U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

Scientific Name:

Spirinchus thaleichthys

Common Name:

longfin Smelt

Lead region:

Region 8 (California/Nevada Region)

Information current as of:

05/15/2015

Status/Action

___ Funding provided for a proposed rule. Assessment not updated.

___ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

___ New Candidate

_X_ Continuing Candidate

___ Candidate Removal

> ___ Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status
>
> ___ Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species
>
> ___ Range is no longer a U.S. territory
>
> ___ Insufficient information exists on biological vulnerability and threats to support listing

___ Taxon mistakenly included in past notice of review

___ Taxon does not meet the definition of "species"

___ Taxon believed to be extinct

___ Conservation efforts have removed or reduced threats

___ More abundant than believed, diminished threats, or threats eliminated.

Petition Information

___ Non-Petitioned

_X_ Petitioned - Date petition received: 08/08/2007

90-Day Positive:05/06/2008

12 Month Positive:04/02/2012

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

We find that the immediate issuance of a proposed rule and timely promulgation of a final rule for this species has been, for the preceding 12 months, and continues to be, precluded by higher priority listing actions (including candidate species with lower LPNs). During the past 12 months, the majority our entire national listing budget has been consumed by work on various listing actions to comply with court orders and court-approved settlement agreements; meeting statutory deadlines for petition findings or listing determinations; emergency listing evaluations and determinations; and essential litigation-related administrative and program management tasks. We will continue to monitor the status of this species as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures. For information on listing actions taken over the past 12 months, see the discussion of Progress on Revising the Lists, in the current CNOR which can be viewed on our Internet website (http://endangered.fws.gov/).

Historical States/Territories/Countries of Occurrence:

- **States/US Territories**: California
- **US Counties**:County information not available
- **Countries**:Country information not available

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: California
- **US Counties**:County information not available
- **Countries**:Country information not available

Land Ownership:

This species occurs in open waters. The San Francisco Bay-Delta covers a total area of approximately 738,000 acres, including approximately 538,000 acres of agricultural land uses, 60,000 acres of open water, and 64,000 acres of urban land uses.

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Biological Information

Species Description:

Longfin smelt measure 9–11 centimeters (cm) (3.5–4.3 inches (in)) standard length, although third-year females may grow up to 15 cm (5.9 in). The sides and lining of the gut cavity appear translucent silver, the back has an olive to iridescent pinkish hue, and mature males are usually darker in color than females. Longfin smelt can be distinguished from other smelts by their long pectoral fins, weak or absent striations on their opercular (covering the gills) bones, incomplete lateral line, low numbers of scales in the lateral series (54 to 65), long maxillary bones (in adults, these bones extend past mid-eye, just short of the posterior margin of the eye), and lower jaw extending anterior of the upper jaw (Mcallister 1963, p. 10; Miller and Lea 1972, pp. 158–160; Moyle 2002, pp. 234–236).

Taxonomy:

In the 12-month finding published on April 2, 2012 (77 FR 19756), we determined that longfin smelt was not warranted for listing under the Act rangewide, but that the San Francisco Bay-Delta distinct population segment (Bay-Delta DPS) was warranted for listing, although listing was determined to be precluded by higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants. In this candidate species assessment, we focus on the Bay-Delta DPS; the reader is referred to the 2012 12-month finding for information on the status of the species rangewide.

We have carefully reviewed the available taxonomic information to reach the conclusion that the longfin smelt (*Spirinchus thaleichthys*) is a valid taxon. The longfin smelt belongs to the true smelt family Osmeridae and is one of three species in the Spirinchus genus; the night smelt (*Spirinchus starksi*) also occurs in California, and the shishamo (*Spirinchus lanceolatus*) occurs in northern Japan (McAllister 1963, pp. 10, 15). Because of its distinctive physical characteristics, the Bay-Delta population of longfin smelt was once described as a species separate from more northern populations (Moyle 2002, p. 235). McAllister (1963, p. 12) merged the two species *S. thaleichthys* and *S. dilatus* because the difference in morphological characters represented a gradual change along the north-south distribution rather than a discrete set. Stanley et al. (1995, p. 395) found that individuals from the Bay-Delta population and Lake Washington population differed significantly in allele (proteins used as genetic markers) frequencies at several loci (gene locations), although the authors also stated that the overall genetic dissimilarity was within the range of other conspecific fish species. They concluded that longfin smelt from Lake Washington and the Bay-Delta are conspecific (of the same species) despite the large geographic separation. Delta smelt and longfin smelt hybrids have been observed in the Bay-Delta estuary (California Department of Fish and Game (CDFG) 2001, p. 473).

Habitat/Life History:

Biology

Longfin smelt are considered pelagic and anadromous (Moyle 2002, p. 236), although anadromy in longfin smelt is poorly understood, and certain populations are not anadromous and complete their entire life cycle in freshwater lakes and streams (see Lake Washington Population section below). Within the Bay-Delta, the term pelagic refers to organisms that occur in open water away from the bottom of the water column and away from the shore. Juvenile and adult longfin smelt have been found throughout the year in salinities ranging from pure freshwater to pure seawater, although once past the juvenile stage, they are typically collected in waters with salinities ranging from 14 to 28 parts per thousand (ppt) (Baxter 1999, pp. 189–192). Longfin smelt are thought to be restricted by high water temperatures, generally greater than 22 degrees Celsius (C) (71 degrees Fahrenheit (°F)) (Baxter et. al. 2010, p. 68), and will move down the estuary (seaward) and into deeper water during the summer months, when water temperatures in the Bay-Delta are higher. Within the Bay-Delta, adult longfin smelt occupy water at temperatures from 16 to 20 C (61 to 68 F), with spawning occurring in water with temperatures from 5.6 to 14.5 C (41 to 58 F) (Wang 1986, pp. 6–9).

Longfin smelt usually live for 2 years, spawn, and then die, although some individuals may spawn as 1- or 3-year-old fish before dying (Moyle 2002, p. 36). In the Bay-Delta, longfin smelt are believed to spawn primarily in freshwater in the lower reaches of the Sacramento River and San Joaquin River. Longfin smelt congregate in deep waters in the vicinity of the low salinity zone (LSZ) near X2 (see definition below) during the spawning period, and it is thought that they make short runs upstream, possibly at night, to spawn from these locations (CDFG 2009, p. 12; Rosenfield 2010, p. 8). The LSZ is the area where salinities range from 0.5 to 6 practical salinity units (psu) within the Bay-Delta (Kimmerer 1998, p. 1). Salinity in psu is determined by electrical conductivity of a solution, whereas salinity in parts per thousand (ppt) is determined as the weight of salts in a solution. For use in this document, the two measurements are essentially equivalent. X2 is defined as the distance in kilometers up the axis of the estuary (to the east) from the Golden Gate Bridge to the location where the daily average near-bottom salinity is 2 psu (Jassby *et al.* 1995, p. 274; Dege and Brown 2004, p. 51)).
Longfin smelt in the Bay-Delta may spawn as early as November and as late as June, although spawning typically occurs from January to April (CDFG 2009, p. 10; Moyle 2002, p. 36). Longfin smelt have been observed in their winter and spring spawning period as far upstream as Isleton in the Sacramento River, Santa Clara shoal in the San Joaquin system, Hog Slough off the South-Fork Mokelumne River, and in Old River south of Indian Slough (CDFG 2009a, p. 7; Radtke 1966, pp. 115–119).

Exact spawning locations in the Delta are unknown and may vary from year to year in location, depending on environmental conditions. However, it seems likely that spawning locations consist of the overlap of appropriate conditions of flow, temperature, and salinity with appropriate substrate (Rosenfield 2010, p. 8). Longfin smelt are known to spawn over sandy substrates in Lake Washington and likely prefer similar substrates for spawning in the Delta (Baxter et al. 2010, p. 62; Sibley and Brocksmith 1995, pp. 32–74). Baxter found that female longfin smelt produced between 1,900 and 18,000 eggs, with fecundity greater in fish with greater lengths (CDFG 2009, p. 11). At 7°C (44.6°F), embryos hatch in 40 days (Dryfoos 1965, p. 42); however, incubation time decreases with increased water temperature. At 8–9.5°C (46.4–49.1 °F), embryos hatch at 29 days (Sibley and Brocksmith 1995, pp. 32–74).

Larval longfin smelt less than 12 millimeters (mm) (0.5 in) in length are buoyant because they have not yet developed an air bladder; as a result, they occupy the upper one-third of the water column. After hatching, they quickly make their way to the LSZ via river currents (CDFG 2009, p. 8; Baxter 2011a, pers. comm.). Longfin smelt develop an air bladder at approximately 12–15 mm (0.5–0.6 in.) in length and are able to migrate vertically in the water column. At this time, they shift habitat and begin living in the bottom two-thirds of the water column (CDFG 2009, p. 8; Baxter 2008, p. 1).

Longfin smelt larvae can tolerate salinities of 2–6 psu within days of hatching, and can tolerate salinities up to 8 psu within weeks of hatching (Baxter 2011a, pers. comm.). However, very few larvae (individuals less than 20 mm in length) are found in salinities greater than 8 psu, and it takes almost 3 months for longfin smelt to reach juvenile stage. A fraction of juvenile longfin smelt individuals are believed to tolerate full marine salinities (greater than 8 psu) (Baxter 2011a, pers. comm.).

Longfin smelt are dispersed broadly in the Bay-Delta by high flows and currents, which facilitate transport of larvae and juveniles long distances. Longfin smelt larvae are dispersed farther downstream during high freshwater flows (Dege and Brown 2004, p. 59). They spend approximately 21 months of their 24-month life cycle in brackish or marine waters (Baxter 1999, pp. 2–14; Dege and Brown 2004, pp. 58–60).

In the Bay-Delta, most longfin smelt spend their first year in Suisun Bay and Marsh, although surveys conducted by the City of San Francisco collected some first-year longfin in coastal waters (Baxter 2011c, pers. comm.; City of San Francisco 1995, no pagination). The remainder of their life is spent in the San Francisco Bay or the Gulf of Farallones (Moyle 2008, p. 366; City of San Francisco 1995, no pagination). Rosenfield and Baxter (2007, pp. 1587, 1590) inferred based on monthly survey results that the majority of longfin smelt from the Bay-Delta were migrating out of the estuary after the first winter of their life cycle and returning during late fall to winter of their second year. They noted that migration out of the estuary into nearby coastal waters is consistent with captures of longfin smelt in the coastal waters of the Gulf of Farallones. It is possible that some longfin smelt may stay in the ocean and not re-enter freshwater to spawn until the end of their third year of life (Baxter 2011d, pers. comm.). Moyle (2010, p. 8) states that longfin smelt that migrate out of and back into the Bay-Delta estuary may primarily be feeding on the rich planktonic food supply in the Gulf of Farallones. Rosenfield and Baxter (2007, p. 1290) hypothesize that the movement of longfin smelt into the ocean or deeper water habitat in summer months is at least partly a behavioral response to warm water temperatures found during summer and early fall in the shallows of south San Francisco Bay and San Pablo Bay (Rosenfield and Baxter 2007, p. 1590).

In the Bay-Delta, calanoid copepods such as Pseudodiatomus forbesi and Eurytemora sp., as well as the cyclopoid copepod *Acanthocyclops vernali* (no common names), are the primary prey of longfin smelt during the first few months of their lives (approximately January through May) (Slater 2009b, slide 45). Copepods are a type of zooplankton (organisms drifting in the water column of oceans, seas, and bodies of fresh water). The longfin smelt’s diet shifts to include mysids such as opossum shrimp (*Neomysis mercedis*) and other small crustaceans (*Acanthomysis sp*.) as soon as they are large enough (20–30 mm (0.78–1.18 in)) to consume these larger prey items, sometime during the summer months of the first year of their lives (CDFG 2009, p. 12). Upstream of San Pablo Bay, mysids and amphipods form 80–95 percent or more of the juvenile longfin smelt diet by weight from July through September (Slater 2009, unpublished data). Longfin smelt occurrence is likely associated with the occurrence of their prey, and both of these invertebrate groups occur near the bottom of the water column during the day under clear water marine conditions.

Habitat

The Bay-Delta is the largest estuary on the West Coast of the United States (Sommer et al. 2007, p. 271). The modern Bay-Delta bears only a superficial resemblance to the historical Bay-Delta. The Bay-Delta supports an estuary covering approximately 1,235 square kilometers (km^2) (477 square miles (mi^2)) (Rosenfield and Baxter 2007, p. 1577), which receives almost half of California's runoff (Lehman 2004, p. 313). The historical island marshes surrounded by low natural levees are now intensively farmed and protected by large, manmade structures (Moyle 2002, p. 32). The watershed, which drains approximately 40 percent of the land area of California, has been heavily altered by dams and diversions, and nonnative species now dominate, both in terms of numbers of species and numbers of individuals (Kimmerer 2004, pp. 7–9). The Bay Institute has estimated that intertidal wetlands in the Delta have been diked and leveed so extensively that approximately 95 percent of the 141,640 hectares (ha) (350,000 acres (ac)) of tidal wetlands that existed in 1850 are gone (The Bay Institute 1998, p. 17).

The physical and biological characteristics of the estuary define longfin smelt habitat. The Bay-Delta is unique in that it contains significant amounts of tidal freshwater (34 km^2 (13 mi^2)) and mixing zone (194 km^2 (75 mi^2)) habitat (Monaco et al. 1992, pp. 254–255, 258). San Francisco Bay is relatively shallow and consists of a northern bay that receives freshwater inflow from the Sacramento-San Joaquin system and a southern bay that receives little freshwater input (Largier 1996, p. 69). Dominant fish species are highly salt-tolerant and include the commercially important Pacific sardine (*Sardinops sagax*) and rockfish (*Sebastes spp.*). Major habitat types include riverine and tidal wetlands, mud flat, and salt marsh, with substantial areas of diked wetland managed for hunting. The sandy substrates that longfin smelt are presumed to use for spawning are abundant in the Delta.

Historical Range/Distribution:

Longfin smelt have been observed in their winter and spring spawning period as far upstream as Isleton in the Sacramento River, Santa Clara shoal in the San Joaquin system, Hog Slough off the South-Fork Mokelumne River, and in Old River south of Indian Slough (CDFG 2009a, p. 7; Radtke 1966, pp. 115–119). Lonfin smelt are distributed throughout the Bay-Delta including in Suisun Bay and Marsh, San Pablo Bay, and San Francisco Bay. Longfin smelt have also been found in the Napa and Petaluma Rivers (Merz 2013, p. 136). Longfin smelt also migrate out into the ocean including into the Gulf of Farallones to obtain food. In recent surveys, longfin smelt were captured in all major sloughs and tributary sloughs within the Alviso Marsh Complex salt pond restoration area in the South Delta (Hobbs 2012, pg. 39).

Current Range Distribution:

The current distribution of longfin smelt in the Bay-Delta is similar to its historical distribution.

Population Estimates/Status:

Abundance

Within the Bay-Delta, longfin smelt are consistently collected in the monitoring surveys that have been conducted by California Department of Fish and Wildlife ((CDFW) formerly CDFG) as far back as the late 1960s. Longfin smelt numbers in the Bay-Delta have declined significantly since the 1980s (Moyle 2002, p. 237; Rosenfield and Baxter 2007, p. 1590; Baxter et al. 2010, pp. 61-64). Rosenfield and Baxter (2007, pp. 1577-1592) examined abundance trends in longfin smelt using three long-term data sets (1980-2004) and detected a significant decline in the Bay-Delta longfin smelt population. They confirmed the positive correlation between longfin smelt abundance and freshwater flow that had been previously documented by others (Stevens and Miller 1983, p. 432; Baxter et al. 1999, p. 185; Kimmerer 2002b, p. 47), noting that abundances of both adults and juveniles were significantly lower during the 1987-1994 drought than during either the pre- or post-drought periods (Rosenfield and Baxter 2007, pp. 1583-1584).

Despite the correlation between drought and low population in the 1980s and 90s, the declines in the first decade of this century appear to be caused in part by additional factors. Abundance of longfin smelt has remained very low since 2000, even though freshwater flows increased during several of these years (Baxter et al. 2010, p. 62). Abundance indices derived from the Fall Midwater Trawl (FMWT), Bay Study Midwater Trawl (BSMT), and Bay Study Otter Trawl (BSOT) all show marked declines in Bay-Delta longfin smelt populations from 2002 to 2009 (Messineo et al. 2010, p. 57). Longfin smelt abundance over the last decade is the lowest recorded in the 40-year history of CDFW's FMWT monitoring surveys. Scientists became concerned over the simultaneous population declines since the early 2000s of longfin smelt and three other Bay-Delta pelagic fish speciesâdelta smelt (Hypomesus transpacificus), striped bass (Morone saxatilis), and threadfin shad (Dorosoma petenense) (Sommer et al. 2007, p. 273). The declines of longfin smelt and these other pelagic fish species in the Bay-Delta since the early 2000s has come to be known as the Pelagic Organism Decline, and considerable research efforts have been initiated since 2005 to better understand causal mechanisms underlying the declines (Sommer et al. 2007, pp. 270-277; MacNally et al. 2010, pp. 1417-1430; Thomson et al. 2010, pp. 1431-1448). The population did increase in the 2011 FMWT index to 477 (Contreras 2011, p. 2), probably a response to an exceptionally wet year. However, in 2013 and 2014, values returned to the low indices seen in prior years with FMWT indexes of 164 and 16 (CDFW 2015; no pagination).
The FMWT index of abundance in the Bay-Delta shows great annual variation in abundance but a severe decline over the past 40 years (Figure 1). The establishment of the overbite clam (Corbula amurensis) in the Bay-Delta in 1987 is believed to have contributed to the population decline of longfin smelt (See Factor E: Introduced Species, below), as well as to the declining abundance of other pelagic fish species in the Bay-Delta (Sommer et al. 2007, p. 274). Figure 1 shows low values of the abundance index for longfin smelt during drought years (1976-1977, 1986-1992, and 2012-present) and low values overall since the time that the overbite clam became established in the estuary.

Using data from 1975-2004 from the FMWT survey, Rosenfield and Baxter (2007, p. 1589) found that longfin smelt exhibit a significant stock-recruitment relationship-abundance of juvenile (age-0) fish is directly related to the abundance of adult (age-1) fish from the previous year. They found that the abundance of juvenile fish declined by 90 percent during the time period analyzed. Rosenfield and Baxter (2007, p. 1589) also found a decline in age-1 individuals that was significant even after accounting for the decline in the age-0 population. If unfavorable environmental conditions persist for one or more years, recruitment into the population could be suppressed, affecting the species' ability to recover to their previous abundance. The current low abundance of adult longfin smelt within the Bay-Delta could reduce the ability of the species to persist in the presence of various threats.

FIGURE 1. Longfin smelt abundance (total across year-classes) as indexed by the Fall Mid-Water Trawl of the Bay-Delta, 1967-2014.

* The survey was not conducted in 1974 or 1979.

** Abundance indices below 1000 include index value on the figure.Â

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Distinct Population Segment(DPS):

Under the Services' (joint policy of the Fish and Wildlife Service and National Marine Fisheries Service) DPS policy (61 FR 4722; February 7, 1996), three elements are considered in the decision concerning the establishment and classification of a possible DPS. These are applied similarly for additions to or removal from the Federal List of Endangered and Threatened Wildlife. These elements include: (1) The discreteness of a population in relation to the remainder of the species to which it belongs; (2) the significance of the population segment to the species to which it belongs; and (3) the population segment's conservation status in relation to the Act's standards for listing, delisting, or reclassification (i.e., is the population segment endangered or threatened).

Discreteness

Under the DPS policy, a population segment of a vertebrate taxon may be considered discrete if it satisfies either one of the following conditions:

(1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
(2) It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act.

Marked Separation from Other Populations as a Consequence of Physical, Physiological, Ecological, or Behavioral Factors

The limited swimming capabilities of the longfin smelt, existing ocean current patterns, and the great distances between the Bay-Delta and other known breeding populations make it unlikely that regular interchange occurs between the Bay-Delta and other longfin smelt breeding populations. Longfin smelt is a relatively short-lived species that completes its 2- to 3-year life cycle moving between freshwater spawning habitat in the Delta and brackish water rearing habitat downstream (seaward) in the estuary within Suisun Bay, San Pablo Bay, and central San Francisco Bay. At least a portion of the population also migrates into the near-coastal waters of the Gulf of Farallones (Rosenfield and Baxter 2007, p. 1590). Although its swimming capabilities have not been studied, it is a small fish believed to have a limited swimming capacity (Moyle 2010, pp. 5–6). How longfin smelt return to the Bay-Delta from the Gulf of Farallones is not known (Rosenfield and Baxter 2007, p.1590).

The Bay-Delta population is the southernmost population of longfin smelt and is separated from other longfin smelt breeding populations by 56 km (35 mi). The nearest location to the Bay-Delta where longfin smelt have been caught is the Russian River, located north of the Bay-Delta; however, little information is available for this population (see Distribution section, above). Due to limited freshwater flow into the estuary and interannual variation in freshwater flow, it is unlikely that the estuary provides sufficient potential spawning and rearing habitat to support a regularly breeding longfin smelt population (Moyle 2010, p. 4).

The Eel River and Humboldt Bay are the next nearest locations where longfin smelt are known to occur, and they are located much farther to the north—Eel River is located 394 km (245 mi) north of the Bay-Delta, and Humboldt Bay is located 420 km (260 mi) north of the Bay-Delta. Moyle (2010, p. 4) considered Humboldt Bay to be the only other estuary in California potentially capable of supporting longfin smelt in most years.

In our April 9, 2009, longfin smelt 12-month finding (74 FR 16169), we concluded that the Bay-Delta population was not markedly separated from other populations and, therefore, did not meet the discreteness element of the 1996 DPS policy. This conclusion was based in part on the assumption that ocean currents likely facilitated dispersal of anadromous longfin smelt to and from the Bay-Delta to other estuaries in numbers that could readily sustain the Bay-Delta population group if it was to be extirpated. Since 2009, we have obtained information relevant to assumptions that we made in the 2009 12-month finding. Additional clarifying information comes in part from a declaration submitted to the U.S. District Court for the Northern District of California on June 29, 2010, by Dr. Peter Moyle, Professor of Fisheries Biology at the University of California at Davis (Moyle 2010, pp. 1–8). Moyle (2010, pp. 5–6) notes that he believes that we overestimated the swimming capacity of longfin smelt in our 2009 12-month finding. Moyle (2010, p. 8) states that longfin smelt that migrate out of and back into the Bay-Delta estuary may primarily be feeding on the rich planktonic food supply in the Gulf of Farallones, and that this migration between the Bay-Delta and near coastal waters of the Gulf of Farallones does not indicate that longfin smelt are necessarily dispersing long distances to other estuaries to the north.

At the time of our last finding, we did not have information available assessing the ability of longfin smelt to disperse northward from the Bay-Delta or southward to the Bay-Delta using currents in the Pacific Ocean. Since the time of our previous finding (74 FR 16169; April 9, 2009), we have reviewed additional information on ocean currents in nearshore waters and over the continental shelf from approximately the Gulf of Farallones north to Coos Bay. We have evaluated the potential for longfin smelt to disperse northward from the Bay-Delta or southward to the Bay-Delta. On October 28, 2011, we convened a panel of experts to evaluate the potential of longfin smelt dispersal via ocean currents. Oceanographers on the panel were tasked with answering a series of questions on how ocean currents would affect longfin smelt potentially dispersing into or out of the Bay-Delta. Much of the following analysis was derived from that panel discussion. Our analysis relies upon ocean current information as it relates to what is known of longfin smelt biology and life history from the Bay-Delta population.

Table 2 overlays longfin smelt life history with general ocean current patterns in central and northern California. However, the California Current System exhibits a high degree of seasonality as well as weekly variability. Currents are highly variable in fall and winter but tend to be predominately northward. Surface currents are northward during the storm season from December to March and transition to southward in March or April. Offshore of central California the surface currents remain generally southward during summer. However, despite the predominant southward surface current, northward currents are common at depths around 60 to 200 m along the continental slope at all times of the year. This deeper current is known as the California Undercurrent (Paduan 2011, pers. comm.)

TABLE 2. Summary of longfin smelt life history within the Bay-Delta, and generalized coastal ocean circulation.

Month	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
First Year		Peak Hatching-freshwater, upstream Delta										
First Year			Larval Rearing San Pablo and San Francisco Bays-salinities <8 psu									
First Year	Juveniles Rearing				Juvenile Rearing – Primarily San Pablo, San Francisco Bays-							
Second Year			Juvenile Rearing									
Second Year					– Juvenile Rearing -Movement to the coastal ocean begins in the summer, mass movement to coastal ocean begins in July and August							
Second Year	Spawning Migration											Sp. Migr'n
Second Year	Peak Spawning-freshwater, Delta											
Coastal Current	Storm Season (Northward Flow)				Upwelling Season (Predominate Southward and Offshore Flow)				Relaxation Season (Weak Northward Flow)			

Eddies (clockwise water circulation areas) exist at various points between the Bay-Delta and Humboldt Bay at landmarks such as Point Arena and Cape Mendocino. These eddies vary in their distance from shore between 10 to 100 km (6 to 62 mi) (Padaun 2011, pers. comm.). During the summer upwelling season, northerly winds drive a southward offshore flow of near-surface waters (Dever et al. 2006, p. 2109) and also set up a strong current over the continental shelf that is deflected offshore at capes such as Cape Mendocino, Point Arena, and Point Reyes (Magnell et al. 1990, p. 7; Largier 2004, p. 107; Halle and Largier 2011, pp. 1–24). Several studies have used drifters (flotation devices tracked by satellites) and pseudo-drifters (computer-simulated satellite-tracked flotation devices) to evaluate currents in the California region of the Pacific Ocean. These studies indicate that the circulation patterns located off Point Arena and Cape Mendocino limit dispersal (particularly southward) of floatation devices in the region (Sotka et al. 2004, p. 2150; Drake et al. 2011, pp. 1–51; Halle and Largier 2011, posters). This limitation is important because Cape Mendocino and Point Arena are between the Bay-Delta and the nearest likely self-sustaining population of longfin smelt in Humboldt Bay.

Longfin smelt are an euryhaline species, of which an unknown fraction of the population exhibits anadromy (Moyle 2002, p. 236; Rosenfield and Baxter 2007 p. 1578). Based on their small size and limited swimming ability, we expect that longfin smelt would be largely dependent on ocean currents to travel the large distance between the Bay-Delta and the Humboldt Bay. During wet years, newly spawned longfin smelt larvae may be flushed out to the ocean between December and March. It is unlikely that longfin smelt larvae can survive ocean transport because larvae are not known to tolerate salinities greater than 8 ppt (Baxter 2011b, pers. comm.), and surface salinities less than 8 ppt do not exist consistently in the ocean (Bograd and Paduan 2011, pers. comm.).

A portion of the longfin smelt that spawn in the Bay-Delta make their way to the ocean once they are able to tolerate full marine salinities, sometime during the late spring or summer of their first year of life (age-0) (City of San Francisco and CH2MHill 1984 and 1985, entire), and may remain there for 18 months or longer before returning to the Bay-Delta to spawn (Baxter 2011c, pers. comm.). A larger portion of longfin smelt enter the coastal ocean during their second year of life (age-1) (City of San Francisco and CH2MHill 1984 and 1985, entire) and remain there for 3 to 7 months until they re-enter the Bay-Delta to spawn in early winter (Rosenfield and Baxter 2007, p 1590; Baxter 2011c, pers. comm.). Most of these age-1 longfin smelt move to coastal waters in July and August, possibly to escape warm water temperatures or to obtain food (Moyle 2010, p. 8; Rosenfield and Baxter 2007, p. 1290). Some longfin smelt may live to 3 years of age and may remain in the coastal ocean until they are 3 years old. However, no 3-year old longfin smelt have been observed in the coastal ocean (Baxter 2011d, pers. comm.; Service 2011, unpublished data).

It is possible that some of these juvenile or adult longfin smelt could make their way into the Russian River, Eel River, or Humboldt Bay and supplement or sustain those populations by utilizing northward ocean currents (Padaun 2011, pers. comm.; Service 2011b, pp. 1-4), but there is no documentation of such long-distance coastal movements. The northward ocean currents are strongest and most reliable in winter, when satellite-tracked particles move between the Bay-Delta and Humboldt Bay in as little as 2 months (Service 2011, p. 3).

Opportunities for longfin smelt dispersal utilizing ocean currents from northern estuaries to the Bay-Delta are more limited. Studies have revealed that currents near Cape Mendocino and Point arena would carry small objects to the west away from the coast (Padaun 2011b, pers. comm.; Bograd 2011, pers. comm.). It is possible that longfin smelt in nearshore waters could travel south past these eddies if they stay close enough to shore. It is even possible that some longfin smelt may be moved closer to shore by the eddies (Bograd 2011, pers. comm.; Paduan 2011, pers. comm.). However, any longfin smelt that do travel south past the Cape Mendocino and Point Arena escarpments would be unlikely to re-enter the Bay-Delta. These offshore ocean currents could displace any longfin smelt potentially moving south more than 100 km (62 mi) offshore of the Bay-Delta (Paduan 2011a, pers. comm.). Pathways that transport objects close to shore would be expected to be rare, if they exist at all (Padaun 2011b, pers. comm.; Bograd 2011, pers. comm.). So while we considered whether ocean currents may transport or facilitate movement of longfin smelt from northern estuaries to the Bay-Delta estuary, there is no information showing that such dispersal movement occurs.

Using the best scientific data available, we compared longfin smelt biology and life history with the latest available ocean current data provided by oceanographers. We conclude that longfin smelt in the Bay-Delta population do not regularly breed or interact with longfin smelt in other breeding populations to the north and are therefore markedly separated from other longfin smelt populations.

Under the 1996 DPS policy, the discreteness standard does not require absolute separation of a DPS from other members of its species, nor does the standard require absolute reproductive isolation (61 FR 4722). Because of the great distances between the Bay-Delta and known breeding populations to the north, the small size of the longfin smelt, and the low likelihood that ocean currents could facilitate longfin smelt movements between widely separated populations, we conclude that the Bay-Delta population is markedly separated from other longfin smelt populations and therefore discreet.

Quantitative Measures of Genetic or Morphological Discontinuity

The 1996 DPS policy states that quantitative measures of genetic or morphological discontinuity may provide evidence of marked separation and discreteness. Stanley *et al.* (1995, p. 395) compared allozyme variation between longfin smelt from the Bay-Delta population and the Lake Washington population using electrophoresis. They found that individuals from the populations differed significantly in allele (portions of a chromosome that code for the same trait) frequencies at several loci (gene locations). However, the authors also stated that the overall genetic dissimilarity was within the range of other conspecific (of the same species) fish species, and concluded that longfin smelt from Lake Washington and the Bay-Delta are conspecific, despite the large geographic separation (Stanley et al. 1995, p. 395). This study provided evidence that the Bay-Delta population of longfin smelt differed in genetic characteristics from the Lake Washington population, but did not compare other populations rangewide to the Bay-Delta population. More recently, Israel *et al.* (2011, pp. 1–10) presented preliminary results from an ongoing study, but these results were inconclusive in providing evidence of whether the Bay-Delta population is markedly separated from other longfin smelt populations (Cope 2011, pers. comm.; Service 2011a, pp. 1-3).

We conclude that the limited quantitative genetic and morphological information available does not provide additional evidence of marked separation of the Bay-Delta longfin smelt population beyond the evidence presented above under Marked Separation from Other Populations as a Consequence of Physical, Physiological, Ecological, or Behavioral Factors.

Delimited by International Governmental Boundaries Within Which Differences in Control of Exploitation, Management of Habitat, Conservation Status, or Regulatory Mechanisms Exist that are Significant in Light of Section 4(a)(1)(D) of the Act

The Bay-Delta population of longfin smelt is not delimited by an international boundary. Therefore, we conclude that it does not meet the international governmental boundaries criterion for discreteness.

Conclusion for Discreteness

Because of its limited swimming capabilities and because of the great distances between the Bay-Delta and known breeding populations to the north, we conclude that the Bay-Delta population is markedly separated from other longfin smelt populations, and thus meets the discreteness element of the 1996 DPS policy. The best available information indicates that longfin smelt from the Bay-Delta population complete their life cycle moving between freshwater, brackish water, and saltwater portions of the estuary and nearby coastal ocean waters in the Gulf of Farallones. The nearest known breeding population of longfin smelt is Humboldt Bay, 420 km (260 mi) north of the Bay-Delta. As a result, potential interchange between the Bay-Delta population and other longfin smelt breeding populations is limited. Although the best scientific information suggests that potential movement of longfin smelt northward from the Bay-Delta would be facilitated by ocean currents, potential movement from more northern estuaries south to the Bay-Delta would be more difficult and unlikely because of ocean currents. Based on our review of the best available scientific and commercial information available, we conclude that the Bay-Delta population of longfin smelt is markedly separated from other longfin smelt populations as a consequence of physical, physiological, ecological, or behavioral factors.

Significance

Since we have found that the Bay-Delta longfin smelt population meets the discreteness element of the 1996 DPS policy, we now consider its biological and ecological significance in light of Congressional guidance that the authority to list DPSes be used “sparingly” while encouraging the conservation of genetic diversity. In making this determination, we consider available scientific evidence of the discrete population segment’s importance to the taxon to which it belongs. As precise circumstances are likely to vary considerably from case to case, the DPS policy does not describe all the classes of information that might be used in determining the biological and ecological importance of a discrete population. However, the DPS policy describes four possible classes of information that provide evidence of a population segment’s biological and ecological importance to the taxon to which it belongs. As specified in the DPS policy, this consideration of the population segment’s significance may include, but is not limited to, the following:

(1) Persistence of the discrete population segment in an ecological setting unusual or unique to the taxon;
(2) Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon;
(3) Evidence that the discrete population segment represents the only surviving natural occurrence

of a taxon that may be more abundant elsewhere as an introduced population outside its historic range; or
(4) Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

A population segment needs to satisfy only one of these conditions to be considered significant. Furthermore, other information may be used as appropriate to provide evidence for significance.

(1) Persistence of the discrete population segment in an ecological setting unusual or unique to the taxon.

The Bay-Delta population is the southernmost breeding population in the range of the species. Populations at the edge of a species' range may be important in species conservation because environmental conditions at the periphery of a species' range can be different from environmental conditions nearer the center of a species' range. Thus, populations at the edge of the taxon's range may experience different natural selection pressures that promote divergent evolutionary adaptations (Scudder 1989, entire; Fraser 2000, entire). Lomolino and Channell (1998, p. 482) hypothesized that because peripheral populations should be adapted to a greater variety of environmental conditions, they may be better suited to deal with anthropogenic (human-caused) disturbances than populations in the central part of a species' range; however, this hypothesis remains unproven. This could be especially important because of changing natural selection pressures associated with climate change.

For example, increasing ocean temperatures is an environmental change to which the Bay-Delta population of longfin smelt may be uniquely adapted. Because it is the southern-most estuary within the species' range, the Bay-Delta has warmer average water temperatures than estuaries in central and northern parts of the species' range. As a result, the Bay-Delta longfin smelt population may have behavioral or physiological adaptations for coping with higher water temperatures that may come as a result of climate change (see discussion under Factor A: Climate Change). Baxter et al. (2010, p. 68) conclude that high water temperatures in the Bay-Delta influence spatial distribution of longfin smelt in the estuary. Rosenfield and Baxter (2007, p. 1290) hypothesize that the partial anadromy exhibited by the population (part of the population is believed to migrate out into the cooler, nearby coastal ocean waters in the Gulf of Farallones) and concentrations of longfin smelt in deeper water habitat in summer months is at least partly a behavioral response to warm water temperatures found during summer and early fall in the shallows of south San Francisco Bay and San Pablo Bay (Rosenfield and Baxter 2007, p. 1590).

The Bay-Delta estuary, although greatly degraded, is the largest estuary on the Pacific Coast of the United States (Sommer *et al.* 2007, p. 271). Because of its large size and diverse habitat, it is capable of supporting a large longfin smelt population. Large populations are valuable in the conservation of species because of their lower extinction risks compared to small populations. Historically, longfin smelt is believed to have been one of the more abundant pelagic fishes in the Bay-Delta. The areal extent of tidal freshwater habitat in the Bay-Delta estuary exceeds that of other California estuaries by an order of magnitude (NOAA 2007, p. 1), providing not only more available spawning habitat but also important habitat diversity should conditions at any one location become unsuitable. The Bay-Delta contains significant amounts of tidal freshwater and mixing zone habitat (Monaco et al. 1992, p. 255), which is crucial for spawning and rearing of juvenile longfin smelt. Other Pacific Coast estuaries where longfin smelt occur are predominately river-dominated estuaries (e.g., Russian River, Eel River, Klamath River, Columbia River), which have much smaller areas of low-salinity brackish water for longfin smelt rearing habitat.

(2) Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon.

Loss of the Bay-Delta population of longfin smelt would result in a significant gap in the range of the taxon because the nearest persistent longfin smelt breeding population to the Bay-Delta population is in Humboldt Bay, which is located approximately 420 km (260 mi) away. Loss of the Bay-Delta population would truncate the range of the species by hundreds of miles.

(3) Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range.

This factor does not apply to the Bay-Delta longfin smelt population because other naturally occurring populations are found within the species' range.

(4) Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

As discussed above under Quantitative Measures of Genetic or Morphological Discontinuity, two studies have evaluated genetic characteristics of the Bay-Delta longfin smelt population. One study concluded that genetic characteristics of the Bay-Delta population differed from the Lake Washington population but did not compare any other populations (Stanley *et al.* 1995, pp. 390–396). Israel et al. (2011, pp. 1–10) presented preliminary results from an ongoing study, but these results are inconclusive in determining whether the Bay-Delta population differs markedly from other longfin smelt populations in its genetic characteristics. Therefore, although information indicates that the genetic characteristics of the Bay-Delta population differs from at least one other longfin smelt population (Lake Washington), there is no other information currently available indicating that the genetic characteristics of the Bay-Delta population differ markedly from other longfin smelt populations.

Conclusion for Significance

We conclude that the Bay-Delta population is biologically significant to the longfin smelt species because the population occurs in an ecological setting unusual or unique for the species and its loss would result in a significant truncation of the range of the species. The Bay-Delta longfin smelt population occurs at the southern edge of the species' range and has likely experienced different natural selection pressures than those experienced by populations in middle portions of the species' range. The population may therefore possess unique evolutionary adaptations important to the conservation of the species. The Bay-Delta also is unique because it is the largest estuary on the Pacific Coast of the United States. Because of its large size and diverse aquatic habitats, the Bay-Delta has the potential to support a large longfin smelt population and is thus potentially important in the conservation of the species. The Bay-Delta population also is significant to the taxon because the nearest known breeding population of longfin smelt is hundreds of miles away, so loss of the Bay-Delta population would significantly truncate the range of the species and result in a significant gap in the species' range. Based on our review of the best available scientific and commercial information, we conclude that the Bay-Delta population meets the significance element of the 1996 DPS policy.

Determination of Distinct Population Segment

Because we have determined that the Bay-Delta population meets both the discreteness and significance elements of the 1996 DPS policy, we find that the Bay-Delta longfin smelt population is a valid DPS and thus is a listable entity under the Act. Therefore, we next evaluate its conservation status in relation to the Act's standards for listing (i.e., is the population segment, when treated as if it were a species, endangered or threatened?).

Threats

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

Reduced Freshwater Flow

The primary threat to the Bay-Delta longfin smelt is reduced freshwater flows. In the Bay-Delta, freshwater flow is strongly related to the natural hydrologic cycles of drought and flood. Studies of Bay-Delta longfin smelt have found that increased Delta outflow during the winter and spring is the largest factor positively affecting longfin smelt abundance (Stevens and Miller 1983, pp. 431–432; Jassby *et al.* 1995, p. 285; Sommer *et al.* 2007, p. 274; Thomson *et al.* 2010, pp. 1439–1440). During high outflow periods larvae are believed to benefit from increased transport and dispersal downstream, increased food production, reduced predation through increased turbidity, and reduced loss to entrainment due to a westward shift in the boundary of spawning habitat and strong downstream transport of larvae (CFDG 1992, pp. 45-61; Hieb and Baxter 1993, pp. 106-107;

CDFG 2009a, p. 18). Conversely, during low outflow periods, the negative effects of reduced transport and dispersal, reduced turbidity, and potentially increased loss of larvae to predation and increased loss at the export facilities result in lower young-of-the-year recruitment. Despite numerous studies of longfin smelt abundance and flow in the Bay-Delta, the underlying causal mechanisms are still not fully understood (Baxter et al. 2010, p. 69; Rosenfield 2010, p. 9).

As California's population has grown, demands for reliable water supplies and flood protection have grown. In response, State and Federal agencies built dams and canals, and captured water in reservoirs, to increase capacity for water storage and conveyance resulting in one of the largest manmade water systems in the world (Nichols *et al.* 1986, p. 569). Operation of this system has altered the seasonal pattern of freshwater flows in the watershed. Storage in the upper watershed of peak runoff and release of the captured water for irrigation and urban needs during subsequent low flow periods result in a broader, flatter hydrograph with less seasonal variability in freshwater flows into the estuary (Kimmerer 2004, p. 15).

In addition to the system of dams and canals built throughout the Sacramento River-San Joaquin River basin, the Bay-Delta is unique in having a large water diversion system located within the estuary (Kimmerer 2002b, p. 1279). The State Water Project (SWP) and Central Valley Project (CVP) operate two water export facilities in the Delta (Sommer *et al.* 2007, p. 272). Project operation and management is dependent upon upstream water supply and export area demands. Despite the size of the water storage and diversion projects, much of the interannual variability in Delta hydrology is due to variability in precipitation from year to year. Annual inflow from the watershed to the Delta is strongly correlated to unimpaired flow (runoff that would hypothetically occur if upstream dams and diversions were not in existence), mainly due to the effects of high-flow events (Kimmerer 2004, p. 15). Water operations are regulated in part by the California State Water Resources Control Board (SWRCB) according to the Water Quality Control Plan (WQCP) (SWRCB 2000, entire). The WQCP limits Delta water exports in relation to Delta inflow (the Export/Inflow, or E/I ratio).

It is important to note that in the case of the Bay-Delta, freshwater flow is expressed as both Delta inflow (from the rivers into the Delta) and as Delta outflow (from the Delta into the lower estuary), which are closely correlated, but not equivalent. Freshwater flow affects the location of the two-parts-per-thousand salinity isohaline (X2, indexed as distance in kilometers from the Golden Gate Bridge). The location of X2 is influenced by precipitation in the watershed (i.e., wetter or drier seasonal weather patterns) and by water operations both upstream at the dams and diversions, and in the Delta at the water export facilities (Jassby *et al.* 1995; Kimmerer 2004). Because X2 integrates many physical attributes over time and space, many Bay-Delta organisms respond to it, making it a useful indicator of habitat conditions (Jassby *et al.* 1995; Dege and Brown 2004). Along with seasonality and export volume, X2 may be an indicator of the risk of entrainment (Jassby *et al.* 1995; USFWS 2008; Grimaldo *et al.* 2009).

In periods with greater freshwater flow into the Delta, X2 is pushed farther downstream (seaward); in periods with low flows, X2 is positioned farther landward (upstream) in the estuary and into the Delta. As flow reductions alter the position of X2 and the low-salinity zone moves upstream, longfin smelt must migrate farther upstream to obtain freshwater to spawn (CDFG 2009, p. 17). Longer migration distances into the Bay-Delta make longfin smelt more susceptible to entrainment in the State and Federal water pumps (see Factor E: Entrainment Losses, below). Not only is longfin smelt abundance in the Bay-Delta strongly correlated with Delta inflow and X2, but the spatial distribution of longfin smelt larvae is also strongly associated with X2 (Dege and Brown 2004, pp. 58–60; Baxter *et al.* 2010, p. 61). As longfin hatch into larvae, they move from the areas where they are spawned and orient themselves just downstream of X2 (Dege and Brown 2004, pp. 58-60). Larval (winter-spring) habitat varies with outflow and with the location of X2 (CDFG 2009, p. 12), and has been reduced since the 1990s due to a general upstream shift in the location of X2 (Hilts 2012, unpublished data). The amount of rearing habitat (salinity between 0.1 and 18 ppt) is also presumed to vary with the location of X2 (Baxter *et al.* 2010, p. 64). However, as previously stated, the location of X2 is of particular importance to the distribution of newly-hatched larvae and spawning adults. The influence of water project operations from November through April, when spawning adults and newly-hatched larvae are oriented to X2, is greater in drier years than in wetter years (Knowles 2002, p. 7).

In addition to the effects of reduced freshwater flow on habitat suitability for longfin smelt and other organisms in the Bay-Delta, one of the principal concerns over the biological impacts of these water export facilities has been entrainment of fish and other aquatic organisms. For a detailed discussion, see Factor E: Entrainment Losses, below.

Climate Change

Our analyses under the Endangered Species Act include consideration of ongoing and projected changes in climate. The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007a, p. 78). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007a, p. 78).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions. (For these and other examples, see IPCC 2007a, p. 30; and

Solomon *et al.* 2007, pp. 35–54, 82–85). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is “very likely” (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (IPCC 2007a, pp. 5-6 and figures SPM.3 and SPM.4; Solomon *et al.* 2007, pp. 21–35). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011, p. 4), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (e.g., Meehl et al. 2007, entire; Ganguly *et al.* 2009, pp. 11555, 15558; Prinn *et al.* 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (IPCC 2007a, pp. 44–45; Meehl et al. 2007, pp. 760–764 and 797–811; Ganguly et al. 2009, pp. 15555–15558; Prinn et al. 2011, pp. 527, 529). (See IPCC 2007b, p. 8, for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation. Also see IPCC 2011(entire) for a summary of observations and projections of extreme climate events.)

Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (IPCC 2007a, p. 89; see also Glick *et al.* 2011, pp. 19–22). There is no single method for conducting such analyses that applies to all situations (Glick *et al.* 2011, p. 3). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

Global climate projections are informative, and, in some cases, the only or the best scientific information available for us to use. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (e.g., IPCC 2007a, pp. 8–12). Therefore, we use “downscaled” projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick et al. 2011, pp. 58–61, for a discussion of downscaling). With regard to our analysis for the Bay-Delta longfin smelt DPS, downscaled projections are available.

San Francisco Bay-Delta Climate Change

Climate change may affect the Bay-Delta DPS of longfin smelt habitat as a result of (1) Changes in the timing and availability of freshwater flow into the estuary due to reduced snowpack and earlier melting of the snowpack; (2) sea level rise and saltwater intrusion into the estuary; (3) effects associated with increased water temperatures; and (4) effects related to changes in frequency and intensity of storms, floods, and droughts. It is difficult to evaluate effects related to changes in the timing and availability of freshwater flow into the estuary due to reduced snowpack and earlier melting of the snowpack because these potential effects will likely be impacted to some extent through decisions on water management in the intensively managed Sacramento River-San Joaquin River water basin. Continued sea level rise will result in saltwater intrusion and landward displacement of the low-salinity zone, which would likely negatively affect longfin smelt habitat suitability. Increasing water temperatures would likely affect distribution and movement patterns of longfin smelt in the estuary; longfin smelt may be displaced to locations with deeper and cooler water temperatures. This displacement may result in decreased survival and productivity. Increased frequency and severity of storms, floods, and droughts could result in reduced longfin smelt habitat suitability, but it is difficult to estimate these effects because of uncertainty about the frequency and severity of these events. However, warming may result in more precipitation falling as rain and less storage as snow, increasing winter runoff as spring runoff decreases (USBR 2011, p. 147).

It is uncertain how a change in the timing and duration of freshwater flows will affect longfin smelt. Higher flows in January and February (peak spawning and hatching months) resulting from snow packs that melt sooner and rain-on-snow events could potentially create better spawning and larval rearing conditions. This would reduce adult migration distance and increase areas of freshwater spawning habitat during these months. In addition, the higher turbidity associated with these flows may reduce predation on longfin smelt adults and larvae (Baxter 2011, pers. comm.). However, if high flows last only a short period, benefits may be negated by poorer conditions before and after the high flows.

The National Academy of Sciences (NAS) projected that sea levels along the California coast south of Cape Mendocino will rise 4–30 centimeters (cm) (2–12 inches (in)) by 2030, 12–61 cm (5–24 in) by 2050, and 42–167 cm (16–66 in) by 2100 (NAS 2012, p. 131) compared to 2000 sea levels. Research indicates that the coastal land area south of Cape Mendocino is sinking at an average rate of about 1 millimeter (mm) (.04 in) per year, although Global Positioning System (GPS)-measured rates vary widely (-3.7–0.6 mm per year) (NAS 2012, p. 93). The NAS committee used output from global ocean models under an IPCC (2007) mid-range greenhouse gas emission scenario (NAS 2012, p. 5). However, carbon dioxide emissions from fossil fuels for the past decade have been at the high end of IPCC scenarios owing to rapid economic growth in developing countries (Le Qu´er´e et al. 2009). Because emissions for the last decade have been on the high end of the IPCC scenarios, a maximum rise of 5.48 feet (ft) (167 cm) by 2100 is appropriate for analyzing the impact of sea level rise on longfin smelt. As the freshwater boundary and X2 move farther inland into the Delta with increasing sea level (see below) and reduced flows, adults will need to migrate farther into the Delta to spawn, increasing the risk of predation and the potential for entrainment into water export facilities and diversions for both themselves and their progeny.

Channel Disturbances

Channel maintenance dredging in the Bay-Delta is an ongoing periodic disturbance of longfin smelt habitat, but most activity occurs in areas where longfin smelt are not likely to be present. Dredging and other channel disturbances potentially degrade spawning habitat and cause entrainment loss of individual fish and eggs; disposal of dredge spoils also can create large sediment plumes that expose fish to gill-clogging sediments and possibly to decreased oxygen availability (Levine-Fricke 2004, p. 56). Longfin smelt is a pelagic species (living away from the bottom of the water column and shoreline), and thus less likely to be directly affected by dredging, sand and gravel mining, and other disturbances to the channel bed compared to bottom-dwelling fish species. Longfin smelt are likely most vulnerable to entrainment by dredging during spawning and egg incubation because eggs are deposited and develop on channel bottom substrates (CDFG 2009, p. 27). Egg development takes approximately 40 days (Moyle 2002, p. 236). Sand mining does occur in longfin smelt habitat, but has been reduced in recent years (Barnard 2012, S. 9) although this trend will likely not continue as demand for sand is partly controlled by road and other construction demands. Because spawning substrate is not limited for the species, loss of sand is not expected to result in a decline of the species.

We have found no information documenting population impacts of dredging or sand and gravel mining on longfin smelt. Channel maintenance dredging occurs regularly within the Bay-Delta and other estuaries that serve as shipping channels (e.g., Humboldt Bay, Coos Bay, Yaquina Bay, Columbia River). In their 2009 status review on longfin smelt, CDFW concluded that effects of regular maintenance dredging and sand mining within the Bay-Delta estuary on longfin smelt were expected to be small and localized (CDFG 2009, p. 26). They reviewed two studies on entrainment effects of channel dredging, and each study found that no longfin smelt were entrained during dredging (fish that were entrained were primarily bottom-dwelling species).

Summary of Factor A

In summary, we conclude that the best available scientific and commercial information available indicates that the effects of reduced freshwater flows constitute a threat to the Bay-Delta DPS of longfin smelt. We find that the Bay-Delta DPS of longfin smelt is currently threatened in part due to the present or threatened destruction, modification, or curtailment of its habitat or range due to reduced freshwater flow.

B. Overutilization for commercial, recreational, scientific, or educational purposes:

Commercial and Recreational Take

Because of its status as a threatened species under the California Endangered Species Act, take of longfin smelt in the Bay-Delta is illegal, unless authorized by an incidental take permit or other take authorization. However, longfin smelt are caught as bycatch in a small bay shrimp trawl commercial fishery that operates in South San Francisco Bay, San Pablo Bay, and Carquinez Strait (Hieb 2009, p. 1). CDFG (Hieb 2009, pp. 6, 9) estimated the total longfin smelt bycatch from this fishery from 1989–1990 at 15,539 fish, and in 2004 at 18,815–30,574 fish. The California Department of Fish and Wildlife (CDFW (Formerly CDFG)) noted in 2009 that they thought the bay shrimp trawl fishery had declined since 2004 (Hieb, p. 3) and just recently reported the number of active shrimp permits at less than 10 (Hieb 2011, pers. comm.).

Scientific Take

Within the Bay-Delta, longfin smelt are regularly captured in monitoring surveys. The Interagency Ecological Program (IEP) implements scientific research in the Bay-Delta. Although the focus of its studies and the level of effort have changed over time, in general, their surveys have been directed at researching the Pelagic Organism Decline in the Bay-Delta. Between the years of 1987 to 2011, combined take of longfin smelt less than 20 mm (0.8 in) in length ranged from 2,405 to 158,588 annually. All of these fish were preserved for research or assumed to die in processing. During the same time period, combined take for juveniles and adults (fish greater than or equal to 20 mm (0.8 in)) ranged from 461 to 68,974 annually (IEP 2011). Although mortality is unknown, the majority of these fish likely do not survive. The Chipps Island survey, which is conducted by the Service, has captured an average of 2,697 longfin smelt per year during the past 10 years. Biologists attempt to release these fish unharmed, but at least 5,154 longfin smelt were known to have died during the Chipps Island survey between 2001 and 2008 (Service 2010, entire).

Incidental take from bycatch and monitoring surveys has not been identified as a possible factor related to recent longfin smelt population declines in the Bay-Delta (Baxter *et al.* 2010, pp. 61–69).

CDFG (2009, p. 32) recommended adaptively managing scientific collection of longfin smelt to avoid adverse population effects, and survey methods have been modified recently to minimize potential impacts to delta smelt (75 FR 17669; April 7, 2010). These modifications likely have resulted in reduced impacts to longfin smelt. Based on the best scientific and commercial information, we conclude that the Bay-Delta DPS of longfin smelt is not currently threatened by overutilization for commercial, recreational, scientific, or educational purposes, nor do we anticipate overutilization posing a threat in the future.

C. Disease or predation:

Disease

Little information is available on incidence of disease in the Bay-Delta longfin smelt DPS. Larval and juvenile longfin smelt were collected from the Bay-Delta in 2006 and 2007 and analyzed for signs of disease and parasites (Foott and Stone 2006, entire; Foott and Stone 2007, entire). No significant health problem was detected in either year (Foott and Stone 2007, p. 15). The south Delta is fed by water from the San Joaquin River, where pesticides (e.g., chlorpyrifos, carbofuran, and diazinon), salts (e.g., sodium sulfates), trace elements (boron and selenium), and high levels of total dissolved solids are prevalent due to agricultural runoff (64 FR 5963; February 8, 1999). Pesticides and other toxic chemicals may adversely affect the immune system of longfin smelt and other fish in the Bay-Delta and other estuaries, but we found no information documenting such effects.

Predation

Striped bass were introduced into the Bay-Delta in 1879 and quickly became abundant throughout the estuary. However, their numbers have declined substantially over the last 40 years (Thomson *et al.* 2010, p. 1440), and they are themselves one of the four species studied under Pelagic Organism Decline investigations (Baxter *et al.* 2010, p. 16). Numbers of largemouth bass, another introduced species in the Bay-Delta, have increased in the Delta over the past few decades (Brown and Michniuk 2007, p. 195). Largemouth bass, however, occur in shallow freshwater habitats, closer to shore than the pelagic longfin smelt, and so do not tend to co-occur with longfin for much of their life history. Baxter *et al.* (2010, p. 40) reported that no longfin smelt have been found in largemouth bass stomachs sampled in a recent study of largemouth bass diet. Moyle (2002, p. 238) believed that inland silverside, another nonnative predatory fish, may be an important predator on longfin eggs and larvae, but Rosenfield et al. (2010, p. 18) believed that to be unlikely because inland silversides prefer shallow water habitats where juvenile and subadult longfin smelt are rare.

In the Bay-Delta, predation of longfin smelt may be high in the Clifton Court Forebay, where the SWP water export pumping plant is located (Moyle 2002, p. 238; Baxter *et al.* 2010, p. 42). However, once they are entrained in the Clifton Court Forebay, longfin smelt mortality would be high anyway due to high water temperatures in the Forebay (CDFG 2009b, p. 4) and entrainment into the SWP water export pumping plant. In addition to elevated predation levels in the Clifton Court Forebay, predation also is concentrated at sites where fish salvaged from the SWP and CVP export facilities are released (Moyle 2002, p. 238). However, few longfin smelt survive the salvage and transport process (see Factor E: Entrainment Losses, below), and therefore predation is not expected to be an important factor at drop off sites. As discussed above, reduced freshwater flows may result in lower turbidity and increased water clarity (see discussion under DPS' Factor A), which may contribute to increased risk of predation (Baxter *et al.* 2010, p. 64).

Based on a review of the best available scientific and commercial information, we conclude that disease does not constitute a threat to the Bay-Delta longfin smelt DPS. Available information indicates that Bay-Delta longfin smelt experience elevated levels of predation near the water diversions at the SWP and CVP water export facilities in the south Delta and at the salvage release sites. Reduced freshwater flows resulting from water diversions result in increased water clarity, and increased water clarity may result in increased predation risks to longfin smelt.

In summary, striped bass predation is in decline and largemouth bass predation is unlikely a threat because of the minimal overlap in time and space of largemouth bass and longfin smelt. Therefore, the current rates of predation on longfin smelt are not expected to be having a substantial effect on the overall population level. Based on the best available scientific and commercial information, we conclude that neither disease nor predation is a current or future threat to the Bay-Delta longfin smelt DPS.

D. The inadequacy of existing regulatory mechanisms:

Existing Federal and State regulatory mechanisms include: California Endangered Species Act, Porter-Cologne Water Quality Control Act, California Marine Invasive Species Act, Central Valley Project Improvement Act, and Clean Water Act (including the National Pollutant Discharge Elimination System). Several of these regulatory mechanisms provide important protections for the Bay-Delta DPS of longfin smelt and act to reduce threats, such as reduction of freshwater outflow, the invasion of the overbite clam and ammonia discharges (See Factors A, above, and E, below).

State Laws

California Endangered Species Act: The longfin smelt was listed under the California Endangered Species Act as threatened throughout its range in California on March 5, 2009 (CDFG 2009, p. V).

CESA does allow take of species for otherwise lawful projects through use of an incidental take permit. A take permit requires that impacts be minimized and fully mitigated (CESA sections 2081 (b) and (c)). Furthermore, the CESA ensures through the issuance of a permit for a project that may affect longfin smelt or its habitat, that the project will not jeopardize the continued existence of a State-listed species.

Porter Cologne Water Quality Control Act: The Porter-Cologne Water Quality Control Act is the California State law that establishes the State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards that are responsible for the regulation of activities and factors that could degrade California water quality and for the allocation of surface water rights. The State Water Resources Control Board Water Rights Decision 1641 (D-1641) imposes flow and water quality standards on the State and Federal water export facilities to assure protection of beneficial uses in the Delta (FWS 2008, pp. 21-27). The various flow objectives and export restraints are designed, in part, to protect fisheries. These objectives include specific outflow requirements throughout the year, specific water export restraints in the spring, and water export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal, industrial, and fishery uses; they vary throughout the year and by the wetness of the year. These protections have had limited effectiveness in providing adequate freshwater flows within the Delta. Lack of freshwater outflow continues to be the primary contributing factor to the decline of the longfin smelt in the Bay-Delta (see Factor A, above, for further discussion). In addition to regulating freshwater outflow, the Porter Cologne Water Quality Control Act also regulates contaminants released into the delta (see Clean Water Act).

California Marine Invasive Species Act : The California Marine Invasive Species Act requires ballast water management for all vessels that intend to discharge ballast water in California waters. All qualifying vessels coming from ports within the Pacific Coast region must conduct an exchange in waters at least 50 nautical mi offshore and 200 m (656 ft) deep or retain all ballast water and associated sediments. To determine the effectiveness of the management provisions of the this State act, the legislation also requires State agencies to conduct a series of biological surveys to monitor new introductions to coastal and estuarine waters. These measures should further minimize the introduction of new invasive species into California’s coastal waters that could be a threat to the longfin smelt.

Federal Laws

National Environmental Policy Act: The National Environmental Policy Act (NEPA) (42 U.S.C. 4321 *et seq.*) requires all Federal agencies to formally document, consider, and publicly disclose the environmental impacts of major Federal actions and management decisions significantly affecting the human environment. NEPA documentation is provided in an environmental impact statement, an environmental assessment, or a categorical exclusion, and may be subject to administrative or judicial appeal. However, the Federal agency is not required to select an alternative having the least significant environmental impacts, and may select an action that will adversely affect sensitive species provided that these effects are known and identified in a NEPA document. Therefore, we do not consider the NEPA process in itself to be a regulatory mechanism that is certain to provide significant protection for the longfin smelt.

Central Valley Project Improvement Act: The Central Valley Project Improvement Act amends the previous Central Valley Project authorizations to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic uses, and fish and wildlife enhancement as having an equal priority with power generation. Included in CVPIA section 3406 (b)(2) was a provision to dedicate 800,000 acre-feet of Central Valley Project yield annually (referred to as “(b)(2) water”) for fish, wildlife, and habitat restoration. Since 1993, (b)(2) water has been used and supplemented with acquired environmental water (Environmental Water Account and CVPIA section 3406 (b)(3) water) to increase stream flows and reduce Central Valley Project export pumping in the Delta. These management actions were taken to contribute to the CVPIA salmonid population doubling goals and to protect delta smelt and their habitat (Guinee 2011, pers. comm.). As discussed above (under Biology and Factor A), increased freshwater flows have been shown to be positively correlated with longfin smelt abundance; therefore, these management actions, although targeted towards other species, should also benefit longfin smelt.

Clean Water Act: The Clean Water Act (CWA) provides the basis for the National Pollutant Discharge Elimination System (NPDES). The CWA gives the EPA the authority to set effluent limits and requires any entity discharging pollutants to obtain a NPDES permit. The EPA is authorized through the CWA to delegate the authority to issue NPDES Permits to State governments. In States that have been authorized to implement CWA programs, the EPA still retains oversight responsibilities (EPA 2011, p. 1). California is one of these States to which the EPA has delegated CWA authority. The Porter-Cologne Water Quality Control Act established the California State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards that are now responsible for issuing these NPDES permits, including permits for the discharge of effluents such as ammonia. The SWRCB is responsible for regulating activities and factors that could degrade California water quality (California Water Code Division 7, section 13370-13389).

The release of ammonia into the estuary is having detrimental effects on the Delta ecosystem and food chain (see Factor E, below). There is currently no TMDL in place for ammonia discharge into the Sacramento watershed. The release of ammonia is controlled primarily by the CWA (Federal law) and secondarily through the Porter-Cologne Water Quality Control Act (State law). EPA is currently updating freshwater discharge criteria that will include new limits on ammonia (EPA 2009, pp. 1-46). An NPDES permit for the Sacramento Regional Wastewater Treatment Plant, a major discharger, was prepared by the California Central Valley Regional Water Quality Control Board in the fall of 2010, with new ammonia limitations intended to reduce loadings to the Delta. The new ammonia limits will take effect in 2020. Until that time, CWA protections for longfin smelt are limited, and do not reduce the current threat to longfin smelt.

Summary of Factor D

The continued decline in indices of longfin smelt abundance in the Bay-Delta suggest that existing regulatory mechanisms, as currently implemented, are not adequate to reduce threats to the species. Therefore, based on a review of the best scientific information available, we find existing regulatory mechanisms are either not sufficient or may not be addressing key threats to the species.

E. Other natural or manmade factors affecting its continued existence:

Other factors affecting the continued existence of the Bay-Delta DPS of longfin smelt are entrainment losses due to water diversions, introduced species, and contaminants.

Agricultural Diversions: Water is diverted at numerous sites throughout the Bay-Delta for agricultural irrigation. Herren and Kawasaki (2001) reported over 2,200 such water diversions within the Delta, but CDFG (2009, p. 25) notes that number may be high because Herren and Kawasaki (2001) did not accurately distinguish intake siphons and pumps from discharge pipes. CALFED's Ecosystem Restoration Program (ERP) includes a program to screen remaining unscreened small agricultural diversions in the Delta and the Sacramento and San Joaquin Rivers. The purpose of screening fish diversions is to prevent entrainment losses; however, very little information is available on the efficacy of screening these diversions (Moyle and Israel 2005, p. 20). Agricultural operations begin to divert water in March and April, and many longfin smelt have begun leaving the Delta by this time. Water diversions are primarily located on the edge of channels and along river banks. Longfin smelt are a pelagic fish species and tend to occupy the middle of the channel and the middle of the water column, where they are unlikely to be vulnerable to entrainment into these diversions.

Power Plants: Two power plants located near the confluence of the Sacramento and San Joaquin Rivers, the Contra Costa Generating Station and the Pittsburg Generating Station, pose an entrainment risk to longfin smelt. Past entrainment losses of delta smelt at these two facilities were significant and considered a threat to delta smelt (75 FR 17671; April 7, 2010). Power plant operations have been substantially reduced since the late 1970s, when high entrainment and impingement were documented (CDFG 2009, p. 24); the power plants are now either kept offline or operating at very low levels, except as necessary to meet peak power needs. From 2007–2010, capacity utilization of these units averaged only 2.3 percent of maximum capacity. No longfin smelt were detected during impingement sampling conducted between May of 2010 and April of 2011 to monitor entrainment losses at the two power plants (Tenera Environmental 2011, entire). The company that owns the two power plants has retired one of the two power stations (Contra Costa Generating Station) (Hansen 2013, pers. comm.).

Water Export Facilities: The four State and Federal water export facilities (pumping stations) in the Delta are the State Water Project (SWP) facility in the south Delta, the Central Valley Project (CVP) in the south Delta, the Contra Costa facility in the south Delta, and the North Bay Aqueduct facility in the north Delta. The SWP and CVP facilities pump the majority of the water exported from the Delta. Average annual volumes of water exported from these facilities between 1995 and 2005 were 3.60 km3 at the SWP facility, 3.10 km3 at the CVP facility, 0.15 km3 at the Contra Costa facility, and 0.05 km3 at the North Bay Aqueduct facility (Sommer *et al.* 2007, p. 272). Depending on upstream flow through the Delta, operation of the SWP and CVP facilities often causes reverse flows in the river channels leading to them; longfin smelt that occupy these channels during certain times of the year may be entrained by these reverse flows. The SWP and CVP water export facilities are equipped with their own fish collection facilities that divert entrained fish into holding pens using louver-bypass systems to protect them from being killed in the pumps. The fish collected at the facilities are referred to as "salvaged," and are loaded onto tanker trucks and returned to the western Delta downstream (Aasen 2009, p. 36). The movement of fish can result in mortality due to overcrowding in the tanks, stress, moving procedures, or predation at locations where the fish are released. Salvage is an index of entrainment, not an estimate, and is much smaller than total entrainment (Castillo *et al.* in review). Of spawning age fish (age-1 and age-2), which contribute most to longfin smelt population dynamics in the Bay-Delta, the total number of longfin smelt salvaged at both pumps between 1993 and 2007 was 1,133 (CDFG 2009, Attachment 3, p. 2).

Fish entering the intake channel of the CVP or the radial gates of the 31,000-acre Clifton Court Forebay reservoir (SWP) are considered entrained (Fujimura 2009, p. 5; CDFG 2009b, p. 2). Most longfin smelt that become entrained in Clifton Court Forebay are unable to escape (CDFG 2009b, p. 4). The number of fish entrained at the SWP and CVP facilities has never been determined directly, but entrainment losses have been estimated indirectly using data from research and monitoring efforts. The magnitude of entrainment of larval longfin smelt is unknown because only fish greater than 20 mm in length are salvaged at the two facilities (Baxter et al. 2008, p. 21). In years with low freshwater flows, approximately half of the longfin smelt larvae and early juveniles may remain for weeks within the Sacramento-San Joaquin Delta (Dege and Brown 2004), where model simulations indicate they are vulnerable to entrainment into State Water Project, Central Valley Project, and other diversions (Kimmerer and Nobriga 2008, CDFG 2009a, p. 8).

Entrainment Losses Due to Water Diversions

Entrainment losses at the SWP and CVP water export facilities are a known source of mortality of longfin smelt and other pelagic fish species in the Bay Delta , although the full magnitude of entrainment losses and population-level implications of these losses have not been quantified. Elevated salvage of longfin smelt and other Bay-Delta pelagic fish between 2000 and 2005 corresponded with high volumes of water exports during winter (Baxter *et al.* 2010, p. 63). Baxter *et al.* (2010, p. 62) hypothesized that entrainment can impact the longfin smelt population during winter, particularly during years with low freshwater flows when a higher proportion of the population may spawn farther upstream in the Delta. However, Baxter et al. (2010, p. 63) conclude that these losses have yet to be placed in a population context, and no conclusions were drawn regarding their effects on recent longfin smelt abundance. CDFG (2009, p. 22) believes that efforts to reduce past delta smelt entrainment loss through the implementation of the 2008 delta smelt biological opinion for SWP and CVP operations may have reduced longfin smelt entrainment losses, incidentally providing a benefit to the longfin smelt. These efforts to manage entrainment losses in drier years, when entrainment risk is greater, substantially reduce entrainment of longfin smelt of all life stages.

Fujimura (2009) estimated cumulative longfin smelt entrainment at the SWP facility between 1993 and 2008 at 1,376,432 juveniles and 11,054 adults, and estimated that 97.6 percent of juveniles and 95 percent of adults entrained were lost. Fujimura (2009) estimated cumulative longfin entrainment at the CVP facility between 1993 and 2008 at 224,606 juveniles and 1,325 adults, and estimated that 85.2 percent of the juveniles and 82.1 percent of the adults entrained were lost showing that a large majority of salvage is unsuccessful. These estimated losses are 4 times higher than observed salvage at the CVP and 21 times higher than the actual salvage numbers at the SWP (Fujimura 2009, p. 2). The estimated entrainment numbers were much higher than the actual salvage numbers at the SWP, due in large part to the assumption that there are high pre-screen losses in the Clifton Court Forebay (CDFG 2009a, p. 21). It should be noted that these estimates were calculated using equations and parameters devised for other species and may not accurately estimate longfin smelt losses. Further, estimates may be misleading because the majority of estimated losses occurred during the dry year of 2002 (1.1 million juveniles estimated at the SWP) while during all other years estimated entrainment was below 70,000 individuals.

Old and Middle river flow limits in the NMFS and USFWS Biological Opinions and the existing CESA regulations for longfin smelt have reduced longfin smelt entrainment losses. The comparatively high salvage that occurred in 2002 is unlikely to recur under the current Old and Middle river flow limits in the NMFS and USFWS Biological Opinions and the CESA regulations (see Factor D discussion, above).

Longfin smelt congregate in deep waters in the vicinity of the low salinity zone (LSZ) near X2 during the spawning period, and it is thought that they make short runs upstream, possibly at night, to spawn from these locations (CDFG 2009, p. 12; Rosenfield 2010, p. 8). Adult longfin smelt can be entrained as a result of these spawning migrations; larvae and juveniles can be entrained when they rear in the Delta. Entrainment in the water export facilities in the Delta and losses are elevated during dry years when X2 is upstream and export volumes from the CVP and SWP pumps are high (Grimaldo *et al.* 2009, pp. 1260-1261, Rosenfield 2010, p. 19). However, the best available science suggests that the vast majority of longfin smelt do not spawn or rear in areas of the Delta (CDFW 2013, no pagination) where they or their progeny are in danger of entrainment in the majority of years and current regulations have likely reduced longfin smelt entrainment.

Introduced Species

In Suisun Bay, a key longfin smelt rearing area, phytoplankton biomass is influenced by the overbite or Amur River clam (*Potamocorbula amurensis*). A sharp decline in phytoplankton biomass occurred following the invasion of the estuary by this species, even though nutrients were not found to be limiting (Alpine and Cloern 1992, pp. 950–951). Abundance of zooplankton decreased across several taxa, and peaks that formerly occurred in time and space were absent, reduced or relocated after 1987 (Kimmerer and Orsi 1996, p. 412). The general decline in phytoplankton and zooplankton is likely affecting longfin smelt by decreasing food supply for their prey species, such as opossum shrimp (*Neomysis mercedis*) (Kimmerer and Orsi 1996, pp. 418–419). Models indicate that the longfin smelt abundance index has been on a steady linear decline since about the time of the invasion of the nonnative overbite clam in 1987 (Rosenfield and Swanson 2010, p. 14).

Given the observed negative association between the introduction of the overbite clam and longfin smelt abundance in the Bay-Delta and the documented decline of key longfin smelt prey items, we consider the current overbite clam population to be a threat to the Bay-Delta DPS of longfin smelt. Based on the observed associations in the Bay-Delta between overbite clam invasion and longfin abundance and the lack of effective control mechanisms, we expect the degree of this threat will continue into the foreseeable future. The Bay-Delta has numerous other invasive species that have disrupted ecosystem dynamics; however, only the overbite clam has been shown to have an impact on the longfin smelt population. We consider the overbite clam to be an ongoing threat to the Bay-Delta longfin smelt population.

Contaminants

In 2009, over 15 million pounds of pesticides were applied within the five-county Bay-Delta area and Bay-Delta waters are listed as impaired for several legacy and currently used pesticides under the Clean Water Act section 303(d) (California Department of Pesticide Regulation 2011, p. 1). Concentrations of dissolved pesticides vary in the Delta both temporally and spatially (Kuivila 2000, p. 1). Several areas of the Delta, particularly the San Joaquin River and its tributaries, are impaired due to elevated levels of diazinon and chlorpyrifos, which are toxic at low concentrations to some aquatic organisms (MacCoy et al. 1995, pp. 21–30). Several studies have demonstrated the acute and chronic toxicity of two common dormant-spray insecticides, diazinon and esfenvalerate, in fish species (Barry *et al.* 1995, p. 273; Goodman *et al.* 1979, p. 479; Holdway et al.; 1994, p. 169; Scholz et al. 2000, p. 1911; Tanner and Knuth 1996, p. 244).

Extensive research on the role of contaminants in the Pelagic Organism Decline is currently being conducted (Baxter et al. 2010, pp. 28–36). Of potential concern are effects of high levels of mercury and other metals; high ammonium concentrations from municipal wastewater; potentially harmful cyanobacteria algal blooms; and pesticides, especially pyrethroid pesticides, which are heavily used in San Joaquin Valley agriculture. Contaminants may have direct toxic effects to longfin smelt and other pelagic fish and indirect effects as a result of impacts to prey abundance and composition. Ammonium has been shown to impact longfin smelt habitat by affecting primary production and prey abundance within the Bay-Delta (Dugdale et al. 2007, p. 26). While contaminants are suspected of playing a role in declines of pelagic fish species in the Bay-Delta (Baxter et al. 2010, p. 28), contaminant effects remain unresolved.

Ammonia is un-ionized and has the chemical formula NH_3. Ammonium is ionized and has the formula NH_4^+. The major factors determining the proportion of ammonia or ammonium in water are water pH and temperature. This is important, as NH_3 ammonia is the form that can be directly toxic to aquatic organisms, and NH_4^+ ammonium is the form documented to interfere with uptake of nitrates by phytoplankton (Dugdale et al. 2007, p. 17; Jassby 2008, p. 3).

In addition to direct effects on fish, ammonia in the form of ammonium has been shown to reduce primary production by inhibiting nitrate uptake and suppressing spring phytoplankton blooms in Suisun and Grizzly Bays (Dugdale *et al.* 2007, pp. 26–28). The role of ammonium nitrogen uptake inhibition in Sacramento River primary production is less certain than in the Bays. Parker et al. (2012, pp. 577–580) observed primary production in the Sacramento River decreased in the SRWTP region as compared to the upper river region during the months of March and April. However, a previous study found that chlorophyll declines above the SRWTP between the Tower Bridge in Sacramento and Garcia Bend (Foe *et al.* 2010, p. 13). The application of general ecological principles would lead us to believe that decreased primary productivity, wherever it occurs in longfin smelt habitat, is likely to lead to a decrease in copepods and other zooplankton that longfin smelt rely upon for food. A link between primary productivity and productivity in higher trophic levels has been documented in various pelagic food webs (Nixon 1988, Sobczak et al. 2005), although it has not been shown specifically in the San Francisco Bay-Delta. Kimmerer 2008 (p. 24) showed a statistically significant relationship between juvenile delta smelt survival and zooplankton biomass over the long term. In summary, although no direct link has been made between contaminants and longfin smelt (Baxter et al. 2010, p. 68), ammonium has been shown to have a direct effect on the food supply that the Bay-Delta longfin smelt DPS relies upon. Therefore, we conclude that high ammonium concentrations may be a current and future threat to the Bay-Delta DPS of longfin smelt.

Summary of Factor E

The best available information indicates that introduced species constitute a threat to the Bay-Delta DPS of longfin smelt, and that contaminants (high ammonium concentrations) may constitute a threat to the Bay-Delta DPS of longfin smelt. Therefore, based on the best scientific evidence available, we conclude that the Bay-Delta longfin smelt DPS is threatened in part due to other natural or manmade factors including the nonnative overbite clam and high ammonium concentrations.

Conservation Measures Planned or Implemented :

Bay-Delta

The CALFED Ecosystem Restoration Program (ERP) developed a strategic plan for implementing an ecosystem-based approach for achieving conservation targets (CALFED 2000a, pp. 1–3). The CDFW is the primary implementing agency for the ERP. The goal of ERP in improving conditions for longfin smelt will carry forward, irrespective of the species' Federal listing status. CALFED had an explicit goal to balance the water supply program elements with the restoration of the Bay-Delta and tributary ecosystems and recovery of the longfin smelt and other species. Because achieving the diverse goals of the program is iterative and subject to annual funding by diverse agencies, the CALFED agencies have committed to maintaining balanced implementation of the program within an adaptive management framework. The intention of this framework is that the storage, conveyance, and levee program elements would be implemented in such a way that the longfin smelt's status would be maintained and eventually improved.

The Bay-Delta Conservation Plan (BDCP), an effort to help provide restoration of the Bay-Delta ecosystem and reliable water supplies, is currently in preparation by a collaborative effort between water agencies, resource agencies, and environmental groups. The BDCP is intended to provide a basis for permitting take of listed species under sections 7 and 10 of the Act and the California Natural Communities Conservation Planning Act, and would provide a comprehensive habitat conservation and restoration plan for the Bay-Delta, as well as a new funding source. The BDCP shares many of the same goals outlined in the 2000 CALFED Record of Decision (CALFED 2000) but would not specifically address all listed-species issues. The BDCP would, however, target many of the threats to current and future listed species and could contribute to species recovery. However, the BDCP, if completed, would not be initiated until at least 2014 or later. The plan's implementation is anticipated to extend through 2060.

Summary of Threats :

This status review identified threats to the Bay-Delta DPS of longfin smelt attributable to Factors A, D, and E, as well as interactions between these threats. The primary threat to the DPS is from reduced freshwater flows. Upstream dams and water storage, exacerbated by water diversions, especially from the SWP and CVP water export facilities, result in reduced freshwater flows within the estuary, and these reductions in freshwater flows result in reduced habitat suitability for longfin smelt (Factor A). Freshwater flows, especially winter-spring flows, are significantly correlated with longfin smelt abundance—longfin smelt abundance is lower when winter-spring flows are lower. While freshwater flows have been shown to be significantly correlated with longfin smelt abundance, causal mechanisms underlying this correlation are still not fully understood and are the subject of ongoing research on the Pelagic Organism Decline.

In addition to the threat caused by reduced freshwater flow into the Bay-Delta, and alteration of natural flow regimes resulting from water storage and diversion, there appear to be other factors contributing to the Pelagic Organism Decline (Baxter 2010 et al., p. 69). Models indicate a steady linear decline in abundance of longfin smelt since about the time of the invasion of the nonnative overbite clam in 1987 (Rosenfield and Swanson 2010, pp. 13–14; see Factor E: Introduced Species) in the Bay-Delta. However, not all aspects of the longfin smelt decline can be attributed to the overbite clam invasion, as a decline in abundance of pre-spawning adults in Suisun Marsh occurred before the invasion of the clam, and a partial rebound in longfin smelt abundance occurred in the early 2000s (Rosenfield and Baxter 2007, p. 1589).

The long-term decline in abundance of longfin smelt in the Bay-Delta has been partially attributed to reductions in food availability and disruptions of the Bay-Delta food web caused by establishment of the nonnative overbite clam in 1987 (Factor E) and ammonium concentrations (Factor E). Impacts of the overbite clam and ammonium on the Bay-Delta food web have been long-lasting and are ongoing. We conclude that ongoing disruptions of the food web caused by the overbite clam are a threat to the continued existence of the Bay-Delta DPS of longfin smelt. We also conclude that high ammonium concentrations in the Bay-Delta may constitute a threat to the continued existence of the Bay-Delta DPS of longfin smelt.

Multiple existing Federal and State regulatory mechanisms provide important protections for the Bay-Delta DPS of longfin smelt and act to reduce threats to the DPS. However, the continued decline in the abundance of the Bay-Delta longfin smelt DPS indicates that existing regulatory mechanisms, as currently implemented, are not adequate to sufficiently reduce threats identified in this finding. Therefore, we find that inadequate existing regulatory mechanisms contribute to threats faced by the Bay-Delta longfin smelt DPS.

The threats identified are likely acting together to contribute to the decline of the population (Baxter et al. 2010, p. 69). Reduced freshwater flows result in effects to longfin smelt habitat suitability, at the same time that the food web has been altered by introduced species and ammonium concentrations. It is possible that climate change could exacerbate these threats. The combined effects of reduced freshwater flows, the invasive overbite clam (reduced levels of phytoplankton and zooplankton that are important to the Bay-Delta food web), and high ammonium concentrations act to significantly reduce habitat suitability for longfin smelt.

The best scientific and commercial information available indicates that the threats facing the Bay-Delta DPS of longfin smelt are of sufficient imminence, intensity, and magnitude to threaten the continued existence of the species now or in the foreseeable future. Therefore, we find that listing the Bay-Delta longfin smelt DPS is warranted. We will make a determination on the status of the DPS as endangered or threatened when we prepare a proposed listing determination. However, as explained in more detail below, an immediate proposal of a regulation implementing this action is precluded by higher priority listing actions, and progress is being made to add or remove qualified species from the Lists of Endangered and Threatened Wildlife and Plants.
We reviewed the available information to determine if the existing and foreseeable threats render the species at risk of extinction now such that issuing an emergency regulation temporarily listing the species under section 4(b)(7) of the Act is warranted. We determined that issuing an emergency regulation temporarily listing the DPS is not warranted at this time because the threats are not of sufficient magnitude and imminence to pose an immediate threat to the continued existence of the DPS. However, if at any time we determine that issuing an emergency regulation temporarily listing the Bay-Delta DPS of longfin smelt is warranted, we will initiate this action at that time.

For species that are being removed from candidate status:

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

Recommended Conservation Measures :

Increasing Delta outflows so that they more closely approximate unimpaired flows in the watershed would address several needs of the longfin smelt, likely improving habitat quality and quantity. Furthermore, increased winter and spring flows may reduce water clarity, which would increase habitat quality for longfin smelt. Contaminant reduction within the Bay-Delta could improve primary productivity while at the same time limiting toxicity exposure to longfin smelt. Reducing ammonia concentrations from the Sacramento Waste Water Treatment Plant may help to increase primary productivity within the Bay-Delta, resulting in better longfin smelt growth and survival. The reduction of pesticides entering the Delta could also improve habitat conditions. Therefore, the FWS recommends the reduction of contaminants entering the estuary.

Priority Table

Magnitude	Immediacy	Taxonomy	Priority
High	**Imminent**	Monotypic genus	1
		Species	2
		Subspecies/Population	**3**
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/Population	6
Moderate to Low	Imminent	Monotype genus	7
		Species	8
		Subspecies/Population	9
	Non-Imminent	Monotype genus	10
		Species	11
		Subspecies/Population	12

Rationale for Change in Listing Priority Number:

Magnitude:

The magnitude of threats is high due to a number of ongoing threats. These threats include lack of freshwater flow and the invasive species overbite clam. Ammonia in the form of ammonium may also be a threat to the survival of longfin smelt. The ecology and biology of the San Francisco Bay-Delta has changed drastically over the last 100 years. Although a number of conservation measures have been put in place to protect the Bay-Delta DPS of longfin smelt and its habitat, the population continues to decline. Changes in the position of the low salinity zone in the Bay-Delta have altered foraging and breeding habitat. Although this threat does not extend throughout the range of the Bay-Delta DPS of longfin smelt, it does encompass areas that are key to the longfin smelt's survival, including Suisun Marsh and Suisun Bay. Longfin smelt numbers have declined to a fraction of what they were before these changes took place. Stress from water pumping operations and invasive species is expected to continue into the future as water demands for an ever-growing population in California continue to grow.

Imminence :

The threats discussed above are ongoing and likely to continue into the future. We therefore consider threats to be imminent.

__Yes__ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

Emergency Listing Review

__No__ Is Emergency Listing Warranted?

Description of Monitoring:

There are several ongoing fish monitoring efforts in the Bay-Delta that provide seasonal longfin smelt abundance and distribution data. These efforts are led primarily by the Interagency Ecological Program (IEP), an interagency entity made up of State, Federal- and non-government agencies that work collaboratively to oversee data collection and scientific analysis in the Bay-Delta. The IEP implements a suite of ecological investigations, and in 2005, the IEP initiated an effort to research the Pelagic Organism Decline (POD), concentrating resources on gaining an understanding of the precipitous declines in abundance of delta smelt, longfin smelt, striped bass and threadfin shad. Several of the IEP's field investigations provide annual longfin smelt abundance and distribution data, including the San Francisco Bay study, surveys of the Delta juvenile fish monitoring program, the spring Kodiak trawl, the smelt larva survey, the 20mm survey, the summer townet survey, and the fall midwater trawl (see table). Additionally, the IEP leads several research efforts that include studying the effects of contaminants, invasive species, export pump entrainment and freshwater outflow on the POD species. Although the focus of its studies and the level of effort have changed over time, in general, data from the IEP surveys have provided information on the decline of longfin smelt in the Bay-Delta. In 2009, the IEP's Delta Smelt Larva Survey was redesigned to specifically target longfin smelt for the purpose of assessing entrainment risk as it pertains to water operations in the Bay-Delta.

An additional source of information on longfin smelt comes from data collected during fish salvage operations at the State and Federal pumping facilities located in the south Delta. The number of longfin smelt salvaged at the pumping facilities can be used to provide an annual index of entrainment into the diversion pumps.

Survey	Lead Agency	Target Species	Season of Sample	Frequency
San Francisco Bay Study	CDFW	General Species Composition	Jan-Dec	Monthly
Delta Juvenile Fish Monitoring Program	USFWS	Juvenile Chinook*	Jan-Dec	Weekly
Kodiak Spring Trawl	CDFW	Delta Smelt	Jan-May	Monthly
Smelt Larva Survey	CDFW	Longfin Smelt**	Jan-March	Biweekly
20mm Survey	CDFW	Delta Smelt	March-July	Biweekly
Summer Townet Survey	CDFW	Striped Bass***	June-Aug	Biweekly
Fall Midwater Trawl	CDFW	Striped Bass***	Sept-Dec	Monthly

* In 2001, DJFMP was expanded to include monitoring objectives for many species of juvenile fishes in the Delta.

** The SLS was originally a delta smelt-targeted pilot study, with a study design that changed from year to year. In 2009, the SLS was redesigned to collect longfin smelt distribution data for the purpose of providing recommendations for water operations in the Delta.
*** The FMWT and TNS were originally implemented to monitor distribution and abundance of striped bass. These surveys also collect information on the distribution and abundance of longfin smelt.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

California

Indicate which State(s) did not provide any information or comment:

none

State Coordination:

Much of the coordination has been done through the Interagency Ecological Program and includes research and abundance surveys (See Description of Monitoring above). In addition, the Ecological Services Program and the Assistant Regional Director for Ecological Services meets with the California Department of Fish and Wildlife regarding listing and reclassification actions in the State.

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Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: 06/12/2015
Date

Concur: 12/15/2015
Date

Did not concur: ______________________ ________
Date

Director's Remarks: