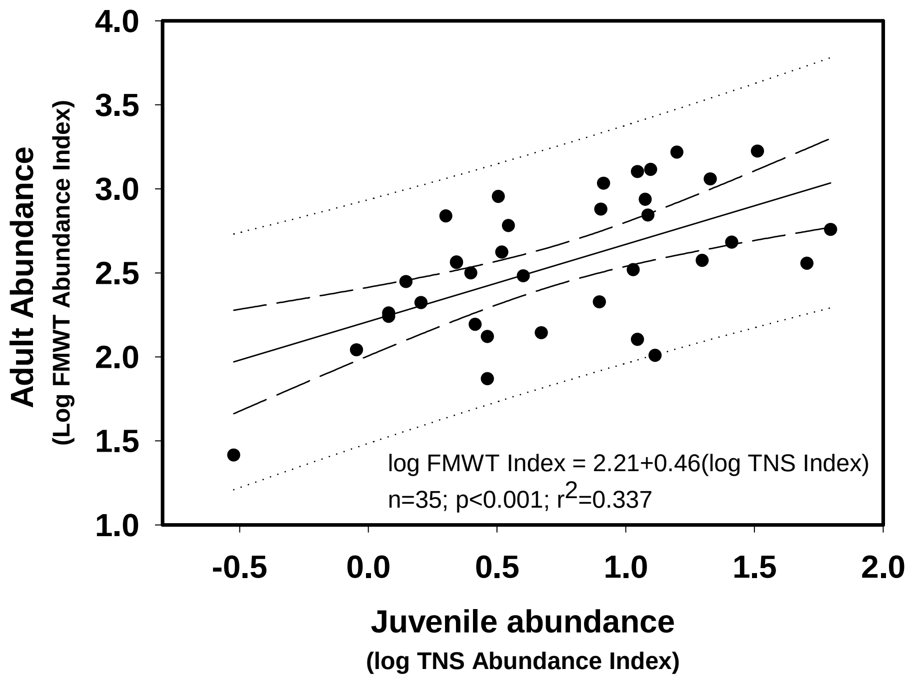

Figure 3. The relationship between the abundance of adult delta smelt (log FMWT Index) and the abundance of juvenile measured earlier in the same year (log TNS Index). Data are for 1969 to 2005. Regression equation and associated statistics are shown with the graph and are provided in the text. Data source: California Department of Fish and Game.

6. Natural Mortality

The most recent review of delta smelt status reports that there is insufficient evidence for effects of disease, competition or predation on delta smelt population abundance (USFWS 2004). However, diseases and parasites of delta smelt have not been well studied and numerous introduced species are abundant in the estuary. Competition and predation by introduced species has been shown to affect delta smelt size and condition (Souza et al. 2005; Teh 2005) but its role in affecting delta smelt population abundance has not been quantified (see discussion of Disease, Competition, or Predation below).

B. CHANGES IN DISTRIBUTION AND ABUNDANCE

1. Historic and Current Distribution

Historic distribution: The delta smelt's historic distribution extended from San Pablo Bay upstream to Sacramento on the Sacramento River and Mossdale on the San Joaquin River (Radtke 1966; Moyle et al. 1992; Moyle 2002), with the actual location of the population varying seasonally and with freshwater outflow. Based on results of CDFG sampling surveys for juveniles during the Summer Townet Survey (TNS) and adults during the Fall Mid Water Trawl (FMWT) survey conducted since the late 1950s as well as earlier published reports (cited in the references above), delta smelt were found in shallow (<3 m) and/or surface waters in bays, river channels and sloughs, including in San Pablo Bay, Carquinez Strait, the Napa River, Suisun Bay, Suisun Marsh, Montezuma Slough, the Sacramento River, the Cache Slough region, the Mokelumne River system, the San Joaquin River, Old and Middle Rivers, and all other channels and sloughs in the Delta with accessible subtidal, shallow-water habitat. In general, the rivers, channels, and sloughs in the Delta function as both rearing habitat for larval and juvenile delta smelt and a migration corridor for both the adult and juvenile life stages while the brackish, open bay areas serve as rearing habitat for older juveniles and sub-adult delta smelt (see Habitat Requirements and Life History).

Current distribution: Since the late 1970s, large areas of historic delta smelt habitat (and designated critical habitat) within the Delta have been degraded for a key life history stage of the species: the distribution of the species has been substantially reduced. Based on results from the summer TNS, which has been conducted annually since 1959, juvenile delta smelt have virtually disappeared from the Delta in areas south of the San Joaquin River (Miller 2000; CDFG 2003; Fleming and Nobriga 2004). Most of the environmental characteristics of these south Delta channels and sloughs known to be necessary for the species (e.g., temperature, salinity, water depth) have not changed. Recent surveys for adult delta smelt (CDFG Spring Kodiak Trawl) and larvae (CDFG 20 mm Survey) indicate that this region of the Delta is still used for spawning in the spring. But, by two to three months later, few or no juvenile delta smelt are collected during the summer TNS, a marked change compared to results of the first 20 years of the survey. This is the region of the Delta most directly affected by State Water Project (SWP) and Central Valley Project (CVP) water export operations and by the installation and spring-summer operations of three south Delta tidal gate barriers designed to maintain water levels and water quality for local agricultural water diverters. The period during which juvenile delta smelt disappeared from this portion of their historic habitat (i.e., the late 1970s) coincides with substantial increases in the amounts of water exported, increases in frequency of high volume export operations, and the initiation and increasing duration of south Delta barrier operations (Simi and Ruhl 2005; Fleming and Nobriga 2004; and see Figure 4).

Recent analyses by scientists with the California Department of Water Resources (CDWR) indicate that overall habitat quality and the area of habitat in the estuary suitable for delta smelt have declined during the past fifteen years (Feyrer et al. 2005, 2006).

Using water temperature, salinity, turbidity and delta smelt catch data from the CDFG's FMWT survey, the authors constructed a "habitat quality" index that related those environmental factors to the presence of delta smelt. Their results showed a long-term decline in fall habitat quality since the early 1990s and a more recent, sharp decline in the 2000s, coincident with the recent precipitous decline in the delta smelt population (see Historic and Current Population Abundance). The decline in habitat quality was driven by reduced freshwater outflows and resultant increased salinity in the western Delta.

2. Historic and Current Abundance

More than a dozen regular surveys collect data on delta smelt within the estuary (USFWS 2004) but the population abundance estimates used for most analyses and for tracking the species' population status are calculated from results of two surveys conducted by the CDFG: the TNS which samples juvenile delta smelt and the FMWT which samples sub-adult and adult delta smelt. From each survey, an abundance index is calculated by extrapolating the numbers of fish caught at 30 to 80 fixed stations, using a weighting factor that accounts for differences in water volume at various sub-regions from San Pablo Bay through the Delta (Bennett 2005). A subset of stations and months from the FMWT is also used to calculate the Recovery Index (Moyle et al.1996). None of these indexes provide direct measurements of actual population abundance. However, total population size calculated from the raw survey data and habitat volume estimates by Bennett (2005) show a good linear correspondence with the abundance indices, suggesting that the indices represent reasonable estimates of relative population abundance.

Historic abundance: As recently as 30 years ago, delta smelt was one of the most common and abundant of the pelagic fishes caught in the estuary, as indicated by its abundance in CDFG trawl catches (Erkkila et al. 1950; Radtke 1966; Stevens and Miller 1983). For the first 16 years of the FMWT survey (1967-1982), the most comprehensive survey for the species, the abundance index averaged 806, a value that roughly corresponds to an estimated 800,000 adult fish (Bennett 2005). But, in the early 1980s, the population declined by more than 80% (based on the FMWT Index; the decline was 95% based on the TNS Index; Table 1 and Figure 4). According to Bennett (2005) this precipitous decline was the result of the combination of extremely high winter and spring outflows, elevated springtime water temperatures and resultant short duration spawning periods, and two consecutive years of extremely high levels of incidental take at the SWP and CVP water export facilities. From 1983 through 1992, delta smelt abundance (measured as the FMWT Index) was consistently low, averaging just 33% of the 1967-1982 average abundance levels. In 1993, abundance increased considerably and, throughout the rest of the decade, population levels fluctuated but were, on average, roughly double those measured during the 1983-1992 period (Table 1). This increase prompted several stakeholder groups to challenge the listing, an action that ultimately led to the recent 5-year status review for the species (USFWS 2004).

Table 1. Abundance of delta smelt as measured by the CDFG Summer Tow Net Survey (TNS, juvenile delta smelt), Fall Mid Water Trawl Survey (FMWT, adult delta smelt), and the Recovery Index (based on FMWT data, adult delta smelt). NA= abundance index not yet available.

Year	TNS Index	FMWT Index	FMWT averages	Recovery Index	Comments
1959	12.1				Comparisons are based on FMWT Indices
1960	25.4				
1961	21.3				
1962	24.9				
1963	1.8				
1964	24.6				
1965	6.0				
1966	no data				
1967	no data	414	1967-1982: 806	139	
1968	no data	696		251	
1969	2.5	315		128	
1970	32.5	1673		598	
1971	12.5	1303		352	
1972	11.1	1265		551	
1973	21.3	1145		305	
1974	13.0	no data		no data	
1975	12.2	697		239	
1976	50.6	360		22	
1977	25.8	481		146	
1978	62.5	572		108	
1979	13.3	no data		no data	
1980	15.8	1653		312	
1981	19.8	374		78	
1982	10.7	330		37	
1983	2.9	132	1983-1992: 267	17	Population declines 84% (from 1967-1982 FWMT).
1984	1.2	182		51	
1985	0.9	110		29	
1986	7.9	212		70	
1987	1.4	280		72	
1988	1.2	174		67	
1989	2.2	366		76	
1990	2.2	364		81	
1991	2.0	689		171	
1992	2.6	156		26	
1993	8.2	1078	1993-2001: 572 1999-2001: 741	400	Delta smelt listed as threatened
1994	13	102		19	Abundance is 9% of 1993 level.
1995	3.2	899		252	Abundance is 83% of 1993 level.
1996	11.1	127		28	Abundance is 12% of 1993 level.
1997	4.0	303		62	Abundance is 28% of 1993 level.
1998	3.3	420		169	Abundance is 39% of 1993 level.
1999	11.9	864		322	Abundance is 80% of 1993 level.
2000	8	756		265	Abundance is 70% of 1993 level.
2001	3.5	603		314	Abundance is 56% of 1993 level.
2002	4.7	139		33	Population declines 81% (from 1999-2001 FWMT). Abundance is 13% of 1993 level.
2003	1.6	210		101	Some recovery criteria met (this year only). Abundance is 19% of 1993 level.
2004	2.9	74		25	Abundance is 7% of 1993 level.
2005	0.3	26		4	Abundance is 3% of 1967-1982 average, 4% of 1999-2001 average, and 2% of 1993 level.
2006	0.4	41		21	Abundance is 5% of 1967-1982 average, 6% of 1999-2001 average, and 4% of 1993 level.

Current abundance: In 2002, the delta smelt population again experienced a drastic population decline, dropping more than 80% from levels measured during the previous three years (1999-2001 average) (based on the FMWT Index; the decline was 77% based on the 2003 TNS Index compared to the 1999-2002 average; Table 1 and Figure 4). Since then, the population has continued to decline, falling to what was then a record low in 2004 (FMWT=74, or an estimated 60,000-70,000 adult fish) and then plummeting again by 65% to a FMWT Index of just 26 in 2005, the lowest abundance level ever recorded for sub-adult and adult delta smelt. The recently released 2006 FMWT Index, 41, is the second lowest level measured during the 40-year survey. Based on Bennett's (2005) analyses, the 2006 FMWT Index roughly corresponds to fewer than 35,000 adult fish.

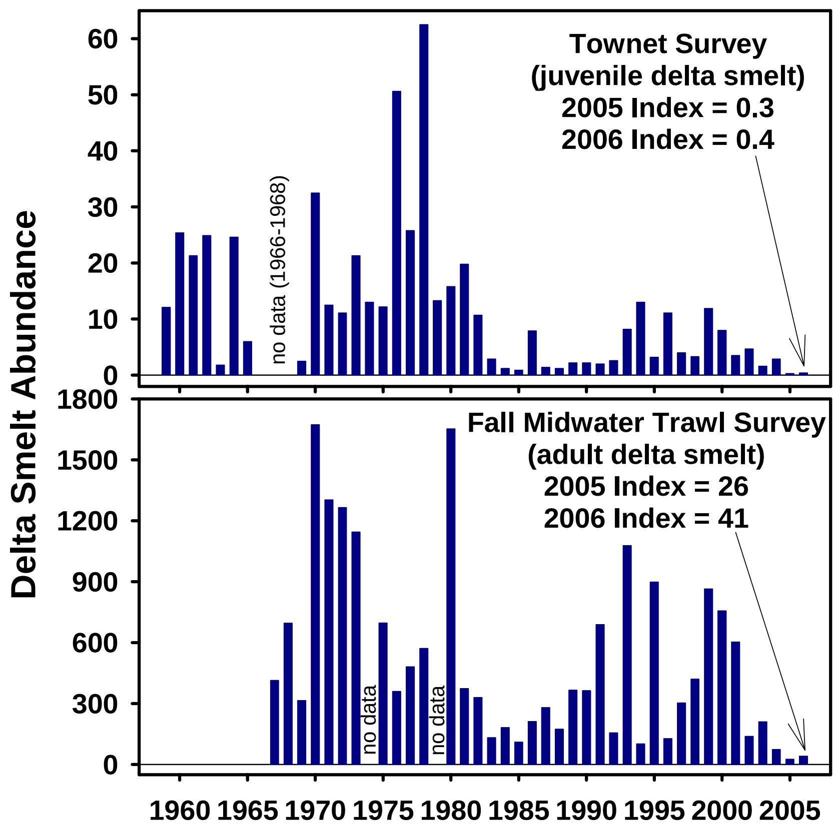

Figure 4. Trends in abundance of delta smelt as measured by two different surveys. The upper panel shows the abundance index calculated from the Summer Townet Survey (TNS, 1959-2006), which samples juvenile delta smelt. The lower panel shows the abundance Index calculated from the Fall Midwater Trawl Survey (FMWT, 1967-2006), which samples sub-adult and adult delta smelt. Data source: California Department of Fish and Game.

3. Population Trend and Extinction Risk Analysis

By the time the delta smelt was listed as threatened in 1993, the species had experienced a decade of chronically low population abundance followed by the beginnings of an apparent recovery, with both juvenile and adult abundance indices increasing (Table 1 and Figure 4). In 1993, delta smelt abundance was the highest measured since the major population decline in the early 1980s. During the rest of the 1990s, abundance fluctuated but generally continued to improve. This period corresponded with favorable water temperature and flow conditions. The most recent population decline began in 2000 and, in 2002, abundance of adult delta smelt dropped by more than 75% compared to the previous year. The following year, abundance of the juvenile fish was 66% lower than that measured in the previous year. Since then, population abundance as measured by both life-stage specific surveys has continued to decline. By 2005, abundance of juvenile delta smelt was just 3.7% of that measured in 1993 when the species was listed under the CESA and the abundance of adult delta smelt was just 2.4% of the 1993 level. Abundance levels measured in 2006 showed no signs of meaningful improvement.

Using data on past measured population abundance and variability, Bennett (2003, 2005) conducted a population viability analysis for delta smelt, calculating probabilities and predicted time frames for extinction of the species.[2] In the first step of his analysis, Bennett (2003) estimated the delta smelt population would be below its "effective population size", the population level below which a species is subject to inbreeding and genetic drift, if the FMWT Index fell below 100 for two consecutive years. At the time of this analysis, this abundance level was similar to the lowest FMWT Index ever measured for the species (1994 FMWT Index of 102, or an estimated 86,203 adult fish). The USFWS 5-year status review (2004) recognized this definition of an effective population size and noted that this population size reflected an "unprecedented low number of delta smelt." Based on this analysis, the current delta smelt population has been well below its effective population size for the past three consecutive years, with the 2004, 2005 and 2006 FMWT Index values of 74, 26 and 41 respectively (Table 1).

Using the now defined effective population size as a benchmark, Bennett (2003, 2005) then conducted an extinction risk analysis using three progressively more extreme population size criteria to simulate extinction: 80,000, 8,000, and 800 fish. For each population level, the analysis used FMWT data for the 1982-2003 period to calculate the median time to a 50% probability of extinction and the probability that extinction would occur within 20 years. For the highest population level, the analysis predicted that the median time to when there was a 50% chance that the population would fall below 80,000 fish was only 1.2 to 1.5 years, a statistic confirmed one year later when the FMWT Index fell to 74. Using the lower extinction levels, Bennett (2005) predicted that the median time to 50% probability of extinction defined as a population size of just 8,000 fish was only 20 years and, for a population size of 800 fish, 42 to 55 years. For this lowest extinction level (800 fish), there was a 26-30% probability that extinction would occur within 20 years. Bennett (2005) compared his results to criteria developed by the International Union for Conservation of Nature and Natural Resources, which defines an endangered species as one with a 20% probability of extinction in 20 years, and concluded that "delta smelt qualifies for Endangered … status" (page 55).

[2] Another extinction probability analysis conducted by the San Luis & Delta-Mendota Water Authority (2002) was considered by the USFWS in their 5-year review (USFWS 2004). However, independent peer-review of this analysis by USGS (2003) concluded that this extinction probability analysis and estimate was seriously flawed.

II. CRITERIA FOR CALIFORNIA ENDANGERED SPECIES ACT LISTING

A. THE DELTA SMELT IS A "SPECIES" UNDER THE CESA

The Delta smelt is indisputably a species, as discussed in the section on taxonomy above. The California Fish and Game Commission acknowledged the delta smelt is a distinct species in the state threatened listing of December 1993. The USFWS has also concluded the delta smelt is a distinct species in the October 1991 proposed federal listing (56 FR 50075 50084), a March 1993 determination of threatened status (58 FR 12854 12864), a January 1994 revised critical habitat determination (59 FR 852 862), a December 1994 critical habitat determination for the species, and a 2004 5-year status review for the species (USFWS 2004).

B. THE DELTA SMELT IS ENDANGERED UNDER THE CESA

The CESA defines an "endangered species" as "a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and Game Code §2062). The threats to a species' survival are categorized according to the CESA as:

(1) Present or threatened modification or destruction of its habitat;
(2) Overexploitation;
(3) Predation;
(4) Competition;
(5) Disease; or
(6) Other natural occurrences or human-related activities.

According to the USFWS 5-year status review (USFWS 2004), there are sufficient data and analyses available to identify (1) present or threatened modification or destruction of habitat and (6) other natural occurrences or human-related activities as present and ongoing threats to the species. Additionally, the delta smelt is threatened with extinction by the inadequacy of current regulatory mechanisms and management efforts. In their recent 5-year status review for the species, the USFWS (2004) concluded that for delta smelt, "most threats which were discussed in the original listing remain." In this petition to list delta smelt as endangered under the CESA, we concur with the USFWS conclusion and we add new analyses and information to demonstrate that the nature, degree, and increasing severity of the threats of modification or destruction of habitat and the inadequacy of existing regulatory mechanisms to protect the species, arrayed against a dramatically reduced delta smelt population, combine to place the species in severe and immediate danger of extinction throughout its range.

Delta smelt are environmentally sensitive because they have a short life span, have a limited diet, have a low fecundity for a fish producing planktonic larvae, are poor swimmers, are easily stressed, and reside primarily in the interface between salt and fresh water within a limited geographic extent. In addition to these characteristics, the species is highly vulnerable to extinction because of its present small population size. As noted by Moyle (2002), a substantial population is necessary to keep delta smelt from becoming extinct, and the species has recently fallen below the effective population size for viability (as defined by Bennett 2003) to an "unprecedented low number of delta smelt" (USFWS 2004). Multiple factors are thought to be contributing to the continuing population decline of the species, including: reductions in freshwater inflows and outflows to the estuary; direct and indirect adverse impacts of Delta water diversions and exports; effects of water management operations on estuarine habitat quality; reductions in abundance of prey food organisms; lethal, sub-lethal and indirect effects of toxic substances; disease, competition, and predation; and loss of genetic integrity. The magnitude and frequency of occurrence of most of these factors are increasing and current regulatory protections for the species and its habitat are clearly inadequate

The delta smelt indisputably merits immediate emergency listing under the CESA as an endangered species. The factors threatening the continued survival of the delta smelt are detailed below.

1. Present or Threatened Modification or Destruction of Its Habitat

Delta smelt reside entirely within the estuary, confined to a relatively small geographic range of low salinity and freshwater habitat. For some life history stages, the species is restricted to even smaller subregions within the estuary (e.g., the Delta for spawning in most years). Delta smelt live in the water column and, in their movements within their habitat, they often move "with the flow". For delta smelt, water is habitat. Therefore changes in the timing and amounts for freshwater inflow and outflow to and from the estuary, water export regimes, in-Delta hydrodynamics, water quality, and the estuarine food web have direct and significant impacts on the species.

The Delta, the heart of delta smelt spawning and early rearing habitat, is a major hub for California's water management system and a region of intensive irrigated agriculture. Water management operations of the massive SWP and the federal CVP in the Delta and its Sacramento and San Joaquin River watersheds have had major and often detrimental effects on freshwater inflow to the Delta, in-Delta hydrodynamics, freshwater outflow from the Delta, and water quality. For example, during periods of low freshwater inflow and high volume water exports, conditions that are common during periods when the bulk of the delta smelt population is distributed in the Delta, as much as 65% of the total freshwater inflow may be diverted, and net movement of water and entrained plankton, larvae and small fish in the central and southern Delta is towards the export facilities. At times, the net flows of the lower San Joaquin River in the Delta and several other important Delta channels are reversed, confusing and delaying migrating adult fish, impairing downstream transport of larval and juvenile delta smelt from the upper estuary where they were spawned to their brackish water rearing habitat, and lethally entraining large numbers of larval, juvenile, and adult delta smelt into state, federal, and local water diversions. The fish screens at the SWP and CVP fish facilities are known to be inadequate for protection of delta smelt (as well as for most other species; e.g., Bowen et al. 2004). Despite evidence of the limited effectiveness of these facilities for fish protection, and evidence that this effectiveness is further deteriorating (Bowen et al. 2004), plans to upgrade or replace the facilities have been delayed indefinitely (SDFFF 2005).

Freshwater Inflows and Outflows

The Sacramento-San Joaquin Delta Estuary is a highly managed system: for much of most years, freshwater flows into the Delta from the estuary's largest tributaries, the Sacramento and San Joaquin Rivers, and freshwater outflows from the Delta are precisely managed by the federal and state water projects to support water export demands while minimally meeting water quality and outflow standards mandated by the California State Water Resources Control Board (SWRCB 1995). Historically, the San Joaquin River provided 21% of the total freshwater inflow to the Delta (based on data from the CDWR). In recent years, freshwater inflows from this river have declined substantially, averaging just 10% during the 2001-2005 period, with consecutive record low freshwater inflows in 2003 (6.4%) and 2004 (6.2%). Recent research by scientists from the U.S. Geological Survey (USGS) has shown that low San Joaquin River inflows, in combination with high water export rates, disrupt in-Delta tidal exchange and flows, cause negative (or "reverse") flows in important Delta channels such as the lower San Joaquin River, Old River and Middle River, and result in nearly all water and small pelagic organisms (such as delta smelt) in the central and southern Delta being drawn inexorably to the SWP and CVP pumps (Simi and Ruhl 2005; Ruhl et al. 2006). These researchers also showed that low San Joaquin River inflows, negative flows on Old and Middle Rivers, and high exports were significantly related to high levels of incidental take of delta smelt at the SWP and CVP facilities (see Water Exports and Diversions below), and that the frequency of occurrence of these conditions had increased during the past two decades.

New analyses by scientists from the Contra Costa Water District have demonstrated the negative effects of reduced freshwater outflows on delta smelt population abundance. Guerin et al. (2006) showed that reduced freshwater outflows during the fall, and resultant increases in western Delta salinity, significantly corresponded to reduced population abundance of juvenile delta smelt measured by the CDFG TNS the following year (Figure 5). Given the significant stock recruitment relationship for delta smelt (see Figure 2), these researchers further improved this statistical model for juvenile delta smelt abundance by inclusion of information on the size of the adult population that produced them. Equation 3 shows the multiple regression model for predicting the abundance of juvenile delta smelt based on western Delta salinity and the FMWT Abundance Index measured the previous fall.[3] Guerin et al. (2006) also reported that the frequency of occurrence of reduced fall freshwater outflows and elevated salinity in the western Delta had increased during the past ten years.

[3] Guerin et al. (2006) used untransformed TNS and FMWT Abundance Indices in their analyses. Because the FMWT and TNS abundance index data are generally not normally distributed, we have repeated their analyses using $\log_{(10)}$ transformed data (as with Equations 1 and 2, and similar to the approach used by Bennett 2005).

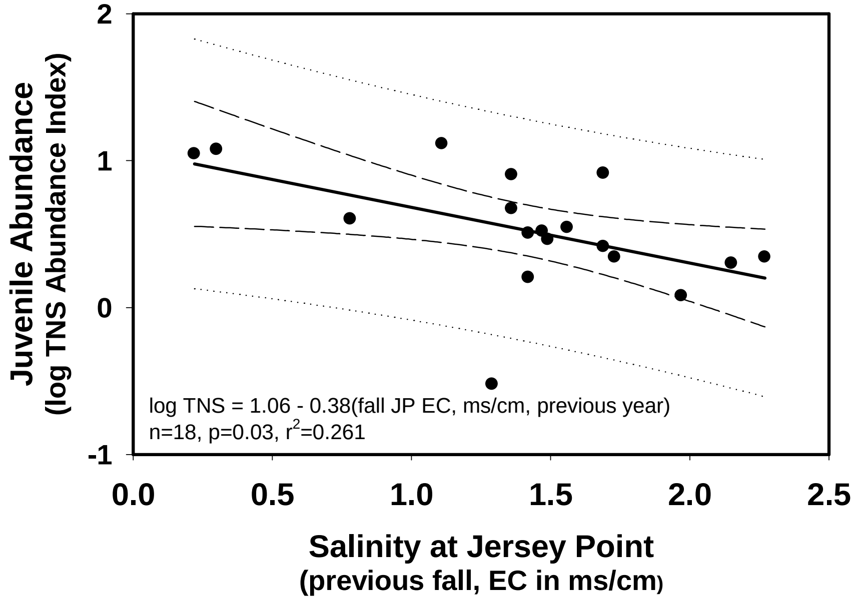

Figure 5. The relationship between fall salinity in the western Delta (Jersey Point EC [ms/cm], Oct.-Dec.) and abundance of juvenile delta smelt measured the following year (log TNS Abundance Index). Data are for 1988-2005. Regression equation and associated statistics, 95% confidence limits and the prediction limits are shown with the graph. A multiple regression model for this relationship that incorporates an additional variable is shown below in the text (Equation 3). Data sources: California Department of Fish and Game, Contra Costa Water District.

Log TNS Index =
-0.535 - 0.297(JP EC, prev. fall) + 0.593(log FMWT Index prev. year) **(Equation 3)**
n=18; p=0.004; r^2=0.522
where: log TNS Index is abundance of juvenile delta smelt;
JP EC is salinity (ms/cm) at Jersey Point (Oct.-Dec.) measured the previous year; and
log FMWT Index is the abundance of sub-adult/adult delta smelt measured the previous year.

These analyses indicate that seasonally reduced freshwater inflows and elevated salinity in Suisun Bay and the western Delta adversely alter delta smelt habitat (a conclusion also reached by Feyrer et al. [2005, 2006] using a different analytical approach; see Historic and Current Distribution). These conditions are related to establishment and increased abundance of the invasive clam, *Corbula amurensis*, in upper Suisun Bay and the western Delta measured in recent years (Thompson and Parchaso 2006). The negative impact of this invasive filter-feeder on the estuarine planktonic food web upon which delta smelt depends is well documented (Kimmerer and Orsi 1996; Thompson and Parchaso 2006). In addition, reduced freshwater outflows and the consequent shift of the low salinity habit preferred by delta smelt further upstream increases the proximity and vulnerability of the fish to lethal entrainment at state, federal, industrial, and agricultural water diversions (Herbold et al. 2006). Guerin et al. (2006) suggested that both of these ecosystem responses were potential mechanisms driving the relationship between reduced freshwater outflows and reduced delta smelt population abundance.

Water Exports and Diversions

In addition to the SWP and CVP water export facilities, more than 1,800 smaller diversions extract water for local consumptive use, and two power plants use Delta water for cooling (Herren and Kawasaki 2001). The USFWS (2004) concluded that the power plants at Pittsburg and Antioch, which use flow-through cooling and are located within the region of seasonal maximum abundance of delta smelt, can impose significant mortality on delta smelt. Fish screens at the SWP and CVP export facilities are known to be inadequate to protect delta smelt (Bowen et al. 2004) and the vast majority of the other Delta diversions are unscreened (Herren and Kawasaki 2001).

Water exports and diversions adversely affect delta smelt directly by entrainment (i.e., movement of fish due to the hydraulic effects of pumping and lethal removal of the fish from its habitat through unscreened or inadequately screened water diversions) or impingement (getting stuck on fish or debris screens at pumps); and indirectly by adversely modifying their critical habitat (e.g., by altering in-Delta hydrodynamics, reducing freshwater outflow and shifting the location of suitable low salinity rearing habitat, and/or removing planktonic food organisms). The species is at greatest risk from water diversions at two critical times in its life cycle, first as larvae and juveniles when the young fish move downstream to low salinity rearing habitat (spring and early summer) and then again as pre-spawning and spawning adults when maturing fish move up into the Delta for reproduction (winter and early spring). All of these life stages are known to be lethally entrained at government, urban, industrial, and agricultural diversions in the Delta (e.g., Matica and Sommer 2005; Nobriga et al. 2002; Moyle 2002). A portion of the entrainment loss of delta smelt >20 mm in length is monitored and reported as incidental take at only the SWP and CVP water export facilities.[4] Incidental take of delta smelt at the other diversions and of larval and juvenile fish <20 mm in length at the government water project facilities is neither monitored nor reported and no effort is made to rescue these fish. Therefore, the incomplete incidental take data are of limited value for evaluating the effects of water export activities on delta smelt population levels, although they do provide useful information on the timing and presence of the fish in the south and central Delta.

[4] Incidental take reported for delta smelt at the state and federal water export facilities is known to be a gross underestimate of the actual numbers of fish lethally entrained. The daily take number is calculated from counts of fish >20 mm in length collected in regular sub-samples of water bypassed through two sequential sets of louvers and/or fish screens. However, efficiency of the louvers to remove delta smelt from the diverted water is known to be low for delta smelt (i.e., under many conditions, more than half of the diverted fish pass through the louvers and are transported uncounted to the pumps; Bowen et al. 2004). Delta smelt larvae and juveniles <20 mm in length are not counted, but the loss of larval and juvenile delta smelt to entrainment is estimated at several million each year (USFWS 2004). In addition, unknown proportions of the fish entrained into the facilities are lost to predation and/or other mortality factors and never reach the fish salvage facilities to be counted.

Since the delta smelt was first listed as threatened under the CESA in 1993, annual water exports from the Delta have increased by more than 25% (1994-1998 average: 4.773 million acre-feet [MAF] per year; 2002-2006 average: 5.992 MAF per year).[5] In 2005, annual water exports reached a new record high of 6.305 MAF. Annual exports for 2006, 6.157 MAF, were the third highest on record. This increase continues a long-term trend of increases in Delta water exports (Figure 6, top panel). During the periods when delta smelt are vulnerable to entrainment, the relative increases in exports have been even greater, with a 49% increase in winter exports (December-March, when pre-spawning and spawning adults are in the Delta, Figure 6, middle panel) and a 30% increase in spring exports (March-July, when larvae and small juveniles are in the Delta, Figure 6, bottom panel).

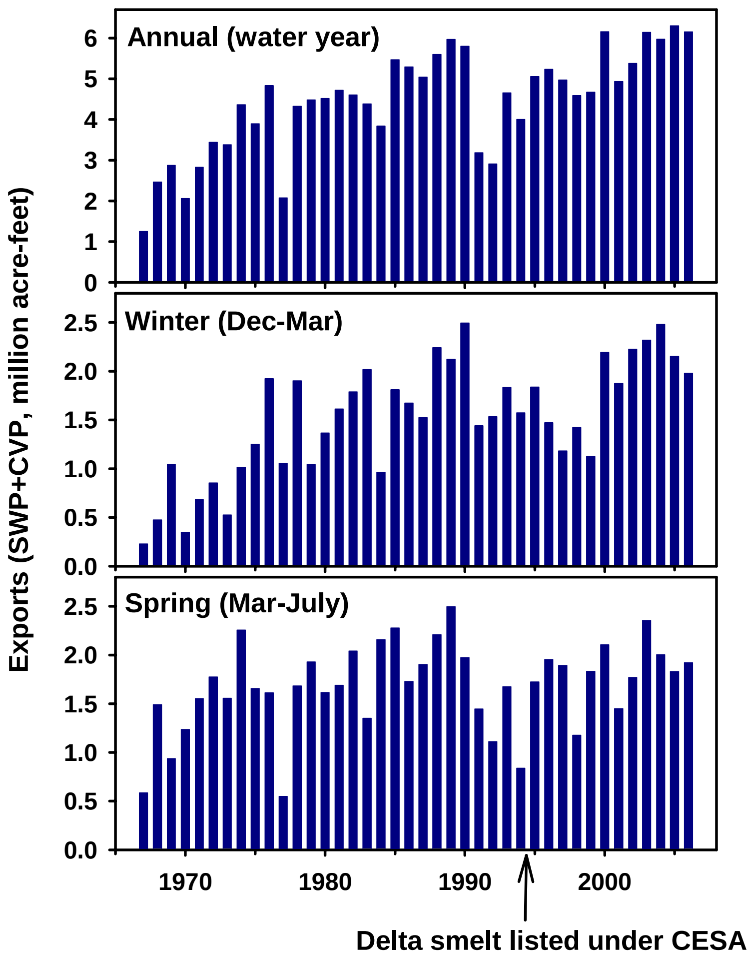

Figure 6. Combined water exports (million acre-feet, MAF) of the Central Valley Project and the State Water Project from 1967-2006. The upper panel shows total export volumes for each water year. The middle panel shows exports for the winter period (December-March). The lower panel shows springtime exports (March-July). Data source: California Department of Water Resources, Dayflow.

[5] Exports are calculated as the combined annual total (using the water year calendar) for Central Valley Project and State Water Project exports using data from Dayflow (California Department of Water Resources).

Direct Impacts: The CDFG (2003) expressed concern that entrainment of delta smelt at the CVP and SWP could be a major source of population impacts under certain conditions. Data from the summer TNS show an almost complete disappearance of juvenile delta smelt in south Delta sampling stations by the mid-1970s, coincident with a trend of increasing combined water exports from the south Delta (CDFG 2003). CDFG (2003) estimated losses of delta smelt juveniles to SWP and CVP operations to range from 11 to 46% of the population annually.

Analyses conducted by Herbold et al. (2005) as part of the ongoing multi-agency research program to investigate the recent pelagic fish declines in the Delta indicate that the direct impacts of water exports on delta smelt (and other Delta pelagic fish species) during the winter have increased in recent years, coincident with substantial population declines measured for all the affected species.[6] Beginning in 2000, incidental take (also referred to as "salvage") of adult delta smelt increased markedly (Figure 7, top panel), concurrent with substantial increases in exports during the same period (see Figure 6, middle panel). In 2003, direct loss of adult delta smelt at the pumps in relation to the species' population abundance reached its highest level in more than ten years (Figure 7, bottom panel). On the basis of these and other analyses conducted by researchers investigating the pelagic organism decline, the "Winter Adult Entrainment Hypothesis" is one of two leading hypotheses to explain the pelagic fish decline that will be the focus of continuing research in the next two years (Armor et al. 2005, Armor 2006).[7]

Recent analyses by scientists from the USGS have suggested a mechanism for the recent disproportionately high take of delta smelt (and other fish species) at the SWP and CVP facilities (Simi and Ruhl 2005; Ruhl et al. 2006). Using data from the past twenty years, these researchers reported a significant correlation between high incidental take and hydrodynamic conditions in the central and southern Delta caused by low San Joaquin River inflows and high water export rates. Under these conditions, normal tidal exchange and flows are disrupted (with the ebb tidal flow nearly eliminated); flows in two important Delta channels, Old River and Middle River, are negative; virtually all water in the central and southern regions of the Delta is drawn inexorably to the pumps; and incidental take of delta smelt is high. During the past twenty years, the frequency of occurrence of these types of conditions has increased.

[6] Herbold et al. (2005) used the November-March period for their analyses.
[7] In 2005 the Interagency Ecological Program began an intensive research program to investigate the cause(s) of the Pelagic Organism Decline (POD) in the Delta. Preliminary results of this research are available at: http://science.calwater.ca.gov/workshop/workshop_pod.shtml.

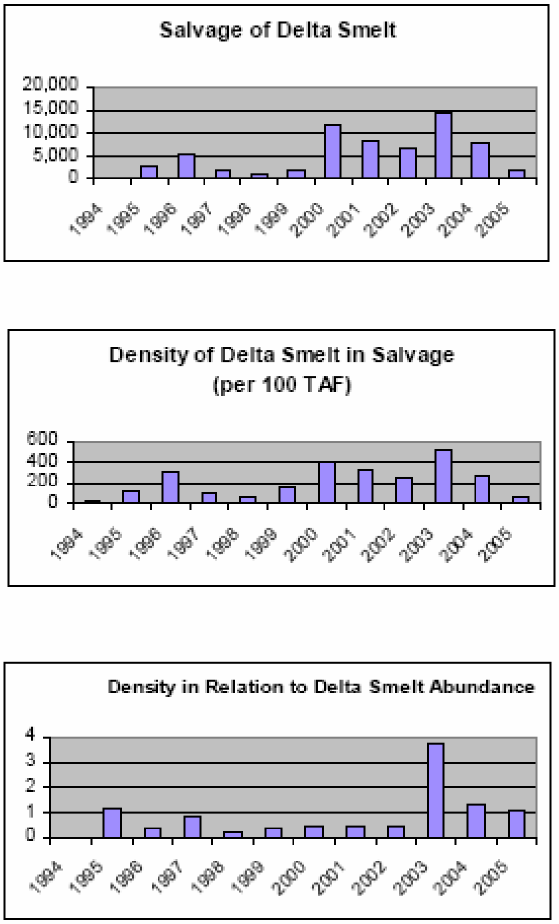

Figure 7. Recent patterns in incidental take (or salvage) of delta smelt during the November-March period. Top panel: total salvage (# fish); Middle panel: salvage density (# of fish/thousand acre-feet); and Bottom panel: salvage density in relation to preceding FMWT abundance Index (salvage density/FMWT Index previous year). Source: Herbold et al. 2005, Figure 3.

In addition to the direct effects of export rates on lethal entrainment of delta smelt at the SWP and CVP facilities, anthropogenic changes to Delta channel configuration, circulation and infrastructure have increased diversion-related mortality of delta smelt. During the spring, summer and fall, the CDWR installs and operates four "temporary agricultural barriers" in the south Delta (i.e., the Grant Line Canal, Old River near the Delta Mendota Canal, Middle River, and Head of Old River barriers) for the purpose of maintaining adequate water levels and quality for south Delta agricultural diverters under conditions of low Delta inflow and high SWP and CVP export rates. When these barriers are closed, they physically prevent delta smelt movement (e.g., block downstream migration of juveniles to low salinity habitat in Suisun Bay) and alter south Delta hydrodynamics, increasing central Delta flows toward the state and federal water export facilities (USFWS 2004). According to results of particle tracking modeling analyses conducted by CDWR and USFWS (USFWS 2004), this increases the incidental take of delta smelt at the SWP and CVP as well as lethal entrainment of the fish into unscreened agricultural diversions (and see also Figure 10 below).[8] The number of days per year during which the barriers are closed, as well as the numbers of barriers installed, has increased significantly, from less than 150 days per year in the 1990s to well over 200 days per year since 2003, coincident with the recent precipitous delta smelt population decline (Figure 8; Simi and Ruhl 2005). The USFWS (2004) noted that the California Department of Water Resources (CDWR) and the U.S. Bureau of Reclamation (BOR) proposal to replace temporary barriers at the SWP and CVP with permanent barriers could result in additional effects to delta smelt. The proposed permanent barriers operations may include barrier closures during additional periods and may include different operations that could affect delta smelt (USFWS 2004).

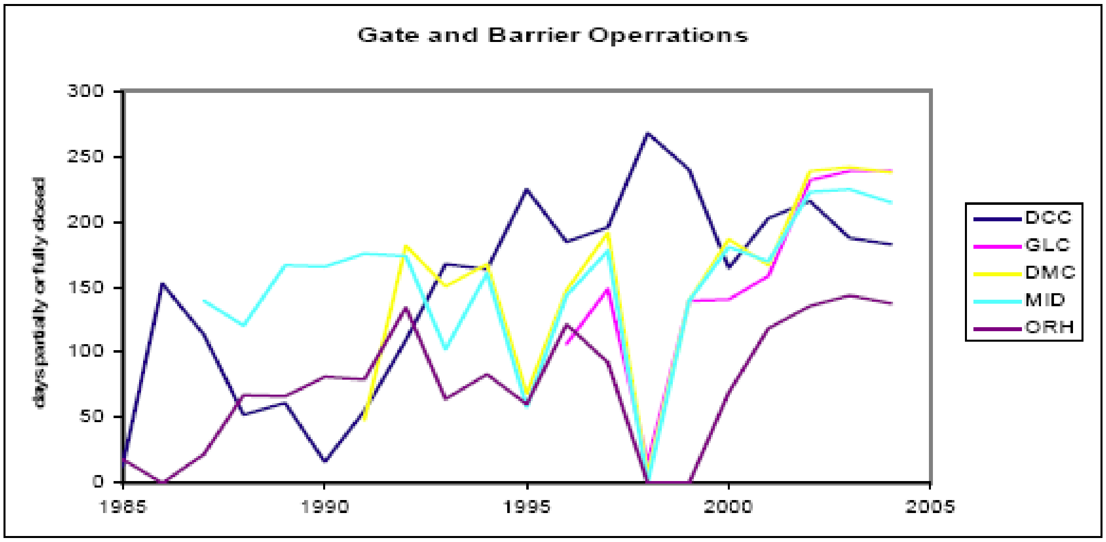

Figure 8. The number of days per year during which the four temporary agricultural barriers installed in south Delta channels are closed. Based on particle tracking model results, closure of the barriers corresponds to increased entrainment of small pelagic organisms such as juvenile delta smelt at SWP, CVP and local agricultural diversions. DCC=Delta Cross Channel; GLS=Grant Line Canal barrier; DMC=Old River near the Delta Mendota Canal barrier; MID=Middle River barrier; and ORH=Head of Old River barrier. Source: Simi and Ruhl 2005, Figure 15.

Population Level Impacts: Recent analyses have shown that delta smelt population abundance is significantly and inversely related to seasonal export rates (Swanson 2005).[9]

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[8] CDWR uses a computer-based particle tracking model (a module of their Delta Simulation Model, DSM-2) to track and predict the fate of neutrally buoyant particles (which simulate small planktonic and pelagic organisms, or "virtual fish") injected at various location into the Delta under specified inflow, export and barrier operations. Results of particle tracking model studies can be used to evaluate the effects of different water management or barrier operations on fish entrainment rates at SWP, CVP and local agricultural water diversions.

[9] These analyses were conducted by C. Swanson and earlier versions of these results were presented at the CALFED Bay-Delta Program-sponsored Environmental Water Account Review Workshop, Dec. 7-8, 2005, Sacramento, CA. Presentation and supplemental report are available at: http://science.calwater.ca.gov/workshop/ewa.shtml. Analyses presented in this petition have been updated by C. Swanson to incorporate abundance and export data from 2005 and 2006.

Figure 9 and Equations 4 and 5 show that export rates during the winter (December-March) significantly and negatively correlate with the abundances of adult and juvenile delta smelt measured later that year: for both life stages, abundance decreased with increases in exports.[10]

Adult delta smelt (1967-2006):

Log FMWT = 3.11 – 0.37(Dec-Mar exports, MAF) **(Equation 4)**

$n=38$; $p<0.001$; $r^2=0.263$

Juvenile delta smelt (1967-2006):

Log TNS = 1.43 – 0.44 (Dec-Mar exports, MAF) **(Equation 5)**

$n=38$ $p=0.006$, $r^2=0.194$

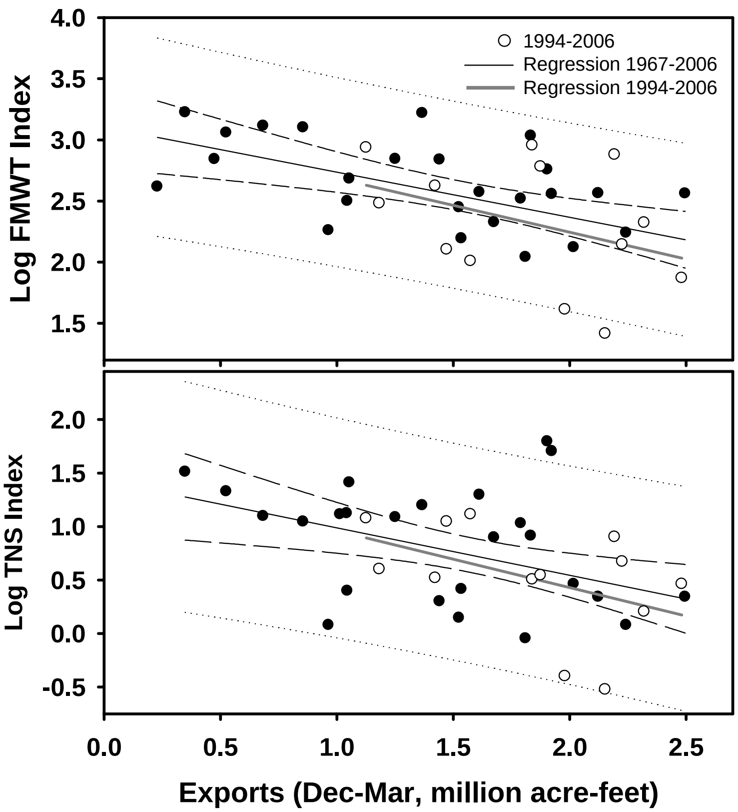

Figure 9. The relationship between winter (December-March) export amounts and subsequent abundance of delta smelt. a) sub-adult and adult delta smelt as measured by the FMWT Index (using data from 1967-2006); and b) juvenile delta smelt as measured by the TNS Index (using data from 1969-2006). For each graph, the regression, 95% confidence limits and the prediction limits are shown calculated for the entire datasets. The open symbols and the dark gray regression line highlight the years since the delta smelt was listed under the ESA (1994-2006). Data Sources: California Department of Fish and Game, California Department of Water Resources, Dayflow.

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[10] For reference, export of 2.0 MAF during the December-March period corresponds to an average daily combined export rate of the SWP and the CVP of approximately 8,300 cubic feet per second (cfs).

Analyses for the alternative winter periods (November-February, November-March, and December-February) yielded similar and statistically significant results (although p values were somewhat higher and r^2 values were somewhat lower).

Large scale ecological changes have occurred in the Delta during the past 30 years, such as the establishment of the invasive clam *Corbula amurensis* and its impacts on the planktonic food web (Kimmerer and Orsi 1996), but they do not strongly affect the results of these types of correlation and regression analyses. For example, the significant relationship between winter exports and the subsequent population abundance of adult delta smelt was apparent in the 20 years prior to the clam's invasion (1967-1986, Equation 6).

Adult delta smelt (1967-1986):

Log FMWT = 3.109 – 0.353(Dec-Mar exports, MAF) **(Equation 6)**
$n=18; p=0.013; r^2=0.329$

Linear regression using smaller subsets of more recent years (e.g., post-*Corbula* invasion, 1987-2006; post-CESA listing, 1994-2006) were not statistically significant but both the slopes and intercepts of the relationships were very similar to those generated using the entire dataset (see Figure 9). The significant relationship between winter exports and abundance was not "driven" by the low abundances measured during the past three or four years. For example, after excluding the three most recent years for the FMWT abundance indices (2002-2006) from the dataset, the regression was still significant ($p=0.02$) and the slope and intercept were similar to those generated with the entire dataset. Given that the significant relationship between winter exports and adult abundance was detectable by 2002 (and before), this indicates that the low abundances measured during the past three years, a period during which winter exports were at near record high levels, were predictable as early as three years ago.

The abundance of juvenile delta smelt was also significantly affected by spring-summer exports (March-July). The linear regression for this relationship is:

Log TNS = 1.46 – 0.42(Mar-July exports, MAF) **(Equation 7)**
$N=38; p=0.044; r^2=0.108$

Recent analyses by scientists from University of California, Davis, have provided new insights into the negative effects of high winter and early spring export rates on delta smelt population abundance. Using data and analyses of water temperature, fish distribution, fish size and reproductive condition from CDFG surveys, fish birthdate and age data from otolith analysis, life history models and cohort analyses, Bennett et al. (2006) reported that larger adult delta smelt migrated into the Delta, became reproductively mature and spawned earlier in the season than smaller fish in the population. For most fish species, larger fish are more fecund, produce larger and better quality eggs, and their progeny are more robust and contribute disproportionately to the population (Mager 1996; Moyle and Cech, 2004). However, despite clear evidence of reproductive readiness and spawning by these fish in March and early April, Bennett et al. (2006) reported that, based on the birthdates of juvenile delta smelt collected later in the year, virtually none of the progeny of these early spawners survived to contribute to the delta smelt population. In fact, only delta smelt hatched shortly before, during, or shortly after the 31-day Vernalis Adaptive Management Program (VAMP) survived to be collected by the CDFG summer TNS.[11] During the VAMP, exports are restricted to very low levels (e.g., 1,500 cfs, or approximately 15-20% of average export rates typical during the months immediately prior to and after the VAMP period) and San Joaquin River inflows to the Delta are increased. Bennett et al. (2006) concluded that the high export rates, low San Joaquin River inflows and associated adverse Delta hydrodynamic conditions during the late winter and early spring of recent years were the major contributor to this massive recruitment failure, lethally entraining both the early spawning adults and, although not reported as incidental take, their larvae and young juvenile progeny. These researchers further concluded that the repeated, near total loss of the most productive and robust component of the delta smelt population was a major contributor to the species' recent precipitous population decline during the 2000s.

Degree and Immediacy of Threat of Present or Threatened Modification or Destruction of Its Habitat

In 1993, when the delta smelt was listed as threatened under both the state and federal Endangered Species Acts, the USFWS identified 21 major federal, state, local or private organization proposals for increased exports (USFWS 1993). By 2006, multiple scientific analyses clearly document that modification and destruction of delta smelt habitat by adverse alteration in freshwater inflows, freshwater outflows, and water exports and diversions has increased significantly since 1993. During the past four years, the magnitudes of these harmful impacts have reached higher levels than have been recorded during the entire 48-year period for which data on delta smelt population abundance exist (1959-2006). Plans for future management of delta smelt habitat and federal and state water management operations, described in detail by USBR (2004a), include plans to increase the magnitude of most of these harmful habitat alterations. The recent 5-year review (USFWS 2004) noted that the potential threat of increased demands on surface water resources in the Central Valley and Delta was growing, citing planned or proposed new water diversion projects such as the Freeport Regional Water Project, increases in pumping capacity at the SWP pumping plant as part of the South Delta Improvement Project, the California Aqueduct/Delta-Mendota Canal inter-tie to allow increased pumping at the CVP pumping plant, Empire Tract on the San Joaquin River; and potential expanded water storage capacity projects at Los Vaqueros, north of the Delta off-stream storage, Shasta Reservoir, in-Delta storage, and south of the Delta surface and groundwater storage projects. Biological evaluations of the impacts of these changes on delta smelt conducted by both USBR (USBR 2004b) and USFWS (2005) conclude that these changes, reduced freshwater outflows, increased Delta exports, and increased lethal entrainment losses, will have negative impacts on the species. In addition, none of the above analyses have considered the predicted consequence of global climate change on delta smelt habitat or on state, federal and local water management operations. Finally, the current severely depressed population abundance of delta smelt,

[11] The Vernalis Adaptive Management Program is usually implemented from April 15 to May 15.

as well as the direct negative impacts of these habitat alterations on key life history stages (i.e., spawning adults) critical to the species continued existence, has reduced the resilience of the species and its capacity to withstand increased harmful habitat degradation.

2. Overexploitation

Overexploitation for commercial, recreational, scientific, or educational purposes is not known or thought to be a factor in the decline of the delta smelt population (USFWS 2004). Delta smelt may be harvested as a non-target by-catch in commercial bait fisheries for other baitfish species and some scientific collecting is conducted for the delta smelt, but the USFWS (1993) did not believe these activities were adversely affecting the species.

3. Predation, Competition or Disease

According to Moyle et al. (1996, 2004b), there is little evidence that predation, competition or disease has caused the delta smelt population to decline, although diseases and parasites of delta smelt have been little studied. However, introduced species are abundant and increasing in the estuary, including non-native invertebrates and fishes that feed on phytoplankton, zooplankton and/or small fish, and may adversely affect the delta smelt (USFWS 2004). There is some evidence that increased predation pressure on the planktonic food web by introduced species such as the invasive clam *Corbula amurensis* have reduced food availability for delta smelt (and other planktivorous fishes in the estuary; Kimmerer and Orsi 1996; Armor et al. 2005; Thompson and Parchaso 2006) and recent studies have related reduced plankton biomass to reduced delta smelt size (Souza et al. 2005) and liver glycogen levels (Teh 2005), although growth rates are unchanged (Souza et al 2005). However, to date, there is no quantitative evidence that competition for food or space with other aquatic organisms has affected delta smelt abundance.

Introduced striped bass may have caused an increase in predation on all size classes of the delta smelt (USFWS 2004). Efforts to enhance striped bass populations by planting large numbers of juveniles from hatcheries could have had a negative effect on other pelagic fishes in the estuary once the striped bass reached a size where they begin preying upon fish. The enhanced predator populations, without a concomitant enhancement of prey populations such as delta smelt, may have resulted in excessive predation pressure on prey species. Striped bass appear to have switched to piscivorous feeding habits at smaller sizes than they did historically following severe declines in abundance of mysid shrimp (CDWR 2003). The CDFG has completed a Habitat Conservation Plan for their striped bass management program which includes measures designed to help conserve delta smelt.

Introduced planktivores (fish that eat plankton) such as threadfin shad (*Dorosoma pretense*) and inland silverside (*Menidia beryllina*) compete for the zooplankton food of delta smelt, or alter the species composition of the zooplankton community, thereby further decreasing the ability of the delta smelt population to recover. Although the delta smelt has managed to coexist with these species in the past, it is possible that, at low population levels, interactions with them could prevent recovery. In particular, inland silversides are frequently collected in areas where delta smelt may spawn and they could be major predators on eggs and larvae (Bennett 1995, 2005; 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 a competitor for copepod prey. 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. Since the early 1980s, there have been increases in other potential larval fish predators such as tagged Chinook salmon smolts released in the delta for survival experiments and non-native centrarchids (CDWR 2003). Introduced species such as the chameleon goby (*Tridentiger trigonocephalus*) and yellowfin goby (*Acanthogobius fiavimanus*) may prey on delta smelt eggs and larvae and interfere with recovery of the species.

4. Other Natural Occurrences or Human-Related Activities

Global Climate Change

The is gathering evidence that, in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary habitat of delta smelt, the effects of climate change will manifest as:

(1) sea level rise;
(2) changes in timing and amounts freshwater inflow; and
(3) increased frequency and intensity of floods (CCAT 2006).

Sea level raise will shift the interface between inflowing fresh water and saline water from the Bay further upstream in the estuary, a condition known to adversely affect delta smelt habitat quality (Feyrer et al. 2005, 2006; Guerin et al. 2006; and see Historic and Current Distribution and Present and Threatened Modification or Destruction of Its Habitat, Freshwater Inflows and Outflows). Increases in air temperature in the estuary's high elevation watershed is predicted to reduce the volume of the snowpack (i.e., more precipitation will fall as rain rather than snow) and accelerate snowmelt (earlier snowmelt timing in the Sacramento-San Joaquin watershed is already detectable). These changes will result in more frequent and larger flood events, which will likely affect delta smelt habitat by increasing freshwater inflows during the winter and early spring rather than the late springtime freshwater inflows to which the species is adapted. In addition, these changes will have substantial effects on water management operations in the watershed and estuary, including the amounts and timing of upstream storage releases (and resultant Delta inflows), changes in carryover storage amounts (and the ability to provide habitat maintenance flows in sequential dry years), and Delta exports (Anderson 2006; Easton and Ejeta 2006). Recent evaluations of the effects of water management operations on delta smelt (including the most recent Biological Opinion; USFWS 2005) have failed to consider climate change-related effects on either water management operations or on delta smelt habitat.

Reduction in Prey Food Organisms

In recent years, untreated discharges of ship ballast water have introduced non-indigenous aquatic species to the Delta ecosystem (Carlton et al. 1990), several of which adversely affect the delta smelt and its habitat. The USFWS (2004) noted that the discharge of any ballast water into San Francisco Bay is not prohibited and that compliance with a Coast Guard requirement to discharge ballast water before entering U.S. ports is voluntary. Without strictly enforced prohibitions on ballast water discharge in the Bay, additional introductions of non-native species can be expected to continue (Moyle et al. 1996, Moyle 2003). The USFWS (1993, 2004, 2005) discussed the impacts of an introduced clam (*Corbula amurensis*) on the primary food of delta smelt and of non-native copepods that reduce food availability or feeding efficiency of delta smelt. The USFWS (1993, 2004, 2005) also discussed the altered plankton food web in the Delta that may have decreased the growth efficiency of delta smelt larvae.

Toxic Substances

The USFWS (1993, 2004, 2005) discussed the threat to delta smelt of poor water quality due to discharge and transport of agricultural and industrial chemicals from the Central Valley and Delta. Surveys of Delta waters have detected multiple pesticides and herbicides (Kuivila 2000; Houston et al. 2000). The USFWS (1993) noted that irrigation drain water can be harmful to other Delta fish larvae and embryos and to the planktonic food organisms for delta smelt. The SWRCB has designated all of the important water bodies in the delta smelt's range as impaired by one or more contaminants, commonly including pesticides such as diazinon, chlorpyrifos, malathion, chlordane, DDT and dieldrin. There is growing evidence that fish species in the Delta are suffering direct mortality, and physiological and/or developmental impairment from the presence of toxic substances in the water and in the plankton upon which the smelt feed, and that their planktonic food supply may being depleted by periodic, highly concentrated pulses of herbicides and pesticides through the Delta (see USFWS 1996, 1999).

Potential Loss of Genetic Integrity:

Species for which the population level falls below its effective population size are subject to inbreeding and genetic drift. This can result in depressed reproductive vigor and loss of genetic variation, reducing evolutionary fitness of the species and increasing its extinction risk. Using the effective population size criterion developed by Bennett (2003, 2005) and recognized by the USFWS (2004), three consecutive years of a FMWT Index less than 100, the delta smelt is now at risk for loss of its genetic integrity and at greater risk of extinction than when the species was listed under the CESA.

5. Inadequacy of Existing Regulatory Mechanisms

The recent delta smelt population decline, substantial increases in environmental and anthropogenic stressors already identified as threats to the species (e.g., Delta water exports), concurrent increases in incidental take, and statistical analyses that reveal significant relationships between those stressors and the recent and long-term declines in the delta smelt population clearly show that current regulatory mechanisms do not provide adequate protection for the species. In addition, specific protections and management tools identified in the USFWS's 2005 Biological Opinion (USFWS 2005) have proved inadequate and, apparently, unavailable to state and federal fish agency managers attempting to use them to protect the species. Current regulatory mechanisms and their inadequacy to prevent the imminent extinction of the delta smelt are discussed below.

State Threatened Listing

The delta smelt was listed by the State of California as a state threatened species under CESA in December 1993. A CESA listing as threatened theoretically provides some minimal measure of protection to the species because state agencies are required to consult with the CDFG if any project they fund or carry out would adversely affect (or benefit) the delta smelt, and identify and implement protection measures needed to fully mitigate all adverse impacts. As far as we are able to determine, it is unclear if CDFG is enforcing compliance with CESA for the delta smelt: for example, for several important state projects, including recent substantial changes in the SWP (USBR 2004a), no specific mitigation measures have been proposed, no specific incidental take permits have been issued, and no formal or specific consistency determination with federal ESA requirements has been reported. In addition, no state recovery plan exists for the species. This, combined with the collapse of the delta smelt population since state listing, is de facto evidence that the threatened CESA listing is inadequate to protect the species. In contrast, a CESA listing of "endangered" would require evaluation of delta smelt management and the impacts of state-sponsored projects through a sharper lens, supported by the clear evidence provided in this petition that the species is at imminent risk of extinction largely as a result of anthropogenic habitat modification and degradation.

State Listing of Other Species Within the Range of the Delta Smelt

Two other fish species that periodically co-occur with delta smelt are listed under the CESA: winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and spring-run Chinook salmon (*O. tshawytscha*). With the exception of periodic water export reductions using either the CVPIA or EWA (see sections below), most of the habitat restoration and protective actions for Chinook salmon have been implemented outside the geographic range of the delta smelt and therefore provide neither benefit to nor protection of the species.

Federal Threatened Listing

As demonstrated by the declining population trend since delta smelt was federally listed as threatened in 1993, a trend that has culminated in the recent catastrophic decline to record low levels, as well as the extinction risk analysis discussed above, the protections currently afforded by the federal threatened listing, and implementation and enforcement of those protections, are clearly inadequate to protect delta smelt. During the past 13 years, many of the threats identified by the USFWS in the original listing documents have not been eliminated or mitigated and have instead, in a number of instances, increased. Proposals to further increase the level of several key threats to the species (e.g., Delta water exports) have been approved by USFWS with "no jeopardy" biological opinions (USFWS 2005, and see below). It is also apparent that the qualitative and quantitative recovery criteria specified for the species (Moyle et al. 1996) are insufficiently protective and inadequate to ensure continued existence of the species, particularly in the context of escalating threats to the species and inadequate regulatory protections.

<u>1995 SWRCB Water Quality Control Plan</u>

Overall water management operations in the Sacramento-San Joaquin Delta are regulated by the California State Water Resources Control Board, according to their 1995 Water Quality Control Plan (WQCP) (SWRCB 1995). One subset of the WQCP's water quality objectives is specifically for the protection of fish and wildlife beneficial uses. Among other protections, these regulations limit Delta water exports in relation to Delta inflow (the Export/Inflow, or E/I, ratio), allowing up to 35% of total Delta inflow to be exported during the spring (February-June) and up to 65% to be exported during the rest of the year (July-January).[12] However, depending on inflow conditions, this can allow exports to be as high as (or higher than) 600,000 thousand acre-feet (AF) per month (or >10,000 cubic feet per second [cfs]), levels that, according the analyses above, reliably correspond to low population levels for delta smelt.[13] For example, December-March exports have exceeded 2 million AF in nine of 40 years since 1967 (1983, 1988, 1989, 1990, 2000, 2002, 2003, 2004, and 2005). For those years, the delta smelt Recovery Index averaged 74, the level identified by the 2005 Biological Opinion to correspond to a "high level of concern" for the species and which is supposed to trigger additional protective actions (see Table 1). The Recovery Index fell below 74 in five of the nine years. By comparison, the Recovery Index exceeded 74 in 82% of years in which December-March exports were less than 1.5 million AF. Given that the Recovery Index has a threshold value of 239 that must be achieved in two of five sequential years for recovery of the species, this suggests that high export levels currently allowed by the WQCP and which have been implemented with increasing frequency during recent years (and which are predicted to occur even more frequently in the future; see 2005 Biological Opinion below) are incompatible with the recovery of delta smelt.

Export levels allowed under the WQCP also do not protect key areas of delta smelt critical habitat. Recent analyses using CDWR's Delta Simulation Model (DSM-2) and its Particle Tracking Module show that most particles (which are thought to reasonably

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[12] In the WQCP exports are defined as the combined exports of the federal Central Valley Project and the State Water Project. For a 31-day period during the spring (usually April 15-May 15), lower exports are required by the San Joaquin River Agreement as part of the Vernalis Adaptive Management Plan.

[13] Average Delta exports rates for the December-March period exceeded 10,000 cfs in 1990 and 2004. Since 2000, average December-March exports exceeded 9,000 cfs in four of the last seven years (2000, 2002, 2003, and 2004).

simulate larval and small juvenile delta smelt but be somewhat less accurate simulations for adult delta smelt) released into the southern and central Delta were lost within two weeks to entrainment at either the government water project diversions or the many unscreened agricultural diversions located in this area of the Delta (Figure 10). For particles released at Bacon Island in the southern Delta, virtually all the particles were entrained at E/I ratios >20%, a level well within the currently allowed operations. For particles released in the central Delta (Twitchell Island), the percentage entrained increased linearly with the E/I ratio. This shows that E/I ratios allowed by the current WQCP may be effectively eliminating large areas of the southern and central Delta as usable habitat for delta smelt spawning and early rearing (see Historic and Current Distribution above).

Although the E/I regulations established in 1995 with the WQCP prevented extreme water management operations such as those that occurred in the late 1980s and early 1990s, since that time (and since the delta smelt was listed under the CESA), seasonal E/I ratios have increased by more than 90% for the winter period (from 14% in 1995-1999 to 27% in 2002-2006) and by 50% in the spring (from 16% to 24%) (Figure 11).

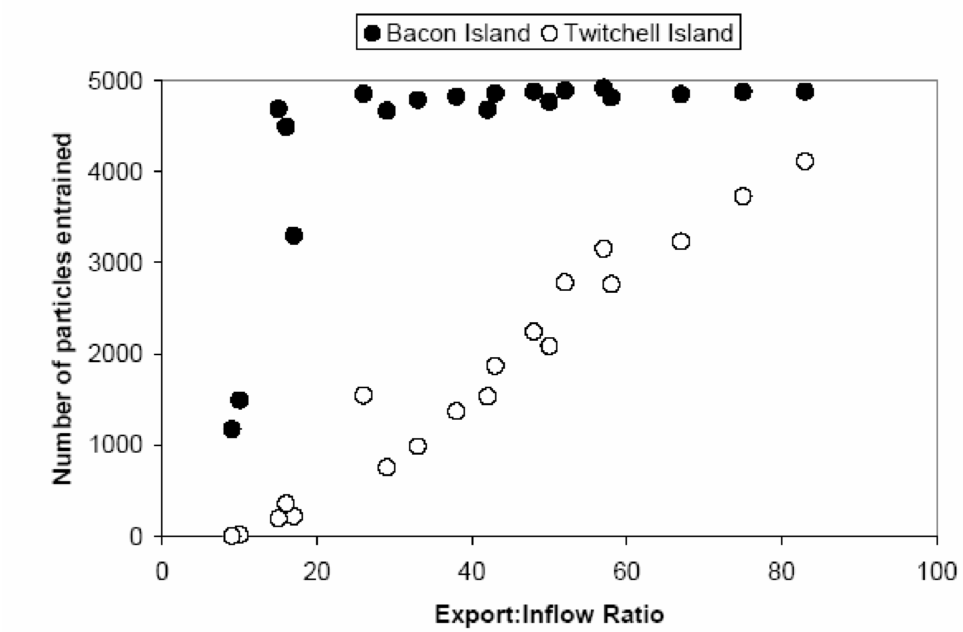

Figure 10. The relationship of the E/I ratio to the number of particles entrained (out of 5,000 particles released) over a series of Particle Tracking Model runs. Source: Herbold et al. 2005, Figure 8.

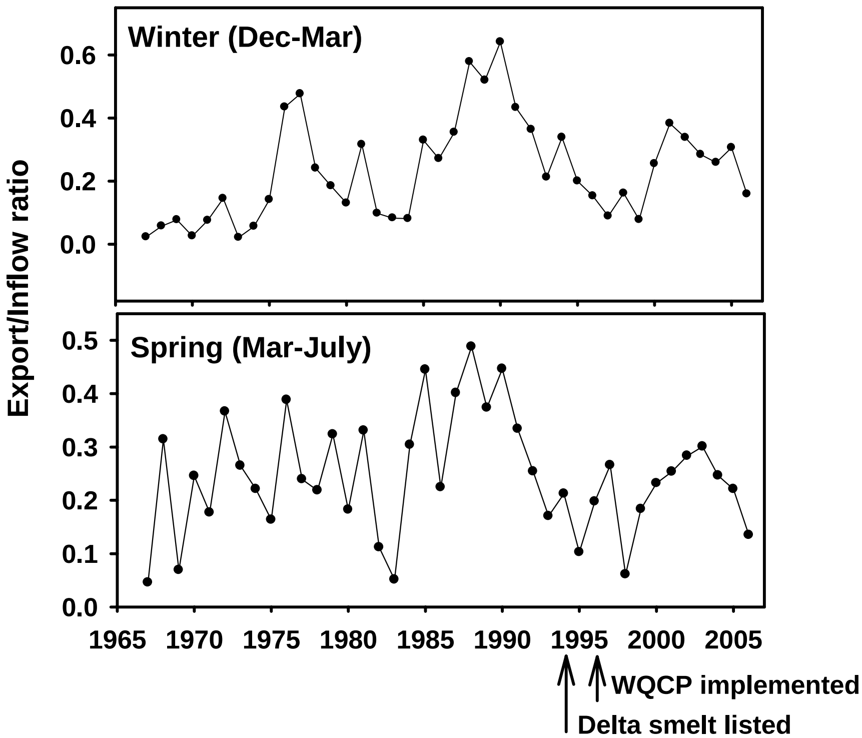

Figure 11. Trends in the Export/Inflow ratio (E/I) during the winter (December-March, upper panel) and spring (March-July, lower panel). The Water Quality Control Plan allows a maximum E/I of 65% during the fall and winter (July-January) and 35% during the spring (February-June). Data source: California Department of Water Resources, Dayflow.

In 2004 and 2005, the SWRCB began review of the 1995 WQCP, holding a series of informational workshops to evaluate the adequacy of the regulatory objectives designed to protect fish and wildlife beneficial uses in the estuary. Petitioners (The Bay Institute) submitted extensive comments on the status of the estuarine ecosystem and delta smelt, information and interpretation of the relevant science available at the time, and made a number of recommendations for changes in the regulatory objectives that were specifically designed to improve protection of the estuarine habitat and delta smelt (and other species).[14] However, despite clear evidence of the deteriorating condition of the species and its estuarine habitat (including well publicized reports of the dramatic pelagic organism decline in early 2005), the 2006 WQCP recently released by the SWRCB includes no changes in water quality, freshwater inflow and outflow, or export operation objectives known to affect delta smelt and which, based on information available then, were known to be inadequate to protect the delta smelt.[15]

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[14] The Bay Institute's submissions to the SWRCB for the review of the 1995 WQCP are available at: http://www.waterrights.ca.gov/baydelta/exhibits_list.htm#bi

[15] The 2006 WQCP is available at: http://www.waterrights.ca.gov/baydelta/2006controlplan.html

2005 USFWS Biological Opinion

A 2005 Formal and Early Endangered Species Consultation on the Coordinated Operations of the CVP and SWP and an Operations Criteria and Plan (USFWS 2005) was intended to evaluate the impacts of the proposed future federal and state water management operations on delta smelt.[16] The Consultation resulted in a February 2005 Biological Opinion by the U.S. Department of the Interior concluding that federal and state water exports from the Delta could increase without jeopardizing listed delta smelt. The Consultation identified specific fish protection management tools, such as the CALFED Environmental Water Account (EWA), that will be used to mitigate the impacts of those actions on delta smelt using real-time management.[17] This regulatory mechanism provides inadequate protection for delta smelt for numerous reasons, including: 1) the effects of the proposed action are not adequately or correctly evaluated and adverse impacts are therefore seriously underestimated; and 2) the specified protective tools and management actions are known to be inadequate, not guaranteed to be available, and are not required to be implemented when requested by state and federal fish agencies for protection of the species.

The only evaluation of the impacts to delta smelt from the predicted increases in Delta water exports included in the 2005 Biological Opinion was based on estimates of increased incidental take. Increased take was calculated based on linear increases with increases in exports, an estimate that recent analyses by Herbold et al. (2005) suggest is seriously flawed (this analysis showed disproportionate increases in incidental take with recent increases in exports; see Figure 7). In addition, incidental take is known to be a poor predictor of either actual direct impacts or population level effects. The Biological Opinion lacks even basic statistical analyses of the effects of Delta exports on delta smelt population abundance. Given that statistically significant relationships between these important variables are detectable using the data that were available to the USFWS (and the BOR, which prepared the Biological Assessment) at the time the Biological Opinion was prepared (see Modification of Habitat, Population Level Effects above and Figure 9), this represents a failure to use best available science, a legal requirement for this type of regulatory mechanism. Further, the results of these types of analyses (as well as even a cursory review of recent abundance and export data) clearly show that export rates proposed in the described project are incompatible with stabilizing the population at levels above those identified in the Biological Opinion that trigger a “high level of concern”, much less recovering the species.[18]

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[16] In July 2006, the USBR requested reintitiation of consultation for the effects of coordinated water management operations on delta smelt. They proposed, and the USFWS agreed, to leave the 2005 Biological Opinion in effect during the estimated 20-month period while the Biological Opinion was completed.

[17] The Environmental Water Account (EWA) is a supply of water managed by the state and federal fish agencies to facilitate periodic reductions in SWP and/or CVP exports at times when ESA-listed fish species are near the facilities and vulnerable to entrainment. EWA water is used to compensate the SWP and CVP for reductions in deliveries that might result from the export curtailment.

[18] In the action evaluated by the Biological Opinion, average December-March exports are predicted to be >9,000-10,000 cfs in nearly all years.

The 2005 Biological Opinion uses a “Delta Smelt Risk Assessment Matrix” (DSRAM) to identify conditions under which delta smelt are at risk from water project operations (primarily entrainment loss at the Delta export facilities) and identifies “export reduction at one or both facilities” as one its protective “tools for change”.

To implement protective actions recommended by the multi-agency Delta Smelt Working Group (DSWG, also specified and described in the Biological Opinion), the Biological Opinion relies on the CALFED Bay-Delta Program’s EWA to facilitate export reductions and to provide water resources to compensate for reduced deliveries that might result from the fish protection action. However, to date the EWA has been authorized and funded only on an annual basis and the likelihood of its continued existence beyond 2007 is unknown. In addition, the EWA’s utility for fish protection and the ability of the state and federal fish agencies to use it to implement specific protective actions as recommended by the multi-agency DSWG appears highly uncertain. In 2005, two out of three recommendations for protective actions made by the DSWG based on the risk criteria in the DSRAM were not implemented as recommended by the state and federal water project agencies (despite adequate water assets in the EWA) (Poage 2005). For example, in January of 2005 at least three of the risk criteria were exceeded and the monthly incidental take limit was nearly exceeded before an export reduction was implemented, an inexplicable delay given the high level of concern based on the then record low FMWT Index. When the reduction was finally implemented, neither the recommended export level nor duration was agreed to by the Water Operations Management Team (WOMT), who opted instead for a smaller and shorter export curtailment. Later in the spring, the DSWG-recommended export level for the 31-day Vernalis Adaptive Management Plan (VAMP) was rejected by the WOMT, who allowed for exports 50% greater than the recommended level. Three weeks later the SWP unilaterally discontinued its export curtailment before the VAMP period was concluded. The following summer, the abundance of juvenile delta smelt reached a record low and, when adult fish were surveyed in the fall, their numbers were also at new record lows. More recently, the DSWG has explicitly declined to make recommendations for Delta exports actions that their analyses have determined would provide the benefit for delta smelt, citing concerns about the inadequate supplies of EWA water assets. In December 2006, the DSWG rejected a proposed protective action to eliminate negative flows on Old and Middle rivers in the south Delta during the delta smelt’s winter spawning season that “would be better for delta smelt” because it “could consume all available environmental water, leaving no assets for spring actions for larvae or juveniles” (DSWG 2006).

Central Valley Project Improvement Act

The Central Valley Project Improvement Act (CVPIA), implemented in 1992, was intended to improve habitat conditions and reduce adverse direct and indirect impacts of CVP operations on fish and wildlife resources, with an emphasis on anadromous fish species. With the exception of small, short-duration water export reductions at the CVP export facility (usually timed to protect migrating juvenile salmonids), most of the habitat restoration and protective actions specified by the program (e.g., gravel restoration, stream flow enhancement, installation of fish screens and ladders) have been implemented outside the geographic range of the delta smelt and therefore provide neither benefit nor protection to the species.

CALFED Bay-Delta Program

The CALFED Bay-Delta Program (CALFED) is a joint state-federal effort to restore the ecological health of the Bay-Delta system, protect and recover fish and wildlife species, increase water supply and reliability, and improve levee integrity and water quality. The delta smelt is identified by CALFED as a priority species. Within delta smelt habitat, CALFED has implemented three categories of restoration and protective actions intended, at least in part, to protect and recover the species: restoration of shallow water habitat; reduction of entrainment losses using the EWA; and installation of fish screens.

Habitat restoration: Restoration of shallow water habitat within the delta smelt's range has proceeded slowly and there is little evidence that the species derives benefit from the few small projects that have been completed (Brown 2003). There is no real evidence that access to shallow water habitat represents a limiting factor for the species (Bennett 2005).

Export curtailments and the EWA: The most recent Biological Opinion for delta smelt (USFWS 2005) relies heavily on use of the EWA, a tool to facilitate periodic export curtailments and reduce entrainment losses that was developed by CALFED as a four-year experiment. The USFWS (2004) cited the EWA and the 31-day-long spring VAMP export curtailment that is largely implemented using EWA water as examples of water management tools that are addressing specific needs of delta smelt. During the past six years, however, state and federal agencies have reduced by 300,000 to 400,000 acre-feet per year the amount of water required by the CALFED Record of Decision (ROD) to protect the Delta and fisheries under the EWA (Environmental Defense 2005). Moreover, the USFWS (2004) also noted that the delta smelt population declined during the three years of EWA actions that were analyzed in their 5-year review. In 2006, after six years of EWA implementation, Delta exports during seasons when delta smelt are vulnerable to direct and indirect impacts have continued to increase and the abundance of juvenile and adult delta smelt population has dropped to critically low levels.

The EWA is now in its seventh year of implementation. The program has been subject to five formal reviews by an independent science panel (2001, 2002, 2003, 2004, and 2006) and a sixth informal review in 2005. Despite these exhaustive reviews, the state and federal fish agencies managing the EWA have presented no evidence to indicate that the EWA is an effective tool for mitigating the adverse impacts of Delta export operations or even for reducing entrainment loss of fish at the SWP and CVP facilities. Similarly, there is no evidence that the EWA provides population level benefits to any of the ESA-listed species that are the focus of its actions. The current EWA is clearly not providing adequate protection to delta smelt. The USFWS (2004) reported that the EWA is currently being "resized" to account for proposed increases in water exports at the state and federal export facilities, however, the proposed future EWA actually has less water than the original version described in the CALFED ROD. Therefore, a "resized" EWA will not likely provide adequate protection for delta smelt either.

Installation of fish screens: The USFWS 5-year review (2004) cited installation of two fish screens on water diversions within the range of delta smelt under the auspices of the CALFED Bay-Delta Program as representing "progress towards eliminating entrainment of delta smelt in unscreened diversions," but acknowledged that over 1,800 unscreened or inadequately screened diversions still operate in delta smelt critical habitat. Plans to renovate and upgrade the fish louvers and screens at the SWP and CVP fish facilities, which entrain the vast majority of larval, juvenile and adult delta smelt, have been indefinitely postponed (SDFFF 2005)

<u>Federal Listing of Other Species Within the Range of the Delta Smelt</u>

Four other fish species that periodically co-occur with delta smelt are listed under the federal ESA: winter-run Chinook salmon (*Oncorhynchus tshawytscha*), spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*), and most recently, the southern population of green sturgeon (*Acipenser medirostris*). With the exception of periodic water export reductions using either the CVPIA or EWA (see above sections), most of the habitat restoration and protective actions for these species have been implemented outside the geographic range of the delta smelt and therefore provide neither benefit to nor protection of the species.

<u>CEQA and NEPA</u>

The environmental review process under the California Environmental Quality Act, California Public Resources Code §21000 et. seq. (CEQA) should theoretically provide some protection to delta smelt. CEQA declares that it is the policy of the state to "(p)revent the elimination of fish or wildlife species due to man's activities, ensure that fish and wildlife populations do not drop below self-perpetuating levels, and preserve for future generations representations of all plant and animal communities." (California Public Resources Code, section 21001(c)). The CEQA process is triggered when discretionary activities of state agencies may have a significant effect on the environment. When the CEQA process is triggered, it requires full disclosure of the potential environmental impacts of proposed projects. The operative document for major projects is usually the Environmental Impact Report.

Theoretically, besides ensuring environmental protection through procedural and informational means, CEQA also has substantive mandates for environmental protection. The most important of these is the provision requiring public agencies to deny approval of a project with significant adverse effects when feasible alternatives or feasible mitigation measures can substantially lessen such effects. *Citizens for Quality Growth v. City of Mt. Shasta*, 198 Cal.App.3d 433, 440_441 (1988); CA. Pub. Res. Code § 21002; 14 Cal. Code Regs. §§ 15002(a)(3), 15021(a)(2) and (c), 15041(c), 15364, 15370. In practice, however, this substantive mandate has not been implemented, especially with regard to protection of the delta smelt. In practice, alternatives that would protect the delta smelt and other wildlife are almost universally dismissed as “infeasible.” Mitigation, when required, is often ineffective or only marginally effective.

The National Environmental Policy Act (“NEPA”) also requires that federal agencies fully and publicly disclose the potential environmental impacts of proposed projects, but NEPA lacks even the minimal substantive provisions of CEQA.

III. RECOMMENDED MANAGEMENT AND RECOVERY ACTIONS

Since 1993, when the delta smelt was first listed under the state and federal ESAs, scientific understanding of the species and its estuarine habitat has increased substantially. During the same period, overall ecological conditions in the estuary have further degraded and the status of species has deteriorated to point where it is at risk of imminent extinction. While there are a number of ongoing monitoring, research and, to a lesser extent, habitat protection efforts underway, additional activities are necessary to protect and improve the status of delta smelt. Based on the results and interpretations of the best available science (much of it described in this petition), and review of current management of the species and its habitat, we recommend the following management and recovery activities.

<u>Activities That Would Protect the Existing Population of Delta Smelt</u>

1. Reduce Delta water exports and/or increase freshwater inflows from the San Joaquin River for a minimum of 30 to 60 consecutive days in the late winter/early spring (i.e., prior to implementation of the VAMP) to improve in-Delta hydrodynamic conditions and improve survival of early arriving adult delta smelt and their larvae. The management action should be timed to coincide with the early spawning period of delta smelt, as determined based on CDFG survey data and Delta water temperatures.
2. Increase freshwater flows through the Delta during the spring (February-June) beyond minimum levels currently required by the SWRCB’s 1995 WQCP to improve estuarine habitat.
3. Increase freshwater outflows during the fall (October-December) to maintain low salinity habitat (as defined by X2) no more than 80 km from the Golden Gate to improve estuarine habitat, restrict the invasive clam *Corbula amurensis*, and reduce proximity of delta smelt to the zone of influence of the exports pumps.
4. Install fish screens on unscreened water diversions in areas of the Delta and Suisun Marsh that are determined to be in operation during periods when juvenile and/or adult delta smelt may be present.
5. Install fish screens on the cooling water intakes for commercial power plants and/or prohibit water intake operations during periods when delta smelt may be present (as based on life history and CDFG survey data).
6. Replace and/or renovate fish and debris screens at the SWP and CVP fish protective facilities and revise operational protocols (e.g., Clifton Court Forebay gate operations, day vs. night pumping regimes, fish collection, handling and transport methods) to reduce entrainment and mortality of delta smelt.
7. Restore and/or accelerate ongoing restoration of tidal marsh habitats in Suisun Marsh, which function to produce phyto- and zooplanktonic food organisms for delta smelt in the marsh and the upper estuary.

Monitoring Programs and Studies

1. Continue ongoing CDFG survey programs, including the FMWT, summer TNS, 20 mm Survey, Spring Kodiak Trawl Survey, Bay Study, and fish salvage monitoring at the SWP and CVP fish protective facilities.
2. Implement monitoring for larval and small juvenile (<20 mm in length) delta smelt entrained into the SWP and CVP export facilities.
3. Complete CDFG-sponsored Collection, Handling, Transport and Release (CHTR) studies and apply results to develop methods for improving survival of delta smelt salvaged at the SWP and CVP facilities.
4. Continue and expand multi-agency research studies of the pelagic organism decline.
5. Develop and facilitate implementation of large scale ecological experiments in the Delta that are designed to test alternative management strategies on the Delta ecosystem (e.g., effects of freshwater inflows or salinity on survival, distribution and abundance of native or invasive species), in-Delta hydrodynamics, and fish entrainment rates.
6. Facilitate the translation and transfer of scientific results to management actions, either as adaptive management experiments, species-specific protection actions, or regulatory objectives.

Needed Amendments to Existing Management and Land-use Plans

1. Revise the state's Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 2006) to incorporate additional protections for estuarine habitat and the delta smelt.
2. Eliminate current waivers for regulation of agricultural discharges from farmlands in the Sacramento and San Joaquin valleys recently approved by the Central Valley Regional Water Quality Control Board (CVRWQCB). Require reductions in the types and amounts of toxic compounds that can be discharged into rivers and streams tributary to the Delta and upper estuary.

Benefits to Other Species

Implementation of additional protection, management and restoration activities for delta smelt (including the recommendations listed above) will, by improving estuarine habitat and reducing adverse in-Delta hydrodynamic conditions, provide benefits to many other sensitive species that reside in or use the estuary for some portion of their life cycle, including longfin smelt (*Spirinchus thaleichthys*), splittail (*Pogonichthys macrolepidotus*), winter-run Chinook salmon (*Oncorhynchus tshawytscha*; CESA-endangered, ESA-endangered), spring-run Chinook salmon (*O. tshawytscha*; CESA-threatened, ESA-threatened), steelhead trout (*O. mykiss*; ESA-threatened), green sturgeon (*Acipenser medirostris*; ESA-threatened), white sturgeon (*A. transmontanus*), and striped bass (*Morone saxatilis*). In addition, improved estuarine habitat will likely provide less favorable conditions for several harmful non-native species, including invasive plants (e.g., *Egeria densa*), invertebrates (*Corbula amurensis*), and fishes (warm water basses, family Centrarchidae).

Agency Participation in Delta Smelt Protection

Protection of delta smelt will require cooperation and participation of state federal and local agencies and organizations, including USFWS, USBR, U. S. Army Corps of Engineers (which participates in repair and maintenance of Delta levees, and regulates maximum export rates at the SWP), CDFG, CDWR, SWRCB, CVRWQCB, Contra Costa Water District and other water districts which receive Delta water deliveries, and local irrigation districts.

Recovery Criteria for Delta Smelt

In 1996, USFWS sponsored development of a recovery plan for native Delta fishes, which included a section for delta smelt (USFWS 1996). The recovery plan included numeric criteria for delta smelt population abundance (based on the Recovery Index, see Table 1) and distribution of the fish within their habitat. Recovery was partially defined as the achievement of specific levels of the two numeric criteria during a period of five consecutive years in which specific hydrological conditions were required to have occurred. Other criteria for recovery included mitigation and/or elimination of threats to the species. In 2003, the numeric abundance, distribution and hydrological criteria were met within the specified five-year window, even though delta population abundance had already declined markedly. This demonstrated that these recovery criteria, developed more than a decade ago without the benefit of the substantial new understanding gained in recent years, were not reliable indicators to characterize a stable and sustainable delta smelt population. Development of new recovery criteria should build on this lesson and also incorporate the new information available on delta smelt extinction risk, population dynamics, subtle variations in life history patterns, habitat requirements and preferences, and emerging threats to the species (e.g., climate change).

IV. CONCLUSION

The USFWS (2004) recently concluded that the threats to delta smelt described in the original listing remain, including the destruction, modification, or curtailment of the delta smelt's habitat or range resulting from extreme freshwater outflow conditions (reduced outflow or high outflow), operations of the State and Federal water projects, and other water diversions. CDFG (2003) and Moyle (2002, 2003) concluded that these threats could result in the extinction of the delta smelt. 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).

In 2003, the USFWS (2004) concluded that new information concerning the delta smelt's population size and extinction probability indicated that the population was at risk of falling below an effective population size and therefore in danger of becoming extinct. Since the USFWS status review, the delta smelt population has indeed fallen below an effective population size and is therefore in danger of becoming extinct.

Recent population viability and extinction risk analyses indicate that, conservatively, the delta smelt could go extinct within the next 20 years and new analyses have demonstrated a statistically significant relationship between delta smelt population abundance and both freshwater outflow levels and Delta export rates. Despite the availability of this new information regarding the likelihood of extinction of the species and the delta smelt's decline to record low levels for three consecutive years (2004, 2005 and 2006), neither the Commission, USFWS nor other agencies charged with protecting the delta smelt and its Delta habitat have taken major actions to reverse the decline. Indeed, state and federal agencies continue to proceed with plans to that would exacerbate current conditions for the delta smelt, including increasing export levels at the Delta pumping facilities and developing new water diversion and storage projects which will reduce Delta inflow and outflow and further degrade delta smelt habitat.

The warning signs could not be clearer: the delta smelt is at high risk of extinction. We urgently petition the California Fish and Game Commission to list the delta smelt as endangered under the CESA, and to immediately implement measures to curtail threats to the species and improve environmental conditions in its Delta habitat.

V. SIGNATURE PAGE

Submitted this 7th day of February, 2007

Christina Swanson, Ph.D.
The Bay Institute
500 Palm Drive, Suite 200
Novato, CA 94949
Phone: (530) 756-9021
Fax: (530) 756-9021
E-mail: swanson@bay.org

Jeff Miller
Center for Biological Diversity
1095 Market Street, Suite 511
San Francisco, CA 94103
Phone: (415) 436-9682 x303
Fax: (415) 436-9683
E-mail: jmiller@biologicaldiversity.org

Katherine S. Poole
Natural Resources Defense Council
111 Sutter Street, 20th Floor
San Francisco, CA 94104
Phone: (415) 875-6100
Fax: (415) 875-6161
E-mail: kpoole@nrdc.org

VI. LIST OF INDIVIDUALS SUPPORTING THE PETITION TO LIST THE DELTA SMELT AS ENDANGERED UNDER THE CALIFORNIA ENDANGERED SPECIES ACT

(Listed in alphabetical order)

William A. Bennett, Ph.D.
John Muir Institute of the Environment, Bodega Marine Laboratory
One Shields Avenue
University of California
Davis, California 95616
(530) 752-5643
E-mail: wabennett@ucdavis.edu

Joseph J. Cech, Jr., Ph.D.
Department of Wildlife, Fish, and Conservation Biology
University of California
One Shields Avenue
Davis, California 95616
(530) 752-3103
E-mail: jjcech@ucdavis.edu

Peter B. Moyle, Ph.D.
Department of Wildlife, Fish, and Conservation Biology
University of California
One Shields Avenue
Davis, California 95616
(530) 752-6355
E-mail: pbmoyle@ucdavis.edu

Jonathan A. Rosenfield, Ph.D.
2447 Derby St.
Berkeley, CA 94705
(510) 684 4757
E-mail: aquaticrestorationconsulting@gmail.com

David H. Wright, Ph.D.
1573 49th Street
Sacramento, California 95819
(916) 739 8906
E-mail: dwrighteco@calweb.com

Paciencia S. Young, Ph.D.
Department of Animal Science
University of California
One Shields Avenue
Davis, California 95616
(530) 752-9546
E-mail: psyoung@ucdavis.edu

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