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Historic and contemporary distribution of Longfin Smelt (*Spirinchus thaleichthys*) along the California coast

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Longfin smelt (*Spirinchus thaleichthys*) was listed as threatened under the California Endangered Species Act in 2009. This anadromous fish exhibits complex life history patterns, using a variety of habitats from nearshore waters, to estuaries and lower portions of freshwater streams. While consistent data collection efforts in the greater San Francisco Bay region provide much information regarding this species, little is known throughout its remaining range in California. To help address this gap in knowledge, the objectives of this review were to gather, synthesize and analyze existing data for this species from areas outside of San Francisco Bay, and to identify areas of historic and contemporary presence, and habitat use along the northern and central California coasts. Observations were gathered from existing published articles, technical reports, museum collections and field observations. Longfin smelt captures were noted dating from 1889 to 2016 in a diverse range of habitats, including coastal lagoons, bays, estuaries, sloughs, tidal freshwater streams and nearshore habitats. Longfin smelt were found throughout northern and central California in 15 watersheds spanning from Moss Landing Harbor north to Lake Earl near the northern California border. Spawning was noted in both the Eel River and in tributaries to Humboldt Bay, with pre-and post-spawn individuals observed in tributaries to Humboldt Bay in more recent years. Use of nearshore waters was also noted with most longfin smelt collected in shallow waters relatively close to shore in the vicinity of known spawning areas. This paper provides a comprehensive look at the existing information available for this species along the California coast, highlights current data gaps, and identifies additional information needed to improve management and enhance recovery of the species within the State.

Key words: Anadromous, California Endangered Species Act, Habitat, Humboldt Bay, Longfin Smelt, Osmeridae

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Members of the family Osmeridae are distributed throughout the cool waters of the northern hemisphere and currently consist of 15 recognized species (Eschmeyer 2006).

These "true smelts" include marine (5), anadromous (6), freshwater (3), and estuarine (1) species, though life history plasticity is common in this family. For example, many species of smelt can tolerate a wide range of salinities, with some anadromous species such as the European smelt (*Osmerus eperlanus*) and the rainbow smelt (*Osmerus mordax*) having self-sustaining freshwater landlocked populations (Baby et al. 1991; Lischka and Magnuson 2006; Tulp et al. 2013). For most species of Osmerids, spawning predominately takes place over coarse gravels or on sandy substrates (Rupp 1965; Hirose and Kawaguchi 1998; de Groot 2002; Stables et al. 2005; Lischka and Magnuson 2006). For example, spawning takes place on beaches for surf smelt (*Hypomesus pretiosus*), and in freshwater streams for species such as eulachon (*Thaleichthys pacificus*), rainbow smelt and wakasaki (*Hypomesus nipponensis*) (de Groot 2002; Stables et al. 2005; Rice 2006). As Osmerids can be found in large numbers in the coastal marine environment, many species are important forage fish and contribute to a variety of commercial and recreational fisheries (Leet et al. 2001).

Seven recognized species of Osmerids occur in California including the longfin smelt (*Spirinchus thaleichthys*), an anadromous species found along the central and northern California coast north to central Alaska (Moyle 2002). Once harvested commercially in San Francisco Bay, this species is currently listed as threatened by the State of California (Leet et al. 2001; CDFW 2009). However, *S. thaleichthys* was found to be "warranted but precluded" from listing under the federal Endangered Species Act in part of its range by the U.S. Fish and Wildlife Service in part due to genetics and the lack of information on populations outside of San Francisco Bay (USFWS 2012). Like other species of Osmerids, population declines are likely due to habitat degradation and loss (de Groot 2002; CDFG 2009). The longfin smelt is a relatively small (to 150 mm TL) fish that exhibits a two-year life history (Leet et al. 2001; Moyle 2002; Rosenfield 2010). Though little is known regarding spawning, it is thought longfin smelt may spawn over coarse gravel or sandy substrates similar to other Osmerids (Moulton 1974; Martin and Swiderski 2001; Rosenfield 2010). This species also inhabits various depths depending on the time of day and life history stage, with adults inhabiting deeper areas close to the bottom during the day and becoming more associated with surface waters at night (Chigbu et al. 1998). Newly hatched larvae (5 mm SL) are associated with the surface waters and can move vertically in the water column once the swim bladder reaches inflation (Bennett et al. 2002; Hobbs et al. 2006).

Much of the existing demographic information on longfin smelt comes from either San Francisco Bay, or from a landlocked population in Lake Washington, WA (Moulton 1974; Stevens and Miller 1983; Chigbu and Sibley 1994; Baxter et al. 1999; Bennett et al. 2002; Rosenfield and Baxter 2007; Merz et al. 2013) with limited information collected in other areas throughout its range (Misitano 1977; McCabe et al. 1983; Robards et al. 1999; Abookire and Piatt 2005; Harding et al. 2011). In California, little is known regarding longfin smelt in areas outside of San Francisco Bay. Longfin smelt were categorized as "common" in surveys of the Klamath River estuary spanning from 1979 to 1989 and Humboldt Bay in the late 1960's (Eldridge and Bryan 1972; Sopher 1974; Kisanuki et al. 1991). However, an extensive fish study conducted in Humboldt Bay from 2000 to 2001 sampled few longfin smelt, consistent with the declines seen in San Francisco Bay, athough the study was not designed to replicate the earlier efforts (Gleason et al. 2007).

The purpose of this comprehensive data review was to gather, synthesize and analyze all available contemporary and historic information on longfin smelt distribution and habitat associations in areas of California outside of San Francisco Bay.

Materials and Methods

Longfin smelt catch data from published studies, technical reports, thesis and museum collections were evaluated for validity and integrated into a spatial database (Appendix 1). The review included sampling efforts conducted within bays, estuaries, the stream-estuary ecotone, lower reaches of freshwater streams, and nearshore waters of California, excluding catches within San Francisco Bay which had its longfin smelt range described by Merz et al. (2013). Museums with longfin smelt records included the California Academy of Sciences (CAS), Humboldt State University (HSU), Harvard University Museum of Comparative Zoology (MCZ), University of Kansas Biodiversity Institute and Natural History Museum Ichthyology Collection (KU and KUIT), Los Angeles County Natural History Museum (LACM), and Stanford University (SU). If available, the information gathered included: location, date, depth, sex, length, method of collection, number collected, and spawning condition. For convenience, observations were lumped into two categories, historic (1999 or earlier) or current. Fish >20 mm were categorized as larvae, juveniles between 20 and 88mm total length (TL), while fish >88 mm TL or >70 mm standard length (SL) were considered adults (Simonsen 1977; Emmett et al. 1991; Rosenfield 2010). Geographic locations were from stated latitude and longitude, specific written descriptions including landmarks and depths, or maps. Locations that were not included, or were too general (e.g. just "Humboldt Bay"), were not placed on the maps, though the observations were reported in Appendix 1.

Results

Longfin smelt observations were noted from 1889 to 2016, with a total of 189 capture locations documented (Appendix 1 and Figure 1). Geographically, longfin smelt were reported from Moss Landing Harbor in central California, north to Lake Earl near the northern California border (Figure 1), encompassing a total of 15 watersheds either with historic or current observations (Figures 1-3). Longfin smelt were captured using a variety of fish sampling gear, with the most common methods being trawls and seines, though individuals were also captured using boat electrofishing and a variety of net types (Appendix 1).

Longfin smelt were observed in a wide variety of habitats throughout its range in coastal California. Populations of longfin smelt spanned much of the central and northern California coastline with individuals collected in both small and large estuaries, over a wide range of flow regimes, and a variety of habitat complexities. For instance, longfin smelt were collected throughout Humboldt Bay, which has multiple small tributaries and extensive slough and brackish areas, but were also collected in areas with minimal off-channel estuarine habitats and waters dominated by freshwater flows (e.g. Russian River, Mad River and Klamath River). The broad use of estuary types by this species highlights the considerable plasticity in the life history and habitat use among Osmerids.

Most longfin smelt occurrences were from the Humboldt Bay or Eel River areas, nearby in nearshore waters, or in lower reaches of tributaries to the Bay, likely reflecting the higher sampling effort in this region (Appendix 1; Figure 2). In Humboldt Bay, longfin smelt were noted in all of the major tributaries including Mad River Slough, Jacoby Creek, Freshwater Slough (also known as Eureka Slough in its lower reaches), Elk River and Salmon Creek (Appendix 1). These observations represent most of the contemporary cap-

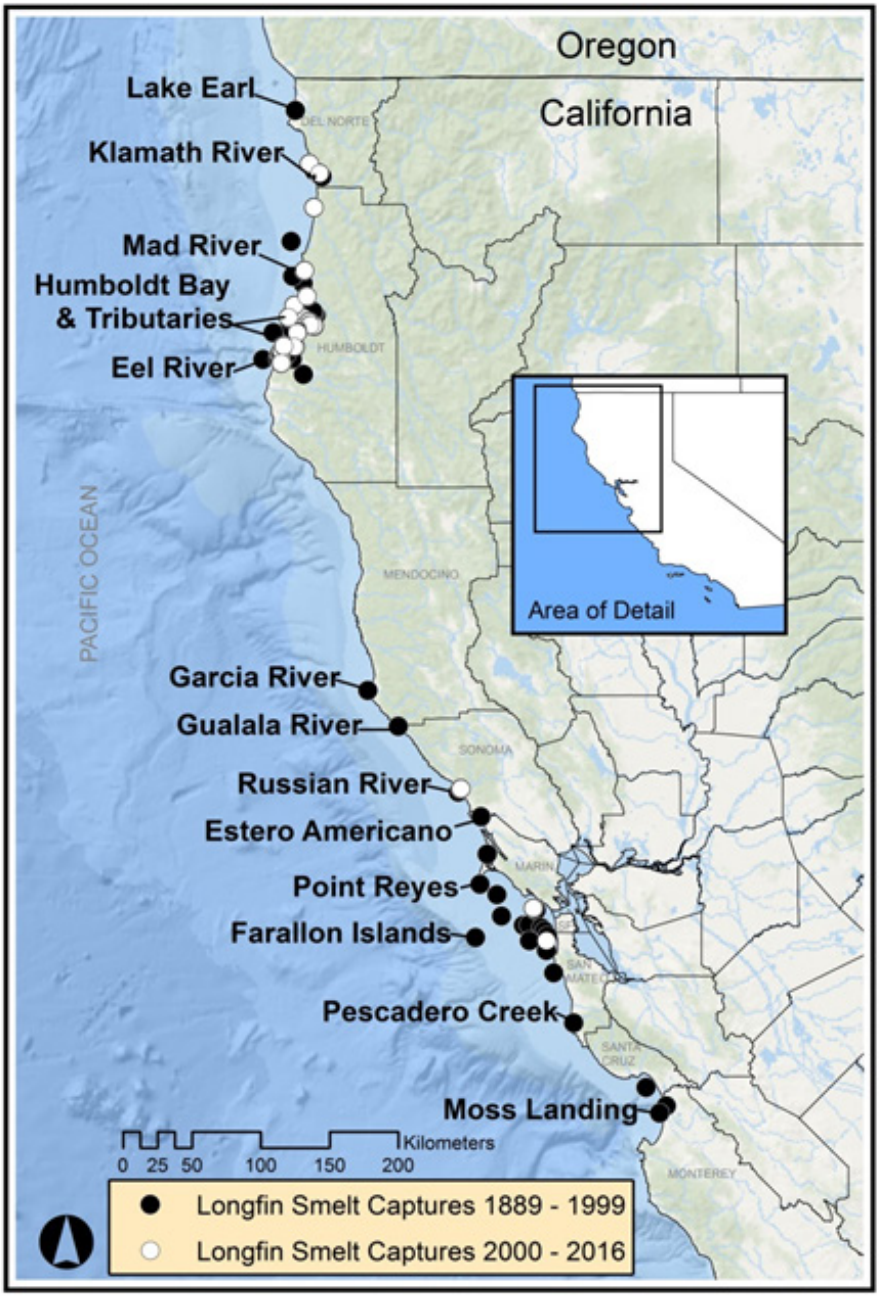

FIGURE 1.—Locations for all longfin smelt (*Spirinchus thaleichthys*) observations identified in this study from 1889 to 2016 (see Appendix 1 for a list of citations). Observations were from California, but did not include captures from San Francisco Bay.

tures of longfin smelt throughout the study area. Since 1999, 23 observations of longfin smelt were documented in waters of Humboldt Bay, its tributaries or in nearshore waters with observations ranging from 1-17 individuals per sampling event. Longfin smelt were found year-round in the waters of Humboldt Bay and ranged in size from 4 to 150 mm (Appendix 1).

Longfin smelt were observed in many areas throughout the Eel River estuary and the mainstem portions of the coastal plain (Figure 2). The Eel River is the third largest watershed in California, with an extensive tidally influenced estuary containing many slough channels and brackish areas (Monroe et al. 1974). Most of the longfin smelt data collected in the Eel River estuary came from two studies, Puckett (1977) and Cannata and Hassler (1995). Both studies used beach seines to sample the lower estuary for approximately one year. Given the large size of the Eel River estuary, much of the estuary was not sampled, though detections of longfin smelt appear to be relatively frequent in areas with consistent sampling (Puckett 1977; Cannata and Hassler 1995). Longfin smelt utilized a wide range of the lower river/estuary with individuals sampled 5.7 km from the mainstem of the river in slough waters, and as far as 20 km upriver from the mouth in alluvial portions well outside the brackish zone (Puckett 1977; Jensen 1957). Both Puckett (1977) and Cannata and Hassler (1995) observed longfin smelt in samples taken in late fall through early spring, though neither detected them in January. This is likely due to the difficulty sampling during high flow events that are common on the Eel River during this month. All longfin smelt observations from the Eel River occurred from late fall through early spring with some observations during summer months (Appendix 1).

Dominated by freshwater flows, the Russian River is a large river system with an estuary that closes periodically cutting off the river from the ocean. Closing and breaching events generally occur from late summer through fall (Sonoma County Water Agency 2001). Trawl surveys were conducted from summer or early fall through mid-November in the lower Russian River over four years (Merritt Smith Consulting 1998; 1999; 2000; Sonoma County Water Agency 2001). Longfin smelt were detected near the mouth of the river with detections occurring in late August through early November. Three individuals were also collected in June. Longfin smelt were not detected in the upstream stations also trawled during the study. In addition, while longfin smelt were captured in trawl surveys, they were not detected in the corresponding shallow water beach seine collections in the lower estuary (Merritt Smith Consulting 1998; 1999; 2000; Sonoma County Water Agency 2001). This indicates longfin smelt were utilizing the deeper, cooler, more saline waters of the estuary. The timing of observations in the Russian River estuary indicates individuals were staging in the estuary prior to spawning, though it is unclear where spawning might occur in the watershed.

Longfin smelt were also collected in two coastal lagoons, Abbotts Lagoon and Lake Earl, using gill nets (McLeod 1989; Saiki and Martin 2001). Abbotts Lagoon and Lake Earl, the largest lagoon on the West Coast of the United States, are frequently disconnected from the ocean by sand bars that commonly form during the summer months (Monroe et al. 1975; Saiki and Martin 2001). These lagoons are dominated by brackish waters for most of the year and also have limited connectivity to freshwater stream habitats. Similar to these coastal lagoons, longfin smelt were also collected in rivers and streams with mouths that close to the ocean for most or part of the year. These included the Gualala River, Russian River, Estero Americano, and Pescadero Creek (Appendix 1).

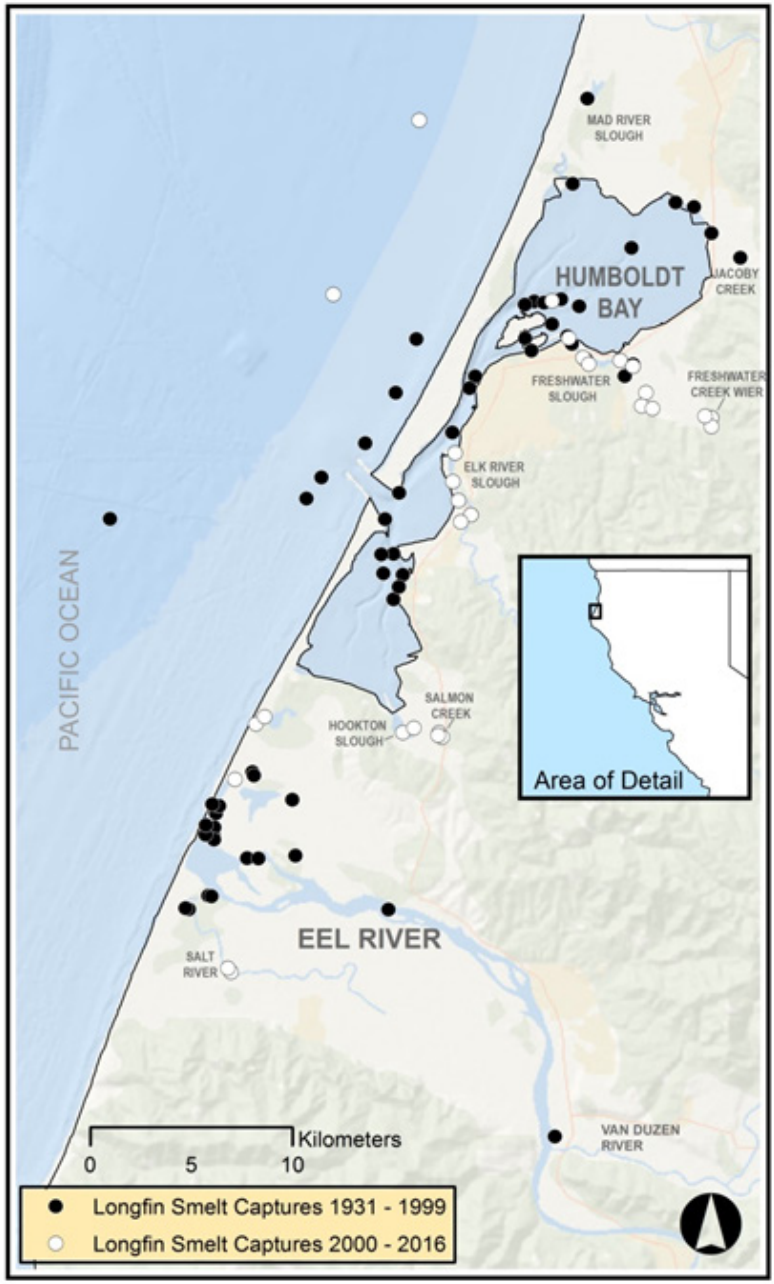

FIGURE 2.—Locations for Longfin Smelt (*Spirinchus thaleichthys)* observations in Humboldt Bay, its tributaries, in the Eel River and offshore waters from 1931 to 2016.

While longfin smelt presence has been documented in nearshore waters, their use of these areas is not well described. Observations compiled from areas outside of rivers and estuaries in nearshore coastal waters generally occurred near watersheds having longfin smelt, with frequent detections adjacent to Humboldt Bay, the Eel River, and San Francisco Bay (Figures 2 & 3). For example, observations in nearshore waters were generally in depths less than 40 m ranging from the shoreline (collected in a beach seine) off of Trinidad Head (HSU Fish Collection #3694), to depths of 55 m in waters offshore of Drakes Bay (B. MacFarlane, National Oceanic and Atmospheric Administration, Southwest Fisheries Science Center, Fisheries Ecology Division, unpublished data). Most were also collected within 10 km of the mainland, with some taken as far as 36 km offshore near the Farallon Islands (CAS Fish Collection #34742). Reported lengths for longfin smelt collected in coastal marine waters using bottom trawls consisted of late juvenile through adult individuals, with sizes ranging from 84 to 145 mm TL. Observations in epipelagic waters off the coast of San Francisco Bay found longfin smelt ranging from young-of-the-year through adult individuals, measuring from 36 to 120 mm SL (B. MacFarlane, unpublished data). Data provided here show longfin smelt utilize waters close to shore and in relatively shallow depths year-round, from juveniles through adult stages, with most sampled as adults from late summer through late fall (Appendix 1). Limited observations in other parts of their range along the west coast show similar findings. Samples taken off the shores of the Columbia River estuary noted longfin smelt in nearshore shallow waters, with benthic samples taken in shallow waters ranging from 9.4 to 18.6 m deep (Hinton and Emmet 1994; Litz et al. 2014). Longfin smelt were also taken using trawls off of Tillamook Bay, Oregon in nearshore shallow waters (Emmet and Hinton 1992). Observations compiled here show longfin smelt were taken frequently with epi-benthic trawl gear (Appendix 1). However, large observations of longfin smelt in the nearshore waters of California and Washington were collected with both epi-pelagic and epi-benthic sampling methods (Hinton and Emmet 1994; Harding et al. 2011; B. MacFarlane, unpublished data).

Spawning populations (i.e. individuals in spawning and post-spawning condition, spawning aggregations, and the presence of early larval stages in freshwater habitats) were also identified in the Eel River and tributaries to Humboldt Bay. In the Eel River, spawning was noted in the Eel River Estuary by Puckett (1977), though the specific location was not reported. Additionally, individuals in spawning condition (i.e. eggs extruded from females with the addition of pressure and milt flowing from males) were collected 7.2 km upstream of the mouth of the Eel River (Jensen 1957). In the Humboldt Bay region, early larvae were observed in Freshwater Creek/Slough as well as in Humboldt Bay (Eldridge and Bryan 1972; Chamberlain 1988). Individuals in spawning condition (i.e. adult sized individuals in areas thought to be used for spawning and with eggs or milt extruded with little pressure) have also been observed in Freshwater Creek from December through February (C. Anderson, Sponsored Programs Foundation, Humboldt State University, personal communication; J. Ray, California Department of Fish and Wildlife, personal communication). Individuals in post-spawn condition (i.e. individuals with elongated pectoral and anal fins, in areas thought to be used for spawning, but with concave abdomens and no eggs or milt upon exerting pressure) were sampled in February in Salmon Creek (M. Wallace, California Department of Fish and Wildlife, personal communication) and in mid-March in Freshwater Creek (J. Garwood, California Department of Fish and Wildlife, personal communication). In addition, individuals with ripe gonads were noted in north Humboldt Bay in November and December (Sopher 1974).

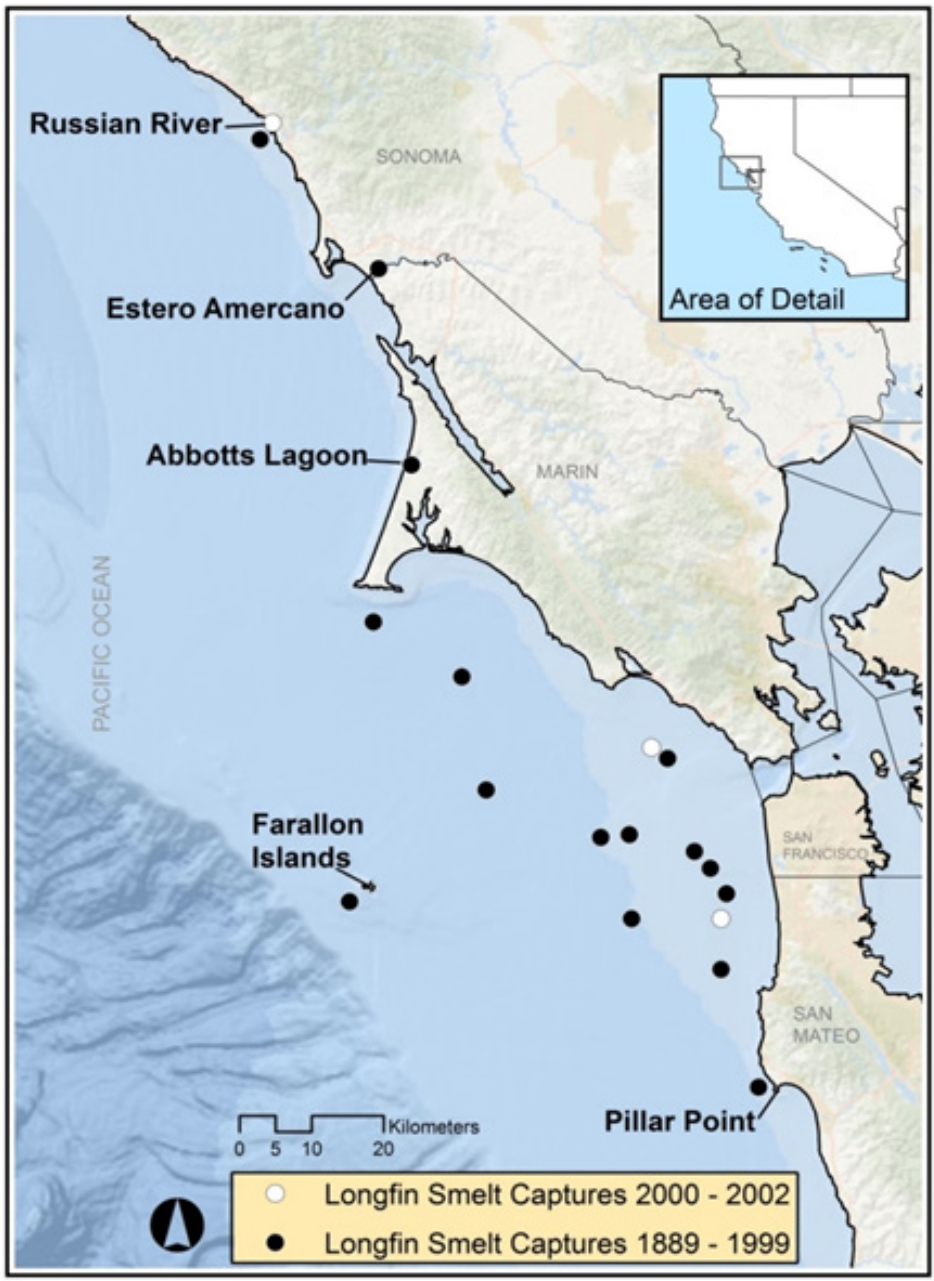

FIGURE 3.—Locations for Longfin Smelt (*Spirinchus thaleichthys*) collections from the Russian River to Pillar Point, CA from 1889 to 2002. Collections from San Francisco Bay were not included in this study.

Information regarding spawning behavior of longfin smelt was also noted in association with salmonid migrant trapping in Freshwater Creek, a tributary to Humboldt Bay. Among the data gathered, a single sex aggregation of longfin smelt was collected at the Freshwater Creek weir in late December 2015 (J. Ray, personal communication). All of the individuals (n=8) sampled on that occasion were pre-spawn males, indicating staging for spawning was segregated by sex. This corresponds with the findings from Moulton (1974) who found male longfin smelt from a landlocked population in Lake Washington, WA., arriving before females in tributary rivers. This is also similar to observations of other Osmerids such as eulachon and rainbow smelt, with males arriving at spawning locations before females and staying at sites longer (Murawski et al. 1980; Moyle 2002).

Females were also documented at spawning grounds for protracted periods. One fin clipped female longfin smelt was recaptured at the Freshwater Creek weir a minimum of 25 days (maximum = 44 days) after initial capture in February 2016 (C. Anderson, personal communication). As the mark was not unique to an individual, the spawning condition at the first capture is unclear though she was noted to be in pre-spawn condition at the time of recapture. This observed recapture interval was longer than reported for female rainbow smelt in the Parker River estuary in Massachusetts, which recorded a maximum period of recapture at spawning grounds to be 14 days (Murawski et al. 1980).

Discussion

This review provides a synthesis of the available data for longfin smelt along the California coastline. However, these data likely underestimate the spatial and temporal distributions and habitat utilization of this species. For example, no longfin smelt were documented in the Smith River. While there are records of longfin smelt in harbor seal scat sampled at the mouth of the Smith River (Gemmer 2002), it is unknown if the fish eaten were from the Smith River, in the waters offshore, or an adjacent watershed. There are also anecdotal records of longfin smelt presence in the Smith River (Fry 1973), though no direct observations of the species in the river were located. In addition, despite the presence of available habitat, no observations of longfin smelt were found in the multitude of streams along the southern Humboldt County coast through southern Mendocino County (Figure 1). While some field observations from this area documented “smelt” or surf smelt, no observations identifying longfin smelt were noted. In addition, in summer and fall longfin smelt may orient toward deep riverine and estuarine channels where shore oriented sampling for salmonids may miss them (Rosenfield and Baxter 2007).

Common among the watersheds longfin smelt were documented to occur, is the significant degradation or loss of tidal wetland habitat and freshwater flows (Moyle et al. 2011; Katz et al. 2013). This degradation of habitat quantity and quality has likely contributed to population declines. To help recover longfin smelt, restoration of natural freshwater flows and former wetlands are needed in areas such as Humboldt Bay and the Eel River estuary, as these areas include both available habitat and extant populations of longfin smelt. There have been a few recent examples of former tidelands, once diked and drained, that have undergone restoration efforts and have subsequently observed longfin smelt use. For example, the Salt River, a major tributary to the lower Eel River estuary, underwent a large restoration project in the summer of 2013 with over 4 km of river channel excavated, widened and deepened (Manning and O’Shea 2015). In the winter of 2014, adult longfin smelt were detected over 4.5 km up-stream in the restored areas (M. Wallace, personal

communication). Longfin smelt were also sampled in slough channels connected to McNulty Slough in the lower portion of the Eel River that were restored to tidal access after a levee breach (M. Wallace, unpublished data). In Salmon Creek, a tributary to Humboldt Bay, longfin smelt were detected in January 2012 in areas that had received extensive restoration during the previous year (M. Wallace, unpublished data). In San Francisco Bay, longfin smelt were also documented in salt ponds restored to tidal flow (Hobbs et al. 2012). These restoration projects highlight that longfin smelt can rapidly utilize restored areas once marine connectivity is re-established or enhanced.

This data review synthesizes a wide variety of information for longfin smelt along the northern and central California coast. However, to enhance the management of this species and guide habitat protection and restoration efforts, systematic studies are needed throughout its range in California. While there are ongoing data collection efforts in San Francisco Bay, there is currently little work being done on populations outside of that area. In Humboldt Bay, most contemporary observations were taken incidental to ongoing salmon monitoring efforts by the California Department of Fish and Wildlife using beach seines in the tributaries to the Bay, or at the salmon weir on Freshwater Creek. Of highest importance is a systematic effort designed specifically for longfin smelt to determine the current presence of this species in watersheds along the California coast most likely to have longfin smelt, especially those having no available data or unclear occupancy. This type of effort could likely be accomplished with new methods such as environmental DNA (eDNA) currently being utilized to detect other listed cryptic aquatic species (Ficetola, et al. 2008; Thomsen et al. 2012; Schmelzle and Kinziger 2016). This would provide a comprehensive and contemporary view of longfin smelt presence to prioritize research and habitat restoration needs for the species (Roni et al. 2002). Future investigations should also determine spatial and temporal habitats and areas important to the species, especially in known watersheds with longfin smelt present such as Humboldt Bay and the Eel River estuary. For example, specific spawning and rearing areas, as well as potential restoration opportunities, should be determined within watersheds. In coastal marine areas, use by longfin smelt should be investigated to ensure important late juvenile and early adult habitats are fully understood and identified. In conclusion, while this review provides a comprehensive look at the known data for this species along the coast of California, focused designed-based studies are needed to determine all extant California populations and their associated limiting factors for population recovery.

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Literature Cited

ABOOKIRE, A. A., AND J. F. PIATT. 2005. Oceanographic Conditions Structure Forage Fishes into Lipid-Rich and Lipid-Poor Communities in Lower Cook Inlet, Alaska, USA. Marine Ecology Progress Series 287:229-240.

BABY, M., L. BERNATCHEZ, AND J. DODSON. 1991. Genetic Structure and Relationships Among Anadromous and Landlocked Populations of Rainbow Smelt, Osmerus Mordax, Mitchill, as Revealed by MTDNA Restriction Analysis. Journal of Fish Biology 39(Sa):61-68.

BAXTER, R., K. HIEB, S. DELEON, K. FLEMING, AND J. ORSI. 1999. Report on the 1980-1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary. James Orsi, Editor. The Interagency Ecological Program for the Sacramento-San Joaquin Estuary, Technical Report 63, Stockton, California.

BENNETT, W. A., W. J. KIMMERER, AND J. R. BURAU. 2002. Plasticity in Vertical Migration by Native and Exotic Estuarine Fishes in a Dynamic Low-Salinity Zone. Limnology and Oceanography 47(5):1496-1507.

CALIFORNIA DEPARTMENT OF FISH AND GAME (CDFW). 2009. A Status Review of the Longfin Smelt (*Spirinchus Thaleichthys*) in California. Sacramento, California.

CANNATA, S., AND T. HASSIER. 1995. Juvenile Salmonid Utilization of the Eel River Estuary. California Cooperative Fishery Research Unit. Humboldt State University. Arcata, California.

CHAMBERLAIN, R. 988. Fish Use of a Mitigation Salt Marsh. M.S. Thesis. Humboldt State University, Arcata, California.

CHAMBERLAIN, R., AND R. BARNHART. 1993. Early Use by Fish of a Mitigation Salt Marsh, Humboldt Bay, California. Estuaries 16(4):769-783.

CHIGBU, P., AND T. 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):1-15.

CHIGBU, P., T. SIBLEY, AND D. BEAUCHAMP. 1998. Abundance and Distribution of Neomysis Mercedis and a Major Predator, Longfin Smelt *(Spirinchus Thaleichthys)* in Lake Washington. Hydrobiologia 386:167-182.

COLE, M. 2004. Distribution of Fish Species in Humboldt Bay, Humboldt County, California, USA: A GIS Perspective. M.S. Thesis. Humboldt State University, Arcata, California.

DEGEORGES, A. 1972. Feasibility of Artificial Reefs in Intertidal Waters. M.S. Thesis. Humboldt State University, Arcata, California.

DE GROOT, S. 2002. A Review of the Past and Present Status of Anadromous Fish Species in the Netherlands: is Restocking the Rhine Feasible? Pages 205-218 In P. H. Nienhuis and R. D. Gulati, Editors. Ecological Restoration of Aquatic and Semi-Aquatic Ecosystems in the Netherlands. Hydrobiologia 478:1-6.

ELDRIDGE, M. 1970. Larval Fish Survey of Humboldt Bay. M.S. Thesis. Humboldt State University, Arcata, California.

ELDRIDGE, M., AND F. BRYAN. 1972. Larval Fish Survey of Humboldt Bay, California. National Oceanic Atmospheric Administration, Technical Report SSRF-665.

EMMETT, R., AND S. HINTON. 1992. Benthic and Epibenthic Invertebrates, Demersal Fishes, and Sediment Structure off Tillamook Bay, Oregon, September 1990, With Com-

parisons to Previous Surveys. Coastal Zone and Estuarine Studies Division, Northwest Fisheries Science Center. Seattle, Washington.

EMMETT, R., S. HINTON, S. STONE, AND M. MONACO. 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries. Volume II: Species Life History Summaries. Elmr Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland.

EMMETT, R., R. LLANSÓ, 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.

ESCHMEYER, W. 2006. Catalogue Of Fishes. [Internet]. California Academy of Sciences, San Francisco. Available From: http//www.calacademy.org/Research/Ichthyology/Catalog. Accessed 28 September, 2015.

FICETOLA, G. F., C. MIAUD, F. POMPANON, AND P. TABERLET. 2008. Species Detection Using Environmental DNA From Water Samples. Biology Letters 4(4):423-425.

FRY, D. 1973. Anadromous Fishes of California. California Department of Fish & Game Booklet. Sacramento, California. USA.

GEMMER, A. 2002. Ecology of Harbor Seals, *Phoca Vitulina*, in Northern California. M.S. Thesis. Humboldt State University, Arcata, California.

GLEASON, E., T. MULLIGAN, AND R. STUDEBAKER. 2007. Fish Distribution in Humboldt Bay, California: A GIS Perspective By Habitat Type. Current Perspectives on the Physical and Biological Processes of Humboldt Bay. Pages 105-169 In S. C. and R. Rasmussen. Editors. Current Perspectives on the Physical and Biological Process of Humboldt Bay. California Sea Grant. Eureka, California.

HARDING, J., A. AMMANN, AND R. MACFARLANE. 2011. Regional and Seasonal Patterns of Epipelagic Fish Assemblages From the Central California Current. Fishery Bulletin 109(3):261-281.

HILL J., AND L. HENDRICKSON. 1991. Haematozoa of Fishes in Humboldt Bay. Journal of Wildlife Diseases 27(4):701-705.

HINTON, S., AND R. EMMETT. 1994. Benthic Infauna, Sediment and Fish Offshore From the Columbia River, July 1992. Coastal Zone and Estuarine Studies Division, Northwest Fisheries Science Center. Seattle, Washington.

HIROSE, T., AND K. KAWAGUCHI. 1998. Spawning Ecology of Japanese Surf Smelt, *Hypomesus Pretiosus Japonicus* (Osmeridae), in Otsuchi Bay, Northeastern Japan. Environmental Biology of Fishes 52(1-3):213-223.

HOBBS, J., W. BENNETT, AND J. BURTON. 2006. Assessing Nursery Habitat Quality For Native Smelts (Osmeridae) in the Low-Salinity Zone of the San Francisco Estuary. Journal of Fish Biology 69:907-922.

HOBBS, J., P. MOYLE, AND N. BUCKMASTER. 2012. Monitoring the Response of Fish Communities to Salt Pond Restoration: Final Report. University of California, Davis. Davis, California.

JENSEN, P. 1957. An Extension of the Range of the Long-Finned Smelt. California Department of Fish and Game Bulletin 43(1):99.

KATZ, J., P. B., MOYLE, R. M. QUIÑONES, J., ISRAEL, AND S. PURDY. 2013. Impending Extinction of Salmon, Steelhead, and Trout *(Salmonidae)* in California. Environmental

Biology of Fishes 96(10-11):1169-1186.

Kisanuki, T., J. Polos, and D. Wills. 1991. Annual Report - Klamath River Assessment Program. U.S. Fish and Wildlife Service, Coastal California Fisheries Fishery Resource Office, Affl-Fro-91-14. Arcata, California

Leet, W. S., Dewees, C. M., Klingbeil, R., and E. J. Larson. 2001. California's Living Marine Resources: A Status Report. The Resources Agency, California Department of Fish and Game. University of California, Agriculture and Natural Resources Publication Sg01-11, Sacramento, California..

Lischka, S., and J. Magnuson. 2006. Timing and Site Selection of Spawning in a Landlocked Population of Rainbow Smelt in Wisconsin. Environmental Biology of Fishes 76(2-4):413-418.

Litz, M., R. Emmett, P. Bentley, A. Claiborne, and C. Barceló. 2014. Biotic and Abiotic Factors Influencing Forage Fish and Pelagic Nekton Community in the Columbia River Plume (USA) Throughout the Upwelling Season 1999–2009. ICES Journal of Marine Science: Journal du Conseil 71(1):5-18.

Manning, S., and D. O'shea. 2015. Post Construction Eelgrass Survey Report, Year 2-2015. Prepared For: The Humboldt County Resource Conservation District, Eureka, California.

Martin K., and D. Swiderski. 2001. Beach Spawning in Fishes: Phylogenetic Test of Hypotheses. American Zoology 41:526-537.

Mccabe Jr, G. T., W. D. Muir, R. L. Emmett, and J. Durkin. 1983. Interrelationships Between Juvenile Salmonids and Nonsalmonid Fish in the Columbia River Estuary. Fishery Bulletin 81(4):815-826.

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. California Fish and Game 99(3):122-148.

Merritt Smith Consulting. 1998. Biological and Water Quality Monitoring in the Russian River Estuary, 1997 - Second Annual Report. Prepared for the Sonoma County Water Agency. Lafayette, Ca.

Merritt-Smith Consulting. 1999. Biological and Water Quality Monitoring in the Russian River Estuary, 1998 - Third Annual Report. Prepared for the Sonoma County Water Agency, Lafayette, Ca.

Merritt-Smith Consulting. 2000. Biological and Water Quality Monitoring in the Russian River Estuary, 1999 - Fourth Annual Report. Prepared for the Sonoma County Water Agency, Lafayette, California.

Misitano, D. 1977. Species Composition and Relative Abundance of Larval and Post-Larval Fishes in Columbia River Estuary, 1973. Fishery Bulletin 75(1):218-222.

Monroe, G., B. Mapes, P. Mclaughlin, B. Browning, D. Rogers, R. Warner, and J. Speth. 1975. Natural Resources of Lake Earl And Smith River Delta. California Department of Fish and Game, Eureka, California.

Monroe, G., Reynolds, F., B. Browning and J. Speth. 1974. Natural Resources of the Eel River Delta. California Department of Fish and Game, Eureka, California.

Moulton, L. 1974. Abundance, Growth, and Spawning of the Longfin Smelt in Lake Washington. Transactions of the American Fisheries Society 103(1):46-52.

Moyle, P. B. 2002. Inland Fishes of California. University of California Press. Berkeley, California. USA.

Moyle, P. B., J. Katz, and R. Quiñones. 2011. Rapid Decline of California's Native Inland Fishes: A Status Assessment. Biological Conservation 144(10):2414-2423.

Murawski, S., G. Clayton, R. Reed, and C. Cole. 1980. Movements Of Spawning Rainbow Smelt, Osmerus Mordax, In A Massachusetts Estuary. Estuaries 3(4):308-314.

Pinnix, W., T. Shaw, K. Acker, and N. Hetrick. 2005. Fish Communities In Eelgrass, Oyster Culture And Mudflat Habitats Of North Humboldt Bay, California, Final Report. Us Fish And Wildlife Service, Arcata, California Technical Report Number Tr2005-02.

Rice, C. 2006. Effects Of Shoreline Modification On A Northern Puget Sound Beach: Microclimate And Embryo Mortality In Surt Smelt (*Hypomesus Pretiosus*). Estuaries And Coasts 29(1):63-71.

Robards, M. D., J. F. Piatt, A. B. Kettle, and A. A. Abookire. 1999. Temporal and Geographic Variation In Fish Communities Of Lower Cook Inlet, Alaska. Fishery Bulletin 97(4):962-977.

Roni, P., T. Beechie, R. Bilby, F. Leonetti, M. Pollock, and G. Pess. 2002. A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. North American Journal of Fisheries Management 22(1):1-20.

Rosenfield, J. A. 2010. Life History Conceptual Model And Sub-Models For Longfin Smelt, San Francisco Estuary Population. Report Submitted To The Sacramento-San Joaquin Delta Regional Ecosystem Restoration Implementation Plan (Drerip). Aquatic Resources Consulting, Sacramento, California.

Rosenfield, J. A., and R. Baxter. 2007. Population Dynamics and Distribution Patterns of Longfin Smelt in the San Francisco Estuary. Transactions of the American Fisheries Society 136(6):1577-1592.

Rupp, R. 1965. Shore-Spawning And Survival of Eggs of the American Smelt. Transactions of the American Fisheries Society 94(2):160-168.

Saiki, M., and B. Martin. 2001. Survey of Fishes and Environmental Conditions In Abbotts Lagoon, Point Reyes National Seashore, California. California Fish and Game 87(4):123-138.

Samuelson, C. 1973. Fishes Of South Humboldt Bay, Humboldt County, California. M.S. Thesis. Humboldt State University, Arcata, California.

Schmelzle, M., and A. Kinziger. 2016. Using Occupancy Modelling To Compare Environmental Dna To Traditional Field Methods For Regional-Scale Monitoring Of An Endangered Aquatic Species. Molecular Ecology Resources. Molecular Ecology Resources 16(4):895-908.

Simonsen, M. 1977. The Use of Discriminate Function Analysis in the Identification of Two Species of Larval Smelt, *Spirinchus Thaleichthys* and *Hypomesus T. Transpacificus*, in the Sacramento-San Joaquin Estuary, California. MS Thesis. University of the Pacific, Stockton, California.

Sonoma County Water Agency. 2001. Biological and Water Quality Monitoring in the Russian River Estuary, 2000 - Fifth Annual Report. Prepared for Sonoma County Water Agency by J. Martini-Lamb. Lafayette, California.

Sopher, T. 1974. A Trawl Survey of the Fishes of Arcata Bay, California. M.S. Thesis. Humboldt State University, Arcata, California.

Stables, T., C. Perrin, and M. Rosenau. 2005. Acoustic and Trawl Surveys to Locate Eulachon Aggregations in the Lower Fraser River, British Columbia. North American Journal of Fisheries Management 25(2):675-688.

Stein, R. 1972. Identification of Some Pacific Cottids. M.S. Thesis. Humboldt State University, Arcata, California.

Stevens, D., and L. 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.

Thomsen, P. F., J. Kielgast, L. L. Iversen, P. R. Møller, M. Rasmussen, and E. Willerslev. 2012. Detection of a Diverse Marine Fish Fauna Using Environmental DNA From Seawater Samples. Plos One 7(8):E41732.

Tulp, I., M. Keller, J. Navez, H. Winter, M. De Graaf, and W. Baeyens. 2013. Connectivity Between Migrating and Landlocked Populations of a Diadromous Fish Species Investigated Using Otolith Microchemistry. Plos One 8(7):E69796.

US Fish and Wildlife Service (USFWS). 2012. Notice of 12-Month Petition Finding (Longfin Smelt). Docket No. FWS-R8-Es-2008-0045.

Waldvogel, J. 1977. Age, Maturity, and Distribution of Northern Anchovy, *Engraulis Mordax*. M.S. Thesis. Humboldt State University, Arcata, California.

Wallace, M. 2006. Juvenile Salmonid Use of Freshwater Slough and Tidal Portion of Freshwater Creek, Humboldt Bay, California 2003. Annual Report. California Department of Fish and Game. Arcata, California.

Young, J. 1984. Identification of Larval Smelt (*Osteichthyes: Salmoniformes: Osmeridae*) From Northern California. M.S. Thesis. Humboldt State University, Arcata, California.

Zuspan, M. and M. Sparkman. 2002. CDFG Annual Report, Mad River Winter-Run Adult Steelhead Run-Size Estimate, 2000-2001 Season. Project 1A3. Arcata, California.

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Appendix 1.—Longfin smelt (Spirinchus thaleichthys) observations compiled for this study from 1889 to 2016. All observations were from coastal California, not including areas east of the Golden Gate Bridge. Observations are listed from north to south.

Area	Location	Month	Year	Number	Size (mm, TL)	Gear[a]	References (Document #)[g]
Del Norte County	Lake Earl (lagoon)	4	1989	1	UNK	GN	McLeod 1989
Klamath River	Estuary	UNK	1979-1989	"common"	UNK	VAR	Kisanuki et al. 1991
		11, 12	1992	≥2	UNK	S; BE	M. Wallace, California Department of Fish and Wildlife, unpublished data
		3	2001	UNK	150	BE	M. Wallace, unpublished data
		7	2003	UNK	UNK	BE	M. Wallace, unpublished data
Offshore	Gold Bluffs Beach	UNK	2005-2007	1	128	OT	Mulligan and Lomeli 2008
Offshore	False Klamath Cove	UNK	2005-2007	3	132-145	OT	Mulligan and Lomeli 2008
Offshore	Offshore of Big Lagoon	11	1968	5	95-116	UNK	LACM Fish Collection #37766.002
Near the Beach	Trinidad	9	2004	2	UNK	UNK	HSU Fish Collection #3694
Offshore	Trinidad	8, 9	1969	125	UNK	OT	Quirollo 1969
Mad River	Estuary	Winter	2002	1	UNK	S	Zuspan & Sparkman 2002; M. Sparkman, California Department of Fish and Wildlife, unpublished data
Offshore	Offshore of North Spit Humboldt Bay	10	2010	7	91-140	OT	Mulligan and Jones 2011
		9	1992	UNK	UNK	OT	Pequegnat and Mondeel-Jarvis 1995
	Offshore of Humboldt Bay	3, 5	1960	51	UNK	OT	Allen 1964
		7	1961	4	UNK	OT	Allen 1964
		1	1962	9	UNK	OT	Allen 1964
	Offshore of South Humboldt Bay	11	1968	5	86-114	T	LACM Fish Collection #30763.003

Appendix 1 continued

Area	Location	Month	Year	Number	Size (mm, TL)	Gear[a]	References (Document #)[g]
Humboldt Bay	Eureka, CA	1931	1931	3	UNK	UNK	MCZ Fish Collection #32743
Humboldt Bay	Entrance Channel	UNK	1974-1976	UNK	UNK	S	Waldvogel 1977
	Throughout	UNK	2000-2001	11	120-131	VAR	Cole 2004; Gleason et al. 2007
		11, 12	1979	9	UNK	PN	Young 1984
		1	1980	4			Young 1984
		1-12	1969	713	4-51	PN	Eldridge 1970; Eldridge and Bryan 1972
	Bay Entrance, North Bay, Jacoby Creek, Freshwater Slough	2-5	1971	687	UNK	UNK	Stein 1972
	UNK	UNK	1983-1984	14	UNK	OT	Hill and Hendrickson 1991
	North Humboldt Bay	12	2014	1	118	LA	J. Ray, California Department of Fish and Wildlife, unpublished data
		1-12	1968	1,586	50-150	OT	Sopher 1974
	North Humboldt Bay	UNK	2003-2005	12	UNK	VAR	Pinnix et al. 2005
	North Humboldt Bay	2-7	1972	110	UNK	S	DeGeorges 1972
	North Humboldt Bay	2	1961	1	UNK	UNK	HSU Fish Collection #2465
	Off Woodley Island	7-11	1981	7	UNK	OT	Chamberlain 1988
		3	1982	10	UNK	OT	Chamberlain 1988
		1	1982	2	Juvenile/ larval	PN	Chamberlain 1988
	South Humboldt Bay	1	1965	72	UNK	OT	Samuelson 1973
	South Humboldt Bay	4	1970	43	UNK	OT	Samuelson 1973
		10	1964	1	UNK	OT	Samuelson 1973
		10	1968	4	UNK	OT	Samuelson 1973

Area	Location	Month	Year	Number	Size (mm, TL)	Gear[a]	References (Document #)[g]
Humboldt Bay (cont.)		11	1963	5	UNK	OT	Samuelson 1973
		11	1968	25	UNK	OT	Samuelson 1973
	Freshwater Slough	4, 7	2003	UNK	UNK	S	M. Wallace, unpublished data; Wallace 2006
	Freshwater Slough (cont.)	3	2005	UNK	UNK	S	M. Wallace, unpublished data
		1-3	2006	UNK	UNK	S	M. Wallace, unpublished data
		4	2007	UNK	UNK	S	M. Wallace, unpublished data
		1	2008	UNK	UNK	S	M. Wallace, unpublished data
	Second Slough	12	1981	7	UNK	CN	Chamberlain 1988
		3, 4	1982	9	UNK	CN	Chamberlain 1988
		11	1981	1	UNK	OT	Chamberlain 1988
		2	1982	2	UNK	OT	Chamberlain 1988
	3rd Slough	7	2003	UNK	UNK	S	M. Wallace, unpublished data
	Park Street Mitigation Marsh	2	1981	7	UNK	CN	Chamberlain 1988
		1-3	1981	72	Juvenile/Lar-val	PN	Chamberlain 1988
		11	1981	3	UNK	OT	Chamberlain 1988
	Freshwater Creek Weir	3	2009	7	108-124[b, e]	W	J. Garwood, California Department of Fish and Wildlife, unpublished data
		12	2012	4	UNK	W	C. Anderson, Sponsored Programs Foundation, HSU, unpublished data
		12	2015	8	123-131[b, d]	W	J. Ray, unpublished data
		1	2016	3	107-132[b, d]	W	C. Anderson, unpublished data
		2	2016	3	130-135[d]	W	C. Anderson, unpublished data

Appendix 1 continued

Area	Location	Month	Year	Number	Size (mm, TL)	Gear[a]	References (Document #)[g]
Humboldt Bay (cont.)	Above Freshwater Creek Weir	12	2014	17	UNK	S	M. Wallace, unpublished data
	Elk River Slough	2, 3	2005	UNK	UNK	S	M. Wallace, unpublished data
		1-3	2006	UNK	UNK	S	M. Wallace, unpublished data
		1	2008	UNK	UNK	S	M. Wallace, unpublished data
	Salmon Creek	2	2006	UNK	UNK	S	M. Wallace, unpublished data
		1	2012	UNK	UNK	S	M. Wallace, unpublished data
		1	2014	UNK	UNK	S	M. Wallace, unpublished data
		2	2015	UNK	UNK	S	M. Wallace, unpublished data
		2	2016	1	114b, [e]	S	M. Wallace, unpublished data
	Hookton Slough	1	2006	UNK	UNK	S	M. Wallace, unpublished data
Offshore of the Eel River		8	1971	4	84-108	OT	LACM #31955.006
Eel River Estuary	Hawk Slough	4	1974	1	121	S	Puckett 1977a[f]; L. Puckett, California Department of Fish and Game (Retired), unpublished field notes
		2, 3	1995	8	112-128	S	Cannata and Hassler 1995
	Quill Slough	4	1974	1	114	S	Puckett 1977a; 1 L. Puckett, unpublished field notes
	North Bay	12	1973	2	130-139	S	Puckett 1977a; L. Puckett, unpublished field notes
	North Bay	6, 12	1994	78	NA	S	Cannata & Hassler 1995
	North Bay	2, 3	1995	3	NA	S	Cannata & Hassler 1995
	Cutoff Slough	2	1974	1	128	S	Puckett 1977a; L. Puckett, unpublished field notes

Area	Location	Month	Year	Number	Size (mm, TL)	Gear[a]	References (Document #)[g]
Eel River Estuary (cont.)	Morgan Slough	3	1974	3	120-130	S	Puckett 1977a; L. Puckett, unpublished field notes
	Salt River	11	1973	3	116-133	S	Puckett 1977a; L. Puckett, unpublished field notes
	Salt River (cont.)	12	2014	1	130	S	M. Wallace, unpublished data
		2	2015	3	UNK	S	M. Wallace, unpublished data
	Main Channel Eel River Estuary	12	1973	2	140; 142	S	Puckett 1977a; L. Puckett, unpublished field notes
	Near Cock Robin Island	12	1952	1	UNK	UNK	CAS Fish Collection #212337
	McNulty Slough	2	2007 & 2009	2	UNK	S	M. Wallace, unpublished data
		7	2007	50-100	UNK	S	M. Wallace, unpublished data
Eel River	20 km from mouth of River	12	1955	23	105c	FN	Jensen 1957 & HSU Fish Collection #240
	Mouth of the Van Duzen River	11	1956	7	UNK	UNK	HSU Fish Collection #2534
Gualala River	River mouth	4	1973	1	UNK	UNK	J. Hopelain, California Department of Fish and Game, unpublished data
Garcia River	UNK	UNK	1973-1977	UNK	UNK	UNK	J. Hopelain, unpublished data
Russian River	Estuary	6, 11	1997	12	UNK	OT	Merritt Smith Consulting 1998
		8, 9	1998	5	UNK	OT	Merritt Smith Consulting 1999
		10, 11	1999	4	UNK	OT	Merritt Smith Consulting 2000
		10	2000	2	UNK	OT	Sonoma County Water Agency 2001
	Offshore	8	1971	1	102	OT	LACM Fish Collection #31982.01
Estero Americano	Estuary	UNK	1988-1990	8	UNK	OT	Hickey et al. 2007
Point Reyes	Abbotts Lagoon	UNK	1999	1	UNK	GN	Saiki and Martin 2001
Point Reyes	Offshore of Lighthouse	10	1971	1	UNK	UNK	CAS Fish Collection #28362

Appendix 1 continued

Area	Location	Month	Year	Number	Size (mm, TL)	Gear[a]	References (Document #)[g]
Offshore of San Francisco Bay	Offshore of North San Francisco Bay	2	2002	54	74-120[c]	NRT	Harding et al. 2011; MacFarlane, B. NOAA SWFSC Fisheries Ecology Division, unpublished data
		3	1999	1162	63-110[c]	NRT	Harding et al. 2011; MacFarlane, B., unpublished data
		6	2000	7	80-95[c]	NRT	Harding et al. 2011; MacFarlane, B., unpublished data
		7	2001	1	99[c]	NRT	Harding et al. 2011; MacFarlane, B., unpublished data
		9	1936	2	UNK	UNK	CAS Fish Collection #63975
Offshore of San Francisco Bay	Offshore of North San Francisco Bay	10	2001	2	69; 72[c]	NRT	Harding et al. 2011; MacFarlane, B., unpublished data
		11	1998	33	63-73[c]	NRT	Harding et al. 2011; MacFarlane, B., unpublished data
	Farallon Islands	10	1973	30	UNK	UNK	CAS Fish Collection #34742
	Offshore of South San Francisco Bay	3	1889	1	UNK	BT	SU Fish Collection #56118
	Offshore of South San Francisco Bay (cont.)	3	1999	17	75[c]	NRT	Harding et al. 2011; MacFarlane, B., unpublished data
		5	1999	34	36-109[c]	NRT	Harding et al. 201; MacFarlane, B., unpublished data
		6	1999	48	42-97[c]	NRT	Harding et al. 2011 ; MacFarlane, B., unpublished data
		6	2002	1	108[c]	NRT	Harding et al. 2011 ; MacFarlane, B., unpublished data
	Offshore of South San Francisco Bay	7	1973	2	UNK	T	CAS Fish Collection #34785
		10	1912	2	UNK	VAR	CAS Fish Collection #12190

Area	Location	Month	Year	Number	Size (mm, TL)	Gear[a]	References (Document #)[g]
Offshore of San Francisco Bay (cont.)		10	1973	12	UNK	T	CAS Fish Collection #34750
		10	1973	1	UNK	T	CAS Fish Collection #34806
		11	1949	2	UNK	T	CAS Fish Collection #63976
Pescadero Creek	Butano Creek		UNK (possibly 12/1893)	1	UNK	UNK	SU Fish Collection #2556
Monterey Bay	Offshore of Santa Cruz	3	1890	4	UNK	BT	SU Fish Collection #5215
Moss Landing	Near Entrance	1	1980	1	UNK	NA	CAS Fish Collection #45425
Monterey Bay	Offshore North of Monterey	7	1993	5	UNK	UNK	KU Fish Collection #9335; #548; #9336; #9337 & #23732

[a]Gear used: BT=Beam Trawl; CN= Channel Net; GN=Gill Net; LA=Lampara Net; NRT= epipelagic 264 Nordic Rope Trawl; S=Seine; OT=Otter Trawl; T=Trawl; W=Weir; FN= Fyke Net; PN=Plankton Net; BE= Boat Electrofisher; UNK=Unknown Gear Type; VAR=Various.
[b]Measurements taken in fork length.
[c]Measurements taken in standard length.
[d]Specimens noted to be in pre-spawn condition.
[e]Specimens noted to be in spawned out condition.
[f]Spawning observed in this study, though the specific location was not reported.
[g]References for unpublished reports

ALLEN G. 1964. An oceanographic study between the points of Trinidad Head and the Eel River, California State Water Quality Control Board. Arcata, California
HICKEY, P., L., HULETTE, L. POZZI, AND J. HECK. 2007. The Estero Americano Watershed Management Plan. Prepared by the Gold Ridge Resource Conservation District.
HOPELAIN, J. 1997. Unpublished Report. Draft final report Dingell-Johnson Coastal Steelhead Study of Gualala and Garcia Rivers- data collection 1973-1977
MCLEOD, D. 1989. Field Note: Lake Earl, Del Norte County. CDFW Field Archives, Arcata, California.
MULLIGAN, T., AND M. JONES. 2011. PG&E Wave Connect Project Final Report Baseline Fisheries Studies. Report to PG&E. Humboldt State University. Arcata, California.
MULLIGAN, T., AND M. LOMELI. 2008. Redwood National and State Parks Subtidal Fish Survey Final Report. Report to Redwood National and State Parks. Humboldt State University. Arcata, California.
PEQUEGNAT, J., AND D. MONDEEL-JARVIS. 1995. 301(m) monitoring program annual report on sediment characteristics, benthic infauna, demersal fish and macroinvertebrates sampled September 1994. Humboldt State University.
PUCKETT, L. 1977A. The Eel River estuary-observations on morphometry, fishes, water quality, and invertebrates. CDFG Memorandum Report. Eureka, California.
QUIROLLO, L. 1969. Field Notes: offshore collections. CDFW Field Archives, Arcata, California.