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:

06/27/2016

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

___ 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.

___ Insufficient information exists on taxonomy, or biological vulnerability and threats, to support listing

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**: Alameda, CA, Colusa, CA, Contra Costa, CA, Marin, CA, Napa, CA, Sacramento, CA, San Francisco, CA, San Joaquin, CA, San Mateo, CA, Santa Clara, CA, Solano, CA, Sonoma, CA, Stanislaus, CA, Sutter, CA, Yolo, CA
- **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.

Lead Region Contact:

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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 (jaw) bones (in adults, these bones extend past the middle 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 extant (currently existing) 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 in the Bay-Delta are considered pelagic and facultatively anadromous (Moyle 2002, p. 236). Within the Bay-Delta, the term pelagic refers to organisms that occur in open water away from shorelines and in-water structures. Anadromous fishes are spawned in fresh water, but migrate to the ocean, usually as juveniles. A facultatively anadromous organism can choose whether to migrate to the ocean or not and may change its migratory behavior depending on variable environmental conditions. Certain longfin smelt populations are not anadromous at all and complete their entire life cycle in freshwater lakes and streams (see Lake Washington Population section below). Juvenile and adult longfin smelt have been found throughout the year in salinities ranging from freshwater (salinity < 0.5) to seawater (salinity > 30), although once they reach the juvenile life stage, they are typically collected in waters with salinities ranging from 14 to at least 28

(Baxter 1999, pp. 189–192). In the Practical Salinity Scale, salinity is defined as a pure ratio, and has no dimensions or units, but it is synonymous with the parts per thousand notation used in older texts. 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 or into coastal waters during the summer months, to avoid warming water. Within the Bay-Delta, adult longfin smelt spawning starts when waters drop below 16 °C (60.8F) and becomes consistent when water temperatures reach 13°C (55.4F) (CDFG 2009, p. 11). However, recent studies indicate successful spawning may require temperatures of 13° C (55.4F) or lower (Baxter 2016, pers. comm.). Minimum spawning temperature of 5.6C (41F) was required in lab studies (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). The spawning period of longfin smelt in the Bay-Delta may begin as early as November and last until as late as June, although spawning typically occurs from January to April (CDFG 2009, p. 10; Moyle 2002, p. 36). 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).

Longfin smelt are known to spawn over sandy substrates in tributaries to Lake Washington and likely prefer similar substrates for spawning in the Bay-Delta (Baxter et al. 2010, p. 62; Sibley and Brocksmith 1995, pp. 32–74). However, exact spawning locations likely vary in location from year to year, depending primarily on the distribution of salinity at the time of spawning. Longfin smelt aggregate in deep waters in the vicinity of the low salinity zone (LSZ) near X2 (see definition below) during the spawning period, and it has been assumed that they make short runs upstream, possibly at night, to spawn in fresh water from these low-salinity staging locations (CDFG 2009, p. 12; Rosenfield 2010, p. 8). However, recent unpublished analyses of larval catch data suggest spawning may also occur in the low-salinity zone (LSZ) itself because the adults and their larvae have similar distributions, which suggests that the adult fish are spawning near where they are collected. In the Bay-Delta, the LSZ has been defined as the area where salinities range from 0.5 to 6 (Kimmerer 1998, p. 1). X2, a variable location within the LSZ used as an estuarine habitat indicator, 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 (Jassby et al. 1995, p. 274; Dege and Brown 2004, p. 51).

In the Bay-Delta, longfin smelt are believed to spawn where conditions are favorable for offspring survival. These locations likely vary depending on the amount of freshwater outflow and the location of the LSZ because this variation affects where water of salinities suitable for spawning is located. In all years, longfin smelt are likely spawning in the Delta, Suisun Marsh and Suisun Bay. In dry years, longfin smelt can spawn in the upper Sacramento River and have been observed as far up as Colusa State Park (Baxter 2010, p. 7). In wet years when outflow is higher and the salinity gradient is pushed downstream, they also spawn in tributaries to San Pablo Bay. Recent findings have found that longfin smelt are now likely attempting to spawn in tributaries of the south Bay near recent restoration project locations, although no larvae have been confirmed at this location (Hobbs et al. 2012b, pg. 40). Longfin smelt larvae are dispersed throughout the Bay-Delta by river net flows and tidal currents, which can facilitate rapid transport of larvae and juveniles long distances, particularly when outflows are high (CDFG 2009, p. 8). However, data from the CDFW's 20-mm Survey suggest a peak of larval distribution near X2 (Dege and Brown 2004, p. 57-58). Merz et al. (2013, p. 142) aggregated survey data of juvenile longfin smelt detections within the estuary to map a large rearing zone that spreads throughout most of the Bay-Delta, illustrating the full estuary extent of potential longfin smelt nursery habitat. However, these authors averaged data across many years of highly varying freshwater flows, so not all of the sites shown to be occupied by young longfin smelt can always be occupied. Further, Hobbs et al. (2010) presented evidence based on the chemicals in longfin smelt otoliths (ear bones) that larvae rearing close to X2 have considerably higher survival than larvae rearing at lower and high salinity.

Larval longfin smelt less than 10-12 millimeters (mm) (0.5 in) in length are buoyant because they have not yet developed an air bladder; as a result, they mostly occupy the upper portion of the water column and are vulnerable to surface currents (CDFG 2009, p. 8; Baxter 2011a, pers. comm., Bennett 2002, p. 1501). Longfin smelt develop an air bladder at approximately 12–15 mm (0.5–0.6 in.) in length and at this time tend to occupy the lower portion of the water column. They exhibit more variable use of the water column and are able to migrate vertically and laterally with their zooplankton prey (CDFG 2009, p. 8; Baxter 2008, p. 1, Bennett 2002, p. 1501, Hobbs et al. 2006, p. 918). In the LSZ, longfin smelt exhibit daily vertical migrations based on ebb and flood tide cycles (Bennett et al. 2002, p. 1501, Hobbs et al. 2006, p. 917).

Newly hatched longfin smelt larvae can likely tolerate salinities of ~0–6, and can tolerate salinities up to 8 within weeks of hatching (Baxter 2011a, pers. comm.). Very few larvae (individuals less than 20 mm in length) are found in salinities greater than 8, and it can take nearly 3 months for longfin smelt to reach the juvenile stage.

Some longfin smelt remain in the estuary for their entire life cycle (Rosenfield and Baxter 2007, p 1590, Merz et al. 2013, p. 142), while an unknown portion make their way to the ocean 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 fall or 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 confirmed 3-year old longfin smelt have been observed in the coastal ocean (Baxter 2011d, pers. comm.; Service 2011, unpublished data). 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 (Moyle 2010, p. 8) or may be responding 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 affinis*, 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) (Hobbs et al. 2006, p. 914; 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, which typically occurs during their first summer of life (Dryfoos 1965; Chigbu and Sibley 1998a and 1998b; Hobbs et al. 2006). 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. However, in the LSZ, which is turbid, these crustaceans have been reported to migrate vertically in response to tidal currents rather than darkness (Kimmerer et al. 1998, p. 1704).

Habitat

The Bay-Delta is the largest estuary on the West Coast of the continental United States (Sommer et al. 2007, p. 271). The modern Bay-Delta bears only a superficial resemblance to the historical Bay-Delta (Whipple et al. 2012). 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 and rock-reinforced levees (Moyle 2002, p. 32). The watershed, which drains approximately 40 percent of the land area of California, has been heavily altered by dams and water diversions. In the upper estuary, nonnative species now dominate the fish assemblages, both in terms of numbers of species and numbers of individuals (Matern et al. 2002, Nobriga et al. 2005, Feyrer and Healy 2003). The Bay Institute has estimated that intertidal wetlands in the Bay-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). 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 in San Francisco Bay (including San Pablo and South bays) are highly salt-tolerant and include the commercially important Pacific sardine (Sardinops sagax) and rockfish (Sebastes spp.). In the estuary east of San Pablo Bay, major habitat types include riverine and tidal wetlands, mud flat, and salt marsh, with substantial areas of diked wetlands managed for waterfowl hunting in Suisun Marsh. The sandy substrates that longfin smelt are presumed to use for spawning are abundant in the Delta and Suisun Bay (Nobriga pers comm. 2015).

Historical Range/Distribution:

Longfin smelt have been collected throughout the Bay-Delta and occasionally even upstream of the Delta. Longfin smelt have been observed in their winter and spring spawning period as far upstream as Colusa State Park in the Sacramento River, the City of Lathrop 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; Merz et al. 2013, p. 132). Longfin smelt have also been found in the Napa and Petaluma Rivers (Merz et al. 2013, p. 136), and in recent surveys, longfin smelt were also captured in all major sloughs and tributary sloughs within the Alviso Marsh Complex salt pond restoration area in South Bay (Hobbs 2012, pg. 39). Longfin smelt migrate out into the ocean at least as far as the Gulf of Farallones. Eschmeyer (1983) reported the southern extent of the range as Monterey Bay, and Wang (1986) reported that an individual longfin smelt had been captured at Moss Landing in Monterey Bay in 1980.

Current Range Distribution:

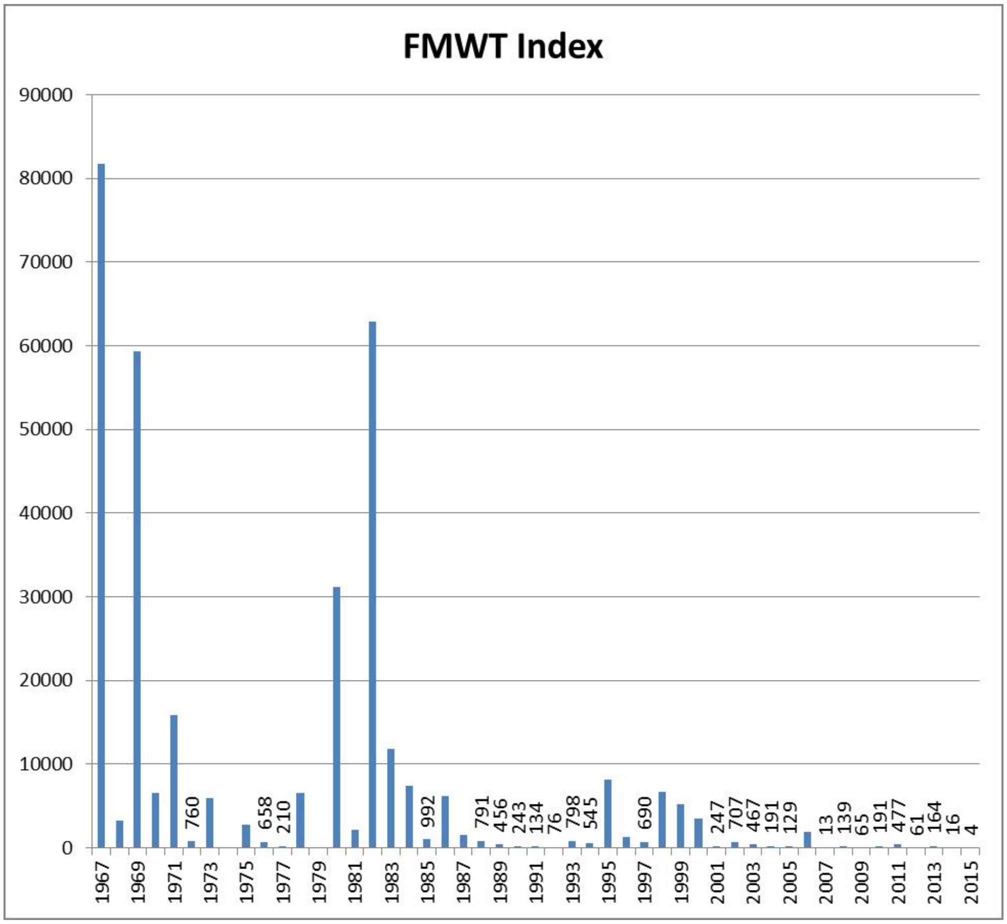
The current distribution of longfin smelt in the Bay-Delta is similar to its historical distribution.

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). Since 2004, relative abundance indices for longfin smelt have generally declined further (CDFW unpublished data). Longfin smelt is one of several fishes in the San Francisco Bay-Delta Estuary that have shown a persistent association between juvenile production and freshwater flow variation experienced early in their life cycle (Stevens and Miller 1983, p. 432; Jassby et al. 1995, p. 280; Kimmerer 2002b, p. 1282; Rosenfield and Baxter 2007, p. 1584; Thomson et al. 2010, p. 1439). It is also well established that longfin smelt production per unit of flow has declined (Kimmerer 2002b, p. 48; Rosenfield and Baxter 2007, p. 1588); the first time between 1989 and 1991, and a second time in about 2004 (Thomson et al. 2010, p. 1442). 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) as the relationship between flow and abundance has weakened in recent years. 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 species—delta 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) and 2015 numbers are the lowest ever recorded with an index of 4.

Figure 1. Longfin smelt abundance (total across year-classes) as indexed by the Fall Mid-Water Trawl of the Bay-Delta, 1967-2015.



* The survey was not conducted in 1974 or 1979.

** Index values for years of abundance indices below 1000 were added.

The establishment of the overbite clam (*Potamocorbula 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). Grazing by the overbite clam reduced the magnitude of the response of longfin smelt to flow because after 1986, comparable levels of flow did not generate the historically expected recruitment of longfin smelt per unit of Delta outflow or X2 (Kimmerer 2002, p. 52)

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 fish between 5-15 months in age (age-class 1) is directly related to the abundance of fish 16-27 months in age (age class 2) from the previous year. Rosenfield and Baxter (2007, p. 1589) also found a disproportionate reduction in age-class 2 individuals even after accounting for the decline in the age-class 1 population – in other words, a decline in the apparent survival of the older fish. The abundance of age-class 1 fish declined by 90 percent during the time period analyzed. 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. Thus, the current low abundance of adult longfin smelt within the Bay-Delta could reduce the ability of the species to persist and eventually recover in the presence of various threats.

Distinct Population Segment(DPS):

Under the Services' DPS policy (joint policy of the Fish and Wildlife Service and National Marine Fisheries Service) (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 the closest known longfin smelt breeding populations at Humboldt Bay by 420 km (260 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 and we have no evidence that this is a breeding population (Baxter 2011b, pers. comm.). Due to limited freshwater flow into the Russian River 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 nearest locations where longfin smelt are thought to spawn. This is known by evidence of spent females and larvae collected from these locations (Baxter 2011b, pers. comm.). Because Humboldt Bay is an estuary and thought to better be able to support a persistent longfin smelt population than the Eel River, we will refer to these locations collectively as the Humboldt Bay population. Moyle (2010, p. 4) considered Humboldt Bay to be the only other estuary in California potentially capable of supporting longfin smelt in most years. Baxter (2011b, pers. comm.) also considers this the closest breeding population.

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.

<table>
<tr><th>Month</th><th>Dec</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th></tr>
<tr><td rowspan="3">First Year</td><td></td><td colspan="3">Peak Hatching-freshwater, upstream Delta</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="4">Larval Rearing San Pablo and San Francisco Bays-salinities <8 psu</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Juveniles Rearing</td><td></td><td></td><td colspan="8">Juvenile Rearing – Primarily San Pablo, San Francisco Bays-</td></tr>
<tr><td rowspan="4">Second Year</td><td></td><td></td><td colspan="5">Juvenile Rearing</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="8">– Juvenile Rearing -Movement to the coastal ocean begins in the summer, mass movement to coastal ocean begins in July and August</td></tr>
<tr><td colspan="2">Spawning Migration</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Sp. Migr'n</td></tr>
<tr><td colspan="4">Peak Spawning-freshwater, Delta</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Coastal Current</td><td colspan="4">Storm Season (Northward Flow)</td><td colspan="4">Upwelling Season (Predominate Southward and Offshore Flow)</td><td colspan="4">Relaxation Season (Weak Northward Flow)</td></tr>
</table>

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 units (Baxter 2011b, pers. comm.), and surface salinities less than 8 units do not exist consistently in the ocean (Bograd and Paduan 2011, pers. comm.).

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 discrete.

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 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 DPSs 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.

<u>Determination of Distinct Population Segment</u>

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 has consistently and positively affected longfin smelt abundance during the past five decades of standardized monitoring (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. The ecological mechanisms that have generated the correlations between freshwater flow and abundance have not received as much research attention as the phenomenon itself and 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, local, state and federal agencies have 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 Bay-Delta. 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).

Two of the key hydrodynamic variables used in the resource management of the Bay-Delta are Delta inflow (from the rivers into the Delta) and Delta outflow (from the Delta into the bays). Due to high flow events, these variables are closely correlated, but they are not interchangeable. In the Bay-Delta, the location where salinity is equal to 2 is called X2. X2 is indexed as distance in kilometers from the Golden Gate Bridge. X2 is important to longfin smelt because it has been shown to affect a variety of factors that contribute to longfin smelt survival, making it a useful indicator of habitat conditions (Jassby et al. 1995, p. 282; Dege and Brown 2004, pp. 56–58). Delta outflow is the variable that most directly affects the location of X2 (Jassby et al. 1995, p. 284). 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 water export facilities (Jassby et al. 1995, entire; Kimmerer 2004, p. 18).

In addition to the system of dams and canals built throughout the Sacramento and San Joaquin River basins, the Bay-Delta is unique in having the largest water diversion system on the west coast. The State Water Project (SWP) and Central Valley Project (CVP) each operate two water export facilities in the Delta (Kimmerer and Nobriga 2008, p. 2). Project operation is dependent upon upstream water supply and export area demands, both of which are strongly affected by the interannual variability in Delta hydrology caused by variability in precipitation. From 1956 to the 1990s, water exports increased from approximately 5% of the Delta inflow to approximately 30% of the Delta inflow (Cloern and Jassby 2012, p. 7). In total, an estimated 39% of the estuary's unimpaired flow is consumed upstream or diverted from the estuary (Cloern and Jassby 2012, p. 8). 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). Operations are also regulated by both the Service's and NMFS's current Biological Opinions (BO's) for the Long-term Operation of the CVP & SWP (USFWS 2008, NMFS 2009). These restrictions are also thought to provide protections for longfin smelt.

In periods with greater freshwater flow out of the Delta, X2 is pushed farther downstream (seaward); in periods with low outflows, X2 is positioned farther landward (upstream) in the estuary and into the Delta. As X2 and by extension, the low-salinity zone, moves upstream, longfin smelt must migrate farther upstream to reach their spawning habitats (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 because it places them closer to the pumps in the south Sacramento San Joaquin Delta and may also increase their vulnerability to predation (CDFG 2009, p. 17)) . Studies of entrainment at the State and Federal export facilities found that entrainment rates increased with reverse flows in the southern Delta, which are a function of export rates and Delta inflows (Kimmerer and Nobriga 2008 p. 17, Fig 16; Kimmerer 2008, p. 20–22). In addition, when X2 is located higher in the estuary, it is likely that there is less spawning habitat available, gravitational circulation is weaker or absent, and water turbidity is usually lower (Kimmerer 2002, p. 1279). All of these conditions may contribute to higher mortality of spawners or their offspring.

Not only is longfin smelt abundance in the Bay-Delta strongly correlated with Delta outflow and its surrogate 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). Larval (winter-spring) habitat varies with outflow and with the location of X2 (CDFG 2009, p. 12). The amount of rearing habitat is also presumed to vary with the location of X2 (Kimmerer, 2013, p. 7). 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). Long term trend values show outflow from September to December has declined significantly from 1956-2010. Outflow from January to April also trended downward from 1956-2010, although this trend was not shown to be statistically significant (Cloern and Jassby 2011, p. 7).

The State of California is currently in a drought which is further decreasing freshwater flows. The Governor of California declared a State of Emergency on January 17, 2014 due to the drought and directed State officials to take all necessary actions to make water immediately available. As of April 2016, the Governor's drought declaration remains in place and the current drought conditions are comparable to the driest years on record in California. The severity of California's drought was exacerbated by record warm temperatures and below normal precipitation in 2015, resulting in a severely reduced snowpack. The Governor responded to this low precipitation by signing emergency drought relief funding for critical water infrastructure projects and emergency drought actions. During the last two years, Federal and State governments (U.S. Bureau of Reclamation [USBR] and California Department of Water Resources [DWR]) have taken actions to ensure the reduced water quality and supply does not reach a level of concern for human health and safety, while complying with biological opinions. The actions taken include the 2015 placement of a salinity rock barrier on West False River and numerous Temporary Urgency Change Orders from the California State Water Resources Control Board to DWR and Reclamation in 2014 and 2015 to modify requirements under Decision 1641 to meet certain water quality objectives, reduction of river flows caused by low reservoir storage, and river temperature requirements. These actions have reduced fresh water outflow to the San Francisco Bay Delta Estuary.

The CDFW fish surveys indicate that the relative abundance of longfin smelt is currently the lowest on record. Detailed results of these surveys were presented above under population indices. The low index numbers represent the additive impact of drought to the longfin smelt and its habitat.

Climate Change

Climate change is likely already impacting longfin smelt. Climate change is discussed here under Factor A because, although it may affect longfin smelt directly by creating physiological stress from warm water temperatures, additional impacts may occur through changes in the availability and distribution of habitat.

Our analyses under the 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 (IPCC 2013a, p. 1450). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, whether the change is due to natural variability or human activity (IPCC 2013a, p. 1450).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased 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 Solomon et al. 2007, pp. 35–54, 82–85; IPCC 2013b, pp. 3–29; IPCC 2014, pp. 1–32). 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 (Solomon et al. 2007, pp. 21–35; IPCC 2013b, pp. 11–12 and figures SPM.4 and SPM.5). 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 (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 increasing 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 (Meehl et al. 2007, pp. 760–764, 797–811; Ganguly et al. 2009, pp. 15555–15558; Prinn et al. 2011, pp. 527, 529; IPCC 2013b, pp. 19–23). See IPCC 2013b (entire), for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation.

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 threats in combination and interactions of climate with other variables (for example, habitat fragmentation) (IPCC 2014, pp. 4–11). 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 (Glick et al. 2011, pp. 19–22; IPCC 2014, p. 5). 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 the best scientific information available regarding 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 across and within different regions of the world (IPCC 2013b, pp. 15–16). 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).

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. However, warming may result in more precipitation falling as rain and less storage as snow, making winter runoff more variable 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 improved spawning and larval rearing conditions by reducing adult migration distance and increasing freshwater and low-salinity habitat. In addition, the higher turbidity associated with winter 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 if outflows during spring decline.

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 with increasing sea level (see below) and reduced flows, adults will need to migrate farther into the Delta to spawn, increasing their risk of predation and entrainment for both themselves and their progeny.

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 for the reasons discussed above in the habitat section. Increasing water temperatures would likely affect distribution and movement patterns of longfin smelt in the estuary; longfin smelt may seek 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 more frequent acute reductions in longfin smelt habitat suitability, but it is difficult to estimate these effects because of uncertainty about the frequency and severity of these events.

Channel Disturbances

Channel maintenance dredging in the Bay-Delta is an ongoing periodic disturbance of longfin smelt habitat. Dredging and other channel disturbances potentially degrade or remove spawning habitat and suction dredging can entrain 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 in open water away from shorelines and in-water structures), 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. 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.

Sand mining is most likely to affect longfin smelt at the egg and larval life stages. There are a number of measures in place to minimize the effects of sand mining in the estuary delta smelt that are excepted to also act as protections for longfin smelt. Applicants are required to install fish screens in compliance with CDFW and NMFS criteria over sand mining vent pipes to exclude juvenile and adult fish from entrainment during sand mining events. In addition, a work window of December 1 through June 30 is in place and during this time sand mining operations are restricted to areas that are 20 ft. or greater in depth. This will avoid spawning habitat in shallower depths for delta smelt. Sand mining volume percentages during the spawning period of delta smelt are also reduced. Because spawning substrate is not known to be limited for the species (Hobbs et al. 2007, entire), restrictions are in place to protect delta smelt, and sand is a dominant substrate in the estuary, sand mining is not expected to limit spawning.

We have found no information documenting population impacts of dredging or sand and gravel mining on longfin smelt in the Bay-Delta or any other system within their range. In their 2009 status review on longfin smelt, CDFW concluded most life stages of longfin smelt are not particularly vulnerable because after the egg stage, they are not reliant on particular substrates and they are able to move away from barges, suction dredges, etc. (particularly as juveniles and adults) (CDFG 2009, p. 27). However, CDFG did conclude that eggs are vulnerable to dredging in winter and spring. Egg development takes approximately 40 days (Moyle 2002, p. 236).

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 and that climate change may exacerbate that effect. 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

Longfin smelt are caught as bycatch in a small commercial shrimp trawl 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) noted in 2009 that they thought the bay shrimp trawl fishery had declined since 2004 (Hieb, p. 3) and reported the number of active shrimp permits in 2011 at less than 10 (Hieb 2011, pers. comm.). The number of boats has continued to drop with 6 boats reported in 2014 and only 3 to date in 2015 (Baxter pers. comm., 2015). We do not have any information indicating that longfin smelt bycatch is affecting the species overall population dynamics.

Scientific Take

Within the Bay-Delta, longfin smelt are regularly captured in monitoring surveys. The Interagency Ecological Program (IEP) implements numerous scientific monitoring and research programs in the Bay-Delta. The primary focus of the IEP is on monitoring status and trends within the estuary and on water project effects on the estuary's ecology. 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 during handling; the vast majority of these larvae were purposely euthanized using preservatives because they were too small to be identified in the field. 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, a portion of these fish do survive. For example, the Chipps Island survey, which is conducted by the Service, has captured an average of 2,697 longfin smelt per year. Biologists attempt to release these fish unharmed, but at least 5,154 longfin smelt were known to have died before release during the Chipps Island survey between 2001 and 2008 (Service 2010, entire). Additional longfin smelt likely died after release, however that number is unknown. The scientific sampling that takes place in the estuary only surveys a small portion of the volume of water in the estuary and the surveys do not specifically target areas where longfin smelt are concentrated.

At this time, we conclude that the number of individuals lost to commercial and scientific take is not affecting the species overall population dynamics. CDFG (2009, p. 32) recommended modifying shrimp fishing regulations to reduce longfin smelt bycatch and adaptively managing scientific collection of longfin smelt to avoid adverse population effects. The Service supports these recommendations. 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).

Predation

Predation often plays a significant role in the regulation of fish populations (Houde 1987, pp. 22–24; Essington and Hansson 2004, p. 2222). Thus, it is possible that predation is one mechanism contributing to the trends in longfin smelt abundance – both the interannual influence of freshwater flow and the long-term decline. The influence of freshwater flow on the longfin smelt population is visible using indices of age-0 fish so flow must affect the fish early in their life cycle. We are not aware of any low-salinity or marine predators of small fishes that have greatly increased in abundance over the past several decades. The role of predation on longfin smelt in the San Francisco Estuary has not been studied and the following is provided for completeness, but it should be considered speculative.

In Lake Washington, longfin smelt can be common prey for rainbow, cutthroat trout, largemouth bass and smallmouth bass (Tabor et al. 2007, p. 1178, (Beauchamp 1990, p. 477; Nowak et al. 2004, p. 627. The only study of predation in the San Francisco Estuary in which longfin smelt was a confirmed prey item is Thomas (1967, p. 51; “Sacramento smelt” in his Table 2) who reported them from the stomach contents of striped bass Morone saxatilis, collected in Suisun Bay between Crockett and Pittsburgh. The striped bass that ate longfin smelt had done so during fall and winter when longfin smelt are returning to the low-salinity regions of the estuary to spawn and thus, the limited available data suggest that longfin smelt are vulnerable to predation by striped bass at this time.

Fish eggs and larvae are small and can be consumed by a large variety of predators (Houde 1987, p. 22). As stated above, longfin smelt larvae are broadly distributed in the estuary with a peak in the low-salinity zone and are frequently captured in open waters and along marsh edge habitats . The potential predators that are most abundant in these habitats during the spring and early summer when longfin smelt are in their larval stages are juvenile striped bass, Chinook salmon and steelhead smolts (Oncorhyncus spp.), and possibly adult northern anchovy (Engraulis mordax) in the more saline part of the range and adult inland silverside (Menidia beryllina) along the marsh edges (Nobriga 2015, pers. comm.). It is also possible that opportunistic predation by other fishes and some invertebrates (e.g, decapod shrimps) could also contribute meaningfully to predation on longfin smelt larvae.

As the fish metamorphose into juveniles and move seaward, they may remain prey for striped bass and begin to be preyed on by other large bay fishes (e.g., California halibut Paralichthys californicus). However, late larval and juvenile longfin smelt are too large to be preyed on by northern anchovy, inland silverside, and invertebrates so these predators fall off the list of potential predators of post-larval longfin smelt. 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 are not expected to frequently come into contact with longfin smelt. Baxter et al. (2010, p. 40) reported that no longfin smelt have been found in largemouth bass stomachs sampled in recent studies of largemouth bass diet.

As it is for other fishes, 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 entrainment into the SWP water export pumping plant. In addition to the potential for 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 are likely to 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.

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 may 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, the striped bass population in the delta is in decline and the best available information indicates striped bass predation is not currently driving the population trajectory of longfin smelt. 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 have no evidence that either disease or 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 in the Delta, which fall heavily on the SWP and CVP to meet (FWS 2008, pp. 21-27). 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 how wet or dry the year is shaping up to be. 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 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. 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). 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, the largest discharger of ammonia into the Delta, 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.

Summary of Factor D

We have identified a number of existing regulatory mechanisms that provide protective measures that affect the stressors acting on the longfin smelt. Despite these existing regulatory mechanisms and other conservations efforts, the stressors continue to act on the species such that it is warranted for listing under the Act.

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, food web changes caused by introduced species and contaminants, and possibly, physiological or behavioral impairment from contaminants.

Agricultural Diversions: Water is diverted at numerous sites throughout the Delta for irrigation of crops. 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 distinguish intake siphons and pumps from discharge pipes. CALFED's Ecosystem Restoration Program (ERP) includes a program to screen agricultural diversions in the Delta and its watershed. Although the ERP has largely run out of funds for the program, there is money set aside in Proposition 1 funding to continue screening some of these diversions. However, all but two of the planned fish screens listed on the current priority list will take place in the upper portions of the Sacramento and San Joaquin rivers upstream of the range of longfin smelt because the priority is to protect emigrating salmon (CDFG 2015b, no pagination). The purpose of screening irrigation diversions is to prevent entrainment; however, very little information is available on the ecological efficacy of screening the numerous small water diversions scattered throughout the Delta (Moyle and Israel 2005, p. 20). Agricultural operations begin to divert water in earnest in March and April and continue into the early fall, so there is limited overlap in time between irrigation of crops in the Delta and the use of the Delta waterways as spawning and rearing habitat by longfin smelt. Water diversions are primarily located along channel levees. Longfin smelt are a pelagic fish species and tend to occupy offshore environments, which likely lowers their vulnerabilty to entrainment into these diversions as similarly described for delta smelt (Nobriga et al. 2004, p. 293).

Power Plants: NRG Delta LLC retired the generators for one (Contra Costa Generating Station (CCGS)) of its two power stations within the range of the longfin smelt in May of 2013 (NRG 2014, no pagination), although some water is still being pumped to the plant for fire suppression systems (50 acre-ft/yr) (NRG 2014, no pagnation). Therefore, this analysis will only consider the other (Pittsburg (PGS)) power station when assessing threats. The Army Corps of Engineers (Corps) is currently in consultation with the Service for the NRG Delta Energy Project. The project includes operation and dredging activities at the PGS. The PGS is located on the shoreline of the Sacramento River and San Joaquin River confluence and utilizes once-through-cooling for its generators. As part of a settlement agreement with the Coalition for a Sustainable Delta, the Army Corps and NRG Delta (the applicant) agreed to reinitiate consultation with the Service for project effects to delta smelt. Power plant operations have been substantially reduced since the late 1970s, when high entrainment and impingement were documented (CDFG 2009a, p. 24).

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). It is likely that at this time, the pumps were also entraining longfin smelt. Power plant operations have been substantially reduced since the late 1970s, when high entrainment and impingement were first 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 two largest pumping facilities located in the South Delta, Jones Pumping Plant (Central Valley Project (CVP)) and Banks Pumping Plant (State Water Project (SWP)) facilities exported between 4.31 and 7.74 km3 (3.49 and 6.28 million acre-feet) per year between water years (October 1–September 30) 1999 and 2008. The average annual water year export amount from 1999–2008 was 6.74 km^3 (5.46 million acre-feet). In December of 2008 (water year 2009), the Service issued a BO that has actions that are designed to protect delta smelt from entrainment into the facilities. Since the BO has been in 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 en route to the SWP are considered entrained by CDFW (Fujimura 2009, p. 5;

CDFG 2009b, p. 2). It is important that we differentiate “entrainment” from “salvage”. Fish are considered “entrained” at the SWP when they enter the 31,000 acre-foot Clifton Court Forebay in the south Delta. Fish are considered “salvaged” at the SWP when they are actually drawn into Skinner Fish Facility within the SWP. At the CVP or Federal facility, fish are considered entrained and salvaged when they are drawn into the louvers of the pumping facility. Entrainment of longfin smelt varies within and among seasons and among years. Studies of entrainment at the State and Federal export facilities found that entrainment rates increased with reverse flows in the southern Delta, which are a function of export rates and Delta inflows (Kimmerer and Nobriga 2008 p. 17, Fig 16; Kimmerer 2008, p. 20–22). 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 counted in salvage at the two facilities (Baxter et al. 2008, p. 21). In years with low freshwater flows, a portion of 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 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 for longfin smelt, the population-level implications of these losses have not been robustly quantified.

The total number of age-1 and older longfin smelt salvaged at both pumps between 1993 and 2007 was 1,133 (CDFG 2009, Attachment 3, p. 2). The total number of age-0 longfin smelt was much higher. For instance, Brown et al. (1996, p. 509) reported that 328,000 longfin smelt were salvaged at the SWP and CVP from 1979-1993, and Grimaldo et al. (2009, p. 1259) reported that 122,747 longfin smelt were salvaged from December 1992 through July 2005. Fujimura (2009) estimated cumulative longfin smelt entrainment at the SWP facility between 1993 and 2008 at 1,376,432 (age-0) juveniles and 11,054 adults (age-1 and older), and estimated that 97.6 percent of juveniles and 95 percent of adults entrained were lost – meaning they were preyed upon, diverted into the California Aqueduct, or died during the salvage process. 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 suggesting 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.

The salvage of longfin smelt is related to net flows in Old and Middle rivers (Grimaldo et al. 2009, p. 1260). Thus, Old and Middle river flow limits in the NMFS and USFWS Biological Opinions and the existing CESA regulations for longfin smelt have very likely reduced longfin smelt entrainment losses. The comparatively high salvage that occurred in 1988 and 2002 (Rosenfield 2010, p. 40) 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 aggregate in deep waters in the vicinity of the low salinity zone (LSZ) near X2 (see definition below) during the spawning period, and it has been assumed that they make short runs upstream, possibly at night, to spawn in fresh water from these low-salinity staging locations (CDFG 2009, p. 12; Rosenfield 2010, p. 8). However, recent unpublished analyses of larval catch data suggest spawning may also occur in the low-salinity zone (LSZ) itself because the adults and their larvae have similar distributions, which suggests that the adult fish are spawning near where they are collected. In the Bay-Delta, the LSZ has been defined as the area where salinities range from 0.5 to 6 (Kimmerer 1998, p. 1). Adult longfin smelt can be entrained as a result of such spawning migrations; larvae and juveniles can be entrained when they rear in parts of the Delta that are subject to reverse net flows (e.g., upper Cache Slough and parts of the San Joaquin River half of the Delta as described and modeled by CDFG (2009b). 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 put in place to protect the delta smelt have reduced longfin smelt entrainment.

Introduced Species

Throughout the majority of the Bay-Delta, phytoplankton and zooplankton biomass are suppressed 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 ceased to be observed any longer, were reduced in magnitude, or shifted 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). Statistical models indicate that the longfin smelt abundance index has been on a steady log-linear decline since about the time of the invasion of the nonnative overbite clam in 1987 (Thomson et al. 2010, p. 1442).

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 pelagic productivity in the estuary, we consider the overbite clam population to be a threat to the Bay-Delta DPS of longfin smelt. Based on 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 and potentially sequestered energy that may have otherwise gone to longfin smelt; however, the evidence for the particular effect of the overbite clam's impact on the longfin smelt population is far better established than for any other introduced species. We consider the overbite clam to be an ongoing threat to the Bay-Delta longfin smelt population.

Contaminants

In 2014, over 21 million pounds of pesticides were applied within the five-county Bay-Delta area, and Bay-Delta waters are listed under the Clean Water Act section 303(d) as impaired for several legacy and currently used pesticides (California Department of Pesticide Regulation 2016, p. 1). Concentrations of dissolved pesticides vary in the Delta both temporally and spatially (Kuivila 1999, entire). Several areas of the Delta, particularly the San Joaquin River and its tributaries, and the tributaries of the Yolo Bypass, 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 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. 2001, p. 1911; Tanner and Knuth 1996, p. 244). The effects to longfin smelt can be direct or indirect (effects that reduce the food supply of the longfin smelt).

Pyrethroid insecticides are of particular concern because of their widespread use, and their tendency to be genotoxic (DNA damaging) to fishes at low doses (in the range of micrograms per liter) (Campana et al. 1999, p. 159). The pyrethroid esfenvalerate is associated with delayed spawning and reduced larval survival of bluegill sunfish (Lepomis macrochirus) (Tanner and Knuth 1996, pp. 246–250) and increased susceptibility of juvenile Chinook salmon (Oncorhynchus tshawytscha) to disease (Clifford et al. 2005, pp. 1770–1771). In addition, pyrethroids may interfere with nerve cell function, which could eventually result in paralysis (Bradbury and Coats 1989, pp. 377–378; Shafer and Meyer 2004, pp. 304–305).

Indirect effects to longfin smelt through the food web have been documented. Weston and Lydy (2010, p. 1835) found the largest source of pyrethroids flowing into the Delta to be coming from the Sacramento Regional Wastewater Treatment Plant (SRWTP), where only secondary treatment occurs. Their data not only indicate the presence of these contaminants, but the concentrations found exceeded acute toxicity thresholds for the amphipod Hyalella azteca. Another study of storm events in five urban creeks in Suisun Marsh in February 2014 detected concentrations of bifenthrin (a pyrethroid) and fipronil outside of the primary agricultural pesticide season. Although the concentrations of these two insecticides were not high enough to cause mortality, they did result in paralysis of either the amphipod Hyalella azteca, or the larval midge Chironomus dilutus in 70% of the samples collected (Weston et al. 2015, pp. 20–25). Toxicity values for estuarine and marine invertebrates are not known for these insecticides but this study raises concerns about the effects to estuarine invertebrates from urban stream insecticide loading. This is of substantial concern because the use of insecticides in the urban environment had not before been considered the primary source of insecticides flowing into the Delta. Furthermore, this was not the case for the Stockton Wastewater Treatment facility, where tertiary treatment occurs, suggesting that different treatment methods may remove or retain pyrethroids differently (Baxter et.al. 2010, p. 33).

Ammonia is un-ionized, has the chemical formula NH3, and is a byproduct of secondary treated wastewater. Ammonium is the ionized form of ammonia and has the formula NH4+. The major factors determining the proportion of ammonia and ammonium in water are water pH and temperature. This is important, as NH3 ammonia is the form that can be directly toxic to aquatic organisms, and NH4+ ammonium is the form documented to suppress the growth rate of planktonic plants that at the base of many aquatic food webs (Dugdale et al. 2007, p. 17; Jassby 2008, p. 3).

In aquatic environments, ammonium can reduce primary production by an important kind of plant plankton, diatoms, because ammonium inhibits the diatoms' ability to take nitrate out of the water. This slows diatom growth rates because diatoms grow faster using nitrate than ammonium. The result can be delays of plankton blooms that ultimately feed young fish or a complete suppression of bloom conditions (Wilkerson et al. 2006, entire; Dugdale et al. 2013, entire). Ammonium in the estuary has been shown to suppress spring phytoplankton blooms in San Francisco, Suisun and Grizzly Bays by slowing down the growth rates of diatoms (Wilkerson et al. 2006, p. 411-412; Dugdale et al. 2007, pp. 26–28; Parker et al. 2012, p. 7). However, Kimmerer et al. 2014 (p. 1214) found no direct evidence of ammonium effects on phytoplankton production within the LSZ from 2006-2008. Another recent study conducted found no evidence that ammonium was inhibiting diatom production in Pacheco Slough in the fall (Esparza et al. 2014, entire). There were several differences between this recent research and past research. The Pacheco Slough study was conducted from August to October as opposed to the the Wilkerson study that started in November it measured biomass and not growth rates, and it took place in a slough rather than in open waters.

The role of ammonium nitrogen uptake inhibition in Sacramento River primary production is also not fully understood. 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 are a possible cause of this decline in productivity (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). At this time, we conclude that more science is needed to determine the role of ammonium in the food web. However, because ammonium may be affecting the food web that the longfin smelt relies on as shown in research described above, we support future actions in the Bay-Delta that would reduce ammonium outputs.

Complex mixtures of contaminants spanning many different classes can be common in regions heavily influenced by agricultural or urban environments. To date, a variety of studies have documented the impacts of complex chemical mixtures on aquatic organisms. Laetz et al. (2009, p.

351) exposed juvenile Coho salmon (Oncorhynchus ktsutch) to a sub-lethal concentrations of five current-use pesticides and found the compounds were acting as synergists with each other. Nørgaard and Cedergreen (2010, p. 962) found that a mixture of fungicides and pyrethroids could produce a 12-fold increase in toxicity over what was expected using an additive model when looking at impacts to Daphnia magna. LeBlanc et al. (2012, p. 383) examined the sub-lethal effects of three pesticides: chlorpyrifos, dimethoate (both organophosphate) and imidacloprid (neonicotinoid), and found a synergistic interaction when aquatic invertebrates (Chironomus dilutus larvae) were exposed to all three at once. Carvalho et al. (2014, pp. 225–228) produced two mixtures of 14 and 19 different compounds of concern, including metals, pesticides, pharmaceuticals, and hydrocarbons, all at concentrations below the Environmental Quality Standards. A host of sub-lethal impacts to many different aquatic organisms were detected including fish embryo toxicity, increased oxidative stress, and decreased invertebrate mobility.

Large blooms of toxic Microcystis aeruginosa (a species of cyanobacteria) were first documented in the Bay-Delta during the summer of 1999 (Lehman et al. 2005, p. 87). M. aeruginosa forms large colonies throughout most of the Delta and increasingly down into Suisun Bay (Lehman et al. 2005, p. 92; 2013, p. 150). Blooms typically occur when water temperatures are above 20 °C (68 °F) (Lehman et al. 2010a, p. 238). It is unclear whether microcystins and other toxins produced by local blooms are acutely toxic to fishes at current concentrations; however, the toxins accumulate in fish and their prey. During summer 2005, Age-0 striped bass and Mississippi silversides that were co-occurring with the Microcystis bloom showed various forms of liver damage (Lehman et al. 2010a, p. 241). When ingested with food, microcystins have been experimentally shown to cause substantial impairment of health in threadfin shad (Acuña et al. 2012, p. 1195). In addition, the copepods that longfin smelt eat are particularly susceptible to these toxins (Ger 2008, pp. 12, 13; Ger et al. 2010, p. 1554). An investigation of food web effects and fish toxicity concluded that even at low abundances, M. aeruginosa may impact estuarine fish productivity through both toxicity and food web impacts (Lehman et al. 2010, p. 241–245). M. aeruginosa is most likely to affect juvenile longfin smelt during summer blooms.

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 :

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 California's water supply program elements with the restoration of the Bay-Delta and tributary ecosystems to recover Chinook Salmon and other species like longfin smelt. 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.

Summary of Threats :

This status review identified threats to the Bay-Delta DPS of longfin smelt attributable to Factors A and E, as well as interactions between these threats. The primary threat to the longfin smelt DPS is from reduced freshwater flows. Upstream dams and water storage, exacerbated by water diversions including 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 currently unkown, but are being actively researched.

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 decline of longfin smelt (Baxter 2010 et al., p. 69). Models indicate a steady log-linear decline in abundance of longfin smelt since about the time of the invasion of the nonnative overbite clam in 1987 (Thomson et al. 2010, p. 1442; 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, 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 later 1990's (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 possibly by ammonium concentrations (Factor E) and water diversions (Factor A). 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. We have identified a number of existing regulatory mechanisms that provide protective measures that affect the stressors acting on the longfin smelt. Despite these existing regulatory mechanisms and other conservations efforts, the stressors continue to act on the species such that it is warranted for uplisting under the Act. 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. Although conservation measures are in place that act to protect the species including the 2008 delta smelt Biological Opinion, these measures have not been sufficient to halt the decline of the species. Therefore, we find that listing the Bay-Delta longfin smelt DPS is still 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. 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 ammonium concentrations from the Sacramento Waste Water Treatment Plant may help to increase primary productivity within the Bay-Delta, resulting in faster longfin smelt growth and higher 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 for a number of reasons. 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 longfin smelt abundance and distribution data (see table). These efforts are led primarily by the Interagency Ecological Program (IEP), an interagency entity formally established in 1972, made up of State, Federal and non-government agencies that work collaboratively to oversee data collection and scientific analysis in the Bay-Delta. In addition to its routine monitoring programs, the IEP often funds research efforts into the effects of contaminants, invasive species, export pump entrainment and freshwater outflow on many fish and invertebrate species and their supporting food web. The IEP monitoring is the best available source of scientific information on the decline of longfin smelt in the Bay-Delta. In 2009, the IEP's Smelt Larva Survey was redesigned from the long discontinued Striped Bass Egg and Larval Survey to specifically target early stage longfin smelt larvae to assess their entrainment risk to water exports from the Bay-Delta.
Specific data relevant to the entrainment of 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 of adult and juvenile longfin smelt into the diversion pumps (Grimaldo et al. 2009, p. 1256).

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 revised its mandate to include monitoring objectives for additional 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:

Coordination is done with the State of California. Much of the coordination is done through the IEP and includes research and abundance surveys.

Literature Cited:

Aasen, G. 2009. Fish Salvage at the State Water Project's and Central Valley Project's Fish Facilities during 2008. Interagency Ecological Program (IEP) Newsletter. 22, # 2, Spring 2009: 36-43.

Aiken SG, Newroth PR, Wile I. 1979. The biology of Canadian weeds, 34:Myriophyllum spicatum L. Canadian Journal of Plant Science 59: 201–215.

Alpers, C.N., R.C. Antweiler, H.E. Taylor, P.D. Dileanis and J.L. Domagalski. 2000a. Metals Transport in the Sacramento River, California, 1996-1997, Volume 1: Methods and Data. U.S. Geological Survey. Water Resources Investigations Report 00-4286. 106 pp.

Alpers, C.N., R.C. Antweiler, H.E. Taylor, P.D. Dileanis and J.L. Domagalski. 2000b. Metals Transport in the Sacramento River, California, 1996-1997, Volume 2: Interpretation of Metal Loads. U.S. Geological Survey. Water Resources Investigations Report 00-4002. 430 pp.

Alpine, A.E. and J.E.Cloern. 1992. Trophic Interactions and Direct Physical Effects Control Phytoplankton Biomass and Production in an Estuary. Limnology and Oceanography.Vol. 37 (5) pp. 946-955.

Barnhart, R.A., M.J. Boyd, and J.E. Pequegnat. 1992. The ecology of Humboldt Bay, California: an estuarine profile. United States Department of the Interior Fish and Wildlife Service, Biological Report 1:1-121.

Barrett, E.M. 1963. The California oyster industry. The Resources Agency of California.

Barry, M.J., D.C. Logan, J.T. Ahokas, and D.A. Holdway. 1995. Effect of Algal food concentration on toxicity of two agricultural pesticides to Daphnia carinata. Ecotoxicology and Environmental Safety 32:273-279.

Baxter, R. D. 1999. Osmeridae in J. Orsi, editor. Report on the 1980-1995 fish, shrimp and crab sampling in the San Francisco Estuary. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Technical Report 63. Pages 179-216.

Baxter et al. 2008. Pelagic Organism Decline Progress Report: 2007 Synthesis of Results.

Interagency Ecological Program for the San Francisco Estuary. California Department of Water Resources. 78 pp.

Baxter, R. 2008. Personal Communications Between Randy Baxter of the California Department of Fish and Game and Arnold Roessler of the USFWS regarding longfin smelt migration movements. June 9, 2008.

Baxter, R. 2010. Oral presentation given at the Delta Science Conference, September 27 - 29, 2010. PowerPoint. 21 slides.

Baxter, R., R. Breuer, L. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solger, T. Sommer, K. Souza. 2010. Interagency Ecological Program 2010 Pelagic organism decline work plan and synthesis of results through August 2010. Interagency Ecological Program for the San Francisco Estuary. 125 pages.

Baxter, R. 2011. Personal Communications Between Randy Baxter of the California Department of Fish and Game and C. Grant of the USFWS regarding climate change.

Baxter, R. 2011a. Personal Communications Between Randy Baxter of the California Department of Fish and Game and C. Grant of the USFWS regarding longfin smelt diet. January 19, 2011.

Baxter, R. 2011b. Personal Communications Between Randy Baxter of the California Department of Fish and Game and C. Grant of the USFWS regarding breeding populations. April 25, 2011.

Baxter, R. 2011c. Personal Communications Between Randy Baxter of the California Department of Fish and Game and C. Grant of the USFWS regarding longfin smelt transport. August 29, 2011.

Baxter, R. 2011d. Personal Communications Between Randy Baxter of the California Department of Fish and Game and C. Grant of the USFWS regarding longfin smelt transport. September 21, 2011.

Baxter, R. 2011e. Personal Communications Between Randy Baxter of the California Department of Fish and Game and C. Grant of the USFWS regarding longfin smelt transport. October 18, 2011.

Baxter, R. 2011f. Personal Communications Between Randy Baxter of the California Department of Fish and Game and C. Grant of the USFWS regarding ocean transport. October 26, 2011.

The Bay Institute. 1998. From the Sierra to the Sea: The Ecological History of the San Francisco Bay-Delta Watershed. Chapter 4: 29 pp.

Blomquist W., K.S. Calbick, and A. Dinar. 2005. Institutional and Policy Analysis of River Basin Management, World Bank Policy Research Working Paper 3525.

Boyd, M.J., T.J. Mulligan, and F.J. Shaughnessy. 2002. Non-indigenous marine species of Humboldt Bay, California: A report to California Department of Fish and Game.

Bradbury, S.P. and J.R. Coats. 1989. Toxicokinetics and toxicodynamics of pyrethroid insecticides in fish. Environmental Toxicology and Chemistry 8:373-380.

Bricker, S.B., C.G. Clement, D.E. Pirhalla, S.P. Orlando, and D.R.G. Farrow. 1999. National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries. Silver Spring, MD: National Oceanic and Atmospheric Administration (NOAA), National Ocean Service. 71 pp.

Brown, L.R., P.B. Moyle. 1997.Invading species in the Eel River, California: successes, failures, and relationships with resident species Environmental Biology of Fishes 49: 271–291, 1997.

Brown, C. A., W. G. Nelson, B. L. Boese, T. H. De Witt, P. M. Eldridge, J. E. Kaldy, H. Lee II, J. H. Power and D. R. Young. 2007. An approach to developing nutrient criteria for pacific northwest estuaries: a case study of Yaquina estuary, Oregon. US EPA Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division. Available on the internet at

Brown, L.R. and D. Michniuk. 2007. Littoral Fish Assemblages of the Alien-dominated Sacramento San Joaquin Delta, California, 1980–1983 and 2001–2003 Estuaries and Coasts Vol. 30, No. 1, p. 186–200

[CDFG] California Department of Fish and Game 1992. Water Quality Proceedings on the San Francisco Bay/Sacramento-San Joaquin Delta prepared for the State Water Resources Control Board: Estuary Dependent Species.

[CDFG] California Department of Fish and Game. 2001. True Smelts. In: California's Living Marine Resources: A Status Report (eds.) W.S. Leet, C.M. Dewees, R. Klingbiel, & E.J. Larson. pp. 472-479.

[CDFG] California Department of Fish and Game. 2009. Report to the Fish and Game Commission: A Status Review of the Longfin Smelt (Spirinchus thaleichthys) In California.

[CDFG] California Department of Fish and Game 2009b Effects Analysis: State Water Project Effects on Longfin Smelt. Baxter et al.

[CDFG] California Department of Fish and Game. 2010. Humboldt Bay Catch Database for Longfin Smelt. 2003-2009.

[CDFW] California Department of Fish and Wildlife. 2013. 20 mm Survey Fish Distribution Map. http://www.dfg.ca.gov/delta/data/20mm/CPUE_map.asp

[CDFW] California Department of Fish and Wildlife. 2015. Fall Midwater Trawl Monthly Abundance Indices. http://www.dfg.ca.gov/delta/data/fmwt/indices.asp

CalFed.Bay-Delta Program 2000. Programatic Record of Decision. August 28, 2000. 118 pp.

CalFed Bay-Delta Program. 2005. Liberty Island Monitoring Program. First Annual Report May 2005.
CalFish. 2011. Calfish map viewer, California Fish Passage Assessment Database. Available on the internet at . Accessed May 13, 2011.

California Department of Pesticide Regulation. 2011. Pesticide Use Reporting database. http://www.cdpr.ca.gov/docs/pur/purmain.htm. Accessed on April 15, 2011.

[CEC] California Energy Commission 2009. The Future is Now: An Update on Climate Change Science Impacts and Response Options for California.

Campana, MA, AM Panzeri, VJ Moreno and FN Dulout. 1999. Genotoxic evaluation on the pyrethroid lambda-cyhalothrin using the micronucleus test in erythrocytes of the fish Cheirodon interruptus interuptus. Mutation Research 438:155-161.

Cannata, S. and S. Downie. 2009. Information Summary of Longfin Smelt (Spirinchus thalyichthys) occurring in CDFG Northern Region. California Department of Fish and Game. Fortuna, California.

Cannata, S, T Hassler. 1995. Juvenile Salmon Utilization of the Eel River Estuary. California Cooperative Fishery Research Unit, Humboldt State University.

[CRWQCB] Central Valley Regional Water Quality Control Board. 2009. Clean Water Act Sections 305(b) AND 303(d) Integrated Report for the Central Valley Region. CRWQCB, Rancho Cordova, CA. 16 pp.

[CSWRCB] California State Water Resources Control Board. 2010 Integrated Report (Clean Water Act Section 303(d) List / 305(b) Report. Available on internet at

Chigbu P., Thomas H. Sibley T.H and Beauchamp D.A. 1998. Abundance and Distribution of Neomysis mercedis and a majorpredator, longfin smelt (Spirinchus thaleichthys) in Lake Washington. Hydrobiologia 386: 167-182, 1998.

Chigbu, P. and T. H. Sibley. 1994. Relationship between abundance, growth, egg size and fecundity in a landlocked population of longfin smelt, Spirinchus thaleichthys. Journal of Fish Biology. 45:1-15.

City of San Francisco. 1984. Ocean Outfall Monitoring Program Report: October 1982 to June 1984. 64 pp.

Clark, J.M. and M.W. Brooks. 1989. Neurotoxicology of pyrethroids: single or multiple mechanisms of action? Environmental Toxicology and Chemistry 8:361-372.

Clifford, M.A., K.J. Eder, I. Werner and R. Hedrick. 2005. Synergistic effects of esfenvalerate and infectious hematopoietic necrosis virus on juvenile Chinook salmon mortality. Environmental Toxicology and Chemistry 24(7):1766-1772.

Cloern, J. E. 2001. Our evolving conceptual model of the coastal eutrophication problem. Marine Ecology Program Series 210:223-253.

Cloern, J. E., N. Knowles, L. R. Brown, D. Cayan, M. D. Dettinger, T. L. Morgan, D. H. Schoellhamer, M. T. Stacey, M. van der Wegens, W. Wanger, A. D. Jassby. 2011. Projected Evolution of California's San Francisco Bay-Delta-River System in a Century of Climate Change. PLoS ONE Volume 6: Issue 9: September 2011, 13 pp.

Contreras, D. 2011. Fall Midwater Trawl 2011 Summary. California Department of Fish and Game. December 22, 2011. p. 2.

Cope, Justin. 2011. Personal Communication between Justin Cope of the National Oceanic and Atmospheric Administration and Colin Grant of the USFWS regarding longfin smelt genetics.

Cronin G., Lewis W.M. and M.A. Schiehser. 2006. Influence of freshwater macrophytes on the littoral ecosystem structure and function of a young Colorado reservoir. Aquatic Botany 85: 37–43.

Dege, M, L.R. Brown. 2004. Effect of Outflow on Spring and Summertime Distribution and Abundance of Larval and Juvinile Fishes in the Upper San Francisco Estuary. American Fisheries Society Symposium 39 (49-65).

Dever, E. P., C. E. Dorman, J. L. Largier, 2006. Surface boundary layer variability off northern California, USA during upwelling. Deep Sea Research II, 53(25-26):2887-2905.

Domagalski, J. L., Weston, D. P., Zhang, M. and Hladik, M. 2010. Pyrethroid insecticide concentrations and toxicity in streambed sediments and loads in surface waters of the San Joaquin Valley, California, USA. Environmental Toxicology and Chemistry, 29: 813–823. doi: 10.1002/etc.10

Drake, P., C. A. Edwards, J. A. Barth. 2011. Dispersion and connectivity estimates along the U.S. west coast from a realistic numerical model. Journal of Marine Research, Volume 69: 1.

Dryfoos, R. L. 1965. The Life History and Ecology of the Longfin Smelt in Lake Washington. University of Washington, Thesis. Submitted May 20, 1965. pg. 42.

Dugdale, R., F. Wilkerson, A. Parker, A. Marchi, S. Blaser, and K. Taberski. 2011. Diatom blooms observed in Suisun Bay during spring 2010: How did ambient nutrients play a role? Interagency Ecological Program (IEP) Annual Workshop. March 30, 2011, Lake Natoma Inn, Folsom, CA. available online http://www.afs-calneva.org/_files/Cal-Neva_AFS_Conf_2011_Abstracts.pdf

Dugdale, R.C., F.P. Wilkerson, V.E. Hogue, and A. Marchi. 2007. The role of ammonia and nitrate in spring bloom development in San Francisco Bay. Estuarine, Coastal and Shelf Science 73:17-29.

Dynesius, M, Jansson, R. Evolutionary consequences of the changes in species' geographical distributions driven by Milanlovitch climate oscillations. PNAS 97 (16).

Edmondson, W.T., G.C. Anderson, D.R. Peterson. 1956. Artificial Eutrophication in Lake Washington. Limnology and Oceanography. 1 (1). pp. 47-53.

Emmett, R., R. Llanso, J. Newton, R. Thom, M. Hornberger, C. Morgan, C. Levings, A. Copping and P. Fishman. 2000. Geographic signatures of North American west coast estuaries. Estuaries 23(6): 765-792

Enos, Cassandra, J. Sutherland and M.L. Nobriga. 2007. Results of a Two Year Fish Entrainment Study at Morow Island Distribution System in the Suisun Marsh. Interagency Ecological Program (IEP) Newsletter. 20, # 1, Winter 2007: 10-19.

Eschmeyer, W.N. and Herald, E.S. 1983. The Peterson field guide series. A Field guide to Pacific Coast fishes of North America: from the Gulf of Alaska to Baja, California. Houghton Mifflin, Boston. 384 pages.

Feyrer , F., B. Herbold, S.A. Matern and P.B. Moyle. 2003. Dietary shifts in a stressed fish assemblage: Consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes 67: 277–288.

Feyrer, F., T. Sommer, J. Hobbs. 2007. Living in a dynamic environment: variability in life history traits of age-0 splittail in tributaries of San Francisco Bay. Transactions of the American Fisheries Society 136:1393–1405.

Fish, M, D. Contreras, V. Afentoulis, J. Messineo, K. Hieb. 2009 Fishes Annual Status and Trends Report for the San Francisco Estuary. Interagency Ecological Program (IEP) Newsletter. 22, # 2, Spring 2009: pp. 17-36.

FishBase search engine. 2011. Available online at http://www.fishbase.org/. Accessed on April 15, 2011.

Foe, C. 1995. Evaluation of the potential impact of contaminants on aquatic resources in the Central Valley and Sacramento-San Joaquin Delta Estuary. Central Valley Regional Water Quality Control Board, Sacramento, CA. 23 pp.

Foe, C.G. and V. Connor. 1991. San Joaquin watershed bioassay results, 1988-90. Staff report. Central Valley Regional Water Quality Control Board, Sacramento, CA.

Foe, C. and R. Sheipline. 1993. Pesticides in surface water from application on orchards and alfalfa during the winter and spring of 1991-1992. Staff report to the Central Valley Regional Water Quality Control Board, Central Valley Region, State of California. 79 pp.

Foott, J.S., R. Stone. 2007. Histological Evaluation and Viral Survey of Juvenile Longfin Smelt (Spirinchus thaleichthys) and Threadfin Shad (Dorosoma petenense) collected from the Sacramento – San Joaquin River Delta. USFWS.

Fujimura, R. 2009. Longfin Smelt Entrainment and Loss Estimates for the State Water Project's and

Central Valley Project's South Delta Export Facilities. Memorandum to Marty Gingras. January 8, 2009. 16 pp.
Ger, K.A. 2008. Extent of acute, chronic and nutritional impacts of Microcystis aeruginosa blooms on the calanoid copepods of the upper San Francisco Estuary. Dissertation. University of California, Davis. 77 pp.
Ger, K.A., S.J. Teh, D.V. Baxa, S. Lesmeister, and C.R. Goldman. 2010. The effects of dietary Microcystis aeruginosa and microcystin on the copepods of the upper San Francisco Estuary. Freshwater Biology 55(7):1548–1559

Gleason, E, T. Mulligan, R. Studebaker. 2004. Proceedings of the Symposium: Current Perspectives on the physical and Biological processes of Humboldt Bay. March 15, 2004.

Glick, P., B.A. Stein, and N.A. Edelson, editors. 2011. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, Washington, D.C. 176 pp.

Goodman, L.R., D.J. Hansen, D.L. Coppage, J.C. Moore and E. Matthews. 1979. Diazinon: Chronic toxicity to and brain acetylcholinesterase inhibition in, the sheepshead minnow, Cyprinodon variegatus. Transaction of the American Fisheries Society 108:479-488.

Grimaldo, L.F, T. Sommer, N.V. Ark, G. Jones, E. Holland, P.B. Moyle, B. Herbold, P. Smith.2009. Factors Affecting Fish Entrainment into Massive Water Diversions in a Tidal Freshwater Estuary: Can Fish Losses be Managed? North American Journal of Fisheries Management (29): 1253-1270.

Guinee, R. Personal Communications Between Roger Guinee of the USFWS and C. Grant of the USFWS regarding CVP operations on October 28, 2011.

Halle, C. M., J. L. Largier, 2011. Surface circulation downstream of the Point Arena upwelling center. Continental Shelf Research (31): 1260-1272.

Hamilton, S. J. 2004. Review of selenium toxicity in the aquatic food chain. Science of the Total Environment 326:1-31.

Hermanutz, R.O. 1992. Malformation of the fathead minnow (Pimephales promelas) in an ecosystem with elevated selenium concentrations. Bulletin of Environmental Contamination and Toxicology 49(2):290-294.

Herren, J.R. and S. Kawasaki. 2001. Inventory of water diversions in four geographic areas in California's Central Valley. Contributions to the biology of Central Valley salmonids, Volume 2. R.L. Brown, Department of Fish and Game Fish Bulletin. 179: 343-355

Hieb, K. Personal Communications Between Kathy Heib of the USFWS and C. Grant of the USFWS regarding shrimping fishery in the San Francisco Bay on October 17, 2011.

Hieb, K. 2009. Report on the longfin smelt estimated bycatch in the Bay Shrimp Trawl Fishery. State of California Memorendum. January 9, 2009.

Hieb, K., and R. Baxter. 1993. Delta outflow/San Francisco Bay. Pages 101-116 in P. L. Herrgesell, editor. 1991 Annual Report - Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary, Sacramento, California.

Hilts, D. 2012. Raw Flow Data. Unpublished data used to average outflow from 1990-2000 and from 2000-2010.

Hobbs, J. Personal Communication between Jim Hobbs of the University of California and Victoria Poage of the USFWS regarding longfin smelt ocean movements on July 6, 2011.

Hobbs, J.A., W.A. Bennett, and J.E. Burton. 2006. Assessing nursery habitat quality form native smelts (Osmeridae) in the low-salinity zone of the San Francisco estuary. Journal of Fish Biology 69: 907-922.

Hobbs, J.A., L.S. Lewis, N. Ikemiyagi, T. Sommer, R.D. Baxter. 2010. The use of otolith strontium isotopes to identify nursery habitat for a threatened estuarine fish. Environmental Biology Fish 89 (557-569).

Holdway, D.A., M.J. Barry, D.C. Logan, D. Robertson, V. Young, J.T. Ahokas. 1994. Toxicity of pulse-exposed fenvalerate and esfenvalerate to larval Australian crimson-spotted rainbow fish (Melanotaenia fluviatilis). Aquatic Toxicology 28:169-187.

Houde, E.D., 1987. Fish Early Life Dynamics and Recruitment Variability. American Fisheries Society Symposium 2 (17-29).

Houston, J.R., L.A. Allen and K.M. Kuivila. 2000. Seasonal Patterns and factors controlling the occurrence of dissolved pesticides in the Sacramento-San Joaquin Delta. Oral presentation to CALFED Bay-Delta Program Science Conference, October 3-5, 2000.

Interagency Ecological Program scientific take. Unpublished data. 1987-2011.

IPCC, 2007a: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate change [Core Writing Team, Pachauri, R.K. and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

IPCC, 2007b: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Quin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and new York, NY, USA.

Israel, J.A., B. May. 2010. Characterization and evaluation of polymorphic microsatellite markers in the anadromous fish Spirinchus thaleichthys. Conservation Genetics Resources. May 28, 2010 Edition.

Israel, J.A., E. Ringelman, B. May. 2011. Preliminary results on longfin smelt genetics. Unpublished data. Genomic Variation Laboratory, University of California, Davis CA.

Jassby, A. 2008. Phytoplankton in the upper San Francisco Estuary: recent biomass trends, their causes and their trophic significance. San Francisco Estuary and Watershed Science 6(1). 24 pp. http://scholarship.org/uc/item/71h077r1

Jassby, A. D., and coauthors. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5(1):272-289.

Johnson, S. Personal Communications Between Scott Johnson of NOAA and C. Grant of the USFWS regarding longfin smelt distribution in Alaska on January 31, 2011.

Johnson, L.L., G.M. Ylitalo, M.R. Arkoosh, A. N. Kagley, C. Stafford, J. L. Bolton, J. Buzitis, B. F. Anulacion, and T.K. Collier. 2007. Contaminant exposure in outmigrant juvenile salmon from Pacific Northwest estuaries of the United States. Environmental Monitoring and Assessment. 124 (1-3): 167-194

Jones, K.E., A. Purvis, J.L. Gittleman. Biological Correlates of Extinction Risk in Bats. The American Naturalist. 161 (4).

Karen, D.J. B.M. Joab, J.M. Wallin and K.A. Johnson. 1998. Partitioning of chlorpyrifos between water and an aquatic macrophyte (Elodea densa). Chemosphere 37(8):1579-1586.

Kennish, M.J. 1989. Practical Handbook of Marine Science. CRC Press Inc, Baton Rouge, Florida. 710 pp.

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

Kimmerer, W.J. 2002b Physical, Biological, and Management Responses to Variable Freshwater Flow into the San Francisco Estuary. Estuaries 25 (68).

Kimmerer, W.J. 2004. Open Water Processes of the San Francisco Estuary: From Physical Forcing to Biological Responses. San Francisco Estuary and Watershed Science. 2 (1) Article 1.

Kimmerer, W.J. 2008, Personnel Communication between Wim Kimmerer of The University of California and Victoria Poage of the U.S. Fish and Wildlife Service. May 9, 2008.

Kimmerer, W.J., J.J. Orsi. 1996. Changes in the Zooplankton of the San Francisco Bay Estuary Since the Introduction of the Clam Potamocorbula Amerensis.

Kimmerer, J.W., and M. Nobriga. 2008. Investigating particle transport and fate in the Sacramento-San Joaquin Delta using a particle tracking model. San Francisco Estuary and Watershed Science, Vol. 6, Issue 1 Article 4.

Kimmerer, W. J., J.R. Burau, W.A. Bennett. 1998. Tidally oriented vertical migration and positon maintenance of zooplankton in a temperate estuary. Limnology Oceanography 43 (7), pp. 1697-1709.

Kimmerer, W., L. Brown, S. Culberson, P. Moyle, M. Nobriga and J. Thompson. 2008. Chapter 4: Aquatic ecosystems. Pages 73-101 In M.C. Healey, M.D. Dettinger and R.B. Norgaard (editors) The State of Bay-Delta Science, 2008. CALFED Science Program. Sacramento, CA. 174 pp. Available on line http://www.science.calwater.ca.gov/pdf/publications/sbds/sbds_final_update_122408.pdf

Kristensen, P. 1994. Sensitivity of embryos and larvae in relation to other stages in the life cycle of fish: a literature review. Pages 155-166 In R. Muller and R. Lloyd (editors). Sublethal and Chronic Effects of Pollutants on Freshwater Fish. Fishing News Books, Blackwell Science Ltd. Oxford, UK.

Kuivila, K.M. 2000. Pesticides in the Sacramento-San Joaquin Delta. State of our knowledge. Oral presentation to CALFED Bay-Delta Program Science Conference, October 3-5, 2000.

Kuivila, K.M. and C.G. Foe. 1995. Concentrations, transport and biological effects of dormant spray pesticides in the San Francisco Estuary, California. Environmental Toxicology and Chemistry 14(7):1141-1150.

Kuivila, K.M. and G.E. Moon. 2004. Potential exposure of larval and juvenile delta smelt to dissolved pesticides in the Sacramento-San Joaquin Delta, California. American Fisheries Society Symposium 39:229-241.

Largier, J. 2011. Personal Communication between John Largier of the University of California and Colin Grant of the U. S. Fish and Wildlife Service on April 15, 2011.

Largier, J., 2004. The importance of retention zones in the dispersal of larvae. American Fisheries Society Symposium, 45:105-122

Lehman, P.W. 2004. The Influence of Climate on Mechanistic Pathways that Affect Lower Food Web Production in Northern San Francisco Bay Estuary. Estuaries 27 (2) pp. 311-324.

Lehman, P.W. G. Boyer, C. Hall, S. Walker and K. Gehrts. 2005. Distribution and toxicity of a new colonial Microcystis aeruginosa bloom in the San Francisco Bay Estuary, California. Hydrobiologia 541:87-99.

Levine-Fricke. 2004. Final report for the U.S. Army Corps of Engineers: Framework for Assessment of Potential Effects of Dredging on Sensitive Fish Species in San Francisco Bay.

Linbo, T.L., Stehr, C.M., Incardona, J.P., and Scholz, N.L. 2006. Dissolved copper triggers cell death in the peripheral mechanosensory system of larval fish. Environmental Toxicology and Chemistry 25:597-603.

Linville, R., G.S. Luoma, L. Cutter and G. Cutter. 2002. Increased selenium threat as a result of invasion of the exotic bivalve Potamacorbula amurensis into the San Francisco Bay-Delta. Aquatic Toxicology 57:51-64.

Lisle, T.E. 1982. Effects of aggradation and degradation on riffle-pool morphology in natural gravel channels, northwestern California. Water resources research 18(6): 1643–1651

Liu W, Gan J, Lee S, Kabashima JN. 2004. Phase distribution of synthetic pyrethroids in runoff and stream water. Environ Toxicol Chem 23: 7–11.

Lurling, M. and M. Scheffer. 2007. Info-distruption: pollution and the transfer of chemical information between organisms. Trends in Ecology and Evolution 22(7):374-379.

MacCoy, D.E.; Domagalski, J.L. 1999. Trace elements and organic compounds in streambed sediment and aquatic biota from the Sacramento River Basin, California, October and November 1995: U.S. Geological Survey Water-Resources Investigations Report 1999-4151, 37 pp.

MacCoy, D., K.L. Crepeau, K.M. Kuivila. 1995. Dissolved pesticide data for the San Joaquin River at Vernalis and the Sacramento River at Sacramento, California, 1991-94. US Geological Survey, Earth Science Information Center Open-File Reports Section, Denver, CO. 27 pp.

Magnell, B.A., N.A. Bray, C.D. Winant, C.L. Greengrove, J.L. Largier, F. Borchardt, R.L. Bernstein and C.E. Dorman, 1990. Convergent shelf flow at Cape Mendocino. Oceanography, 3(1), 4-11.

Manne, L.L, T.M. Brooks, S.L. Pimm. 1999. Relative risk of extinction of passerine birds on continenents and islands. Nature Vol. 399.

Marshall, M, .H. Webb and R. Wilder. Spatial and temporal patterns in use by native and nonnative fish larvae of a recently flooded island in the Sacramento-San Joaquin River Delta.40th annual meeting of the American Fisheries Society California-Nevada Chapter. 3/30-4/1/2006. San Luis Obispo, CA.

McAllister, D.E. 1963. A Revision of the Smelt Family, Osmeridae. National Museum of Canada. Bulletin No. 191. Biological Series No. 71. Department of Northern Affairs and National Resources. Ottawa.

Meng, L., S.A. Matern. 2001. Native and Introduced Larval Fishes of Suisun Marsh California: The effects of freshwater flow. Transactions of the American Fisheries Society. 130 (750-765).

Merz, J. E., P. S. Bergman, J. F. Melgo, and S. Hamilton. 2013. Longfin smelt: spatial dynamics and ontogeny in the San Francisco Estuary. California Fish and Game 99(3):122-148.

Messineo, J., M. Fish, D. Contreras, K. Hieb, V. Afentoulis. 2009 Fishes Annual Status and Trends Report for the San Francisco Estuary. Vol. 23, # 2. Spring 2010. pp. 49-71.

Miller, D.J., R.N. Lea. 1972. Guide to the Coastal Marine Fishes of California. The Resources Agency. department of Fish and Game. Fish Bulletin 157.

Monaco, M.E., T.A. Lowery, R.L. Emmett. 1992. Assemblages of U.S. west coast estuaries based on the distribution of fishes. Journal of Biogeography. 19 (251-267).

Monsen, N.E., J.E. Cloern, J.R. Burau. 2007. Effects of flow diversions on water and habitat quality: examples from California’s highly manipulated Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. Vol. 5, Issue 3 [July 2007]. Article 2.

Mote, P., SalathÃ©, E., DuliÃ¨re, V., Jump, E. 2008. Scenarios of future climate for the Pacific Northwest.

Mount, J. and R. Twiss. Subsidence, sea level rise, and seismicity in the Sacramento-San Joaquin Delta. 2005. San Francisco Estuary and Watershed Science Vol. 3, Issue 1 (March 2005), Article 5. http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art5

Moyle 2010. Plantiffs' Notice of Motion and Motion to supplement the Administrative Record. August 9, 2010. Court Proceedings.

Moyle, P.B. 2002. Inland Fishes of California (Revised and Expanded). University of California Press, Ltd. London, England. 146-150.

Moyle, P.B. 2008. The Future of Fish in Response to Large-Scale Change in the San Francisco Estuary, California. American Fisheries Society Symposium 64: 357-374.

Moyle, P. B., and J. A. Israel. 2005. Untested assumptions: effectiveness of screening diversions for the conservation of fish populations. Fisheries 30(5):20-28.

Moyle, P.B., R. M. Yoshiyama, J. E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California. Department of Wildlife & Fisheries Biology University of California, Davis. 277 pp.

Moyle, P.B., R. Baxter, T. Sommer, T.C. Foin, S.A Matern. 2004. Biology and Population Dynamics of Sacramento Splittail (Pogonichthys macrolepidotus) in the San Francisco Estuary: A Review. San Francisco Estuary & Watershed Science Vol. 2 Issue 2, Article 3 http://repositories.cdlib.org/jmie/sfews/vol2/iss2/art3

[NPS] National Park Service 2011. Response to Request for information for status review of the longfin smelt. National Park Service Natural Resource Information Portal database.

Nichols, F.H., J.E.Cloern, S.N.Luoma, D.H.Peterson. 1986. The Modification of an Estuary. Science. Volume 231: 567-573.

Nobriga, M. 2009. Bioenergetic modeling evidence for a context-dependent role of food limitation in California’s Sacramento-San Joaquin Delta. California Fish and Game 95(3):111-121.

Nobriga, M. 2010. Longfin smelt and the Bay Delta Conservation Plan Environmental Assessment. Unpublished, PowerPoint. 9 slides.

Nobriga, M.L. and F. Feyrer. 2007. Shallow-Water Piscivore-Prey Dynamics in California's Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 5, Issue 2. Article 4.

Nobriga, M.L., Z. Matica and Z. P. Hymanson. 2004. Evaluating Entrainment Vulnerability to Agricultural Irrigation Diversions: A Comparison among Open-Water Fishes. American Fisheries Society Symposium 39:281–295.

Nowak, G. M., R.A. Tabor, E. J. Warner, K. L. Fresh, and T. P. Quinn. 2004. Ontogenetic Shifts in Habitat and Diet of Cutthroat Trout in Lake Washington, Washington. North American Journal of Fisheries Management. 24:624-635.

Oros, D.R. and I. Werner. 2005. Pyrethroid Insecticides: An Analysis of Use Patterns, Distributions, Potential Toxicity and Fate in the Sacramento-San Joaquin Delta and Central Valley. White Paper for the Interagency Ecological Program. SFEI Contribution 415. San Francisco Estuary Institute, Oakland, CA. 112 pp.

Paduan, Jeff. Personal Communications Between Jeff Padaun of the Naval Postgraduate School and C. Grant of the USFWS regarding longfin smelt dispersal potential on November 7, 2011.

Page, L. and Burr, B.M. 1991. The Peterson Field Guide Series: A Field Guide to Freshwater Fishes North America North of New Mexico. Houghton Mifflin, Boston, 1991. 432 pages.

Parker, A., A. Marchi, J. Davidson-Drexel, R. Dugdale, and F. Wilkerson. 2010. Effect of Ammonium and Wastewater Effluent on Riverine Phytoplankton in the Sacramento River, CA. Technical report for the California State Water Resources Board.

Payne, J.L., S. Finnegan. 2007 The effect of geographic range on extinction risk during background and mass extinction. PNAS 104 (25).

Pequegnat J.E. and J.H. Butler. 1982. The biological oceanography of Humboldt Bay in C. Toole and C. Diebel (eds) Humboldt Bay Symposium Proceedings. Center for Community Development, Humboldt State University, Arcata, CA pp 39–51

Pimentel D, Zuniga R, Morrison D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52: 273–288.

PRBO Conservation Science. 2011. Projected Effects of Climate Change in California Ecoregional Summaries Emphasizing Consequences for Wildlife.

Quirollo, L. 1994. Personel communication between L. Quirollo of the CDFG and Michael Thabault of the USFWS on May 2, 1994.

Radtke, L.D. 1966. State of California: The Resource Agency Department of Fish and Game: Fish Bulletin 136. Ecological Studies of The Sacramento-San Joaquin Delta Part II: Fishes of The Delta. 20 pp.

Rahmstorf, S. 2007. A Semi-Empirical Approach to Projecting Future Sea-Level Rise. Science 315: 368-370.

Raifsnider, C. 2011. Personal communication between Carol Raifsnider of Tenera Environmental, Consultant for GenOn Power, and Brian Hansen of the U.S. Fish and Wildlife Service regarding operation for the Contra Costa and Pittsburg Generating Stations on May 17, 2011

Rand, G.M. 1995. Fundamentals of Aquatic Toxicology. Second Edition. Taylor & Francis. Washington, D.C. 1148 pp.

Rieman, B.E., Isaak, D.J. 2010. Climate Change, Aquatic Ecosystems, and Fishes in the Rocky Mountain West: Implications and Alternatives for Management.

Rice, Casimir. 2010. Personnel Communication between Casimer Rice of the NOAA and Colin Grant of the USFWS regarding longfin smelt beach seining in the Snohomish estuary on December 17, 2010.

Roegner, C. 2008. Personnel Communication between Curtis Roegner of the NOAA and Randalll Baxter of the CDFG regarding longfin smelt distribution along the Oregon Coast on January 15, 2008.

Rosenfield, J.A. 2010. Life History Conceptual Model and Sub-Models. Longfin Smelt, San Francisco Estuary Population. Delta Regional Ecosystem Restoration Implementation Plan [DRERIP].

Rosenfield, J. A., and R. D. Baxter. 2007. Population dynamics and distribution patterns of longfin smelt in the San Francisco Estuary. Transactions American Fisheries Society 136:1577-1592.

Rosenfield, J, and C. Swanson. 2010. Exhibit 2 Regarding Flow Criteria for the Delta Necessary to Protect Public Trust Resources: SWRCB Public Trust Flow Criteria Proceedings.

Scholz, N.L., N.K. Truelove, B.L. French, B.A. Berejikian, T.P. Quinn, E. Casillas, T.K. Collier. 2000. Diazinon disrupts antipredator and homing behaviors in Chinook salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Science 57:1911-1918.

Scott, G.R. and K.A. Sloman. 2004. The effects of environmental pollutants on complex fish behavior: integrating behavioral and physiological indicators of toxicity, Aquatic Toxicology 68:369–392.

Shafer, T.J. and D.A. Meyer. 2004. Effects of pyrethroids on voltage-sensitive calcium channels: a critical evaluation of strengths, weaknesses, data needs, and relationship to assessment of cumulative neurotoxicity. Toxicology and Applied Pharmacology 196:303-318.

Simberloff D, Parker I, Windle P. 2005. Introduced species policy, management, and future research needs. Frontiers in Ecology and the Environment 3: 12–20.

Slater, S. B. 2008. Personal communication between Steven B. Slater of the CDFG and Colin Grant of the USFWS regarding longfin smelt diet on February 3, 2011.

Solomon, S., D. Quin, M.Manning, R.B. Alley, T. Bernsten, N.L. Bindoff, Z. Chen, A. Chidthaison, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Comerville, T.F. Stocker, P. Whetton, R.A. Wood and D. Wratt, 2007: Technical Summary. In: Climate Change2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Quin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Sommer, T. R., R. D. Baxter and F. Feyrer. 2007. Splittail Delisting: A Review of Recent Population Trends and Restoration Activities. American Fisheries Society Symposium 53: 25-38.

Sonoma County Water Agency. 2001. Biological and Water Quality Monitoring in the Russian River Estuary. Fifth Annual Report. 169 pp.

Stanley, S. E., P. B. Moyle, and H. B. Shaffer. 1995. Allozyme analysis of delta smelt, Hypomesus transpacificus and longfin smelt, Spirinchus thaleichthys in the Sacramento-San Joaquin Estuary, California. Copeia 1995(2):390-396.

[SWRCB] State Water Resources Control Board. 1999. Final EIR Implementation of the 1995 Bay/Delta Water Quality Control Plan.

[SWRCB] State Water Resources Control Board. 2000. Revised Water Right Decision 1641. Implementation of Water Quality Objectives for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

[SWRCB] State Water Resources Control Board. 2010. Integrated Report Clean Water Act Sections 303 (d) and 305 (b). April 19, 2010.

Stevens, D. E., and L. W. Miller. 1983. Effects of river flow on abundance of young chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin River System. North American Journal of Fisheries Management 3(4):425-437.

Tanner, D.K. and M.L. Knuth. 1996. Effects of esfenvalerate on the reproductive success of the bluegill sunfish, Lepomis macrochirus in littoral enclosures. Archives of Environmental Contaminants and Toxicology 31:244-251.

Talylor, E. 2011. Personal communication between Eric Taylor of the University of British Columbia and Colin Grant of the USFWS regarding longfin smelt in Pitt Lake on August 9, 2011.

Teh, S., I. Flores, M. Kawaguchi, S. Lesmeister and C. Teh. 2011. Full life-cycle bioassay appoach to assess chronic exposure of Pseudodiaptomus forbesi to ammonia/ammonium. Final report.

Submitted to the State Water Board on March 4, 2011. UC Davis, Aquatic Toxicology Program. Davis, CA.

Tenera Environmental, 2011. Impingement and Entrainment Monitoring Reports for the Contra Costa and Pittsburg Generating Stations.

Thomson, J.R., W.J. Kimmerer, L.R. Brown, K.B Newman, R. MacNally, W.A. Bennett, F. Feyrer, E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications 20 (5). pp. 1431-1448.

Tomosy, M. Personal Communication regarding longfin smelt. Notes from calls made 11/29-12/6/1993.

Unmuth, JML, R.A. Lillie, D.S. Dreikosen, D.W. Marshall. 2000. Influence of dense growth of Eurasian watermilfoil on lake water temperature and dissolved oxygen. Journal of Freshwater Ecology 15: 497–503.

[USACE] United States Army Corp of Engineers. 2011. Sacramento River Deep Water Ship Channel Project. available online at http://www.spn.usace.army.mil/projects/dwsc.

[USBR] United States Bureau of Reclamation. 2009. Central Valley Project. 9 pp.Available online at http://www.usbr.gov/projects/Project.jsp?proj_Name=Central+Valley+Project

[USBR] United States Bureau of Reclamation. 2011. SECURE water act section 9503(c) – Reclamation climate change and water 2011. U.S. Department of the Interior, Denver, CO. 206 pp

[USEPA] United States Environmental Protection Agency 2009. Draft 2009 update aquatic life ambient water quality criteria for ammonia-freshwater. EPA-822-D-09-001.

[USEPA] United States Environmental Protection Agency 2011. National Pollution Discharge System. Available online at http://cfpub.epa.gov/npdes/cwa.cfm?program_id=45. Accessed May 1, 2011.

[USFWS] United States Fish and Wildlife Service 1994. Federal Register Vol. 59 No. 4. Pages 869-871.

[USFWS] U.S. Fish and Wildlife Service. 2002. Biological/Conference Opinion Regarding the Effects of Operation of the U.S. Bureau of Reclamation’s Proposed 10-Year Operation Plan for the Klamath Project and its Effect on the Endangered Lost River Sucker (Deltistes luxatus)

[USFWS] U.S. Fish and Wildlife Service. 2008. Biological/Conference Opinion

[USFWS] United States Fish and Wildlife Service. 2010. Longfin smelt scientific take unpublished spreadsheet.

[USFWS] United States Fish and Wildlife Service. 2011. Scanning the conservation horizon, a guide to climate change vulnerability assessment. National Wildlife Federation, Washington, DC (www.nwf.org). 168 pp

[USFWS] United States Fish and Wildlife Service. 2011. Fall Midwater Trawl Catch Data. Unpublished spreadsheet.

[USFWS] United States Fish and Wildlife Service. 2011a. Genetics Panel Discussion.

[USFWS] United States Fish and Wildlife Service. 2011b. Ocean Currents Panel Discussion.

[USFWS] United States Fish and Wildlife Service. 2011c. Smelt Working Group Notes January 3rd, 2011. Available online at http://www.fws.gov/sfbaydelta/ocap/.

[USGS] United States Geological Survey. 2003. Earthquake Probabilities in the San Francisco Bay Region: 2002-2031. By Working Group On California Earthquake Probabilities. Open File Report 03-214.

Veroujean, D. 1994. Personal communication between Daniel H. Varoujean of the Marine and Estuarine Research Company and Peter Moyle of theUniversity of California regarding longfin smelt distribution in Oregon on April 16, 1994.

Wang, J.C.S. 1986. Fishes of the Sacramento – San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. Technical Report 9 January 1986. Interagency Ecological Study Program For the Sacramento-San Joaquin Estuary.12 pages plus appendices.

Werner, I., L.A. Deanovic, V. Connor, V. De Vlaming, H.C. Bailey and D.E. Hinton. 2000. Insecticide-caused toxicity to Ceriodaphnia dubia (Cladocera) in the Sacramento-San Joaquin River Delta, California, USA. Environmental Toxicology and Chemistry 19(1):215-227.

Werner, I., L. Deanovic, D. Markiewicz, M. Stillway, N. Offer, R. Connon, S. Brander. 2008. Pelagic Organism Decline (POD): Acute and chronic invertebrate and fish toxicity testing in the Sacramento-San Joaquin Delta, 2006-2007. Final Report, 30 April, 2008. Aquatic Toxicology Laboratory, School of Veterinary Medicine, University of California, Davis.

Werner, I., D. Markiewicz, L. Deanovic, R. Connon, S. Beggel, S. Teh, M. Stillway and C. Reece. 2010. Pelagic Organism Decline (POD): Acute and chronic invertebrate and fish toxicity testing in the Sacramento-San Joaquin Delta, 2008-2010. Final Report submitted to the California Department of Water Resources, July 24, 2010. Aquatic Toxicology Laboratory, School of Veterinary Medicine, University of California, Davis.

Weston, DP and MJ Lydy. 2010. Urban and agricultural sources of pyrethroid insecticides to the Sacramento-San Joaquin Delta of California. Environmental Science and Technology 44:1833-1840.

Wicks, B.J., R. Joensen, Q. Tang, and D.J. Randall. 2002. Swimming and ammonia toxicity in salmonids: the effect of sub lethal ammonia exposures on the swimming performance of coho salmon and the acute toxicity of ammonia in swimming in rainbow trout. Aquatic Toxicology 59:55-69.

Wilder RM, MJ Marshall, JF Ingram, J Pedretti, BP Powell. 2010. Just add water: spatial and temporal patterns of larval, juvenile, and adult fishes within Liberty Island. 4th Biennial CALFED Science Conference. 10/23-10/25/2006. Sacramento, CA. [Powerpoint of Presentation - 17.1 MB]

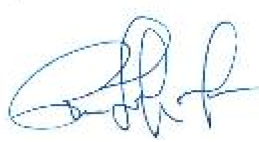
Wildlands Corporation. Wildlands Completes 186-acre Fish Habitat Restoration at Liberty Island. Available online at http://www.wildlandsinc.com/news/index.php/2011/04/19/wildlands-completes-fish-habitat-restoration Accessed May 20, 2011.

Williams, G.D, Pearson, W.H., Evans, N.R., Anderson, M.G. 2004. Benson Beach Demonstration Project: Composition and Abundance of Biota at Three Alternative Sump sites. Marine Sciences Laboratory. 31 pages plus appendices.

Wing, B. 2010. Personal communication between Bruce Wing of NOAA and Rod Simmons of the USFWS regarding longfin smelt distribution in Alaska on December 6, 2010.

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: 

06/29/2016
Date

Concur: 

11/14/2016
Date

Did not concur: ______________________

______
Date

Director's Remarks: