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

LONGFIN SMELT *(Spirinchus thaleichthys)*

AS AN ENDANGERED SPECIES UNDER THE CALIFORNIA ENDANGERED SPECIES ACT

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: August 8, 2007

EXECUTIVE SUMMARY

The Bay Institute, Center for Biological Diversity and Natural Resources Defense Council formally request that the California Fish and Game Commission list the longfin smelt (*Spirinchus thaleichthys*) as an endangered species under the California Endangered Species Act (CESA), on an emergency basis. All available scientific information and monitoring data indicate that the abundance of longfin smelt in all major estuaries in California, the southern extent of the species' range, has declined severely in the past two decades. In the San Francisco Bay-Delta Estuary, which supports the largest and southernmost longfin smelt population, abundance has reached record low levels. In some smaller California estuaries to the north the species may already be extinct. Given these trends, longfin smelt in California are at risk of extinction, the criterion for endangered status.

Longfin smelt are widely but patchily distributed along North America's Pacific coast as a series of disjunct estuarine-anadromous or land-locked populations. This species historically occupied only three estuaries and the lower reaches of their larger tributary rivers in California: the San Francisco Bay-Delta Estuary, Humboldt Bay, and the Klamath River Estuary. Presently, the largest and southernmost self-sustaining longfin smelt population is in the San Francisco Bay-Delta Estuary. The Humboldt Bay and Klamath River populations are thought to be extinct, and the small numbers of fish recently reported in the Russian River do not likely represent a self-sustaining population.

Comparison of physical characteristics, genetic analysis and ecological information indicates that the San Francisco Bay-Delta longfin smelt population is reproductively isolated from other populations, including the Humboldt Bay, Klamath River, and other populations farther to the north. As the southernmost population, the San Francisco Bay-Delta longfin smelt population represents an important component of the evolutionary legacy of the species, and also clearly represents a significant portion of the range of the species in California.

Longfin smelt in the San Francisco Bay-Delta Estuary have experienced two catastrophic population declines in the past 20 years and have dropped to record low population numbers for the past four consecutive years. Recent surveys indicate that environmental conditions in this Estuary are poor and declining, particularly spring outflow conditions that are strongly correlated to longfin abundance.

Longfin smelt require specific environmental conditions (freshwater flow, water temperature, salinity) and habitat types within estuaries for migration, spawning, egg incubation, rearing, and larval and juvenile transport from spawning to rearing habitats. Most individual longfin smelt live only two years. They feed exclusively on plankton. Their prey base has declined markedly in the San Francisco Bay-Delta Estuary in recent years. Throughout their life cycle, longfin smelt seasonally occupy a range of open water habitats in estuaries, from fresh to brackish water areas for spawning to brackish and marine habitats for juvenile and sub-adult rearing. In the San Francisco Bay-Delta

Estuary, adult fish aggregate in Suisun Bay and the western Delta in late fall, then spawn in freshwater areas immediately upstream during winter and early spring.

During spawning longfin smelt are vulnerable to lethal entrainment into federal, state, industrial, and local agricultural water diversions and export facilities. Throughout their life cycle, longfin smelt are susceptible to major physical disruptions (such as dredging) and are exposed to toxic pollution from San Francisco Bay Area, in-Delta and upstream agricultural and urban runoff and discharges. In the San Francisco Bay-Delta Estuary, longfin smelt population abundance is directly related to the amount of freshwater flow into the Estuary during the spring. In years when spring flows are high and low salinity habitat is located in Suisun or San Pablo Bay, longfin smelt have better reproductive and larval recruitment success and population abundance measured later in the year is high, while low spring flows strongly correspond to low longfin smelt abundance.

Longfin smelt were historically one of the most abundant of the pelagic fishes in the San Francisco Bay-Delta Estuary. Historic population levels once supported a commercial smelt fishery and the species was likely a central component of the food web that sustained other commercially important species in this estuary. During the 1987-1992 drought, which coincided with a period of record high levels of diversions and exports from the Estuary, longfin smelt abundance fell more than 95%, reaching record low levels by the early 1990s. The population partially recovered during the late 1990s, when hydrological conditions improved, but collapsed again in 2003 despite moderate hydrological conditions. For the 2003-2005 period, average longfin smelt abundance in the Bay-Delta Estuary was less than 1% of the 1967-1986 average and just 4% of the average abundance for the 1995-2000 period.

The threats to longfin smelt include: reductions in freshwater inflow to the estuaries they inhabit; loss of larval, juvenile and adult fish at agricultural, urban, industrial, and local water diversions (usually located in freshwater areas of estuaries used by the species for spawning); direct and indirect impacts of non-native species on the longfin smelt food supply and habitat; lethal and sub-lethal effects of toxic chemicals; physical disruption of their spawning substrates and the habitat of their prey species (e.g. by dredging); and warming of estuary waters resulting from global climate change.

Water management operations by the massive California State Water Project and the federal Central Valley Project regularly divert large proportions of the freshwater flows to the San Francisco Bay-Delta Estuary, both by impounding water in reservoirs upstream of the Delta and by exporting water directly from the Delta, resulting in habitat degradation and entrainment-related mortality. The recent decline of longfin smelt in this estuary coincides with significant increases in Delta water exports, particularly during the sensitive winter and early spring periods when adult longfin smelt and their larvae are concentrated in the freshwater and low salinity regions of the Estuary. Hydrodynamic analyses of Delta flows indicate that, under water inflow and export conditions comparable to those reported during the past several years, all larval and juvenile longfin smelt present in the central and southern regions of the Delta are likely to be entrained and killed. In the 2000s, winter and early spring exports at the state and federal water pumps averaged 41% higher than exports during the mid-1990s. New analyses have demonstrated a statistically significant negative relationship between longfin smelt population abundance and Delta water exports as a fraction of Delta inflow: high export ratios during the winter and early spring consistently correspond to low longfin smelt abundance. It is clear that current water management and export operations are contributing to the critically low abundance of longfin smelt and are incompatible with recovery of the Bay-Delta longfin smelt population.

Ecological conditions in longfin smelt habitat in the Bay-Delta have also deteriorated. Reduced freshwater outflows have shifted the location and degraded the quality of low salinity habitat seasonally used by the fish. The invasive clam *Corbula amurensis* has reduced the abundance of the longfin 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 longfin smelt and their estuarine ecosystems. Water rights permits issued by the State Water Resources Control Board allow Bay-Delta export operations at levels exceeding those necessary to maintain a healthy longfin smelt population. Dedications of water for the environment and money for supplemental acquisitions of environmental water (as mandated in the 1992 Central Valley Project Improvement Act), which were 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 the future status of this program is highly uncertain. Despite precipitous population declines of longfin smelt (and other sympatric, ESA-listed species such as Chinook salmon, green sturgeon, and delta smelt, which is now critically imperiled), the agencies charged with protecting the fisheries resources have recently approved increases in the Bay-Delta water management operations and infrastructure known to be threats to longfin smelt and other native fish.

Fifteen years ago, a catastrophic decline in the abundance of longfin smelt in the San Francisco Bay-Delta Estuary and scientific identification of multiple threats to the species were reported to the USFWS in a petition to list the species under the federal Endangered Species Act. The USFWS rejected the listing petition based on flawed interpretation of genetic and ecological information relating to the evolutionary isolation of the San Francisco Bay-Delta Estuary's longfin smelt population. Today, longfin smelt populations have undergone further decline or are already extinct in all of California's largest estuaries, from San Francisco to the Oregon border. Virtually all of the threats to the species identified in the 1990s have intensified and new threats have emerged. Ecologically similar and sympatric species such as delta smelt are on the verge of extinction. The warning signs could not be clearer: longfin smelt in California are at high risk of extinction. The species merits emergency listing under the California Endangered Species Act and requires immediate implementation of measures to improve environmental conditions in its estuarine habitats.

NOTICE OF PETITION

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Petitioners The Bay Institute, Center for Biological Diversity, and Natural Resources Defense Council formally request that the California Fish and Game Commission (Commission) list the longfin smelt (*Spirinchus thaleichthys*) as an endangered species under the California Endangered Species Act (CESA), Fish and Game Code §2050-2068. Alternatively, petitioners request that the Commission list the longfin smelt as a threatened species under the CESA.

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).

Documentation of the recent and continuing longfin smelt population decline in California, and new information published in peer-reviewed literature and presented at scientific meetings and CALFED Bay-Delta Program workshops described in this petition, demonstrates that longfin smelt in California should be listed as endangered – at risk of extinction. Evidence to support the endangered listing requested in this petition includes record low population abundance in the last four years for the San Francisco

Bay-Delta population, the largest remaining longfin smelt population in California and the population that represents a significant portion of the species' range in California. The petition also includes new analyses of Bay-Delta population abundance and trends over the past 40 years; evidence that the Bay-Delta population has experienced two multi-generation long population bottlenecks in the past twenty years that have likely reduced its genetic integrity; evidence for a significant stock recruitment relationship for the species; and new information regarding the significant effects of water management and Delta exports on Bay-Delta longfin smelt population abundance. Due to this extreme situation, the threats documented in this petition constitute an emergency.

Petitioners:

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 longfin smelt and its habitat.

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I. NATURAL HISTORY AND STATUS OF LONGFIN SMELT

A. NATURAL HISTORY

1. Description

The longfin smelt (*Spirinchus thaleichthys*) is a medium sized (90-110 mm standard length at maturity), osmerid fish associated with estuaries along the eastern Pacific coast, found from the San Francisco Bay-Delta Estuary north to Prince William Sound, Alaska.[1] Longfin smelt are described as follows by Moyle (2002):

> The sides of living [longfin smelt] appear translucent silver, while the back has an olive to iridescent pinkish hue. Mature males are usually darker than females, with enlarged and stiffened dorsal and anal fins, a dilated lateral line region, and breeding tubercles on paired fins and scales.

Moyle (2002) also noted that:

> Longfin smelt can be distinguished from other California smelt by their long pectoral fins (which reach or nearly reach the bases of the pelvic fins), incomplete lateral line, weak or absent striations on the opercular bones, low number of scales in the lateral line (54-65) and long maxillary bones (which in adults extend just short of the posterior margin of the eye). The lower jaw projects forward of the upper jaw when the mouth is closed. Small, fine teeth are present on both jaws, as well as on the tongue, vomer, and palatines. The number of dorsal rays is 8-10; anal rays, 15-22; pectoral rays, 10-12; gill rakers, 38-47; and pyloric caeca, 4-6.

2. Taxonomy

Longfin smelt are one of seven osmerid fish species that occupy habitats in California estuaries and coastal waters (Moyle 2002). Among these species, the longfin smelt is most closely related to the night smelt (*S. starksi*) (Stanley et al. 1995). Historically, the longfin smelt population of the San Francisco Bay-Delta Estuary was considered to be a separate species (*Spirinchus thaleichthys*) from longfin smelt populations to the north (which were referred to as *S. dilatus*). McAllister (1963) recognized that the meristic differences between these groups represented variation along a north-south gradient and merged the populations under the name *S. thaleichthys*. Thirty years later, genetic analyses conducted by Stanley et al. (1995) confirmed that longfin smelt from the San Francisco Bay-Delta Estuary are the same species as longfin smelt from Lake Washington in Washington State. However, these authors also concluded that the gene pool of the San Francisco Bay-Delta population was significantly different and isolated from the Washington population of longfin smelt. These researchers wrote:

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[1] A single longfin smelt collected from the Monterey Bay area was reported by Eschmeyer et al. (1983) but the San Francisco Bay-Delta population is considered to be the southernmost population for the species (Moyle 2002).

> …[G]ene frequencies among these two populations of [longfin smelt] differed significantly, suggesting that current gene flow between them is restricted. This result, combined with geographic isolation between them suggests that the [San Francisco Bay-] delta population of [longfin smelt] warrants management as an isolated and genetically distinct entity. [Stanley et al. (1995, p. 390)]

With regard to longfin smelt population structure, these results are particularly striking because Stanley et al. (1995) studied inter-population variation in allozymes. Allozymes are genetic markers that, because they are believed to experience natural selection, are not particularly sensitive indicators of population structure within species. More modern techniques and more sensitive markers of population structure (e.g. mtDNA, nuclear microsatellites, and nuclear introns, which have been used to describe the degree of genetic independence among Evolutionarily Significant Units (ESUs), or Distinct Vertebrate Population Segments (DPSs), populations, and sub-populations) have not yet been employed to delineate the geographic sub-structuring of longfin smelt populations. Given that the San Francisco Bay-Delta population of longfin smelt demonstrates significantly different allozyme frequencies than other self-sustaining longfin smelt populations, it is highly likely that techniques designed to detect intraspecific population structure will confirm that the San Francisco Bay-Delta Estuary longfin smelt population represents an independent lineage and is a Distinct Population Segment. On these bases, Moyle et al. (1995) reported to the California Department of Fish and Game (CDFG) that this longfin smelt population was “very isolated from other populations” and “clearly [qualified for] listing as a ‘species’ under the federal Endangered Species Act.” Several years later, Moyle (2002) stated that:

> Longfin smelt in the San Francisco Estuary are isolated from other populations and are the southernmost of the species. They are similar in this respect to a recognized run of chinook salmon (e.g., winter-run chinook) and fit the definition of an Evolutionarily Significant Unit (ESU) established by NMFS [Waples 1991].[2] A population must satisfy two criteria to be an ESU: (1) it must be substantially reproductively isolated from other conspecific population units; and (2) it must represent an important component of the evolutionary legacy of the species. The longfin smelt in the San Francisco Estuary fills both of these criteria.

The USFWS (1996) also concluded that the longfin smelt population in the San Francisco Bay-Delta Estuary “is isolated from other populations,” including the Humboldt Bay population located more than 260 miles (420 km) by sea to the north.

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[2] The Evolutionarily Significant Unit concept was developed by the National Marine Fisheries Service (Waples 1991) to describe the criteria for a stock of fish to be “considered ‘distinct’ (and hence a ‘species’) for the purposes of the ESA.” NMFS also noted that the first criterion (reproductive isolation) “does not have to be absolute, but it must be strong enough to permit evolutionarily important differences to accrue in different population units,” and that the second criterion (that the species represents an important component of the evolutionary legacy of the species) would be met if the “population contributed substantially to the ecological/genetic diversity of the species as a whole.”

3. Range and Distribution

The longfin smelt is an estuarine-anadromous fish native to the Pacific Coast of North America (Lee et al. 1980; Moyle 2002). The species occurs in scattered populations along the coast from the San Francisco Bay-Delta Estuary to Prince William Sound, Alaska (see map, Appendix 1). There are landlocked populations in Lake Washington, Washington and Harrison Lake, British Columbia.

The longfin smelt population in the San Francisco Bay-Delta Estuary[3] is the southernmost population in the species' range and is by far the largest population in California (Moyle 2002). Other populations of longfin smelt in California have been recorded in Humboldt Bay, and the estuaries of the Russian, Eel, and Klamath Rivers. These populations are believed to currently be very small and the Humboldt Bay population has apparently experienced a major decline or may be extinct (see Historic and Current Distribution and Historic and Current Abundance).

Based on meristic and genetic analyses (see Taxonomy above), there is no evidence that large numbers of longfin smelt migrate between populations within their eastern Pacific range or even along the California coast. Available survey data indicate that all other longfin smelt populations within several hundred miles of San Francisco Bay are small (and possibly declining; see Historic and Current Abundance). It is unknown whether the few longfin smelt that are occasionally captured in the Russian River or Bodega Bay were spawned in the areas where they were captured or migrated from the San Francisco Bay-Delta Estuary. In any case it is highly unlikely that the San Francisco Bay-Delta Estuary longfin smelt population is sustained or even supplemented by immigration from these other areas. The distribution and range of the San Francisco Bay-Delta Estuary longfin smelt population extends from Rio Vista (on the Sacramento River in the Delta) and Medford Island (on the San Joaquin River in the Delta) through Suisun Bay and Suisun Marsh, San Pablo Bay, San Francisco Bay, and the South Bay, and into the Gulf of the Farallones, just outside of the Golden Gate (see map, Appendix 1).

4. Habitat Requirements

Longfin smelt are a pelagic (i.e., they live in open waters), estuarine-anadromous species. They tolerate of wide range of salinities (i.e. they are euryhaline) and are capable of living in fresh, brackish and marine waters. Most of their life cycle is completed in brackish to marine waters, with most post-larval fish in the San Francisco Bay-Delta population found in salinities from 15-30 psu (practical salinity units) (Baxter et al. 1999). Based on the locations where gravid adults are captured, spawning probably occurs in fresh to slightly brackish waters.

[3] The San Francisco Bay-Delta Estuary includes the Sacramento and San Joaquin Rivers, their confluence (or "delta"), the open water embayments known as Suisun Bay, San Pablo Bay, the Central Bay, and the South Bay, and associated wetlands (such as Suisun Marsh) and tributaries to these water bodies.

Longfin smelt migrate throughout the Bay-Delta Estuary over the course of their life cycle (e.g., Baxter et al. 1999; Moyle 2002; Rosenfield and Baxter *in press*).[4] Based on results from nearly 40 years of monthly and seasonal sampling, the species is found in open waters throughout the Estuary and in the larger channels and sloughs of Suisun Marsh.[5] During fall and winter months, longfin smelt numbers are greatest in the northern Estuary (particularly Suisun Bay and the western Delta) although they are also found in shallow bays such as San Pablo Bay and the South Bay at that time. During summer months, higher densities of longfin smelt are found in the Central Bay.

Longfin smelt distribution in the San Francisco Bay-Delta Estuary may be limited by high water temperatures. Moyle (2002) reported that longfin smelt are not commonly found in waters above 20^{o}C. The species' geographic range and this population's migration and habitat choice patterns, including a preference for deep and/or marine waters during summer months, suggest that these fish may not be very tolerant of warm water conditions. The fish are found at the greatest diversity of sites in the Estuary during late-fall and winter months, suggesting that their use of certain habitats may be restricted by temperatures at other times of the year.

Exact locations and environmental conditions of spawning sites are currently unknown but, based on their behavior in other water bodies (Dryfoos 1965; Chigbu 2000), it is likely that longfin smelt in the San Francisco Bay-Delta Estuary deposit their eggs on cobble or plant substrates at the bottom of deep channel habitats. Historically, spawning longfin smelt were common in Suisun Marsh as well, although in recent years very few adult, spawning-age longfin smelt have been collected in this area (Matern et al. 2002; Rosenfield and Baxter, *in press*). Larval and juvenile longfin smelt are found throughout Suisun Bay and the western Delta during the spring. As adults, longfin smelt densities are greatest in and above deep water habitats of San Francisco Bay. Their prevalence in the CDFG's Bay Study otter trawl, a net that collects fish near the bottom, also indicates a preference for deeper waters within the Estuary. During summer months, longfin smelt numbers and frequency of occurrence decrease at sampling localities throughout the Estuary suggesting that some portion of this population migrates to near shore marine habitats (Rosenfield and Baxter, 2007). Detection of longfin smelt outside of the Golden Gate during the City of San Francisco's sewage outfall monitoring program confirms that some longfin smelt from the San Francisco Bay-Delta Estuary population do make use of near shore marine habitats (City of San Francisco 1985).

5. Life History

Longfin smelt have a two-year life cycle, although a small fraction of individuals may spawn as one- or three-year old fish. Spawning in the San Francisco Bay-Delta Estuary

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[4] There is extensive published information on the landlocked population of longfin smelt in Lake Washington (Dryfoos 1965; Chigbu and Sibley, 1994; Chigbu et al. 1998; Chigbu 2000), but this population is reproductively isolated and ecologically different from all other longfin smelt populations.

[5] In the San Francisco Bay-Delta estuary, longfin smelt are surveyed the California Department of Fish and Game in their Bay Study Midwater and Otter Trawl surveys (monthly, 1980 to present) and Fall Midwater Trawl Survey (September-December, 1967 to present), and by the University of California, Davis, Suisun Marsh Otter Trawl survey (1980 to present).

takes place in fresh or slightly brackish water over sandy or gravel substrates and at temperatures ranging from 7 to 14.5°C. Spawning at lower temperatures has been observed in other populations (Wang 1986). Based on their distribution patterns during the spawning season, the main spawning area for the San Francisco Bay-Delta Estuary longfin smelt population appears to be downstream of Rio Vista on the Sacramento River. Spawning probably also occurs in the eastern portion of Suisun Bay and, in some years, the larger sloughs of Suisun Marsh. Historically, spawning probably also occurred in the San Joaquin River, but recent catches of longfin smelt in the San Joaquin River have been extremely low. Flows in the San Joaquin River have been drastically reduced, contributing to habitat, temperature and water quality degradation.

The longfin smelt spawning season is protracted and timing varies somewhat from year-to-year. Most spawning occurs between January and March. Males arrive on the spawning grounds before females. Females carry between 5,000 and 24,000 eggs. Embryos hatch in 40 days at 7°C (Dryfoos 1965). In the San Francisco Bay-Delta Estuary, larvae are frequently caught upstream of the Sacramento-San Joaquin River confluence in the Delta and then become widely dispersed throughout the upper Estuary, with the volume of freshwater outflow to the Estuary having a significant effect on the breadth of their final distribution (CDFG *unpublished data*). Larval longfin smelt appear to use vertical migrations synchronized with tides to adjust or maintain their geographic position in the Estuary (Bennett et al. 2002). Larval metamorphosis into juveniles occurs roughly 30-60 days after hatching and varies with water temperature (Emmett et al. 1991).

At least in the San Francisco Bay-Delta Estuary, longfin smelt exhibit a significant stock recruitment relationship. Using data from the CDFG Fall Midwater Trawl (FMWT) survey that measures the abundance of juvenile (age-1) and adult (age-2) longfin smelt, 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 the previous year (see Equation 1 and Figure 1; also see Historic and Current Distribution for more information on the FMWT survey).[6]

Log_{10} #juveniles/trawl = 0.48 + 0.55(log #adults/trawl prev. year) **(Equation 1)**
Time period=1975-2004, excluding 1976 and 1979[7]; n=25; p=0.013; r^2=0.239

[6] Fish abundance data, expressed either as catch per unit effort or as an abundance index, are typically not normally distributed. Therefore, for these and other statistical analyses, longfin smelt abundance data were $\log_{10}$ transformed, similar to the approach used by Bennett (2005) in his analyses for delta smelt.
[7] Abundance data for 1976 and 1979 were excluded from this analysis because sampling effort was low in these years.

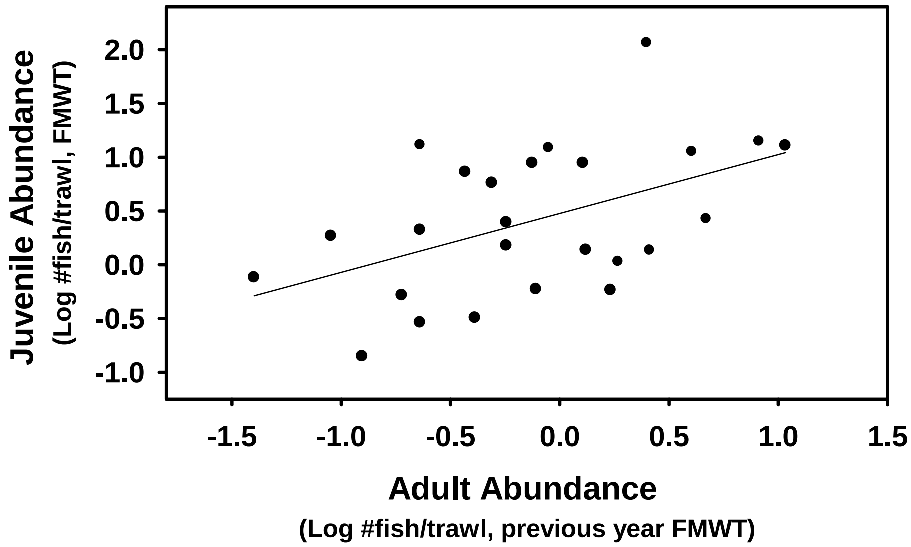

Figure 1. The relationship between the abundance of juvenile longfin smelt (log #age-1 fish/trawl) and the abundance of the adult fish that produced them (log #age-2/trawl for the previous year) in the San Francisco Bay-Delta Estuary. Data are for 1975 to 2004 but exclude 1976 and 1979 when the survey sampling effort was low. Regression equation and associated statistics are provided in the text as Equation 1. Data source: CDFG Fall Midwater Trawl Survey.

Similarly, the abundance of adult (age-2) fish is significantly and directly related to the abundance of juvenile (age-1) fish measured the previous year (see Equation 2 and Figure 2).

Log_{10} #adults/trawl = -0.37 + 0.46(log #juveniles/trawl prev. year) **(Equation 2)**
Time period=1975-2004, excluding 1976 and 1979; n=25; p=0.008; r^2=0.272

Similar stock recruitment analyses using data from the CDFG Bay Study Midwater and Otter Trawl surveys yielded comparable results.

In the San Francisco Bay-Delta Estuary, the principal prey items for adult longfin smelt are believed to be opossum shrimp, *Acanthomysis* sp. and *Neomysis mercedis*; although populations of the latter species have dropped dramatically in recent years in the Estuary (Orsi and Mecum 1996). Copepods and other crustaceans are also important prey, especially for smaller fish (Feyrer et al. 2003; Hobbs et al. 2006). Longfin smelt are probably preyed upon by fishes, birds, and marine mammals, but their importance in the aquatic food web has been documented only in Lake Washington (Nowak et al. 2004) and not in the San Francisco Bay-Delta Estuary. As a result of their position in the estuarine food web and their former abundance, longfin smelt historically played an important role in the structure and function of the San Francisco Bay-Delta Estuary ecosystem.

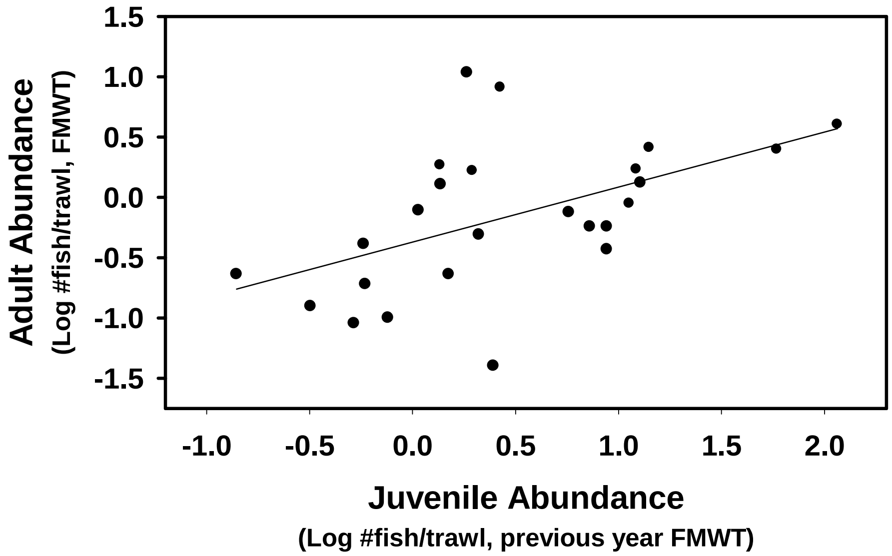

Figure 2. The relationship between the abundance of adult longfin smelt (log #age-2 fish/trawl) and the abundance of juvenile longfin smelt measured the previous year (log #age-1 fish/trawl for the previous year) in the San Francisco Bay-Delta Estuary. Data are for 1975 to 2004, and exclude 1976 and 1979 when the survey sampling effort was low. Regression equation and associated statistics are provided in the text as Equation 2. Data source: CDFG Fall Midwater Trawl Survey.

The San Francisco Bay-Delta population of longfin smelt exhibits a strong positive correlation between abundance (measured as the CDFG FMWT abundance index[8]) and the amount of freshwater outflow[9] from the Delta during the spring (Stevens and Miller 1983; Jassby et al. 1995; Meng and Matern 2001; Kimmerer 2002, 2004; Rosenfield and Baxter, *in press*). In years with high spring flows to the Estuary, longfin smelt abundance is higher than in years with lower spring flows (see Figure 3, and Equations 3 and 4). A number of other estuary-dependent species in the San Francisco Bay-Delta Estuary, such as bay shrimp (*Crangon franciscorum*), starry founder (*Platichthys stellatus*), splittail (*Pogonichthys macrolepidotus*), and striped bass (*Morone saxatilis*), also exhibit this spring flow-abundance relationship, but the strength of the relationship, as measured by both the slope of the regression and r^2 values, is strongest for the longfin smelt (Kimmerer 2004). This statistically significant relationship between spring flows and longfin smelt abundance is driven largely by the abundance of juvenile (age-1) fish, which are 10- to 100-fold more numerous than adult (age-2) fish in all surveys, and has remained strong despite substantial changes to the Estuary's ecology. In the late 1980s, the alien clam *Corbula amurensis* became established in the Estuary and has had severe effects on the planktonic food web (Kimmerer and Orsi 1996). For the years since the establishment of the clam (1988-2006, open circles in Figure 3, and Equation 4), the

[8] CDFG Fall Midwater Trawl (FMWT) abundance indices for longfin smelt are calculated using combined data for juvenile (age-1) fish and adult (age-2) fish. Annual abundance indices for longfin smelt and several other fish species are available at: http://www.delta.dfg.ca.gov/data/mwt/charts.asp.

[9] Freshwater outflow is usually referred to as "Delta outflow" and measured indirectly in terms of "X2", the location of the 2 psu isohaline in km from the Golden Gate.

relationship between spring flows and longfin smelt abundance is still highly significant, although the intercept and the slope of the regression are somewhat lower.

The regression equations for longfin smelt abundance and spring flows for the 1967-1987 (pre-clam, Equation 3) and 1988-2006 (post-clam, Equation 4) are shown below.

Log_{10} FMWT abundance index = 7.368 – 0.056(Feb-May X2) **Equation 3**
Time period=1967-1987, n=19, p<0.001, r^2=0.729

Log_{10} FMWT abundance index = 5.212 – 0.036(Feb-May X2) **Equation 4**
Time period=1988-2006, n=19, p<0.001, r^2=0.487

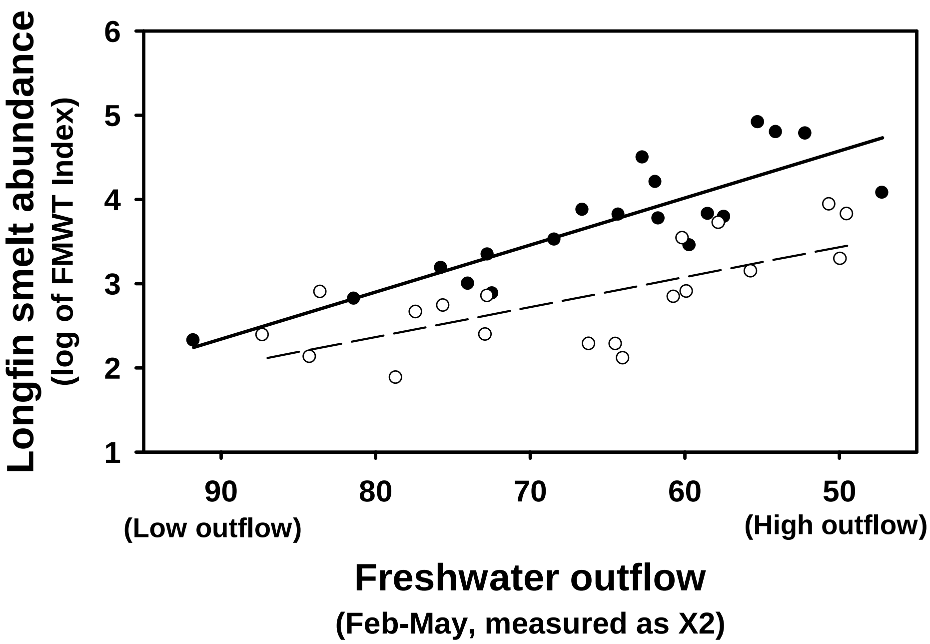

Figure 3. The relationship between longfin smelt abundance (measured as the log_{10} of the CDFG Fall Midwater Trawl abundance index) and spring freshwater outflow to the San Francisco Bay-Delta Estuary (measured in terms of X2, a commonly used metric that measures Delta outflow in terms of the location of the 2 psu isohaline in km from the Golden Gate,[10] and calculated as the average X2 for the February-May period). Closed circles and the solid regression line are for the years prior to the invasion of the alien clam, *Corbula amurensis* (1967-1987); open circles and the dashed regression line are for the years following the clam's invasion (1988-2006). Regression equations are shown in the text as Equations 3 and 4. Data sources: California Department of Water Resources (CDWR), Dayflow model for Delta outflow and X2; CDFG FMWT abundance index for longfin smelt.

[10] X2 is usually calculated from daily net Delta Outflow Index using the following equation:
$X2 (d_i) = 10.16 + 0.945(X2, d_{i-1}) – 1.487(log[outflow, d_i])$; where d_i is the current day, d_{i-1} is the previous day, and outflow is in cubic feet per second (cfs).

6. Natural Mortality

Based on our review of the literature, as well as of unpublished results of the ongoing multi-agency investigation of the Pelagic Organism Decline (POD) in the San Francisco Bay-Delta Estuary,[11] there is insufficient evidence for effects of disease or predation on longfin smelt population abundance. However, diseases and parasites of longfin smelt have not been well studied and numerous introduced species are abundant in most of the eastern Pacific estuaries used by the species, including the San Francisco Bay-Delta Estuary, which is considered to be the most invaded estuary in the world (Cohen and Carlton 1998). The invasion of the San Francisco Bay-Delta Estuary by the clam *Corbula amurensis* has had an apparent effect on longfin smelt population abundance, presumably through competition and its negative effects on upper Estuary's planktonic food web (Kimmerer 2002, 2004). Both Feyrer et al. (2003) and Hobbs et al. (2006) reported evidence that longfin smelt in this estuary might be food limited. Recent analyses by Rosenfield and Baxter (*in press*) present strong evidence of a decline in survivorship between age-1 (juvenile) and age-2 (adult) longfin smelt since the 1987-1992 drought, when the *Corbula* became established and longfin smelt experienced a significant population decline (see Historic and Current Abundance). These authors also suggested food limitation as a possible mechanism for this response.

B. CHANGES IN DISTRIBUTION AND ABUNDANCE

1. Historic and Current Distribution

Historic distribution: The longfin smelt's historic distribution extended from California's San Francisco Bay-Delta Estuary to Prince William Sound, Alaska (see map, Appendix 1). Along this reach of the eastern Pacific coast, the fish were found in scattered bays and estuaries, including Dixon Entrance, Yakutat Bay, Cook Inlet and Prince William Sound, Alaska; the Fraser River Estuary in British Columbia; Skagit Bay, Grays Harbor, Willapa Bay and Puget Sound in Washington; the lower Columbia River; Yaquina and Coos Bays in Oregon; and in the San Francisco Bay-Delta Estuary, Humboldt Bay, and the estuaries and lower reaches of the Russian, Eel, Van Duzen and the Klamath Rivers in California (Lee et al. 1980; USFWS 1994; Moyle 2002). A single fish was reported from Monterey Bay (Eschmeyer et al. 1983), but the San Francisco Bay-Delta Estuary longfin smelt population is the southernmost self-sustaining population for the species (Moyle 2002). There are also two landlocked populations of longfin smelt, one in Lake Washington, Washington and the other in Harrison Lake, British Columbia.

The historic distribution of the San Francisco Bay-Delta Estuary longfin smelt population extended from the lower rivers entering the Sacramento-San Joaquin Delta downstream

[11] In 2005, state and federal fishery agency biologists reported that populations of several key pelagic fishes that use the upper San Francisco Bay-Delta estuary, including the longfin smelt, had declined to and remained at near record low levels for the previous three years. This pelagic organism decline (referred to as the "POD") prompted the agencies to launch a large multi-disciplinary research program to investigate possible causes for the decline, including effects of water exports from the upper estuary, toxic contaminants and invasive species. Preliminary results and reports of the POD studies are available at: http://science.calwater.ca.gov/pod/pod_synthesis.shtml.

to the San Francisco Bay (including the Suisun, San Pablo, Central and South embayments and Suisun Marsh) and into the Gulf of the Farallones, just outside the Golden Gate (see map, Appendix 1).

Current distribution: There is very little current information on longfin smelt populations or distributions in most areas of their range outside of California (USFWS 1994). In California, the southern limit of the species' range, available data suggest that the distribution of longfin smelt has become more limited in the past 20 years. The relatively large population that existed in Humboldt Bay has declined to the point where longfin smelt are rarely caught and this population may be extinct or nearing extinction (USFWS 1994; Pinnix et al. 2004; and see Historic and Current Abundance). The USFWS (1996) reported in 1996 that the Humboldt Bay population "may now be extinct." The USFWS (1994) reported that the fish had disappeared from the Eel and Van Duzen Rivers and their estuaries. Our own investigations indicate that there are no recent observations of longfin smelt in these systems. Longfin smelt were recorded in the Russian River in the late 1990s (Moyle 2002), however, the number of individual longfin smelt caught was so small that it is unlikely that the Russian River, Bodega Bay, or nearby water bodies maintain a self-sustaining breeding population of the species.

In contrast, in the San Francisco Bay-Delta Estuary, data on longfin smelt distribution and abundance have been collected by several long-term and regular monitoring programs for decades. These data document that the San Francisco Bay-Delta longfin smelt population is a significant population of the species. Four surveys are most relevant to longfin smelt population dynamics:

1. The CDFG Fall Midwater Trawl (FMWT), conducted from September through December of nearly all years since 1967. The FMWT surveys the distribution and abundance of pelagic organisms (including longfin smelt) in the Sacramento-San Joaquin Delta, Suisun Bay, and until the early 1980s, the San Pablo and Central embayments of San Francisco Bay. An abundance index for longfin smelt is calculated using catch data from this survey by extrapolating the total numbers of longfin smelt caught at a number of fixed sampling stations, using a weighting factor that accounts for differences in water volume at various sub-regions from San Pablo Bay through the Delta. Beginning in 1977, length data on individual longfin smelt were also collected, which allowed for differentiation of age-1 and age-2 year classes (i.e., one-year old juvenile fish versus two-year old adult fish).

2. The CDFG Bay Study Midwater Trawl (BSMWT), conducted most months and in all but one year since 1980. The BSMWT surveys the distribution and abundance of pelagic organisms (including longfin smelt) throughout the San Francisco Bay-Delta Estuary. Like the FMWT, this survey uses a midwater trawl that collects fish from the water column. Data on fish lengths for longfin smelt are also collected.

3. The CDFG Bay Study Otter Trawl (BSOT), conducted most months in all years since 1980. The BSOT surveys the distribution and abundance of demersal organisms (including longfin smelt) throughout the San Francisco Bay-Delta Estuary. This survey

uses an otter trawl that collects fish distributed near the bottom. Data on fish lengths for longfin smelt are also collected. The BSOT survey samples at the same sites used by the BSMWT survey.

4. The University of California, Davis, Suisun Marsh Otter Trawl survey (UCDSMOT), conducted monthly since 1980. The UCDSMOT surveys fish (including longfin smelt) and invertebrate distribution and abundance in Suisun Marsh. This survey uses an otter trawl that collects fish distributed near the bottom. Data on fish lengths for longfin smelt are also collected.

Rosenfield and Baxter (*in press*) analyzed distribution patterns of longfin smelt within the San Francisco Bay-Delta Estuary using records from the BSMWT, BSOT and UCDSMOT surveys. Each of these programs samples the Estuary and marsh once per month throughout the year. Combining results from these independent surveys, these researchers found that the average number of sampling sites at which adult (i.e., age-2 fish) longfin smelt were collected had declined significantly during the past twenty years. In the early and mid-1980s, adult longfin smelt were consistently collected at greater than 19% of sites sampled throughout the Estuary and marsh. However, since the mid-1990s, longfin smelt were collected at approximately 11% of stations sampled, a statistically significant decline; in some years, longfin smelt were detected at <10% of stations sampled per month. The decline in the number of sites in the San Francisco Bay-Delta Estuary where longfin smelt are detected appears to reflect the fact that their numbers have declined to a point where they are simply not detectable at as many sites.

2. Historic and Current Abundance

Historic abundance: Longfin smelt have historically been among the most numerically abundant fish species in the San Francisco Bay-Delta Estuary and in Humboldt Bay (Moyle 2002). Today, all of the major fish species of the Bay-Delta Estuary have experienced substantial recent population declines, and longfin smelt are no exception (Sommer et al. 2007). Skinner (1962) reported that the San Francisco Bay-Delta population of longfin smelt was an important component of a large smelt fishery in the Estuary during the 19th century. During the 1987 -1992 period of extreme drought and record high water diversions, longfin smelt abundance declined sharply, falling more than 80% in two years and remaining at record low levels until wet hydrological conditions returned in 1995 (see Table 1 and Figure 4).[12] Over the next five years, the species partially recovered to levels that were approximately 50% of the species' pre-drought abundance. These trends in longfin smelt abundance are remarkably consistent across all four long-term surveys that collect the species in the Estuary (see Figure 4) and in all regions of the San Francisco Bay-Delta Estuary (see Figure 5).

[12] The metrics of longfin smelt abundance produced by the CDFG FMWT and Bay Study surveys and the UC Davis Suisun Marsh survey are calculated using similar methods but certain aspects of the sampling programs and multipliers used differ such that the two metrics may differ by an order of magnitude. The purpose of presenting the different data sets is to compare trends over time *within* those data sets not to compare *between* datasets or to attempt to estimate the total population size in any precise way.

Table 1. Abundance of longfin smelt in the San Francisco Bay-Delta Estuary as measured by the CDFG Fall Midwater Trawl survey (FMWT, expressed as the abundance index), the CDFG Bay Study Midwater and Otter Trawl surveys (BS MWT+OT, expressed as combined catch per trawl from the two nets), and the UC Davis Suisun March Otter Trawl survey (UCDSMOT, catch per trawl). For each survey, catch data for both age-1 and age-2 years classes of fish are combined.

Year	FMWT Index	FMWT averages	BS MWT+OT (catch/effort)	Bay Study averages	UCDSMOT (catch/effort)	Comments
1967	81790					
1968	3300					
1969	60059					
1970	6535					
1971	15987					
1972	760					
1973	5897					
1974	no data					
1975	2819	1967-1986: 17616				
1976	658					
1977	210					
1978	6675					
1979	no data					
1980	31155		135.8		1.353	
1981	2202		33.4		.074	
1982	62549	1980-1986: 17485	276.5	1980-1986: 95.9	1.459	
1983	11875		139.6		.050	
1984	7459		38.5		0.200	
1985	992		24.6		0.054	
1986	6160		22.0		0.138	
1987	1520		15.3		0.028	Longfin smelt population declines by 97% (FMWT), 94% (Bay Study) and 98% (UCDSMOT) during 1987-1992 drought. Longfin smelt nearly disappear from Suisun Marsh.
1988	791		9.8		0.014	
1989	456	1987-1994: 537	5.2	1987-1993: 5.7	0.003	
1990	243		1.7		0.002	
1991	134		1.4		0.001	
1992	76		0.9		0	
1993	798		5.63		0.006	
1994	545		no data		0.003	
1995	8646		138.3		0.068	Longfin smelt population increases to 11% (SMOT) and 51% (Bay Study) of pre-drought population levels during six-year long wet period. Number of fish using Suisun Marsh remains low.
1996	1388		15.5		0.003	
1997	690	1995-2000: 4343	10.3	1995-2000: 48.6	0.005	
1998	6654		44.6		0.028	
1999	5242		61.0		0.077	
2000	3438		22.0		0.140	
2001	247		9.6		0.021	Longfin smelt population declines by 84% (Bay Study) and 87% (FMWT) from 1995-2000 levels. Average abundances levels in 2000s are just 3% (FMWT) and 8% (Bay Study) of 1980-1986 population levels. In Suisun Marsh, longfin smelt are 70% lower than 1980-1986 levels.
2002	707		9.9		0.147	
2003	191		6.7		0.066	
2004	190	2001-2006: 569	6.4	2001-2005: 7.8	0.066	
2005	129		6.3			
2006	1949					

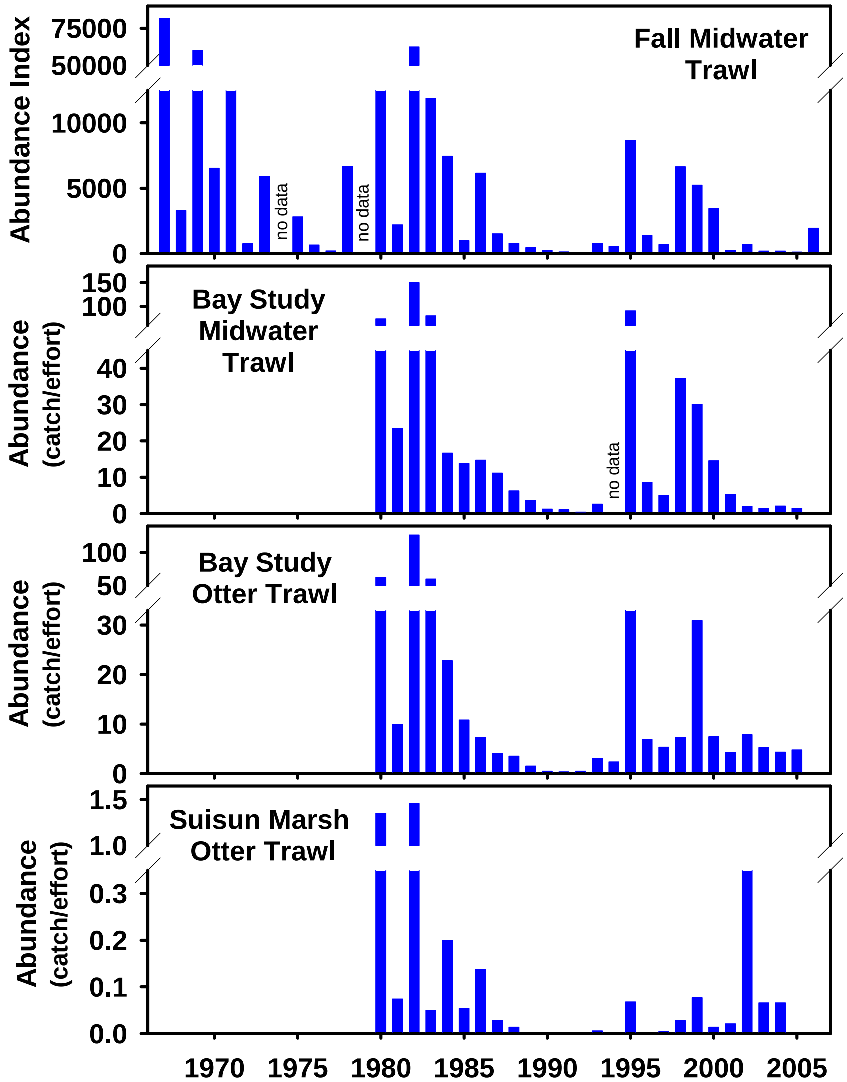

Figure 4. Long-term and recent declines in the abundance of longfin smelt (all age classes combined) as measured by four different long-term surveys conducted in the San Francisco Bay-Delta Estuary. From top to bottom, the graphs show longfin smelt abundance measured by the CDFG FMWT survey, which samples primarily in the upper Estuary (Suisun Bay and the Delta); by the Bay Study Midwater and Otter Trawl surveys, which sample in all of the Estuary's four major embayments and the lower Delta; and the U.C. Davis Suisun Marsh Otter Trawl survey, which samples only in Suisun Marsh. For all surveys, the abundance of longfin smelt during the period of record varied widely, therefore the Y axis scale has been "broken" to eliminate intermediate abundance levels and better present relative changes in abundance during years with low abundance. Information on sampling methods for each survey is provided in the text. Data sources: CDFG and Department of Wildlife, Fish, and Conservation Biology, University of California, Davis.

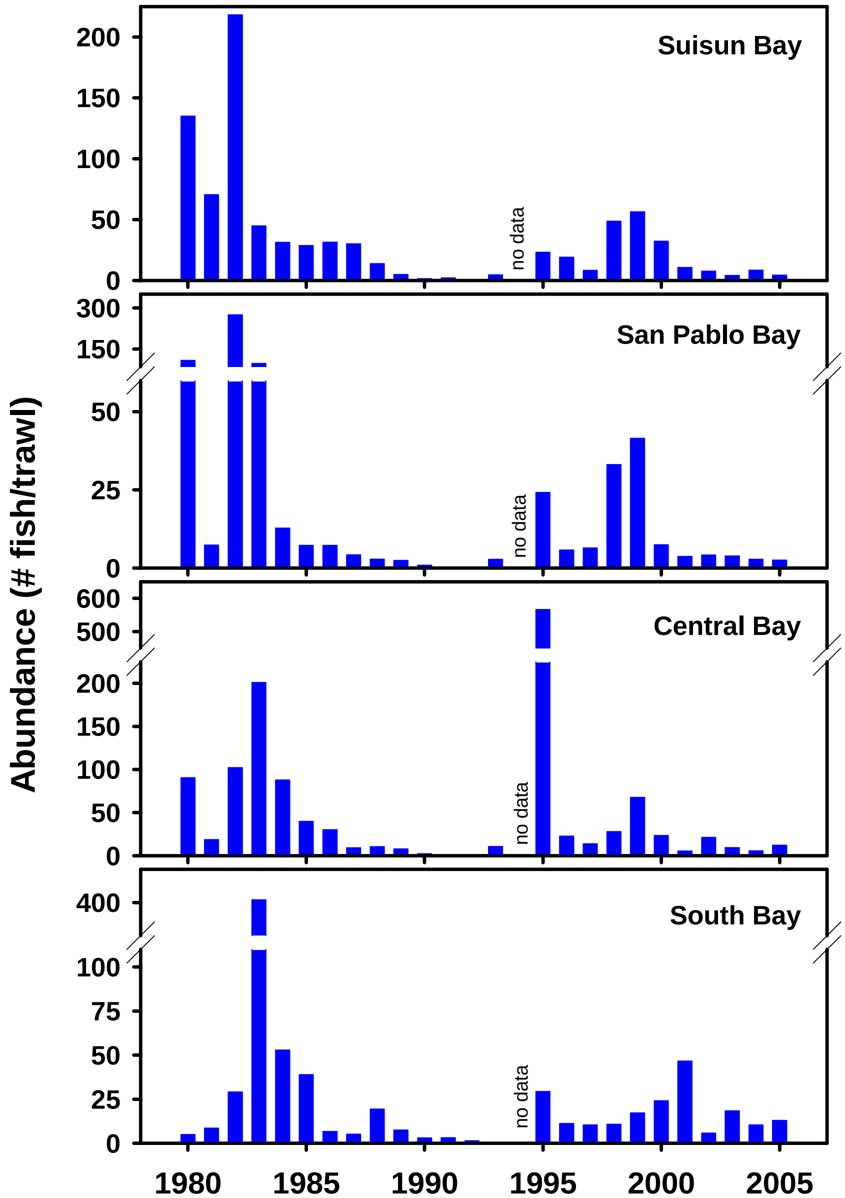

Figure 5. Long-term and recent declines in the abundance of longfin smelt (all age classes combined) as measured in each of the four major embayments of the San Francisco Bay-Delta Estuary by the CDFG Bay Study Midwater and Otter Trawl surveys. Abundance is shown as combined catch per trawl for the two surveys. For all regions except the Suisun Bay, the abundance of longfin smelt during the period of record varied widely, therefore the Y axis scale has been "broken" to eliminate intermediate abundance levels and better present relative changes in abundance during years with low abundance. Data source: CDFG.

In Humboldt Bay, longfin smelt were the fourth most abundant fish species captured in trawls in the late 1960s and early 1970s (USFWS 1994). There is less information on historical abundance of longfin smelt outside of California, although the USFWS (1994) reported that the species "may be common in Willapa Bay, Skagit Bay and Puget Sound in Washington and Coos Bay and Yaquina Bay in Oregon" and "were common to highly abundant in the Columbia River and Grays Harbor, Washington." However, in a more recent review of longfin smelt distribution and abundance, the USFWS (1996) concluded that the Service's early inference that the species was abundant in Oregon and Washington was "not based on actual sampling and may contradict the results of field programs" in which longfin smelt were "rarely collected … in the past 20 years despite intensive fish sampling programs…"

Current Abundance: Since the late 1990s, the abundance of longfin smelt has been declining in all areas of the San Francisco Bay-Delta Estuary except in Suisun Marsh, where the species was never abundant (see Table 1 and Figure 4). By 2001, longfin smelt abundance as measured by the CDFG FMWT survey was just 6% of the average levels measured during the late 1990s, levels that were themselves just 25% of the pre-drought abundance levels measured during the 1980s. Beginning in 2003 longfin smelt numbers fell to just 1% of pre-drought levels for three consecutive years (2003-2005); during this period longfin smelt abundance was 68% lower than the previous critically low levels measured during the 1987-1992 drought. The 2005 FMWT abundance index for longfin smelt was the second lowest ever measured during the 40-year history of the survey, while the 2004 and 2003 abundance indices were the fourth and fifth lowest, respectively. The CDFG Bay Study measured a greater than 80% decline during the same period (see Table 1 and Figure 4) throughout the entire range of the San Francisco Bay-Delta Estuary longfin smelt population (see Figure 5). Unlike the previous population decline, which occurred during the multi-year drought (1987-1992), hydrological conditions during the 2000s were moderate, indicating that other factors contributed to this recent population decline.[13]

While overall abundance of longfin smelt has clearly declined to near record low levels, the decline of the adult component of the population is even more worrisome (see Figure 6). Abundance of adult (age-2 fish) longfin smelt measured by the CDFG FMWT, which samples the fish shortly before spawning as they move upstream towards their spawning grounds,[14] fell to record low levels during the 2000s. For the 2002-2004 period, abundance of adult longfin smelt fell to 5% of levels measured during the 1980s and was just 22% of adult abundance levels measured during the 1987-1992 drought. Rosenfield and Baxter (*in press*), found that the decline in age-2 individuals was significant even after accounting for the decline in the age-1 population. Also, the population decline resulted in a significant reduction in the number of sampling stations throughout the Estuary where longfin smelt were caught. Given the significant stock recruitment relationship exhibited by this species (see Life History), these low adult populations reduce the resilience of longfin smelt to respond to more favorable environmental conditions (e.g., higher spring freshwater inflows).

[13] Water year types for the 2001-2006 period ranged from "dry" (2001) to "wet" (2006), compared to the six consecutive "dry" and/or "critically dry" years during the 1987-1992 drought. Water year type information from California Data Exchange Center (CDEC), available at: http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST.
[14] In contrast, the Bay Study and Suisun Marsh surveys sample adult longfin smelt during the entire year.

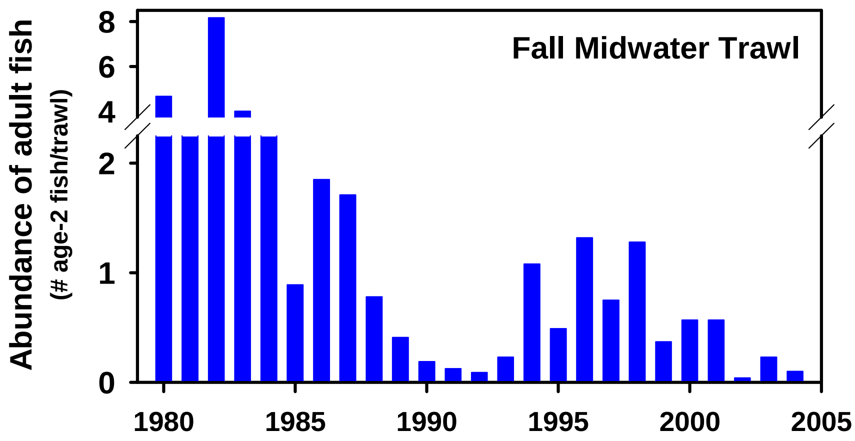

Figure 6. Long-term and recent declines in the abundance of adult longfin smelt (age-2 fish) measured by the CDFG FMWT survey. The abundance of adult longfin smelt during the period of record varied widely, therefore the Y axis scale has been "broken" to eliminate intermediate abundance levels and better present relative changes in abundance during years with low abundance. Data source: CDFG.

Available information indicates that longfin smelt abundance has also declined in other California bays and estuaries. In the most recent review of the species' status, the USFWS (1994) reported:

> In Humboldt Bay, longfin smelt were the fourth most abundant fish captured in trawls in the late 1960s and early 1970s (Roger Barnhart, National Biological Survey, pers. comm., 1993). However, since 1988, no longfin smelt have been captured in Humboldt Bay using similar sampling methods (Tim Mulligan, Humboldt State University, pers. comm., 1993). Historical records of longfin smelt from the mouth of the Van Duzen River exist; however, in recent years, no evidence of the fish exists for this location (Fritzsche, pers. comm., 1993). The Eel River, which is about 3.2 kilometers (2 miles) from Humboldt Bay, is relatively small and probably contains little habitat appropriate for longfin smelt. Longfin smelt likely occurred in the Eel River only when high river outflows introduced fish from Humboldt Bay. Longfin smelt numbers probably declined in the Eel River at the same time declines occurred in Humboldt Bay. Recent surveys have not found the longfin in the Eel estuary (Moyle, pers. comm., 1993).

The USFWS (1996) reported that longfin smelt in Humboldt Bay "may now be extinct." More recently, a year-long survey program in Northern Humboldt Bay collected just eight longfin smelt during 516 trawls at 20 sampling locations (Pinnix et al. 2004).

3. Population Trends

In the 1970s, the longfin smelt was abundant in Humboldt Bay, but since 1983 numbers have plummeted. In 1982, the fall midwinter abundance index was 62,929, the second highest on record, while the index was 73 in 1992, 792 in 1993, and 523 in 1994. Despite extensive sampling the species has not been collected from Humboldt Bay since 1994 and it was presumed extinct or near extinction by 1994 (USFWS 1994). There is little suitable habitat for longfin smelt in the Eel River Estuary, and there are no recent records of the species, and there are few confirmed records for longfin smelt in the Klamath River Estuary and none since two fish were collected in 1992 (Moyle et al. 1995).

Analysis of Trends in Longfin Smelt Abundance in the San Francisco Bay-Delta Estuary: Because San Francisco Bay-Delta Estuary longfin smelt population abundance is highly correlated with springtime freshwater outflow (see Life History), much of the observed inter-annual variation reflects the watershed's variable hydrology and the effects of water management operations (e.g., upstream and in-Delta water diversions and exports that reduce freshwater outflow to the San Francisco Bay-Delta; see Present or Threatened Modification or Destruction of Habitat, Freshwater Inflows and Outflows). To further examine trends in abundance, we took into account the effect of year-to-year differences in outflow on expected longfin smelt abundance, and compared observed longfin smelt abundances over time on this basis. Our results indicate that longfin smelt numbers have been abnormally low since the early 1990s and at record low levels for the most recent four years (2003-2006), despite moderate to favorable hydrology during these years.

To control for the effect of variations in outflow, we used FMWT survey results to compare measured longfin smelt abundance (as the $\log_{10}$ FMWT abundance index) to abundance levels predicted based on spring outflow (as average February-May X2).[15] Using the first 15 years of data (1967-1983), a period that includes a wide range of hydrological conditions, we generated the following regression:

$$\text{Log}_{10}\ \text{FMWT abundance index} = 7.433 - 0.056(\text{Feb-May X2}) \qquad \textbf{Equation 5}$$

Time period=1967-1983, n=15, $p<0.001$, $r^2=0.729$

Both the intercept and the slope of this regression are nearly identical to that calculated for the longer 1967-1987 period (see Equation 3).

We then compared measured abundance to predicted abundance (calculated as [measured $\log_{10}$ FMWT abundance index – predicted $\log_{10}$ FMWT abundance index]; e.g., for years in which measured and predicted values were the same, the result was zero). The results show that longfin smelt abundance was predictable based on 1967-1983 spring outflow regression until the early 1990s (mean [±SD] difference between measured and predicted $\log_{10}$ FMWT abundance index for 1967-1991: -0.057±0.366) (Figure 7). Beginning in

[15] This approach was somewhat similar to that used by the Delta Native Fisheries Recovery Team for development of abundance recovery criteria for this species (USFWS 1996).

1992,[16] abundance declined significantly and remained at levels that averaged nearly an order of magnitude lower than abundance predicted by the 1967-1983 regression and measured during the 1967-1991 period for the next 11 years (mean [±SD] difference between measured and predicted $\log_{10}$ FMWT abundance index for 1992-2002: -0.798±0.312; ANOVA comparison with 1967-1991 period: $p<0.001$). In 2003, longfin smelt abundance again declined to levels that averaged nearly 1.5 orders of magnitude lower that those measured during the 1967-1991 period (mean [±SD] difference between measured and predicted $\log_{10}$ FMWT abundance index for 2003-2006: -1.489±0.165). Using this method to account for the statistically significant and consistent effect of spring outflow on longfin smelt abundance, the abundance of the species measured during the most recent four years (2003-2006) is significantly lower than abundance measured during the 1992-2002 period (ANOVA: $p<0.001$) and the lowest ever measured during the 40-year long survey. Even though the longfin smelt abundance was higher in 2006 (e.g., a FMWT abundance index of 1949 compared to <200 for the three previous years, see Table 1), a wet year, it was still more than 1.3 orders of magnitude lower than would be predicted on the basis of spring outflows.

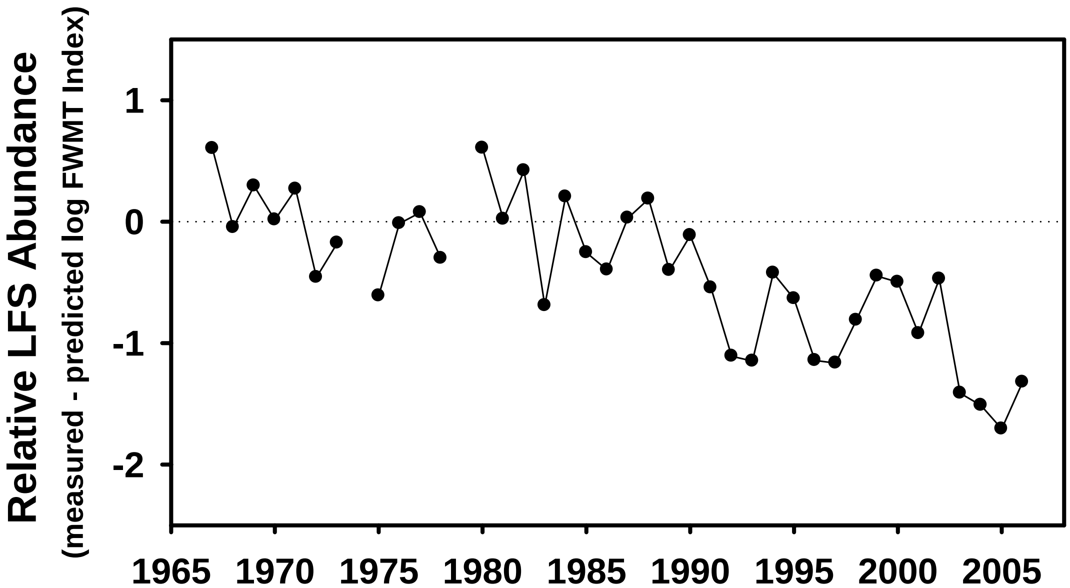

Figure 7. Trends in relative longfin smelt abundance (as $\log_{10}$ FMWT abundance index), calculated as the difference between measured abundance and abundance predicted on the basis of hydrology (as February-June X2; see Equation 5). The dotted horizontal line is at zero, where measured abundance equals predicted abundance. The solid colored horizontal lines show the mean difference between measured and predicted abundance for each multi-year period. Data sources: CDWR, Dayflow model for Delta outflow and X2; CDFG FMWT abundance index for longfin smelt.

[16] The time periods selected for these comparisons and statistical analyses were based on visual and statistical inspection of the data and differ somewhat from previously reported changes in longfin smelt population abundance (e.g., Kimmerer 2004).

This analysis suggests that the low abundance measured during the late 1980s reflected a predictable response to poor habitat conditions, characterized by low natural inflow and high levels of hydrologic alteration from upstream diversions and record high Delta exports that shifted springtime X2 far upstream (see Figures 9 and 11). The population decline in early 1990s coincided with the final years of the 1987-1992 drought (and 1994, also a critically dry year) and the third consecutive generation of longfin smelt subjected to extremely poor springtime conditions. Failure of the species to fully recover following improved hydrological conditions may reflect lower resilience attributable to its extremely low population numbers as well as degraded habitat conditions associated with continued high levels of water diversions and exports, the invasive clam's impact on the planktonic food web, and the numerous other threats to the species, including entrainment losses at agricultural and industrial diversions, toxics, dredging, and pile driving identified in this petition (see Present or Threatened Modification or Destruction of Habitat). The second precipitous population decline occurred in 2003 following two consecutive years of very poor spring outflow conditions (2001 and 2002 spring X2=74, see Figure 9), record high levels of incidental take of adult and juvenile longfin smelt at state and federal Delta export facilities in 2002 (see Present or Threatened Modification or Destruction of Habitat, Water Exports and Diversions and Figure 12), and concurrent with substantial population declines observed for at least three other estuary-dependent pelagic fish species (delta smelt, juvenile striped bass and threadfin shad, collectively referred to as the Pelagic Organism Decline; see Footnote 11). Since 2003, longfin smelt abundance (as calculated relative to spring outflow above) has been on average only 3% of abundance levels measured 25 years earlier and the species has experienced four consecutive years of record low abundance.

II. CRITERIA FOR CALIFORNIA ENDANGERED SPECIES ACT LISTING

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

This petition seeks to have the longfin smelt placed on the list of California endangered species. *Spirinchus thaleichthys* is indisputably a species and the USFWS has recognized the longfin smelt as a distinct species (58 FR 36184 36186; USFWS 1994). The USFWS in 1996 concluded that the San Francisco Bay-Delta longfin smelt population is "isolated from other populations" (USFWS 1996). This population is almost certain to be reproductively isolated from other conspecific population units because of the large distance between the San Francisco Bay-Delta Estuary and the location of the nearest self-sustaining population. Given this spatial isolation and its position at the southern extreme of the species' range, this population represents an important component of the evolutionary legacy of the species (Waples 1991; and see Taxonomy). Evidence of statistically distinct allozyme frequencies (Stanley et al. 1995) supports the conclusion that this population is evolutionarily significant.

B. THE LONGFIN 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.

In the early 1990s, all of these factors except overexploitation were identified as threats to the longfin smelt's survival and likely contributors to its population decline, first in the 1992 petition to list the species under the federal ESA (NHI 1992) and subsequently by Moyle et al. (1995). More than a decade later, results of the intensive research investigating the causes of the Pelagic Organism Decline (POD) indicate that all of these same factors are likely contributors to both its long-term and most recent population declines (Armor et al. 2005; Herbold et al. 2006; Sommer et al. 2007). The POD research has also revealed that most of these threats have become more severe during the past decade. Based on our review of the available literature, the POD results and our own analyses, there are sufficient data to identify the following present and ongoing threats to the species: habitat destruction or modification; predation, competition, or disease; inadequacy of current regulatory mechanisms; and other occurrences or human-related activities.

Longfin smelt are environmentally sensitive because they: have a short life span, a narrow diet, and relatively low fecundity for a fish producing planktonic larvae; reside primarily within estuaries with limited geographic extents; depend on seasonal freshwater flow conditions for successful reproduction and recruitment; and are isolated from other conspecific populations by large distances, reducing or eliminating the potential for immigration to supplement depleted populations or reestablish extirpated populations. All of these characteristics apply to longfin smelt as a species as well as to the San Francisco Bay-Delta longfin smelt population. Both the San Francisco Bay-Delta population, and the species as a whole are highly vulnerable to extinction because of the present small population size and, in particular, the record low numbers of adult fish (see Figure 6). For the San Francisco Bay-Delta longfin smelt population, multiple factors are thought to be contributing to the continuing decline, including: reductions in freshwater inflows and outflows to the Estuary; direct and indirect adverse impacts of Delta water diversions and exports; negative effects of water management operations on estuarine habitat quality; destruction of spawning habitat by dredging; reductions in abundance of prey food organisms; lethal, sub-lethal and indirect effects of toxic substances; disease, competition, and predation; and loss of genetic diversity. 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.

Many of the threats to the longfin smelt are identical to those known to threaten the delta smelt (*Hypomesus transpacificus*), a closely related and ecologically similar species that is sympatric to the longfin smelt for much of its life span. The delta smelt was listed as threatened under both the federal and state ESAs in 1993. In 2004, the 5-year status review for this species concluded that "most threats which were discussed in the original listing remain" (USFWS 2004). In the recently submitted petitions to list delta smelt as endangered under the federal ESA (CBD et al. 2006) and state ESA (TBI et al. 2007), new analyses and information that further described the nature, degree, and increasing severity of the multiple threats to this species and its estuarine habitat were also presented. In a recent memorandum to state and federal fisheries and water project agencies, the Delta Smelt Working Group established by the USFWS to monitor and recommend protective actions for the delta smelt reported that "the species has become critically imperiled and an emergency response is warranted" (DSWG 2007).

1. Present or Threatened Modification or Destruction of Habitat

Longfin smelt live most of their life span entirely within estuaries, bays, and adjacent nearshore coastal waters. For some life history stages, the species is restricted to even smaller sub-regions within the estuary (e.g., the upstream, freshwater regions of estuaries for spawning). Longfin smelt live in the water column and, in their movements within their estuarine habitat, they respond to salinity and temperature conditions. For longfin smelt, water is habitat and thus changes in the timing and amounts for freshwater inflow to the estuary, water export regimes, hydrodynamics, water quality, and the estuarine food web have direct and significant impacts on the species. Longfin smelt also require specific substrates for spawning and incubation of their adhesive eggs. In many estuaries, these types of habitats are also used as shipping channels and thus are subject to regular habitat disturbance (e.g., dredging, noise) and pollution. Also in this section, for consistency with similar analysis of the delta smelt in its listing publication and Five-Year Review, we discuss impacts to longfin smelt due to entrainment by water diversions and associated mortality and effects on reproductive success.

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 to Suisun Bay (the upstream-most embayment of San Francisco Bay; see map, Appendix 1) 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). Alterations in both inflows and outflows, largely the results of upstream and in-Delta water management operations, have degraded longfin smelt habitat quantity and quality.

Inflow Reduction: Historically, the San Joaquin River provided 21% of the total freshwater inflow to the Delta.[17] 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%).[18] 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 longfin smelt) in the central and southern Delta being drawn inexorably to the massive State Water Project (SWP) and federal Central Valley Project (CVP) pumps (Simi and Ruhl 2005; Ruhl et al. 2006). These researchers and others (summarized by Sommer 2007) 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 longfin smelt and other sensitive fish species 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. Our own analysis, shown in Figure 8, confirms that both the frequency and magnitude of negative flow conditions on Old and Middle Rivers has increased steadily during the past 25 years, reaching record levels in recent years. For example, during the most recent five years for which data were available (2001-2005), Old and Middle River flows were less than -5000 cfs (i.e., "more negative" than -5000 cfs) for 269 days per year (74% of the year) and for those days averaged -8177 cfs, conditions that were substantially worse than during the 1995-2000 period, when negative flows averaged -7716 cfs for just 172 days per year (47% of the year).

[17] This estimate of the San Joaquin River's contribution to total Delta inflow is derived from data for the 1930-2006 period from the CDWR's Central Valley Unimpaired Flows dataset.
[18] Data for actual San Joaquin River inflows to the Delta are from the CDWR's Dayflow model, available at: http://wwwiep.water.ca.gov/dayflow/.

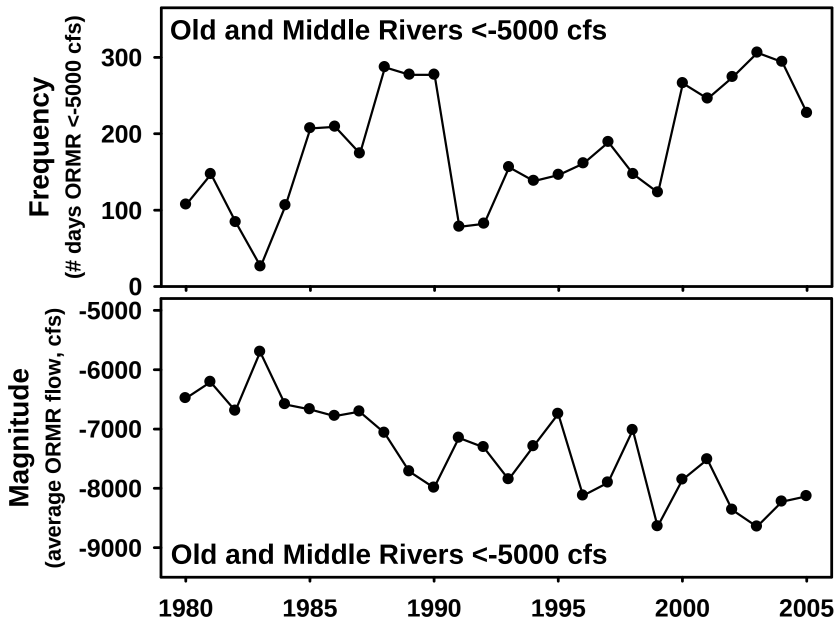

Figure 8. Frequency of extreme negative flows (number of days per year flow <-5000 cfs) on Old and Middle River (combined flow) and the magnitude of those negative flows (average flow for days when flows <-5000cfs) for the 1980-2005 period. Data courtesy of Contra Costa Water District.

Outflow Reductions: Longfin smelt are highly dependent on springtime freshwater outflows from the Delta into the Estuary and the location of low salinity habitat (often expressed as X2) for successful reproduction and recruitment; the abundance of the longfin smelt population in the San Francisco Bay-Delta Estuary is directly and significantly related to springtime freshwater outflow (see Life History, Historical and Current Abundance, and Figure 3). Because of California's Mediterranean climate and unpredictable cycle of droughts and floods, spring outflow and X2 are highly variable from year to year (see Figure 9, top panel). However, since the 1950s, upstream and in-Delta water management operations have significantly reduced the amounts of Delta outflow during the critically important spring period, degrading longfin smelt habitat and depressing population levels. For example, prior to the 1970s when the SWP began Delta export operations, springtime X2 rarely exceeded 75 kilometers (km) (i.e., spring X2 was rarely found higher than 75 km upstream into the Delta – its distance upstream is an inverse measure of how far downstream freshwater flows push this salinity line). A spring X2 higher than 75 km reflects conditions that correspond to very low longfin smelt abundance (see Figure 3). Since the 1970s, spring X2 has been upstream as far as 90 km and exceeded 75 km in 12 of 37 years. Figure 9 (bottom panel), which plots the difference between measured springtime X2 and the predicted X2 location based on unimpaired hydrology for the year, shows the escalating reductions in spring outflow and progressively larger upstream shifts in springtime X2.[19] Reductions in springtime

[19] Monthly and annual unimpaired flows, the amount of flow in a river absent the effects of dams or water diversions, are calculated by the California Department of Water Resources (CDWR) for all the major rivers in the Sacramento-San Joaquin watershed, as well as for total Delta inflow and outflow. We used CDWR's monthly unimpaired flow data

freshwater outflows occur in all water year types,[20] but since the 1970s, severely reduced outflows in years with average or drier hydrological conditions and large upstream shifts in X2 (>10 km) have consistently coincided with dramatic longfin smelt population declines (e.g., 1976-1977, 1981, 1985, 1987-1992, and 2001-2003; see Figure 4, top panel). The most recent population decline for longfin smelt occurred when spring outflows were reduced by 42-72% for five consecutive years (2001-2005 average reduction: 58%), spring X2 was located at 74 km for two consecutive years (a location more than 6 km upstream of average springtime X2 location in critically dry years under estimated unimpaired flow conditions), and springtime X2 values were shifted 10-13 km upstream (compared to unimpaired flow conditions) for three consecutive years (2001-2003).

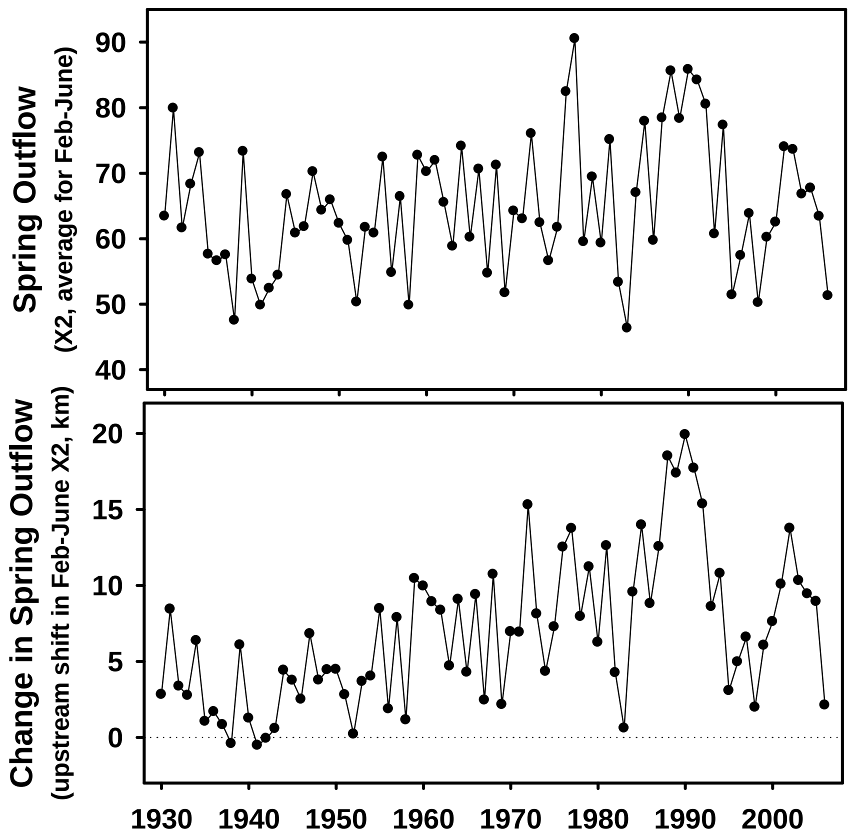

Figure 9. Springtime Delta outflow, expressed as X2 (Feb-June average) for the 1930-2006 period (top panel) and the change in spring X2 (km shifted upstream) compared to its predicted location under unimpaired flow conditions (bottom panel). Change in Spring X2 is calculated as (actual spring X2 – unimpaired spring X2). Data Sources: CDWR, Dayflow model for actual Delta outflow and Central Valley Unimpaired Flows dataset for unimpaired Delta outflow. Unimpaired X2 values were calculated from monthly unimpaired Delta outflows using equation from Jassby et al. (1995).

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to calculate unimpaired spring X2 locations and compared those values to spring X2 values calculated from actual Delta outflows (also provided by CDWR).

[20] In California, hydrological conditions are classified into five water year types: wet, above normal, below normal, dry and critically dry.

Freshwater outflows from the Delta have also declined during the fall, a season when adult longfin smelt migrate upstream in the Estuary towards winter spawning grounds (see Life History). Independent analyses by scientists at CDWR (Feyrer et al. 2007) and the Contra Costa Water District (CCWD) (Guerin et al. 2006) showed that reduced freshwater inflows and elevated salinity in Suisun Bay and the western Delta during the fall degraded habitat quality for delta smelt and juvenile striped bass, pelagic fish species that co-occur with longfin smelt in the upper reaches of the Estuary during this part of the year. These low outflow and elevated salinity conditions appear to have facilitated the 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 longfin smelt depends is well documented (Kimmerer and Orsi 1996; Thompson and Parchaso 2006) and, as Kimmerer (2004) has suggested, may be a contributor to the drastic decline of longfin smelt during the early 1990s. Analyses by the CCWD suggest that the frequency of low fall outflows and elevated western Delta salinity have increased in recent years (Guerin et al. 2006), coincident with the recent longfin smelt population decline (see Figure 10).

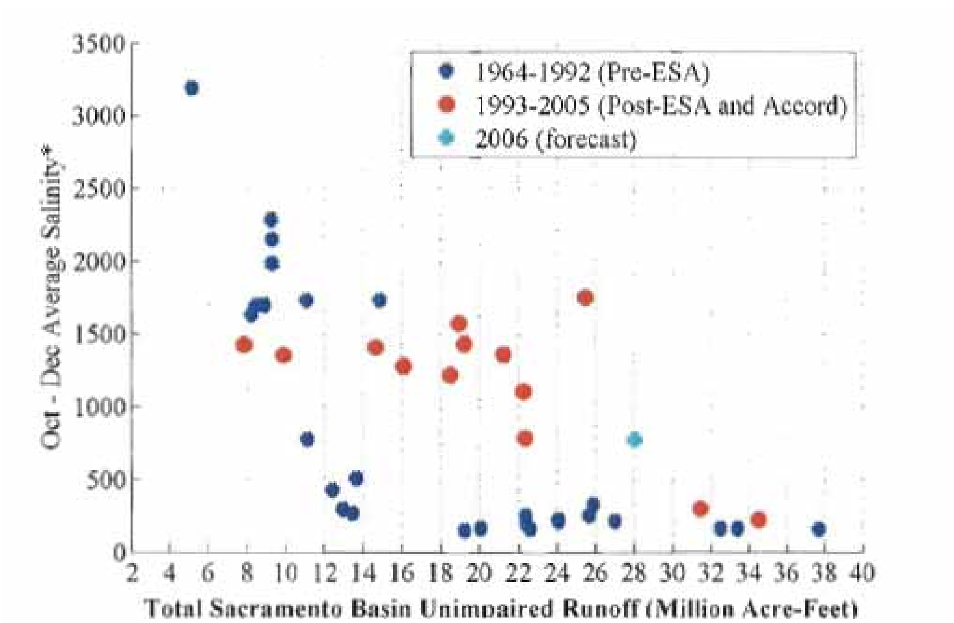

Figure 10. The relationship between fall salinity in the western Delta (measured as average Oct-Dec electrical conductivity at Jersey Point, us/cm) and unimpaired hydrological conditions (measured as Sacramento basin unimpaired runoff, million acre-feet) for the 1964-1992 period (dark blue circles) and more recent years (1993-2005 in red circles and 2006 forecasted value in light blue circle). Since the early 1990s, fall salinities in the western Delta have been higher in all water years types except extremely wet years (e.g., unimpaired Sacramento Basin runoff >26 million acre-feet). Graph from Contra Costa Water District letter submitted as comments to the SWRCB for the Pelagic Organism Decline Workshop, March 22, 2007. Available at: http://www.waterrights.ca.gov/baydelta/docs/pelagicorganism/ccwd_030207.pdf.

Water Exports and Diversions

Water exports and diversions adversely affect longfin 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 screens or debris screens at pumps), and indirectly by adversely modifying their critical habitat (e.g., by altering channel hydrodynamics, reducing freshwater outflow and shifting the location of suitable brackish water rearing habitat, and/or removing planktonic food organisms; see Freshwater Inflows and Outflows above). Longfin smelt are at greatest direct risk from water diversions at two critical times in their life cycle, first as larvae and juveniles when the young fish move downstream from freshwater habitat where they were spawned (during late winter, spring and early summer) and then again as pre-spawning and spawning adults when the fish move up into freshwater areas of estuaries for reproduction (during winter and early spring).

For the San Francisco Bay-Delta longfin smelt population, the freshwater region of the Estuary (i.e., the Delta) used by the fish for spawning is a major hub for California's water management system and a region of intensive irrigated agriculture. Water management operations of the 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 adult longfin smelt population is distributed in the Delta, as much as 65% of the total freshwater inflow may be diverted, and net movement of all water and entrained plankton, larvae and small fish in the central and southern Delta is towards the government water export facilities. At times, the net flows of the lower San Joaquin River in the Delta and several other important Delta channels are reversed (see Figure 8), confusing and delaying migrating adult fish, impairing downstream transport of larval and juvenile longfin 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 longfin 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 most small fishes (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).

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 vast majority of the other Delta diversions are unscreened (Herren and Kawasaki 2001). The U. S. Environmental Protection Agency (2002) estimated that the power plants at Pittsburg and Antioch, which divert water from the western Delta for flow-through cooling, entrained >10,000 longfin smelt each year during the 1987-1990 period (a period when longfin smelt abundance was already very low; see Figure 4), potentially imposing significant mortality on the species.

Export Increases: Since the longfin smelt was first petitioned for listing under the ESA in 1992, annual water exports from the Delta have increased by 25% (1993-1997 average: 4.786 million acre-feet [MAF] per year; 2002-2006 average: 5.992 MAF per year).[21] This increase continues a long-term trend of increases in Delta water exports (see Figure 11, top panel). During the periods when longfin smelt are particularly vulnerable to entrainment, the relative increases in exports have been even greater: during the winter when pre-spawning and spawning adults and early larvae are in the Delta, exports have increased by 41% (see Figure 11, bottom panel).

Entrainment loss of longfin smelt >20 mm in length is monitored and reported as incidental take at only the SWP and CVP water export facilities.[22] Incidental take of longfin 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 data on incidental take are of limited value for evaluating the effects of water export activities on longfin smelt population levels, although they do provide useful information on the timing and presence of the fish in the south and central Delta.

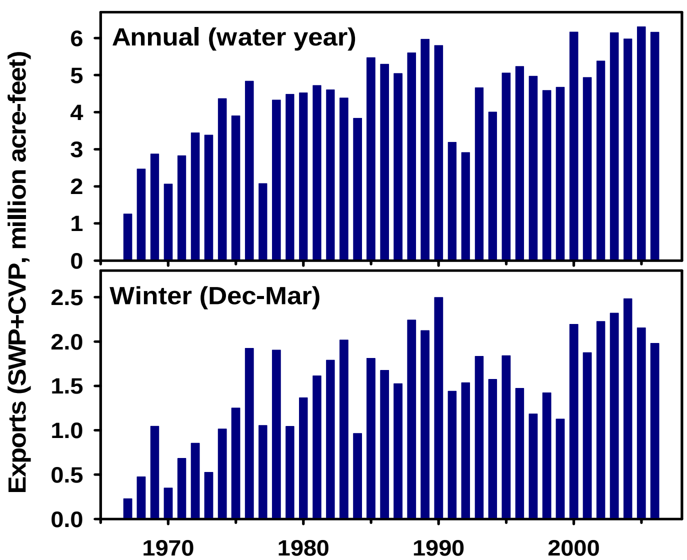

Figure 11. Combined water exports (million acre-feet, MAF) of the Central Valley Project and the State Water Project from 1967-2006. The upper panel shows total export volumes for each water year and the bottom panel shows exports for the winter period (December-March). Data source: CDWR, Dayflow.

[21] 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 (CDWR).

[22] Incidental take reported for longfin 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 small fishes from the diverted water is known to be low (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). Longfin smelt larvae and juveniles <20 mm in length are not counted. 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.

Entrainment Loss Increases: 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 indicated that the direct impacts of water exports on longfin smelt (and other Delta pelagic fish species) during the winter had increased in recent years, coincident with substantial population declines measured for all the affected species.[23] Beginning in 2000, incidental take (also referred to as "salvage") of adult longfin smelt increased markedly, top panel), concurrent with substantial increases in exports (see Figure 11, bottom panel) and declines in longfin smelt abundance (see Figures 4 and 6). In 2002, direct loss of adult longfin smelt at the pumps in relation to the species' population abundance reached its highest level in more than ten years (see Figure 12, bottom panel). The concurrent increases in salvage density (number of longfin smelt per thousand acre-feet of water; see Figure 12, middle panel) indicated that, in recent years the adverse effects of the Delta exports pumps were disproportionately large relative to the increase in exports, a worrisome conclusion at a time when longfin smelt abundance was already at near record lows. On the basis of these and other analyses conducted by researchers investigating the pelagic organism decline, the "Winter Adult Entrainment Hypothesis" was identified as one of two leading hypotheses to explain the pelagic fish decline that was (and continues to be) the focus of continuing research in 2006 and 2007 (Armor et al. 2005; Herbold et al. 2006).[24]

Lethal entrainment of juvenile longfin smelt at the SWP and CVP facilities has also reached record high levels during recent years. In the spring of 2002 (April-May), more than 95,000 juvenile longfin smelt were killed at the pumps, more than ten times higher than the highest total annual take level measured during any year during the previous decade.[25] The following year (2003), longfin smelt population abundance fell to a new record low (see Analysis of Trends in Longfin Smelt Abundance in the San Francisco Bay-Delta Estuary and Figure 7).

Recent analyses by scientists from the USGS and CDWR have suggested a mechanism for the recent disproportionately high take of longfin smelt (and other fish species) at the SWP and CVP facilities (Simi and Ruhl 2005; Ruhl et al. 2006; Sommer 2007). Using data from the past twenty years, these researchers reported a significant correlation between high incidental take of small pelagic fishes like longfin smelt and negative flows in central and southern Delta channels caused by low San Joaquin River inflows and high water export rates (see Figure 13). Under these conditions, normal tidal exchange and flows were disrupted (with the ebb tidal flow nearly eliminated); flows in two important Delta channels, Old River and Middle River, were negative; virtually all water (i.e., habitat for the pelagic longfin smelt) in the central and southern regions of the Delta was drawn inexorably to the pumps; and incidental take of longfin smelt (and other pelagic

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[23] Herbold et al. (2005) used the November-March period for their analyses.

[24] 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.

[25] Data on take of longfin smelt at the SWP and CVP pumps are complied by the CDFG. Data for monthly take of longfin smelt for the 1993-2005 period were provided to C. Swanson by B. Herbold, U. S. Environmental Protection Agency.

fishes) was high. During the past twenty years, the frequency of occurrence of these types of conditions has increased (see Figure 8).

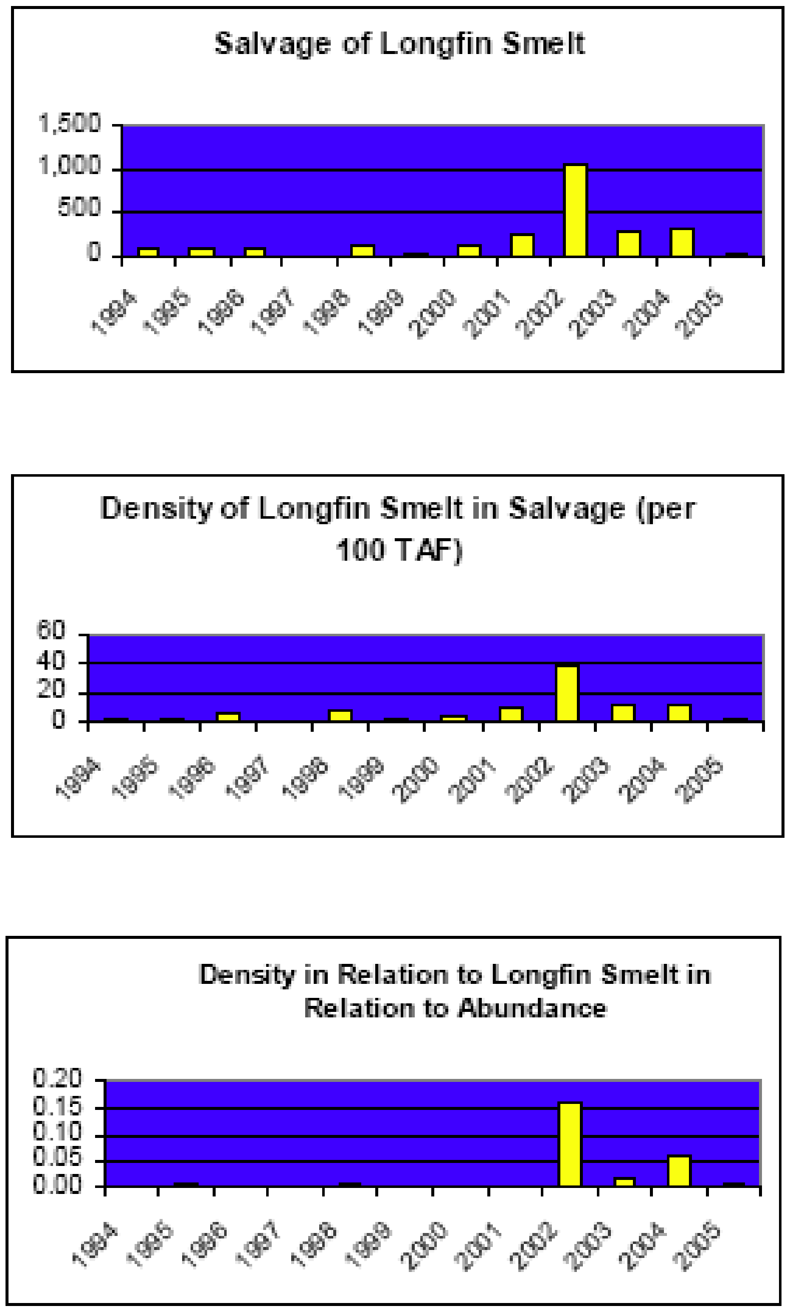


Figure 12. Recent patterns in incidental take (or salvage) of longfin smelt during the November-March period. Top panel: total salvage (# fish); Middle panel: salvage density (# of fish/thousand acre-feet); and Bottom panel: salvage density in relation to preceding FMWT abundance Index (salvage density/FMWT Index previous year). Source: Herbold et al. 2005, Figure 4.

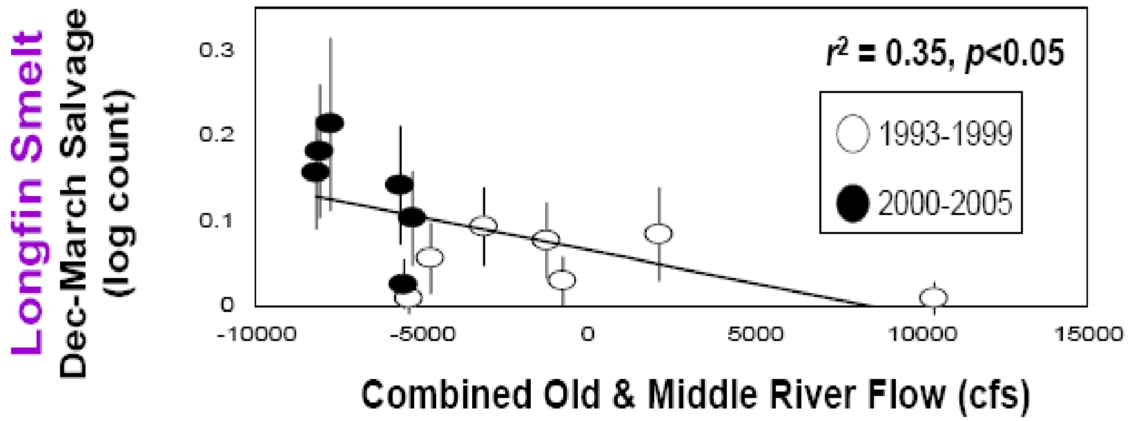


Figure 13. Relationship between incidental take ("salvage", as the log of the number of fish counted) and combined flows in Old and Middle River channels in the southern Delta. Negative flow values indicate net flow is upstream towards the SWP and CVP Delta water export pumps; positive flows indicate net flow downstream toward Suisun Bay. Source: Sommer 2007.

Population Level Impacts: One commonly used metric to quantify the effects of water export operations on the Delta habitat is the Export/Inflow ratio (E/I ratio), the ratio of the amount of water exported at the State and federal Delta pumping facilities to the total amount of fresh water flowing into the Delta. A high E/I ratio indicates that a large proportion of the fresh water flowing into the Delta never reaches Suisun Bay and is instead diverted and removed from the Delta by the SWP and CVP pumps, altering in-Delta hydrodynamics, degrading in-Delta and downstream habitat conditions and, based on recent analyses using CDWR's Delta Simulation Model (DSM-2) and its Particle Tracking Module, lethally entraining most small organisms in the central and southern Delta. CDWR's particle tracking analyses showed that most particles (which are thought to reasonably simulate larval and small juvenile longfin smelt but may be somewhat less accurate simulations for adult longfin smelt) released into the southern and central Delta were lost within two weeks to entrainment at either the government water project export facilities or the many unscreened agricultural diversions located in this area of the Delta (see Figure 14). 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.

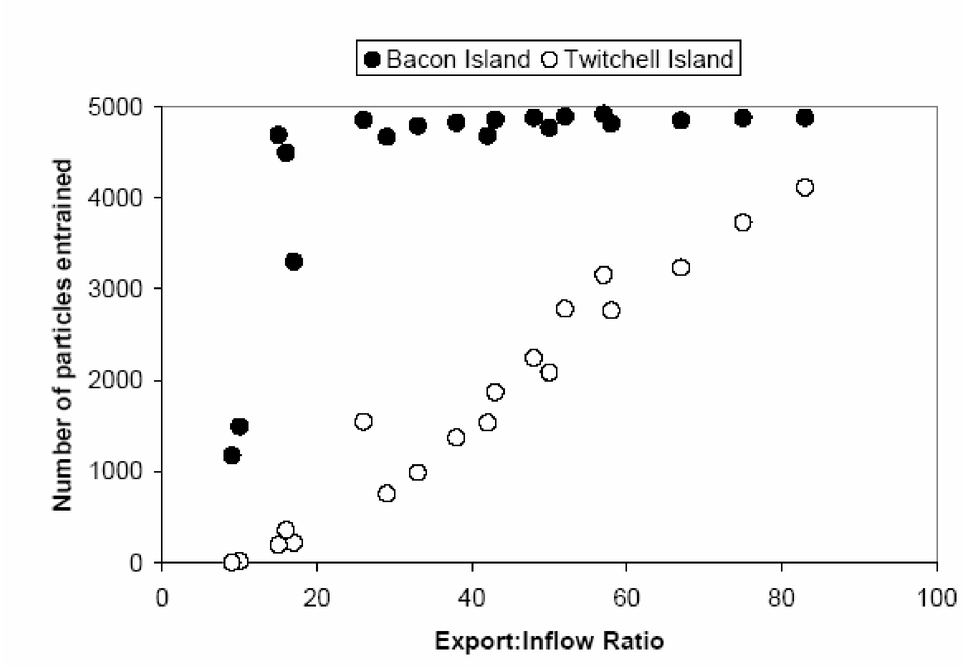


Figure 14. The relationship of the E/I ratio to the number of particles entrained (out of 5,000 particles released) over a series of Particle Tracking Model runs. Source: Herbold et al. 2005, Figure 8.

Below, we present new analyses showing that the abundance of the San Francisco Bay-Delta longfin smelt population is significantly and inversely related to seasonal E/I conditions in the Delta: when E/I ratios are high during the winter, the abundance of longfin smelt measured the following fall is low (see Figure 15). This statistically significant relationship between winter E/I ratios and longfin abundance was detectable before 1992, when longfin smelt were first petitioned for listing under the ESA (see Equation 9), and is still significant using only data from years since then (Equation 10).

Log_{10} FMWT abundance index = 4.31 + 3.48(Dec-Mar E/I) **Equation 9**
Time period=1967-1992, n=24, $p<0.001$, $r^2=0.610$

Log_{10} FMWT abundance index = 3.88 + 3.87(Dec-Mar E/I) **Equation 10**
Time period=1993-2006, n=14, $p=0.022$, $r^2=0.365$

The mechanism driving this statistically significant relationship has not yet been studied or identified for longfin smelt, however new research on delta smelt may yield some insight. Bennett et al. (2006; and summarized by Sommer 2007) has shown that high export rates and adverse in-Delta hydrodynamic conditions (e.g., high magnitude negative flows on Old an Middle River) are likely lethally entraining virtually all larval and small juvenile delta smelt spawned early in the spring, before the 31-day export curtailment required by the SWRCB for fish protection is implemented in mid-April. Bennett et al. (2006) hypothesized that the consistent loss of this important population cohort was a major contributor to the recent catastrophic population decline suffered by delta smelt. Given that longfin smelt also spawn in the Delta in the winter and that the majority of their young hatch into planktonic larvae before April, high winter and early spring export rates, expressed in this analysis as the E/I ratio, are likely having similar effects on larval and juvenile longfin smelt survival and resultant population abundance measured later in the year.

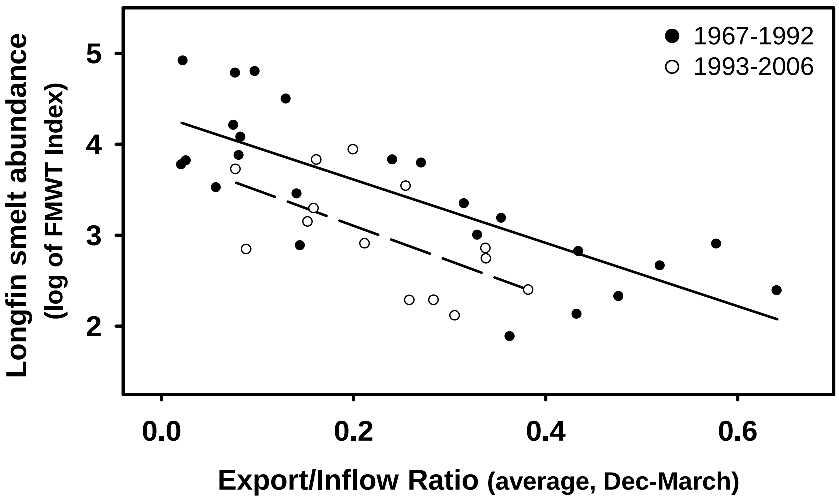


Figure 15. The relationship between winter and spring (December-March) export/inflow ratios and abundance of longfin smelt measured the following fall (as $\log_{10}$ of FMWT Abundance Index). Closed circles and the solid regression lines show results from the 1967-1992 period, open circles and the dashed regression show results from 1993-2006 period. Regression equations and statistics are shown in the text as Equations 9 and 10. Data Sources: CDFG, CDWR, Dayflow.

In-Delta Channel Barriers

In order to allow both high water export rates at the SWP and CVP facilities and local agricultural water diversion under conditions of low freshwater inflow, CDWR regularly installs a series of temporary “agricultural barriers” in several southern Delta channels from the early spring through fall.[26] These tidal barriers, which function to retain water flowing into the Delta during high tides and prevent water from flowing out of these channels on ebb tides, physically prevent movement of longfin smelt (and other small pelagic fishes like delta smelt) and change hydrodynamic conditions in Delta channels, increasing central Delta net flows toward the state and federal water export facilities. Since 1985, the numbers of barriers installed and the numbers of days the barriers are closed has increased (see Figure 16), effectively degrading this portion of the Delta as spawning and early rearing habitat for longfin smelt. In their most recent biological opinion for delta smelt, the USFWS (2005) noted that the CDWR and the U.S. Bureau of Reclamation (USBR) proposal to replace temporary barriers with permanent barriers, which could include barrier closures during additional periods and/or different

[26] The three agricultural barriers are the Grant Line Canal barrier, the Middle River barrier, and the barrier on Old River near the Delta Mendota Canal.

operations, could result in additional adverse effects to delta smelt. The USFWS (2005) also noted that when delta smelt occur in areas influenced by the barriers, entrainment losses at the state and federal export facilities could increase.

In 1988, the Suisun Marsh Salinity Control Gate was installed by the CDWR and USBR on Montezuma Slough, the primary tidal channel in Suisun Marsh. Tidal operations of the gate function to provide low salinity water in the marsh to support water diversion into local diked wetlands managed for waterfowl. The gate blocks passage and movement of resident and migratory fishes that use Montezuma Slough to transit and access this ecologically important brackish tidal marsh and alters marsh habitat and water quality.

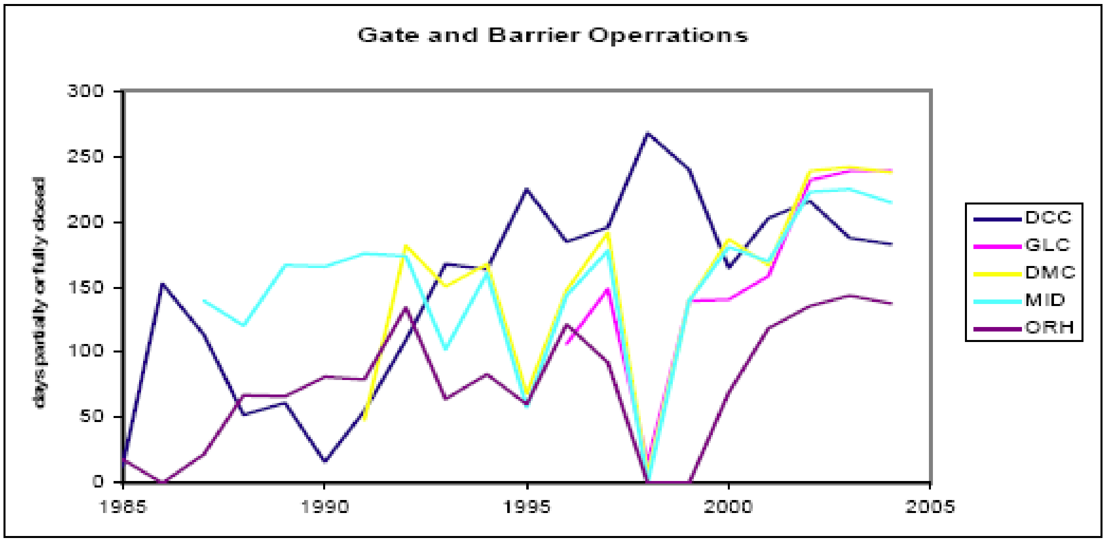


Figure 16. The number of days per year during which agricultural and other water diversion barriers installed in Delta channels are closed. Based on particle tracking model results, closure of the three agricultural barriers in the south Delta (GLC, DMC, and MID) corresponds to increased entrainment of small pelagic organisms such as juvenile delta smelt at SWP, CVP and local agricultural diversions. DCC=Delta Cross Channel; GLC=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.

<u>Dredging</u>

The estuaries and lower river channels in which longfin smelt rear and spawn have been degraded by dredging and disposal of dredge materials. For the San Francisco Bay Delta longfin smelt population, these areas include San Pablo Bay, Suisun Bay and the lower reaches of the Sacramento and San Joaquin Rivers in the Delta. Dredging and disposal of dredge material degrades and/or destroys longfin smelt spawning habitat and dredging activities can entrain individual fish or eggs into the dredge (USACOE 2001).

Pile Driving and Underwater Sound

Pile driving activities for road, bridge, and wharf construction or repair occur throughout longfin smelt estuarine habitat (e.g., Abbott and Reyff 2004). High intensity sounds can alter fish distributions or migration patterns, potentially rendering large areas of habitat intolerable or impassable; can cause physiological damage (e.g., hearing loss, swim bladder rupture, hemorrhaging) and stress; and can be lethal (Abbott and Reyff 2004; Hastings and Popper 2005).

Toxic Substances

As described in the original petition to list longfin smelt (NHI 1992), “pollution is an insidious problem” in most estuaries because “toxic compounds can come from many sources, may be episodic in nature (and therefore hard to detect) and may affect mainly early life stages of fish, where mortality is hard to observe.” In the decade since and in reference to another threatened species, delta smelt, the USFWS (1993, 2004, 2005) repeatedly discussed the threat of poor water quality due to discharge and transport of agricultural and industrial chemicals from California’s 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 San Francisco Bay-Delta longfin smelt population’s estuarine 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 fish feed, and that their planktonic food supply may be depleted by periodic, highly concentrated pulses of herbicides and pesticides through the Delta (see USFWS 1996, 1999).

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

In 1992, when the longfin smelt was first proposed for listing under the federal ESA, the petitioners identified three major threats to the species: pollution, reduced freshwater inflows, and entrainment losses at water diversions. In 1993, when the USFWS listed the ecologically similar and sympatric delta smelt as threatened, the Service identified 21 major federal, state, local or private organization proposals for increased exports in the San Francisco Bay Delta Estuary alone (USFWS 1993). By 2006, multiple scientific analyses identified toxic contaminants, adverse alterations in freshwater inflows, reduced freshwater outflows, and water exports and diversions as the likely causes for the drastic population declines suffered by longfin smelt and several other sympatric pelagic fish species in this estuary and reported that the intensity of most of these habitat modification and destruction activities had increased significantly in the past ten years. During the past four years, as documented above, the magnitudes of most of these harmful impacts have reached higher levels than have been recorded during the entire 39-year period for which consistent data on longfin smelt population abundance exist (1967-2006).

Plans for future management of the San Francisco Bay-Delta longfin smelt habitat and federal and state water management operations, described in detail by the USBR (2004a), include further increases in the magnitude of most of these harmful habitat alterations. The recent 5-year status review for the state and federally listed delta smelt (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 estuarine and anadromous fishes conducted by both the USBR (USBR 2004b) and USFWS (2005) concluded that these changes, reduced freshwater outflows, increased Delta exports, and increased lethal entrainment losses, would have negative impacts on both anadromous and resident estuarine fish species. In addition, none of the above analyses have considered the predicted consequences of global climate change on estuarine habitat or on state, federal and local water management operations. Finally, the current severely depressed population abundance of longfin smelt, 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 longfin smelt population. Longfin 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 longfin smelt, but there is no evidence to suggest that these activities were adversely affecting the species. Unintended take at the CVP and SWP pumps and other water diversions in the Bay-Delta is addressed above.

3. Predation, Competition or Disease

According to Moyle et al. (1996, 2004b), there is little evidence that predation or disease has caused the longfin smelt population to decline, although diseases and parasites of longfin smelt have been little studied. However, introduced species are abundant and increasing in the Bay-Delta Estuary, including non-native invertebrates and fishes that feed on phytoplankton, zooplankton and/or small fish, and may adversely affect the longfin smelt (USFWS 2004).

Predation by striped bass may be an important factor affecting longfin smelt abundance but it is poorly understood (USFWS 1996). 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 longfin 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 small estuarine pelagic fishes like longfin smelt.

Introduced planktivores (fish that eat plankton) such as threadfin shad (*Dorosoma pretense*) and inland silverside (*Menidia beryllina*) may prey upon larval longfin smelt, compete for the zooplankton food of longfin smelt, or alter the species composition of the zooplankton community, thereby further decreasing the ability of the longfin smelt population to recover. Although the longfin 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. For example, Bennett (1995, 2005) reported that inland silversides are frequently collected in areas where delta smelt may spawn, they could be major predators on eggs and larvae, and that estimates of abundance of delta smelt and silversides were negatively correlated, suggesting that inland silversides may be an important predator on larval delta smelt and a competitor for copepod prey. 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 longfin smelt eggs and larvae and interfere with recovery of the species.

4. Other Natural Occurrences or Human-Related Activities

Global Climate Change

There is gathering evidence that, in the estuarine habitats of longfin smelt, the effects of climate change will manifest as:

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

Sea level rise and salt water intrusion higher into the Bay-Delta estuary 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 estuarine habitat quality for delta smelt and striped bass (Feyrer et al. 2005, 2006; Guerin et al. 2006; and see Historic and Current Distribution, and Present and Threatened Modification or Destruction of Habitat, Freshwater Inflows and Outflows). Increases in air temperature in the Estuary's high elevation watershed is predicted to reduce the volume of the snow pack (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 longfin 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).

Competition with Introduced Species

The San Francisco Bay-Delta is considered one of the most highly invaded estuaries in the world (Cohen and Carlton 1998). In recent years, untreated discharges of ship ballast water have introduced non-indigenous aquatic species to the San Francisco Bay-Delta Estuary ecosystem (Carlton et al. 1990), several of which adversely affect the longfin smelt and its habitat. As discussed above (see Natural Mortality), 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 longfin smelt (and other planktivorous fishes in the Estuary; Kimmerer and Orsi 1996; Feyrer et al. 2003; Armor et al. 2005; Hobbs et al. 2006; Thompson and Parchaso 2006; and see Natural Mortality). However, to date, there is no quantitative evidence that competition for space with other aquatic organisms has affected longfin smelt abundance. As early as 1996, the USFWS (1996) discussed the impacts of this introduced clam on the primary food of longfin smelt and of non-native copepods that reduce food availability or feeding efficiency of longfin smelt. The USFWS (2004) also 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).

Potential Loss of Genetic Integrity:

Species for which population numbers fall below a critical level are subject to inbreeding and genetic drift. The resulting loss of genetic variation can result in depressed reproductive success and reduced ability to respond to changes in the physical environment, parasites, and disease. In turn, these effects can increase a population's risk of extirpation. Quantitative estimates of the critical population size for longfin smelt below which genetic drift may occur have not been made. However, available abundance data for the San Francisco Bay-Delta longfin smelt population, the largest population in California (Moyle 2002), show that the population has experienced at least two precipitous and prolonged population declines (1989-1994 and 2001-2005). This raises potential concerns about whether the genetic integrity of the population may be decreased and whether the population is at greater risk of extirpation.

5. Inadequacy of Existing Regulatory Mechanisms

Clear evidence of low and declining longfin smelt populations throughout the species' California range, as well as the recent drastic decline in the well-studied San Francisco Bay-Delta population that resides in one of the most intensively managed and regulated estuaries in the world, show that existing regulatory mechanisms do not provide adequate protection for the species. The fact that substantial increases in multiple environmental stressors known to be harmful to the species, including reduced freshwater outflows to the species' critical estuarine habitats and increases in water exports that degrade habitat and directly kill the fish, have occurred and been granted permits to expand concurrent with documented population declines further supports this conclusion. In addition, specific protections and management tools identified by state and federal agencies to protect estuarine habitat and ecologically similar listed species (e.g., SWRCB 1995 Water Quality Control Plan for the San Francisco Bay Delta Estuary and the USFWS's 2005 Biological Opinion for delta smelt) have not been sufficient to protect longfin smelt or their habitat, or even the listed species at which they are directed.

State Endangered Species Act Listing of Other Species Within the Range of Longfin Smelt

Three species that periodically co-occur with longfin smelt in the San Francisco Estuary are listed under the California Endangered Species Act (CESA): delta smelt, (*Hypomesus transpacificus*), winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and spring-run Chinook salmon (*O. tshawytscha*). 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. However, according to a recent state court ruling with regard to DWR, CDFG is not 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. Like longfin smelt, the delta smelt population has recently collapsed, the result (according to the latest scientific research, discussed above and in TBI et al. 2007) of the combined effects of water management operations (including reduced freshwater inflows and water exports), habitat degradation, invasive species and toxics, the same threats identified for longfin smelt (TBI et al., 2007). For the listed salmonid species, 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 have been implemented outside the geographic range of the longfin smelt and therefore provide neither benefit to nor protection of the species.

Federal Endangered Species Act Listing of Other Species Within the Range of Longfin Smelt

Five species that co-occur with longfin smelt in the San Francisco Estuary are listed under the federal ESA: delta smelt, and winter- and spring-run Chinook salmon, Central Valley steelhead (*O. mykiss*) and green sturgeon (*Acipenser medirostris*). The declining population trend for delta smelt, the species that is most ecologically similar to longfin smelt and which is now at imminent risk of extinction (Bennett 2005; and see TBI et al. 2007 and DSWG 2007), clearly demonstrates that the protections currently afforded by its federal threatened listing are not adequate to protect this species or the habitat that it shares with longfin smelt. As reported by the USFWS (2004), many of the threats to delta smelt identified by the USFWS in the original listing documents (which are identical to the threats identified for longfin smelt in the first petition to list the species; NHI et al. 1992, and again here) have not been eliminated or mitigated and have instead, in a number of instances, increased. There is also evidence that specific protections and protective actions outlined in the most recent biological opinion for delta smelt (USFWS 2005) have not been implemented (TBI et al. 2007).

1995 SWRCB Water Quality Control Plan

Overall water management operations in the Sacramento-San Joaquin Delta (the upstream portion of the San Francisco Bay-Delta Estuary) 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, the WQCP requires minimum freshwater outflows from the Delta during the spring, using a complicated suite of flow and salinity objectives based on upstream hydrological conditions and downstream water quality conditions. That these regulatory protections are inadequate is demonstrated by the fact that recent spring freshwater outflows have been reduced by as much 72% (in 2002, compared to estimated unimpaired spring outflow) and springtime X2 regularly shifted more than 10 km upstream, to locations that correspond to very poor ecological conditions, favor establishment and high abundance of harmful non-native species (e.g., the invasive clam *Corbula*), and predictably result in very low longfin smelt abundance (see Life History, Historic and Current Abundance, and Freshwater Inflows and Outflows, and Figure 10).

The WQCP also limits 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).[27] However, these regulatory objectives do not protect key areas of longfin smelt habitat, particularly during the critical spawning and early rearing season. Recent particle tracking analyses by CDWR showed that, at E/I levels well below these regulatory limits, most planktonic and small pelagic organisms in the southern and central Delta were

[27] 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.

entrained within two weeks into either the government water project diversions or the many smaller agricultural diversions located in this area of the Delta (see Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range and Figure 14). 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 longfin 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, concurrent with the first major collapse of the San Francisco Bay-Delta longfin smelt population, since that time, seasonal E/I ratios have again 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%) (see Figure 17). As shown by our report of the significant effects of the E/I ratio on longfin smelt abundance in this petition (see Present or Threatened Modification or Destruction of Habitat and Figure 16), these recent levels allowed by the SWRCB's WQCP correspond to consistently low longfin smelt population levels and are inadequate to protect the species.

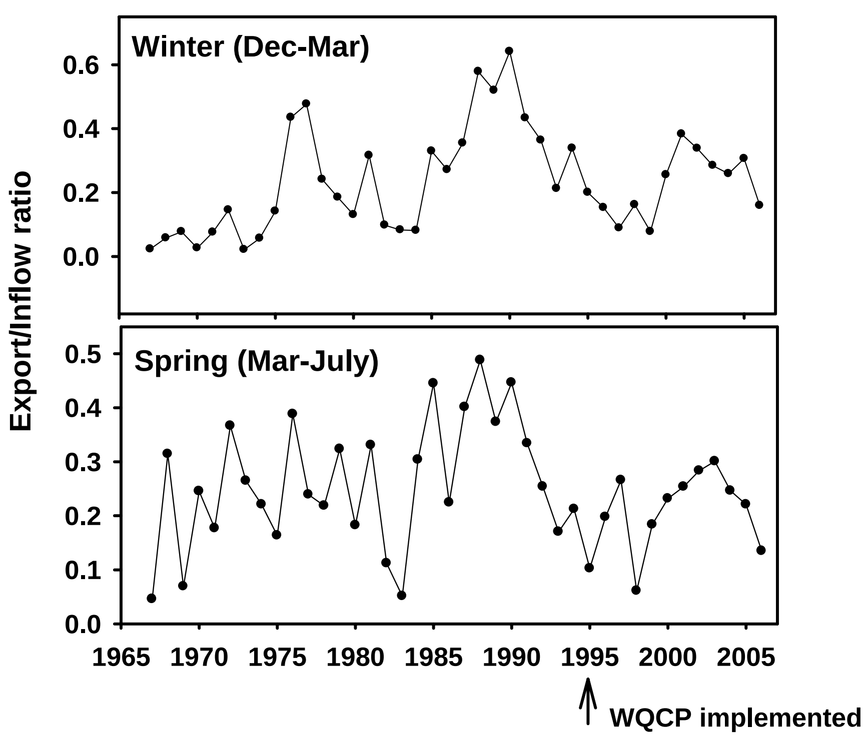


Figure 17. Trends in the Export/Inflow ratio (E/I) during the winter (December-March, upper panel) and spring (March-July, lower panel). The Water Quality Control Plan allows a maximum E/I of 65% during the fall and winter (July-January) and 35% during the spring (February-June). Data source: CDWR, Dayflow.

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 resident and migratory fish species (including longfin 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 longfin smelt (and other fish species).[28] 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 Draft WQCP recently released by the SWRCB included no changes in water quality, freshwater inflow and outflow, or export operation objectives known to affect a number of estuarine fish species and which, based on information available then, were known to be inadequate to protect either the habitat or fisheries resources.[29]

2005 USFWS Biological Opinion for Delta Smelt

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.[30] 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 this listed species. The Consultation identified specific fish protection management tools, such as the CALFED Environmental Water Account (EWA), that would be used to mitigate the impacts of those actions on delta smelt using real-time management.[31] This regulatory mechanism and the specified fish protection tools have clearly provided inadequate protection for delta smelt, whose population has collapsed to critically low levels (see DSWG 2007), and have provided no meaningful ancillary protection for longfin smelt.

On May 25, 2007, the U.S. Eastern District Court ruled that the February 2005 Biological Opinion was in violation of the federal ESA because, among other deficiencies, it failed to use best available science to determine the effects of water management operations on delta smelt and it did not require that recommended protection actions contained with the Biological Opinion be implemented.

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

[28] 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.
[29] The 2006 WQCP is available at: http://www.waterrights.ca.gov/baydelta/2006controlplan.html.
[30] 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.
[31] 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.

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 longfin 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 longfin smelt is identified by CALFED as a priority species. Within longfin smelt habitat, CALFED has implemented three categories of restoration and protective actions intended, at least in part, to protect 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 longfin 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 (Rosenfield and Baxter 2007), and certainly it cannot be responsible for recent extreme population lows.

Export curtailments and the EWA: Since it was implemented in 2001, the EWA has been used to facilitate periodic export curtailments and reduce entrainment losses only for fish species listed under the federal ESA; no export curtailments have been made to protect longfin smelt, despite its status as a priority species and even during periods when incidental takes for the species was extremely high (e.g., 2002, see Figure 13).

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.

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

<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 longfin 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 longfin smelt. In practice, alternatives that would protect the longfin smelt and other wildlife are frequently dismissed as "infeasible," and 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 1992, when the first petition to list longfin smelt under the federal ESA was filed, scientific understanding of the species and its estuarine habitat has increased substantially. During the same period, overall ecological conditions in the San Francisco Bay-Delta Estuary, which supports the largest remaining longfin smelt population in California, have further degraded. The status of the species has deteriorated to the point where it is at risk of imminent extinction, following the trajectory of its sympatric relative, the delta smelt, which is currently listed as threatened under the ESA and a candidate for endangered status under the CESA. The few data available for other longfin smelt populations in California and to the north suggest that those populations are also declining, most likely the result of estuarine habitat degradation. While there are a number of ongoing monitoring, research and, to a lesser extent, habitat protection efforts underway (particularly in the San Francisco Bay-Delta Estuary), additional activities are necessary to protect and improve the status of longfin 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. Most of these recommendations are specifically designed for the San Francisco Bay-Delta Estuary; however they may also be relevant for other Eastern Pacific estuaries inhabited by longfin smelt.

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

1. Immediately list the longfin smelt as endangered under the CESA.
2. 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 mid-April and implementation of the regularly scheduled 31-day export curtailment) to improve in-Delta hydrodynamic conditions and improve survival of spawning adult longfin smelt and their larvae. The management action should be timed to coincide with evidence of spawning and the presence of longfin smelt larvae, as determined based on CDFG survey data and Delta water temperatures.
3. Limit E/I ratios during the January-April period to no greater than 25% (compared to the presently allowed 35-65%).
4. 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. Delta outflows should, at a minimum, maintain springtime X2 downstream of 70 km.
5. 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, and to restrict the invasive clam *Corbula amurensis*.
6. 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 longfin smelt may be present.

7. Install fish screens on the cooling water intakes for commercial power plants and/or prohibit water intake operations during periods when longfin smelt may be present (as based on life history and CDFG survey data).
8. 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 longfin smelt.
9. Restore and/or accelerate ongoing restoration of tidal marsh habitats in Suisun Marsh, which function to produce phyto- and zooplanktonic food organisms for longfin smelt in the marsh and the upper Estuary.
10. Open the Suisun Marsh Salinity Control Gate during the winter, spring and summer to facilitate access to Suisun Marsh by adult and juvenile longfin smelt.
11. Restrict dredging activities in longfin smelt habitat, particularly in areas where spawning is known to or is likely to occur. Prohibit all dredging during the winter and spring (November-May).
12. Restrict pile driving and/or other noise producing activities in areas of longfin smelt habitat where the species would likely be seasonally present. Require implementation of comprehensive sound mitigation technologies (e.g., bubble curtains) for all pile driving activities within longfin smelt habitat.

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) longfin smelt entrained into the SWP and CVP export facilities.
3. Implement monitoring for longfin smelt in coastal waters north and south of the San Francisco Bay.
4. Complete CDFG-sponsored Collection, Handling, Transport and Release (CHTR) studies and apply results to develop methods for improving survival of longfin smelt salvaged at the SWP and CVP facilities.
5. Continue and expand multi-agency research studies of the pelagic organism decline.
6. 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.
7. 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 longfin 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 longfin 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 delta smelt (*Hypomesus transpacificus*; CESA-threatened, ESA-threatened), 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 Longfin Smelt Protection

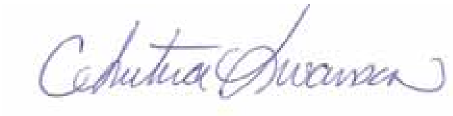
Protection of longfin smelt will require cooperation and participation of state federal and local agencies and organizations, including the USFWS, USBR, U. S. Army Corps of Engineers (which participates in repair and maintenance of Delta levees, and regulates maximum export rates at the SWP), CDFG, CDWR,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

Recovery Criteria for Longfin Smelt

In 1996, the USFWS sponsored development of a recovery plan for native Delta fishes, which included a section for the San Francisco Bay-Delta longfin smelt population (USFWS 1996). The recovery plan included numeric criteria for longfin smelt population abundance based on CDFG FMWT survey results and springtime freshwater outflows, numeric criteria for distribution of the fish within their habitat, and a 10-year long restoration period (corresponding to approximately five generations for the fish). Other criteria for recovery included mitigation and/or elimination of threats to the species. Given the current status of the species, CDFG and the USFWS should develop new recovery criteria that also incorporate more recent information on 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. SIGNATURE PAGE

Submitted this 8th day of August, 2007



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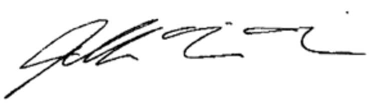

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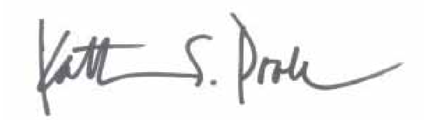

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